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2008

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KANPUR - 208 016

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(as on July, 2008)

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11.	**Industrial & Management Eng.:**	IME	Sharma, N.K.	7553
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18.	**Physics:**	PHY	Mohapatra Y.N.	7563

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R. Sharan (82-84)
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Ghoshdastidar, P.S.	Chairman, SUGC
Gupta, V. K.	Chairman, SPGC
Naik, A. K.	Assistant Registrar, Academic

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I. ACADEMICS AT I.I.T. KANPUR

The Indian Institute of Technology at Kanpur is one of the seven institutions which were established by the Government of India to provide engineering and technological education of internationally recognised excellence. The Institute is located on the historic Grand Trunk Road ten kilometers west of Kanpur. It is a residential campus, planned and landscaped for environmental freedom. Halls of residence, faculty houses and community buildings surround a central cluster of buildings that house educational, administrative and research facilities.

The first batch of 100 students arrived in 1960. The Institute today has more than 2000 undergraduate and 1700 postgraduate students, and a faculty of about 309. During the period 1962-72, IIT Kanpur benefited immensely from the technical assistance provided by a consortium of nine leading Institutions of the U.S.A. The faculty members from these institutions advised the Institute in the initial setting up of the teaching and research facilities and in the installation of highly sophisticated equipment for the laboratories. The assistance programme was made possible jointly by the Government of India and the Government of the United States through the U.S. Agency for International Development. From its very inception, IIT Kanpur has striven to develop itself into an institution of excellence in education and research befitting the spirit of modern India. In its quest for excellence, IIT Kanpur has internalised a drive to rise to the contemporary and future demands of need-oriented education. The Institute is now recognised as a major centre of training in engineering, sciences and several interdisciplinary areas. In addition to training students in formal undergraduate and postgraduate programmes, the Institute is involved with continuing education, research in basic sciences, engineering, and humanities and social sciences as well as research and development in areas of value to Industry and Government. The Institute has considerably strengthened its facilities and faculty to participate in a major way in national scientific and technological endeavours. The Institute has always made special efforts to admit high quality students. The undergraduates, admitted through the Joint Entrance Examination conducted all over the country; represent India's most promising young talents. Twenty-two-and-a-half per cent of the seats in the first-year class are reserved for the scheduled caste/scheduled tribe students. Special curricula evolved for such students ensure their joining the main stream of academic activities quickly and without undue psychological and emotional problems. A number of innovations have been introduced such as the slow-paced programme and academic assistance by senior students, etc.

1.1 Educational Goals

In a world that is fast changing, an engineer/scientist must constantly update his knowledge. Forever interrogating the methods and techniques of the profession, new knowledge continually deepens and broadens the vision of the professional. Intellectual alertness, creativity and talent for innovation will be essential for professional competence more than ever in the future. Keeping this in mind, the objective goals of IIT Kanpur can be formulated as follows:

- To prepare carefully selected students for the highest level of education in technology and science aimed at producing competent, creative and imaginative engineers and scientists;
- To promote higher studies and research with a spirit of free and objective enquiry in different fields of knowledge;
- To attract distinguished faculty who by their scholarship, learning and research contribute to the rapidly growing structures of knowledge and professional excellence;

— To foster inter-disciplinary approaches and inter-departmental involvement in the educational programme by bringing together faculty and student;
— To promote contact with, and be of service to industries, government and civic organisations through research efforts, consultations, conferences and short-term intensive courses on current developments in technology and science;
— To develop the Institute to a critical magnitude ensuring significant contributions to the technical manpower and research needs of the nation, and also to provide an intellectual reservoir for the growing demands of a developing nation.

1.2 Academic programmes and Degrees awarded

IIT Kanpur conducts 10 different educational programmes at the undergraduate and postgraduate (including doctoral) levels. A list of the different programmes, including the number of sanctioned seats† in each, is given below.

				Seats
1.	**Programme:**	**B.Tech.**		**352***
	Nature:	Undergraduate (UG)		
	Degree:	*Bachelor of Technology*		
	Duration:	4 years (8 semesters)		
	Disciplines:	→ Aerospace Engineering		25
		→ Biological Sciences and Bio-Engineering		26
		→ Chemical Engineering		40
		→ Civil Engineering		53
		→ Computer Science & Engineering		34
		→ Electrical Engineering		65
		→ Mechanical Engineering		48
		→ Materials and Metallurgical Engineering		61
	Entry:	IIT-JEE		
	Eligibility:	Passed Class XII with 60% or equivalent		
2.	**Programme:**	**B.Tech.-M.Tech.**		**96***
	Nature:	Dual degree		
	Degrees:	*Bachelor of Technology Master of Technology*		
	Duration:	5 years (10 semesters)		
	Disciplines:	→ Aerospace Engineering	7	
		→ Chemical Engineering	10	
		→ Civil Engineering	15	
		→ Computer Science & Engineering	26	
		→ Electrical Engineering	21	
		→ Mechanical Engineering	17	
	Entry:	IIT-JEE		
	Eligibility:	Passed Class XII with 60% or equivalent		

***** *indicates intake per year*

† Institute reserves the right of not filling-up sanctioned seats under special circumstances, such as non-availability of suitable candidates, or inadequate scholarship funds, etc.

3.	**Programme:**	**M.Tech.**	**1375**
	Nature:	Postgraduate (PG)	
	Degree:	*Master of Technology*	
	Duration:	2 years (4 semesters)	
	Disciplines:	→ Aerospace Engineering	81
		→ Biological Sciences & Bio-Engineering	36
		→ Chemical Engineering	133
		→ Civil Engineering	161
		→ Computer Science & Engineering	145
		→ Electrical Engineering	242
		→ Environmental Eng'g & Management	73
		→ Mechanical Engineering	205
		→ Materials and Metallurgical Engineering	125
		→ Materials Science	44
		→ Industrial & Management Engineering	74
		→ Nuclear Engineering and Technology	28
		→ Laser Technology	28
	Entry:	GATE	
	Eligibility :	B.E. or B.Tech. or equivalent	

4.	**Programme:**	**M.Des.**	**36**
	Nature:	Postgraduate (PG)	
	Degree:	*Master of Design*	
	Duration:	2 years (4 semesters)	
	Disciplines:	→ Design	36
	Entry:	CEED	
	Eligibility:	Bachelor's degree in Engineering, Design or Architecture	

5.	**Programme:**	**D.IIT.**	
	Nature :	Postgraduate (PG)	
	Degree:	*Diploma of the Indian Institute of Technology*	
	Duration:	1 year (2 semesters)	
	Disciplines:		
	Entry:		
	Eligibility :	B.Tech. or M.Sc. or equivalent + sponsorship by a recognized industry	

6.	**Programme:**	**M.B.A.**	**103**
	Nature :	Postgraduate (PG)	
	Degree:	*Master of Business Administration*	
	Duration:	2 years (4 semesters)	
	Disciplines:	→ Management	103
	Entry:	JMET	
	Eligibility :	B.E. or B.Tech. or equivalent	

7.	**Programme:**	**Integrated M.Sc. (Five-year)**	**93***
	Nature:	Undergraduate (UG)	
	Degree:	*Master of Science*	
	Duration:	5 years (10 semesters)	
	Disciplines:	→ Chemistry	18
		→ Economics	25
		→ Physics	18
		→ Mathematics & Scientific Computing	32
	Entry:	IIT-JEE	
	Eligibility:	Passed Class XII with 60% or equivalent	

8.	**Programme:**	**M.Sc. (Two-year)**	**120**
	Nature:	Undergraduate (UG)	
	Degree:	*Master of Science*	
	Duration:	2 years (4 semesters)	
	Disciplines:	→ Chemistry	28
		→ Physics	38
		→ Mathematics	27
		→ Statistics	27
	Entry:	IIT-JAM	
	Eligibility :	B.Sc.	

9.	**Programme:**	**M.Sc.-Ph.D.**	**9**
	Nature:	Dual degree	
	Degrees:	*Master of Science* *Doctor of Philosophy*	
	Duration:	Max. 6 years (12 semesters)	
	Disciplines:	→ Physics	9
	Entry:	IIT-JAM	
	Eligibility:	B.Sc.	

10.	**Programme:**	**Ph.D.**	**1023**
	Nature :	Postgraduate (PG)	
	Degree:	*Doctor of Philosophy*	
	Duration:	Max. 5 years (10 semesters)	
	Disciplines:	→ Aerospace Engineering	47
		→ Biological Sciences and Bio-Engineering	40
		→ Chemical Engineering	81
		→ Civil Engineering	91

	→ Computer Science & Engineering	32
	→ Electrical Engineering	64
	→ Mechanical Engineering	89
	→ Materials & Metallurgical Engineering	52
	→ Materials Science	28
	→ Industrial & Management Engineering	40
	→ Nuclear Engineering and Technology	4
	→ Chemistry	201
	→ Physics	89
	→ Mathematics	101
	→ Statistics	–
	→ Humanities & Social Sciences	64
	- English	
	- Economics	
	- Philosophy	
	- Psychology	
	- Sociology	
Entry:	GATE and/or Written test & Interview	
Eligibility :	M.Tech. or M.Sc. or equivalent	

1.3 Undergraduate programmes

Students who have qualified in the IIT-JEE Examination after passing Standard XII may be admitted to one of

1. The *B.Tech.* (Four-year) programme;
2. The *B.Tech.-M.Tech. (Dual degree)* (Five-year) programme;
3. The *Integrated M.Sc* (Five-year) programme.

All these programmes have two components. The first component is the Core programme common to all students and is carefully planned to give the students a strong base of general education in Mathematics, Physics, Chemistry, Engineering Sciences, Technical Arts, and Humanities and Social Sciences. The course structure in the core curriculum provides for large lecture classes with tutorial discussion hours and laboratory sessions in smaller groups

The second component of the undergraduate programme includes professional courses and a project in the chosen branch of specialisation. The professional programme, while providing the flexibility of having laboratory courses often independent of the lecture classes, culminates in a project involving the application of modern analysis and design techniques. Most of the departments organise educational tours and training during the professional part of the programme. An important feature of the undergraduate programmes in IIT Kanpur is the large number of elective courses which provides the students considerable freedom to develop academically according to their individual tastes.

One of the key features of core and professional courses in IIT Kanpur is the great stress laid on problem-solving and practical applications of the theoretical knowledge gained in the lectures. Audio-visual aids are being increasingly introduced, especially by the newer faculty members.

Students of the *B.Tech.-M.Tech. (Dual degree)* programme spend their first seven semesters doing undergraduate courses together with the students of the *B.Tech.* programme, while the last three semesters are spent doing postgraduate courses together with the students of the *M.Tech.* programme. At the end of five years, they graduate, receiving both *B.Tech.* and *M.Tech.* degrees together. There is no option of early exit with a *B.Tech.* degree only[1] . Students in this programme who have good academic performance are given a scholarship in the final year, which is on par with that given to students of *M.Tech.* programmes.

Students who have qualified in the IIT-JAM Examination after securing a *B.Sc.* or equivalent degree from a recognized University may be admitted to one of

4. The *M.Sc.* (Two-year) programme;
5. The *M.Sc.-Ph.D. (Dual degree)* programme

Such students undergo an intensive training in professional courses, with several electives courses catering to individual tastes.

Students of the *M.Sc.-Ph.D. (Dual degree)* programme (currently only available in the Physics Department) spend their first five semesters doing course work, mostly in common with their peers in the *M.Sc.* (Two-year) programme, after which they concentrate on their doctoral research. At the end of the programme, they graduate, receiving both *M.Sc.* and *Ph.D.* degrees together. There is no option of early exit with an *M.Sc.* degree only[‡]. Students who enter this programme and maintain a good academic performance are given a token scholarship of Rs. 3000/- in the first three semesters, after which they get the regular Assistantship at par with other doctoral students.

Every Department has a *Departmental Undergraduate Committee* (DUGC) for the micro-management of undergraduate programmes in that Department. These committees make specific recommendations to the *Senate Undergraduate Committee* (SUGC), which ensures uniformity between Departments and programmes, and makes specific recommendations to the *Academic Senate* of IIT Kanpur, which is the highest body for making policy in all academic matters. In keeping with the democratic traditions of IIT Kanpur, it is mandatory that some of the members of all these bodies be students of the relevant programmes. Typical matters under the jurisdiction of these bodies are approval of every student's academic registration in every semester, granting of long and short leave, approval of new courses, deletion of obsolete courses, identification of students with deficient performance, consideration of mercy appeals, etc. These bodies also conduct, on behalf of the Dean of Academic Affairs, a student reaction survey for each course, in which the students are encouraged to provide their free and frank opinions about each course, without identifying themselves.

1.4 Postgraduate programmes

The goals of the Postgraduate Programmes at the Indian Institute of Technology Kanpur comprise

[1] unless the student's performance is so poor that he/she is considered incapable of securing the higher degree. Institute reserves the sole right to make the decision in such cases.

the following:

> "*The development of the highest quality of scientific and engineering manpower to cater to the needs of Industry, R & D Organisations and Educational Institutions who shall have a broad grasp of the fundamental principles of sciences and the scientific method, deep understanding of their area of specialisation, innovative ability to solve new problems, and the capacity to learn continually and interact with multidisciplinary groups. Above all, they should have a capacity for free and objective enquiry, courage and integrity, awareness and sensitivity to the needs and aspirations of society*."

With this end in view, the programmes are designed to include submission of a thesis through which a student may develop his/her concepts and intellectual skills. These programmes with their courses and specialised research aim to prepare students for their professions by enabling a perspective and breadth of knowledge related to the principal divisions of their respective fields of specialisation. A postgraduate student will typically be enrolled for three or four courses each semester, until he/she attains the necessary levels of competence before embarking on his/her research thesis.

Students who have passed the qualifying examination, i.e., *B.Tech.*/*B.E.* or *M.Sc.* in the appropriate area, and hold a valid GATE score may be admitted to the *M.Tech.* programme. All *M.Tech.* students admitted through this process who have good academic performance are eligible for scholarship. Admission is also allowed in the *M.Tech.* programmes for sponsored candidates from the industries as well as research organizations. Sponsored candidates do not need to qualify GATE and are not eligible for scholarship.

IIT Kanpur, already recognised for its excellence in engineering and science education, has made a strategic move with the introduction of the MBA programme that aims to become the best in management education. Candidates for admission must have passed the JMET Examination.

To meet the new challenge of design-related professions, a comprehensive and formal training through a curriculum is the need of the day. There is a growing demand for specially trained graduates in the field of Design for the national and international industries. The postgraduate programme of Design at IIT Kanpur seeks to meet this requirement. Admission is made once a year through the CEED examination and an interview for short-listed candidates.

Only candidates sponsored by recognised Industries are eligible for the *D.IIT.* programme of two semesters, which serves to enhance a student's engineering skills beyond the Bachelor's level.

The highest degree awarded by IIT Kanpur is the *Ph.D.*, which is either obtained through a regular programme or may be awarded *honoris causa* to eminent personalities. Students in *Ph.D.* programmes are expected to do some course work, where advanced topics relevant to their research areas are taught. Before commencing their doctoral work, every student is required to appear for a Comprehensive Examination, which tests the student's all-round expertise in the subject. After a semester, the student is expected to present a State-of-the-Art seminar, in which he/she exhibits mastery over the current state of knowledge in the specific area of research. While the actual research work is in progress, every semester, each student's progress is monitored by a three-member Peer Review Committee. When the research work is completed, the student must present an Open Seminar, following which he/she is expected to write up the doctoral thesis. This is then examined and when the thesis reports are all available, the student is expected to defend the thesis in a Viva-voce examination. A student who qualifies this is immediately awarded a provisional degree; the regular degree is awarded at the next Institute Convocation.

The Institute also offers *part-time* postgraduate programmes leading to the *M. Tech.* & *Ph. D.* degree for the local (professionally) employed personnel such as working engineers, scientists and teachers who can regularly attend classes/courses.

Every Department has a *Departmental Postgraduate Committee* (DPGC) for the micro-management of postgraduate programmes in that Department. These committees make specific recommendations to the *Senate Postgraduate Committee* (SPGC), which ensures uniformity between Departments and programmes, and makes specific recommendations to the *Academic Senate* of IIT Kanpur, which is the highest body for making policy in all academic matters. In keeping with the democratic traditions of IIT Kanpur, it is mandatory that some of the members of all these bodies be students of the relevant programmes. Typical matters under the jurisdiction of these bodies are approval of every student's academic registration in every semester, granting of long and short leave, approval of new courses, deletion of obsolete courses, identification of students with deficient performance, consideration of mercy appeals, monitoring of research progress through seminars, assessment of thesis reports, etc. As in the case of undergraduate programmes, these bodies also conduct, on behalf of the Dean of Academic Affairs, a student reaction survey for each course.

1.5 Admissions : Eligibility and Procedure

Admission to the different academic programmes at I.I.T. Kanpur is based on merit alone. The majority of students are admitted through all-India competitive examinations which are common to all seven IITs as well as some other institutions. Candidates for admission through these various competitive examinations should be Indian citizens. IIT Kanpur also admits a limited number of foreign students. Provisions for foreign students, together with the procedure, are available on the website at http://www.iitk.ac.in/doaa/DOAA/foreignstudents.htm .

1.5.1 B. Tech., B.Tech.-M.Tech. & M.Sc. (Integrated) Programmes

Admissions are made once a year, in July. The minimum academic qualification is that candidates should have passed the final examination of 10+2 or equivalent with 60% marks or equivalent (55% or equivalent for SC/ST/PD[1] candidates). The candidates must not be more than 25 years of age (30 years for SC/ST/PD) candidates on October 1 in the year of admission. The candidate must not be or have been a registered student in any IIT or IT-BHU, Varanasi or ISM, Dhanbad. Selection for admission is made through the Joint Entrance Examination (IIT-JEE), held in April every year. A candidate may appear a maximum of two times for this examination - one in the year of appearing for final year of 10+2 and one in the following year. Successful candidates are offered choice of stream on the basis of All-India rank in JEE and preferences of the candidate.

The advertisement appears in all the leading dailies and on the website (http://www.jee.iitk.ac.in/main.php) in September of the previous year. Application forms are available from The Chairman, Joint Entrance Examination, Indian Institute of Technology, Kanpur 208 016 or various branches of major Banks (see website for details). Application fees are Rs. 1000/- (Rs. 500/- for SC/ST and *all* female candidates).

Some relaxations in the minimum criteria have been made for students appearing in the IIT-JEE-2007. Details of this are available on the website (as above).

1.5.2 M.Sc. (2-year) and M.Sc.-Ph.D. (Dual Degree) Programmes

Admissions are made once a year, In July. The minimum academic qualification is that candidates should hold a Bachelor's degree in Science from a recognized University with at least 55% marks in aggregate or equivalent (50% marks for SC/ST/PD candidates). Students in the final year of the qualifying degree may also apply, but the admission would stand cancelled if the final examination is not over at the time of admission, or if the proof of minimum qualification is not submitted by September 30 in the year of admission. Selection for admission is made through the all-IITs Joint Admission Test for M.Sc. (JAM) conducted in May. There is no restriction on the age of the candidate or the number of attempts for JAM. Successful candidates are offered choice of stream on the basis of All-India rank in JAM and preferences of the candidate.

The advertisement appears in all the leading dailies and on the website (http://www.iitk.ac.in/gate/jam/) in February. Application forms are available from The Chairman, Joint Admission Test for M.Sc. (JAM), Indian Institute of Technology, Kanpur 208 016, or some designated branches of the Canara Bank (see website for details). Application fees are Rs. 500/- (Rs. 250/- for SC/ST) for one test paper and Rs. 200/- for a second test paper (in another subject). In addition, *all* candidates are required to deposit a sum of Rs. 4000/- with the Organising Chairman of JAM (this changes from year to year), which is refunded after the results are declared except in cases when the candidate is successful and accepts the offer of admission, but does not join the relevant IIT. Further details are available on the JAM website (as above).

1.5.3 M.Tech. Programme

Admissions are made twice a year, in July and December. The minimum academic qualification is that candidates should hold a Bahelor's degree in Engineering or a Master's degree in Science in the appropriate area from a recognized University with not less than 55% marks or equivalent (no marks restriction for SC/ST/PD candidates) as well as a valid GATE score. Candidates holding a Bachelor's degree in the appropriate area from a recognized University who are sponsored by a recognized industry / research institution may also be considered. B.Tech. graduates from IITs with an overall CGPA of 6.5 or above and a CGPA of 8.0 or above in the final two semesters may also apply (however, they will be eligible for Institute assistantship only if the overall CGPA is 8.0 or above). Selection for admission is made through the Graduate Aptitude Test in Engineering (GATE) conducted in February followed by an interview conducted by the Department to which the candidate is seeking admission. There is no restriction on the age of the candidate or the number of attempts for GATE. Successful candidates are offered choice of stream (where relevant) on the basis of their GATE score and performance in the Interview.

The advertisement appears in all the leading dailies and on the website (http://www.iitk.ac.in/gate/) in March/April & September. Application forms for M.Tech. admission are available from The Assistant Registrar (Academic), Indian Institute of Technology, Kanpur 208 016. Application forms for GATE are available from The Chairman, Graduate Aptitude Test in Engineering (GATE), Indian Institute of Technology, Kanpur 208 016. Application fees are Rs. 1000/- (Rs. 500/- for SC/ST). If application is made online, the application fees are Rs. 900/- (Rs. 400/- for SC/ST). Further details are available on the GATE website (as above).

1.5.4 M. B. A. Programme:

Admissions are made once a year, in July. The minimum academic qualification is that candidates

[1] SC: Scheduled Caste, ST: Scheduled Tribe, PD: Physically Disabled

should hold a Bachelor's degree *in Engineering* with at least 60% marks or equivalent from a recognized University (no marks restriction for SC/ST/PD candidates) as well as a valid JMET score. Candidates from the Architecture stream may also apply provided they have Mathematics as a subject at the 10+2 level. Students in the final year of the qualifying degree may also apply, but the admission would stand cancelled if the final examination is not over at the time of admission, or if the proof of minimum qualification is not submitted by September 30 in the year of admission. Selection for admission is made through the Joint Management Entrance Test (JMET) held in December of the previous year. There is no restriction on the age of the candidate or the number of attempts for JMET. Successful candidates are called for an Interview/ Group Discussion conducted by the relevant Department and admission is granted based on the results if this.

The advertisement appears in all the leading dailies and on the website (http://www.iitk.ac.in/gate/) in April. Application forms for M.B.A. admission are available on the website at the URL http://www.iitk.ac.in/ime and the filled-in forms should be sent to The Convenor DPGC, IME Department, IIT, Kanpur 208 016. Application forms for JMET are available from The Chairman, Graduate Aptitude Test in Engineering (GATE), Indian Institute of Technology, Kanpur 208 016. Application fees are Rs. 800/- (Rs. 400/- for SC/ST candidates). If application is made online, the application fees are Rs. 700/- (Rs. 300/- for SC/ST). Further details are available on the GATE website (as above).

1.5.5 M. Des. Programme:

Admissions are made twice a year, in July and December. The minimum academic qualification is that candidates should hold a Bachelor's degree in Engineering, Design or Architecture from a recognized University with not less than 55% marks or equivalent (no marks restriction for SC/ST/PD candidates) as well as a valid CEED/GATE score. Candidates holding degrees in Fine Arts or Interior Design are not eligible to apply for this programme. Students in the final year of the qualifying degree may also apply, but the admission would stand cancelled if the final examination is not over at the time of admission, or if the proof of minimum qualification is not submitted by September 30 in the year of admission. Selection for admission is made through the Common Entrance Examination for Design (CEED). There is no restriction on the age of the candidate or the number of attempts for CEED. Successful candidates are called for an Interview conducted by the relevant Department and admission is granted based on the results if this.

The advertisement appears in all the leading dailies and on the website (http://www.iitk.ac.in/doaa) in April. Application forms for admission to the M.Des. programme are available on the website at the URL http://www.iitk.ac.in/design/ .Filled-in application forms should be sent to The Convenor DPGC, Design Programme, IIT, Kanpur 208 016. Application fees are Rs. 1000/- (Rs. 500/- for SC/ST). If application is made online, the application fees are Rs. 900/- (Rs. 400/- for SC/ST). Further details are available on the M.Des. website (as above).

1.5.6 D.IIT. Programme:

Admissions are made twice a year, in July and December. The minimum academic qualification is that candidates should hold a Bachelor's degree in Engineering or a Master's degree in Science in the appropriate area from a recognized University with not less than 55% marks or equivalent (no marks restriction for SC/ST/PD candidates) and must be sponsored by a recognized industry. There is no restriction on the age of the candidate. Candidates for admission to the D.IIT. programme will be called for a written test and/or interview for selection.

1.5.7 Ph.D. Programme :

Admissions are made twice a year, in July and December. The minimum academic qualification is that candidates should hold a Master's degree in the appropriate area from a recognized University with not less than 55% marks or equivalent (no marks restriction for SC/ST/PD candidates) as well as a valid GATE score. However, outstanding applicants holding a Bachelor's degree in Engineering with not less than 75% marks or equivalent may also be considered for admission. Candidates for entry to Ph.D. programmes in Sciences and in Humanities & Social Sciences who have qualified the UGC/CSIR NET for Fellowship (not just Lecturereship) may also be considered.

Selection for admission is made through the Graduate Aptitude Test in Engineering (GATE) conducted in February followed by a written test and/or interview conducted by the Department to which the candidate is seeking admission. There is no restriction on the age of the candidate or the number of attempts for GATE. Successful candidates are admitted on the basis of their GATE score and performance in the written test and/or interview.

Admission for sponsored candidates from industries as well as research organisations is also available in the Ph.D. programme. Admission is also encouraged in Ph.D. programmes for external registration to the personnel of R&D establishments which are equipped with necessary laboratory, library and computational facilities. External registration is permitted only after the department concerned has satisfied itself that the sponsoring organisation of the candidate is equipped with necessary facilities for research including the availability of a co-supervisor.

The advertisement appears in all the leading dailies and on the website (http://www.iitk.ac.in/gate/) in March/April & September. Application forms for Ph.D. admission are available from the website at the URL http://www.iitk.ac.in/doaa/pgadmission/form_bro.html. Filled-in admission forms should be sent to The Convenor DPGC, Department of 〈 relevant department〉, IIT, Kanpur 208016. Application fees are Rs. 200/- (Rs. 100/- for SC/ST). You can also apply online at the URL http://www.iitk.ac.in/doaa/.

Application forms for GATE are available from The Chairman, Graduate Aptitude Test in Engineering (GATE), Indian Institute of Technology, Kanpur 208 016. Application fees for GATE are Rs. 1000/- (Rs. 500/- for SC/ST). If application is made online, the application fees are Rs. 900/- (Rs. 400/- for SC/ST). Further details are available on the GATE website (as above).

1.5.8 Part-time Postgraduate Programmes

The Institute also offers part-time postgraduate programmes leading to the M. Tech. & Ph. D. degree for local (professionally) employed personnel such as working engineers, scientists and teachers who can regularly attend classes/courses. Interested candidates should contact The Convenor DPGC, Department of árelevant departmentñ, IIT, Kanpur 208016.

1.5.9 External Registration for Ph.D. programmes

A candidate working in an R&D establishment which is equipped with the necessary research and library facilities may be considered for admission only to the Ph.D. programmes in engineering. Such a candidate must be sponsored by his/her employer and must have been in employment with the sponsoring organization for at least two years at the time of admission. The employer must expressly undertake to pay full salary to the candidate and relieve him/her to stay on the campus to enable the candidate to complete his/her minimum residence requirements.

A candidate applying for admission to the external registration programme must provide detailed information about the research facilities available at his/her organization and a certificate that these would be available to him/her for carrying out research. He/she should also provide the *curriculum vitae* of the prospective supervisor who would supervise the candidate's work at his/her organization. Applications should be made to The Convenor DPGC, Department of árelevant departmentñ, IIT, Kanpur 208016.

1.6 Financial Assistance

IIT Kanpur provides financial assistance to many students through a variety of schemes. Administration of these is carried out by the Dean of Academic Affairs and the Dean of Student Affairs, in consultation with the Head of the Department concerned, the Counselling Service and the Senate Scholarships and Prizes Committee (SSPC).

1.6.1 For Undergraduate Students

A number of Merit-cum-Means scholarships, freeships (i.e., tuition waiver), free basic messing and pocket allowance (for SC/ST categories), and endowment scholarships /fellowships are awarded to the undergraduate students according to the rules and procedures laid down by the Senate. The scholarships, etc. are paid up to the month in which a student completes all the requirements of his/her undergraduate programme. These scholarships, etc. are liable to be withdrawn, partially or wholly, in case of misconduct, deliberate concealment of material, facts and/or giving false information. A student leaving the Institute on his/her own accord without completing the programme of study may be required to refund the amount of scholarship, etc. received during the academic session in which he/ she leaves the Institute.

1.6.2 For Postgraduate Students

The Institute may provide to postgraduate students, financial assistance in the form of teaching or research assistantships (referred to as Institute Assistantship). Assistantships are awarded on a semester-to-semester basis for a period of up to three semesters for M.Tech. students and up to five years for Ph.D. students. The stipend for the assistantship is paid at the approved rates. A student is expected to devote up to eight hours per week towards job(s) assigned to him/her. The renewal of assistantship is contingent on the student's satisfactory performance in the academic programme and in the discharge of assistantship duties. A student on teaching/research assistantship is also reimbursed for some contingency expenses as per the approved terms and procedures as notified from time to time. Such reimbursement for a M.Tech. student is done only once, and for a Ph.D. student annually for the first four years of his/her programme, if he/she is on an Institute Assistantship. Some financial assistantships in the form of research assistantships may also be available from sponsored research projects. Additional assistantships in the form of scholarships, fellowships, etc. may be available through other organizations, such as, the Council of Scientific and Industrial Research (CSIR). Department of Atomic Energy (DAE), etc. In addition to the students admitted with financial assistance, students may also be admitted to the M.Tech./ Ph.D. programmes on a self-financing basis.

1.7 Reservation of Seats

In all the Undergraduate (UG) and Postgraduate (PG) programmes of IIT Kanpur, a certain number of seats is reserved for:

1.	Candidates belonging to Scheduled Castes (SC) :	15.0 %
2.	Candidates belonging to Scheduled Tribes (ST) :	7.5 %
3.	Candidates who are Physically Disabled (PD) with 40% or more disability :	3.0 %
	TOTAL RESERVATION	25.5 %

Admission is granted to such candidates provided they fulfill the basic educational requirements and possess the requisite aptitude as well as proficiency in the area of their choice.

1.7.1 Preparatory Course

In case the reserved seats in the first year of B.Tech./ B.Tech.- M.Tech./ M.Sc. (Integrated) remain vacant, other SC/ST candidates (who appeared in JEE and satisfy certain relaxed conditions) are offered admission to the *Preparatory Course* of one year duration in Physics, Chemistry, Mathematics and English. On completion of the preparatory course and passing of the examination conducted by the Institute, the candidates are offered admission to the first year of B.Tech. / B.Tech.-M.Tech. (Dual degree) / M.Sc. (Integrated) programmes against the vacant reserved seats of the year of their appearance in JEE/entry in the Preparatory Course.

1.8 Registration

All students are required to register each semester for the courses to be pursued by them, as per the programme, on the dates specified in the Academic Calendar. Students are normally expected to register for the full academic load (as described in this bulletin) every semester, unless they are compelled to do otherwise by some regulation. No student is allowed to register for more than two courses during the Summer term. A list of courses to be offered during the semester is put up on the notice boards/ website for On-line Academic Registration (OARS). A student must ensure that he/she has completed the pre-requisites, if any, for each course to be registered. The responsibility for registration rests solely with the student concerned.

The registration procedure involves:

1. filling of the on-line registration form mentioning the courses to be credited in the semester/ summer term,
2. payment of fees and clearance of outstanding dues (if any),
3. signing of the registration roll in the office of the Dean, Students Affairs.

A student who awaits the final result of the qualifying examination is allowed to register provisionally on submission of a certificate from his/her last institution stating that he/she has appeared in the final examination (both theory and practical) *before* the date of joining IIT Kanpur. The candidate is required to submit documents of having passed the qualifying examination by the last date given in the Academic Calendar to get his/her registration regularized.

All M.Tech. and Ph.D. students who are not on authorized leave must continue to register in the following semester till they submit their thesis. If, however, a student is likely to submit his/her thesis within two weeks from the commencement of classes, he/she need not register in that semester. This period will not be extended in any case. Ph.D. students who have submitted their thesis and are waiting for the defence of the thesis will register for zero units. They may, however, apply for leave from the Institute with permission to defend thesis while on leave. The Institute has, in fact, several different provisions for leave for undergraduate and postgraduate students, including vacation leave, casual leave, deputation leave, medical leave, maternity leave and leave prior to thesis defence. Further details regarding registration and leave are available on the website at the URL http://www.iitk.ac.in/doaa/.

1.9 Academic System and Method of Evaluation

In IIT, Kanpur, the academic system is devised with the joint objectives of promoting excellence and at the same time remaining as student-friendly and flexible as possible. All academic programmes follow the semester system. The academic session starts from July 1 and continues till June 30 of the following year. The first semester commences in July and ends in December. The second semester commences in December and ends in June. Classes for the first semester generally begin in the last week of July and continue, with a mid-semester recess of 9 days (usually timed to match with the *Dussehra* festival), till the first week of December. Classes for the second semester generally begin in the last week of December and continue, with a mid-semester recess of 9 days (usually timed to match with the *Holi* festival), till the first week of May. There is also a short summer term of two months, from the middle of May to the middle of July, during which special courses are offered to enable students who have backlogs (due to dropping/ failing courses earlier) to clear them and graduate at the same time as their batch-mates.

During the semester, classes (including laboratory and workshop sessions) are held from 8:00 am till 6:00 pm every day from Monday till Friday. No classes are normally scheduled on Saturdays and Sundays, though special classes may be held by mutual agreement between the Instructor and students. All the classes are normally held within the Academic area of the IIT campus. Attendance at *all* classes is compulsory and every student is provided with mandatory hostel accommodation to enable him/her to attend. IIT Kanpur has *no* provision for day scholars. A student absenting himself/herself from classes is liable to be penalized by the Instructor. As the IIT campus is self-sufficient for most of the ordinary needs, students are not permitted to leave the campus during the semester (even on weekends) without express permission from the Chairman of the Senate Undergraduate /Postgraduate Committee, as may be relevant. Leave of absence for *bona fidé* reasons may be obtained by applying on the appropriate form.

The method of instruction is mostly through lectures, tutorials, demonstrations/discussions and laboratory work. Some instructors may make use of slides, models, video clippings, hands-on demonstrations, etc. for more impact. The sole medium of instruction is **English**, i.e. for delivering lectures or tutorials/ discussions or for answering examinations and making presentations or any other academic activity whatsoever. No other language is permissible. A brief syllabus for each course is contained in this bulletin. However, new courses may be introduced from time to time, with proper approval. The conduct of a course - including the pace of instruction, the order of topics to be covered, the number and level of problems and home assignments, the number of examinations / quizzes, the introduction of term papers, the weightage assigned to these factors (including attendance) for awarding the final grade, etc. - is the sole responsibility of the Instructor or the Instructor-in-charge (for multi-Instructor courses). Generally the weightage of different evaluation modules (including attendance in classes) is announced by the Instructor in the very first lecture and strictly adhered to during the entire semester.

IIT Kanpur follows the Continuous Evaluation system, which means that evaluation proceeds alongside with the progress of the courses. Every semester, there are two mid-semester examinations and an end-semester examination, as well as an unspecified number of quizzes and home assignments. Students are expected to keep themselves prepared at every stage and hence no study leave is granted for the examinations. On the basis of the marks obtained in all the different modules, the Instructor (or Instructor-in-charge) awards a letter grade at the end of the semester. These are usually awarded on the basis of relative performance, i.e. using the percentile marks rather than the actual marks. To compute the student's overall performance, each grade is assigned a numerical value, which is multiplied by a weight factor depending on the number of hours per week spent on the course, and averaged to calculate, every semester, a Semester Point Index (SPI). The average over all semesters, i.e. the Cumulative Point Index (CPI) is the final criterion determining the student's overall performance.

A student who misses the end-semester examinations for *bona fidé* reasons, such as illness, may apply within the next two days to the Chairman, SUGC/ SPGC, for permission to take a Make-up examination. Only one make-up examination, for the end-semester examination, is allowed per course. For failures to appear in mid-semester examinations, etc., it is entirely up to the Instructor to ascertain the proficiency of the student by whatever means he/she considers appropriate if he/ she is satisfied of the student's *bona fidé*s.

Students of the B.Tech. / B.Tech. –M.Tech / M.Sc. (Integrated) programmes who fare poorly in the first mid-semester examination immediately after entry through the IIT-JEE are offered the option of changing to a Slow-paced programme. This is available in English, Mathematics and Physics, or any combination thereof, and is adjusted so that the students may eventually graduate at the same time as their batch-mates.

1.9.1 Grading System for Undergraduates

There are five letter grades: A, B, C, D and F. The letter grades and their numerical equivalents on a 10-point scale (called Grade Points) are as follows:

Letter Grade :	A	B	C	D	F
Grade Points :	10	8	6	4	2

In addition, there are three letter grades, viz., I, S and X, which stand for Incomplete, Satisfactory and Unsatisfactory, respectively. For courses with zero weightage only Satisfactory (S) / Unsatisfactory (X) grades are awarded. A student awarded an F or an X grade is considered to have failed the course and must repeat it when it is next offered.

Each course is assigned a certain number of *Credits*. This is calculated in the following way. The Academic Load *AL* of a given course is calculated using the number of contact hours per week as

$$\mathbf{AL} = 3.0 \times \mathbf{L} + 1.0 \times \mathbf{T} + 1.5 \times \mathbf{P} + 0.0 \times \mathbf{D}$$

where L, T, P and D stand for the number of Lectures (L), Tutorials (T), Laboratory work (P) and Discussion sessions (D). Depending on the academic load of a course, its credits (C) are assigned as follows:

Academic Load AL =	5 – 6	7 – 8	9 – 12	13 – 15
Credits C =	2	3	4	5

The majority of courses are 4-credit courses, i.e. C = 4.

1.9.2 Grading System for Postgraduates

There are six letter grades: A, B, C, D, E and F. The letter grades and their numerical equivalents on a 10-point scale (called Grade Points) are as follows:

Letter Grade :	A	B	C	D	E	F
Grade Points :	10	8	6	4	2	0

In addition, there are I, S and X, grades. A student awarded an E, F or X grade is considered to have failed the course and must repeat it when it is next offered. For project/thesis work, only S or X grades are awarded.

Credits for postgraduate courses are determined according to the following table:

Credits (C)		Academic Load
3	:	2L
4	:	3L or 2L + 1T or 2L + 1P
5	:	3L + 1T or 3L + 1P or 3L + 1T + 1P

where L, T and P have the same meanings as in 1.91.1 above,

A undergraduate or postgraduate student may be awarded the I (Incomplete) grade in a course if he/she has missed, for a genuine reason, a minor part of the course requirement but has done satisfactorily in all other parts. An I grade is not awarded simply because a student has failed to appear in examination(s). An I grade is converted by the Instructor-in-Charge into an appropriate letter grade after the Make-up Examination. Any I grade still outstanding two days after the last scheduled make-up-examination is automatically converted into an F grade.

1.9.3 Performance Indices

Semester Performance Index (SPI) – The Semester Performance Index (SPI) is a weighted average of the grade points earned by a student in all the courses credited and describes his/her academic performance in a semester. If the grade points associated with the letter grades awarded to a student are g_1, g_2, g_3, g_4, and g_5 in five courses and the corresponding credits are C_1, C_2, C_3, C_4, and C_5, the SPI is given by

$$SPI = \frac{C_1 g_1 + C_2 g_2 + C_3 g_3 + C_4 g_4 + C_5 g_5}{C_1 + C_2 + C_3 + C_4 + C_5}$$

S and X grades are not considered in the computation of the SPI.

Cumulative Performance Index (CPI) – The Cumulative Performance Index (CPI) indicates the overall academic performance of a student in all the courses registered up to and including the latest completed semester/summer term. It is computed in the same manner as the SPI, considering all the courses (say, *n*), and is given by

$$CPI = \frac{C_1 g_1 + C_2 g_2 + C_3 g_3 + ... + C_n g_n}{C_1 + C_2 + C_3 + ... + C_n}$$

Whenever a student is permitted to repeat or substitute a course, the new letter grade replaces the old letter grade in the computation of the CPI, but both the grades appear on his/her Grade Report.

1.9.4 Inadequate academic performance

The academic performance of *every* student is carefully assessed at the end of every semester by the Academic Performance Evaluation Committee (APEC - UG/PG), and those having poor performance according to some pre-determined criteria are designated as *academically deficient.*

Undergraduate students are considered to be academically deficient if they have SPI less than 4.5, or CPI less than 5.0, for students of the B.Tech./ BTech.-M.Tech/ M.Sc. (Integrated) programmes and SPI less than 5.5 or CPI les than 6.0 for students of the M.Sc. (Two-year) / M.Sc.-Ph.D. (Dual degree) programmes. Such students are placed in two categories, viz. Warning (WR) and Academic Probation (AP) and their performance is closely monitored, with maximum encouragement being extended to ensure improvement in performance. If a student continues to fare poorly and it becomes clear that he/she will not be able to finish the graduation requirements in the maximum permissible time, the academic programme of the student may be terminated.

Postgraduate students are considered to be academically deficient if they have CPI less than 6.5, for students of the M.Tech. and D.IIT. programmes and CPI less than 7.0 for Ph.D. students. In case the performance does not improve over two semesters, the student may not be allowed to continue in the programme. Detailed criteria are available on the website at http://www.iitk.ac.in/doaa/.

Termination of programme may also happen in cases of prolonged absence without leave, non-payment of fees or culpable involvement in violation of the model code of conduct, e.g. ragging.

1.10 Change of Registration (Branch Change)

Change of programme/branch is normally permitted subject to availability of seats and strength constraints of the departments. Change of programme and/ or branch is a privilege and not a right and is awarded normally to meritorious students only.

Undergraduate students of the B.Tech., B.Tech. – M.Tech. (Dual degree) and M.Sc. (Integrated) programmes may apply to the Chairman, SUGC, for a change of branch at the end of the second semester, provided they have CPI of 8.0 or more (7.0 or more for SC/ST/PD) and no backlog of failed/dropped courses. Students may also apply for change of branch at the end of the third semester, provided they are not in the deficient category and have no backlogs. For this purpose, only the CPI at the end of the first two semesters is considered. At the end of the fourth semester, students belonging to the SC/ST/PD categories in the Slow-paced B.Tech., B.Tech. – M.Tech. (Dual degree) and M.Sc. (Integrated) programmes may apply for change of branch / programme. Such students may also apply at the end of the fifth semester for change of branch.

Students of the M.Sc. (Two-year) programme in Physics only may be permitted to change to the M.Sc.-Ph.D. (Dual degree) programme in Physics at the end of the second or third semesters provided thay have CPI of 7.0 or above.

Students registered for the M.Tech programme may be allowed in the beginning of the second/ third semester to change their registration to that of the Ph.D. programme in Engineering on the recommendation of DPGC and with the approval of the SPGC. However, students in part time

M.Tech. programme are not permitted to change over to part time Ph.D. programme. A student admitted to a part time programme may be allowed to change his/her registration to fulltime (regular) studies at the beginning of a semester upon the recommendation of the DPGC and with the approval of the SPGC and vice versa, subject to several eligibility criteria.

1.11 Graduation Requirements

A student shall be deemed to have completed the graduation requirements. if the student has a) passed all prescribed courses, b) attained the minimum required CPI, c) satisfied minimum academic and residence requirements, d) satisfied all requirements specified by the concerned department, if any, and e) satisfied all requirements specified by the Senate and the Ordinances. In addition, the student should have paid all the dues to the Institute and, should have no pending case of indiscipline.

Degrees are normally awarded to all students in a solemn Annual Convocation ceremony, graced by a distinguished Chief Guest, which is generally held in the last week of May. Only the actual recipient of the degree is permitted to participate in the Convocation ceremony. Students who complete their graduation requirements well before the Convocation ceremony may be issued Provisional Certificates to help them join service or other academic programmes elsewhere.

1.12 Code of Conduct

Each student of IIT Kanpur is expected to conduct himself/herself in a manner befitting his/her association with the IIT's standing as an Institute of National Importance. He/she is expected not to indulge in any activity which is likely to bring down the prestige of the Institute. He/She should also show due respect and courtesy to the teachers, administrators, officers and employees of the Institute, and good neighbourly behaviour to fellow students. Due attention and courtesy is to be paid to visitors to the Institute and residents of the Campus.

Lack of courtesy and decorum, unbecoming conduct (both within and outside the Institute), wilful damage and/or removal of Institute property or belongings of fellow students, disturbing others in their studies, adoption of unfair means during examinations, breach of rules and regulations of the Institute, noisy and unseemly behaviour and similar other undesirable activities shall constitute violation of the Code of Conduct for students and are liable to severe disciplinary action if detected. Ragging in any form whatsoever is strictly prohibited and is considered a serious offence.

By and large, students of IIT Kanpur have a tradition of good behaviour and interest in academics and this has largely contributed to the high academic repute of the institution.

AEROSPACE ENGINEERING

PROFESSORS

Kamle Sudhir	kamle	7561	7689
Ghosh Kunal	kunal	7072	
Ghosh A K	akg	7716	
Mittal Sanjay	smittal	7906	
Poddar Kamal	kamal	7843	
Rathakrishnan E	erath	7847	
Sullerey R K	suller	7863	
Sengupta T K	tksen	7945	
Tewari Ashish	ashtew	7868	
Venkatesan C	cven	7284	
Yadav D	dy	7951	

ASSOCIATE PROFESSORS

Das Depopam	das	7227
Kushari Abhijit	akushari	7126
Mishra D P	mishra	7125
Upadhyay C S	shekhar	7936

ASSISTANT PROFESSORS

Eshpuniyani Brijesh	brijeshe	7062
Mahesh Sivasambu	smahesh	6087
Mohite P M	mohite	6024

Convenor, DUGC :	Eshpuniyani Brijesh	brijeshe	7062
Convenor, DPGC :	Das D	das	7227

Faculty Counsellor :

Email : ________________________________ Tel Nos: +91-512-259______

The Department prepares its students for a professional career in aerospace engineering by offering a comprehensive programme of teaching and research. Particular emphasis is given to aerodynamics, flight mechanics, structural and propulsion problems of aerospace vehicles.

The aerospace engineering programme that follows the completion of the core curriculum is a careful balance of intensive engineering science instruction, laboratory experience and introductory flight-vehicle design. Postgraduate courses and research provide further extension and specialisation in the area of aerodynamics, flight mechanics and control, aerospace structures and propulsion leading to M. Tech. and Ph. D. degrees.

The aerodynamics facilities of the Department include several low speed wind tunnels, a high speed blowdown tunnel, and hot wire anemometry. The National wind tunnel facility is unique in the country and consists of an extralarge wind tunnel that was designed and erected by the faculty of aerospace engineering department. The structures laboratory includes facilities for static and dynamic tests and studies of composite material behaviour. The propulsion laboratory facilities include a cascade tunnel, a continuous combustion unit, and axial compressor. The flight laboratory is a unique national facility with four single-engined planes and several gliders and provides an opportunity for the students to participate in quantitative flight tests. In addition, the department has good computational facilities that aid in teaching and research of computational mechanics.

CURRENT COURSE STRUCTURE FOR B.TECH. STUDENTS

AEROSPACE ENGINEERING

	SEMESTER							
	FIRST	**SECOND**	**THIRD**	**FOURTH**	**FIFTH**	**SIXTH**	**SEVENTH**	**EIGHTH**
COURSE	PHY102	PHY101	MTH203	HSS-I-2	HSS-II-1	SE-1	SE-2	HSS-II-2
	MTH101	CHM101	CHM201	ESO202	AE321	AE312	AE411	AE422
	HSS-I-1/	PHY103	ESO204	TA201	AE331	AE322	AE461	AE462
	ENG112N	MTH102	ESO212	AE232	AE341	AE332	AE471	AE472
	TA101	ESC101	AE231	AE211	AE361	AE342	OE-2	OE-3
	ESC102	AE100			OE-1	DEL-1		DEL-2
	PE101	PE102						

AE 100	Introduction to Profession	AE 231	Elements of Vibration
		AE 211	Aerodynamics I
		AE 232	Aircraft Structures I
			HSS II
AE 321	Flight Mechanics I	AE 312	Aerodynamics II
AE 331	Experiments in Structures	AE 322	Flight Mechanics II
AE 341	Propulsion I	AE 332	Aerospace Structures II
AE 361	Aeromodel Design & Fabrication	AE 342	Propulsion II
	HSS		
		Elective I	Elective II
		Sc Elective I	
AE 411	Experiments in Aerodynamics	AE 422	Experiments in Flight Mechanics
AE 461	Aircraft Design I	AE 462	Aircraft Design II
AE XXX	Aero Elective I	AE 472	Project II
AE 471	Project I	AE XXX	Aero Elective II
	Sc Elective II		Elective III
			HSS II

COURSE DESCRIPTION

AE 100 **INTRODUCTION TO PROFESSION** **Prereq. None**
L-T-P-D-[C]
1-0-2-0-[0]

History of aviation, spaceflight. Aerodynamic shape, generation of forces. Aerodynamics of airfoils. Atmosphere. Performance, stability & control. Structural lay-out. Power plants. Instruments & navigational aids. Materials. Aircraft systems. Missiles, spaceships, helicopters, airships & hovercrafts. Trips to wind tunnel facilities, flight, structural, propulsion and high speed aerodynamic laboratories together with demonstrative experiments.

AE 211 **AERODYNAMICS-I** **Prereq. ESO212**
L-T-P-D-[C]
3-0-0-1-[4]

Incompressible irrotational flow, complex potential, singularities and superposition. Kutta Joukowski Theorem; Thin Aerofoil theory using singularity approach; wing theory; vortex system; panel methods. Qualitative effects on low aspect ratio wings and other complex phenomena. Viscous Flows: Introduction to N-S eqn; need for B.L., Prandtl B.L. Eqns., Similarity solutions. Integral Approach. Introduction to Turbulence. Transition, Turbulent B.L.; structure, estimates.

AE 231 **ELEMENTS OF VIBRATION** **Prereq. ESO 204**
L-T-P-D-[C]
2-0-0-0-[2]

Introduction to rigid body dynamics; single degree of freedom system. Free and forced vibrations (harmonic and general), types of damping. Duhamel's integration. Two degree of freedom system. Modal analysis, diagonalisation, eigensystem, response calculations for general excitation, proportional damping. Principle of virtual work, Lagrange's equations.

AE 232 **AEROSPACE STRUCTURES-I** **Prereq. ESO 204**
L-T-P-D-[C]
3-0-0-1-[4]

Static equilibrium, determinate and indeterminate structures, static stability concepts, planar and space trusses. Beams-bending & extension, stress resultants, modulus weighted section properties, bending shear stresses-solid and open section. Idealization of stiffened shells. Shear center, shear flow in thin walled multicell box beams, effect of taper. Tasian of then walled Section Work and energy principles, strain energy and complementary strain energy, potential and complementary potential theorems, unit load method, reciprocal theorem. Application of energy principles for analysis of determinate and indeterminate structures.

AE 312 **AERODYNAMICS-II** **Prereq. AE 211**
L-T-P-D-[C]
3-0-0-1-[4]

Dynamics & thermodynamics of 1-D flow, isentropic flow,1-D wave: normal shock, central expansion. Supersonics, oblique shock, 2D steady flows: reflection, intersection; Prandtl-Meyer flow. Method of characteristics. Small perturbations applied to, subsonic & supersonic airfoils, slender body. Similarity rules. Transonic area rule. Hypersonics; similitude, high temp and rarefaction.

AE 319 **ENERGY FROM THE WIND** **Prereq. ESO 212**

L-T-P-D-[C]
3-0-0-0-[4]

Renewable sources of energy, history, global wind, terrain, atmospheric boundary layer, wind distribution & sites, survey, measuring instruments. Prospective areas in India. Aerodynamics in wind power. Vertical & horizontal axis wind turbines, translating wind power devices: sail boats and ships.

AE 321 **FLIGHT MECHANICS-I** **Prereq. AE100**

L-T-P-D-[C]
2-1-0-0-[3]

Aerodynamic properties of wings and components, Airplane drag estimation. Airplane propellers. Performance characteristics of aircraft power plants. Performance in cruise, climb, take-off, landing and maneuvers. Optimal performance of airplanes. Introduction to helicopter rotor aerodynamics and performance.

AE 322 **FLIGHT MECHANICS-II** **Prereq. AE 100**

L-T-P-D-[C]
2-1-0-0-[3]

Introduction to aircraft equilibrium, static and dynamic stability. Longitudinal and lateral directional static stability and control, trim drag. Effects of power, compressibility and flexibility. Eqns. of airplane motion. Concept of stability and control derivatives. Longitudinal & lateral directional dynamic modes. Airplane response to controls, Introduction to flying qualities and Stability Augmentation Systems.

AE 331 **EXPERIMENTS IN STRUCTURES-II** **Prereq. AE 232**

L-T-P-D-[C]
1-0-3-0-[3]

Review of elasticity Strain gauge techniques: gauge construction and installation, sensitivity factors, gauge instrumentation, strain gauge transducers, rosette analysis. Photoelastic techniques, basic optics for polariscope, calibration methods, separation and compensation techniques. Brittle coating techniques and its uses. Motion measurement: Piezoelectric transducers, displacement gauges, accelerometers, seismic instruments. Experiments on determination of shear center, asymmetric bending, stress analysis using photo elasticity, torsion of box beams, coating and testing of brittle coated specimens, buckling of channel and z-section, vibration of stiffened plates and beams.

AE 332 **AEROSPACE STRUCTURES-II, 2-0-0-0-2** **Prereq. AE 232**

L-T-P-D-[C]
2-0-0-1-[2]

Buckling of columns. Differential equation approach, energy approach, approximate techniques. Beam columns. Buckling strength of flat sheets in compression, combined stress. Local buckling of composite shapes. Buckling of sheet stiffener combination.

AE 341 **PROPULSION-I** **Prereq. ESO 202, ESO 212**
L-T-P-D-[C]
3-0-0-1-[4]

Principles of propulsion. Basic requirements. Thrust and other performance parameters. Efficiencies. Cycle analysis for turbojet, turbofan and turboprop engines. Centrifugal and axial compressors, Stage dynamics, degree of reaction, cascades & losses. Performance. Axial turbines. Compressor-turbine matching. Aircraft intakes-subsonic and supersonic.

AE 342 **PROPULSION-II** **Prereq. AE 341**
L-T-P-D-[C]
3-0-3/2-1-[4]

Elements of combustion: adiabatic flame temperature, flammability and stability limits. Gas turbine combustors & afterburners. Nozzles types & non-ideal flows, Chemical rockets: Rocket vehicle mechanics, multi-staging, propellants, heat transfer and cooling. Rocket- ramjet. Measurements of volumetric flow rate, speed, torque, power and temperature. Experiments on axial compressor unit, gas turbine unit, and continuous combustion unit, cascades and curved diffuser.

AE 361 **AEROMODELLING DESIGN AND FABRICATION**
L-T-P-D-[C]
0-0-3-0-[2]

Design and fabrication of aero models/components. Balsa and parchment based model making, or design and fabrication of test bed for model engines (aircraft and helicopter), or wing design with fabrication and flutter testing or component replacement/ model upgradation.

AE 380 **INDUSTRIAL TOUR, 0 Credit**

AE 411 **EXPERIMENTS IN AERODYNAMICS** **Prereq. AE 312**
L-T-P-D-[C]
2-0-3-0-[4]

Experiments and model testing. Similiude, flow visualization, low and high speed tunnels: features & performance. Balances, Measurements; flow velocity: hotwire, laser doppler, pressure, temperature.
Lab work: Set of experiments

AE 422 **EXPERIMENTS IN FLIGHT MECHANICS** **Prereq. AE 321, AE 322**
L-T-P-D-[C]
1-0-3/2-0-[2]

Introduction to flight testing, instrumentation, techniques and data reduction methods, calibration of flight and special flight test instruments. Evaluation of glider drag polar. Evaluation of cruise and climb performance of a small airplane. Determination of static and maneuvre stability and control characteristics. Observations of airplane dynamic modes and stall characteristics. Introduction to GPS based navigation. Introduction to auto-pilot.

AE 453 **COMPUTATIONAL AERODYNAMICS** **Prereq. ESO 212**
L-T-P-D-[C]
2-0-3-0-[4]

Introduction to computations. The governing equations for CA. Solution of potential equation by panel method. Solution of full potential equation (FPE) and transonic small disturbance (TSD) equation. Solution of Euler equation. Solving Boundary layer equations for incompressible and compressible flows. Solution of Navier Stokes equation with and without turbulence/SGS models.

AE 461 **AIRCRAFT DESIGN-I** **Prereq. AE 211, 321, 322, 341**
L-T-P-D-[C]
2-0-4-0-[4]

Conceptual aerodynamic design of an airplane to meet the prescribed mission requirements. Collection of statistical data. Preliminary weight estimation. Selection of wing loading, thrust loading, wing section and plane form, and high lift devices. Fuselage layout and weight balance. Estimation of aerodynamic characteristics and performance evaluation. Design of tail areas and control surfaces. Estimation of spanwise load distributions on the wing and tail.

AE 462 **AIRCRAFT DESIGN-II** **Prereq. AE 332, 461**
L-T-P-D-[C]
2-0-4-0-[4]

General structural design of aircraft, load factors, V-n diagram, stress resultants for swept and unswept wings. Application of the following to aircraft design: modified beam theory, wing stress analysis methods, yielding and failure under combined loading: initial buckling and failure loads for columns, plates and stiffened panels. Airworthiness requirements. Factors affecting wing design, constituents of wing structures, rib spacing. Preliminary layout of wing, estimate of wing element cross-sectional areas, wing stressing and margin of safety calculations.

AE 471 **PROJECT-I, 2 Credit**

Registration for project with the selection of topic & getting started on the design, fabrication work, algorithm etc.

AE 472 **PROJECT-II, 4 Credit** **Prereq. 471**

Continuation of the project work initiated as a part of project-I and completion.

AE 490 **INDUSTRIAL TRAINING, 0 Credit**

A minimum of six weeks working in industrial environment.

AE 481 **BOUNDARY LAYER THEORY** **Prereq. ESO 212**
L-T-P-D-[C]
3-0-0-0-[4]

Conclusions from small BL thickness, BL eqns, exact & similar solns: Blasius, Howarth & Merk. Methods: continuation & integral conditions, Polhausen, Walz, Weighardt. Axisymm BL. Mangler transformation, elementary 3-D BL., Transition, turb BL. Walz integral method. BL control.

AE 482 **SIMILITUDE ANALYSIS AND ENGINEERING APPROXIMATIONS**
L-T-P-D-[C] **Prereq. ESO 212 or eqv.**
3-0-0-0-[4]

Similitude by dimensional analysis and by group transformations; self-similitude; bases of engineering approximations; estimation; limit processes and singularity; method of matched asymptotic approximations. Examples from diverse fields.

AE 483 **INTRODUCTION TO INDUSTRIAL AERODYNAMICS**
L-T-P-D-[C] **Prereq. ESO 212 or eqv.**
3-0-0-0-[4]

Wind near ground, atmospheric BL, wind tunnel simulation, forces on tall structures, bluff body, vehicle, flow induced oscillations of suspension bridges, transmission lines, hydraulic structures, architectural aerodynamics, effluent dispersal, ventilation, sheltering, special wind tunnels.

AE 486 **AIRCRAFT CONTROL SYSTEMS** **Prereq. AE 322**
L-T-P-D-[C]
3-1-0-0-[4]

Introduction, representation and classification of control systems, analysis of feedback control systems, steady state error, stability and sensitivity. State-space methods, controllability and observability, synthesis of linear feedback control systems. Optimal design of control systems. Linear Observers and filters, aircraft flight control systems (AFCS). Introduction to fly-by-wire controls.

AE 487 **SPACE SYSTEMS ENGINEERING**
L-T-P-D-[C]
3-0-0-0-[4]

Space environment. Spacecraft applications. Performance of single & multistage rockets. Central force motion, trajectory simulation for powered and unpowered flights. Ballistic trajectories. Orbital transfer and rendezvous, attitude motion, stability and attitude control of systems.

POSTGRADUATE PROGRAMME

AE 601 **INTRODUCTION TO AEROSPACE ENGINEERING** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

History of aviation. History of spaceflight. Earth's atmosphere and gravitational field. Anatomy of Flight vehicles. Bluff bodies v/s streamlined body, airfoil. Lift generation, significance of L/D ratio. Aerodynamic forces. Propulsion. Spacecrafts. Aircraft performance. Aerospace materials. Structural layout. Flight envelope and V-n diagrams. Instruments and navigational aids. Exposure to flight testing.

AE 602 **MATHEMATICS FOR AEROSPACE ENGINEERS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Matrices, determinants, vector spaces, linear transformation, eigensystems, linear equations, introduction to ordinary differential equations, homogeneous linear equations of second order, non-homogeneous linear equations of second order, free and forced oscillation problems, problems with variable coefficients, systems of equations, Fourier series, Fourier transform, Laplace transform, introduction to differencing methods; basic concepts of partial differential equations, classification of second order equations, wave propagation in one-dimension, parabolic equations, higher dimensional problems, Laplace equation, series solutions, transform methods, elements of complex variables.

AE 607 **AVIONICS AND NAVIGATION SYSTEMS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Maps and geodesy; WGS-84 system; co-ordinate systems and transformations; great circle and rhumb line navigation; dead reckoning; INS - gyroscopes and accelerometers, platform stability and strapped down INS; horizontal and vertical mechanisations in INS; baro-altimeter, air speed indicator, compass and gyro compass; radio navigation - beacons, VOR, DME, LS, LORAN and other nav-aids; primary and secondary surveillance radars; Doppler navigation; GPS principles - space and control segments architecture; DOP and computation of position and velocity; GPS in air, surface and space navigation; considerations in air traffic control.

AE 610 **AERODYNAMICS-I** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Basic fluid mechanics -Navier stokes equation, vorticity kinematics, Basic potential flows -viscous flows including boundary layer theory, turbulence (introduction)

AE 612 **AERODYNAMICS-II**
L-T-P-D-[C]
3-0-0-0-[4]

Thin aerofoil theory, finite wing theory, basic thermodynamics, one and two-dimensional flows, isentropic flows, waves (shock, expansion, characteristics etc.), potential flows, perturbation equation, subsonic flows -similarities -Fanno and Rayleigh flows.

AE 614 **VISCOUS FLOWS, 3-0-0-4**
L-T-P-D-[C]
3-0-0-0-[4]

Basic concepts of BL theory; similar flows: generalized techniques of solving BL eqns. for incompressible fluids : thermal BL. BL control. Intro. to turbulent shear flows.

AE 615 **ADVANCED COMPUTATIONAL METHODS IN CFD** **Prereq. AE 622 or eqv.**
L-T-P-D-[C]
3-0-0-0-[4]

Main issues of space-time resolution: Computing time-averaged and unsteady problems. Discretization with operators. Problems in physical and transformed plane: Jacobians and flux vector splitting. Generalized transformation & grid generation techniques: Orthogonal & Chimera grids—application to FIV/aero-elasticity problems. Spectral tools of analysis for discrete schemes: FDM, FVM & FEM. High order and high accuracy schemes of FDMs and FVMs. Design of Dispersion Relation Preservation schemes. Aliasing error & its alleviation. High accuracy methods for DN Sand LES. SGS models for LES and their connection to higher order upwinding. Computing equations with discontinuous solutions and Gibbs' phenomenon. Applications to incompressible viscous and compressible flows. DNS of turbulence and acoustic problems.

AE 617 **BOUNDARY LAYER INSTABILITY AND TRANSITION** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Navier-Stokes eqn. and its various forms, thin shear layer approxn. Various types of flows. Instabilities in laminar flows. Relationship of instability theory with transition to turbulence. Transition prediction. Receptivity for two & three dimensional problems.

AE 618 **FINITE ELEMENT METHODS FOR FLUID DYNAMICS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Fundamental concepts; strong form, weak form, Galerkins approximation; matrix eqns, element and global point of view; numerical integration - Guassian quadrature; termporal discretization - generalized trapeziodal rule; compressible and incompressible flows; implementation of the methods; issues related to high performance computing.

AE 619 **INTRO. TO ENVIRONMENTAL FLUID MECHANICS, 3-0-0-4** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Physical environment; earth, atmosphere, ocean. Concepts of geopotential, water vapor, winds & currents, greenhouse effect. Static equilibrium, stability, clouds, potential temperature, large scale vertical motions. Kinematics and dynamics. Geostrophic motion and applications. Frictional shear layer, the BL. applied problems.

AE 620 **WINDENGINEERING** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Atmosph. pressure grad & wind; wind structure, turb.spectra & FFT. Atmospheric BL. Wind loads and moments on typical bodies, internal pres. Unstability, current along and across wind. Aerodynamic instability. Current dvlpmnts based on random vibrations, wind effects on civil structures, model studies in wind tunnels. Instrumentation. Design practices.

AE 621 **TURBULENCE, 3-0-0-4** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Origin, examples & character of turb, Reynolds stress, energy relations, closure problem, phenomenology, eddy viscosity. Staistics. spectra, space-time correlations, macro & microscales, stat. theory of turb, locally isotropic turb, Kolmogorov's hypothesis, correlation method, spectral method, turb. diffusion. Experimental techniques.

AE 622 **COMPUTATIONAL FLUID DYNAMICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Eqns of fluid dynamics & its classifications. Boundary conditions. Stability analysis & concept of feedback. Various explicit & implicit schemes. Grid generation. Solving parabolic, elliptic PDEs by explicit, implicit, accelerated techniques. Solving advection equation. Integral representation of Navier-Stokes equation;LES & DNS.

AE 623 **TURBULENT FLOWS, 3-0-0-4** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Types of turb flows. Uniform turb flows under axial press gradient. Incomp free turb flows: 2-D and axisymm jets; wakes; free shear layer, self propelled wake, and thermal plume. In compr wall turb flows: pipe and channel flow, equilibrium turb BL, const pres BL, wall jet, turb transport in homogeneous and shear flow, compressible flows.

AE 624 **PERTURBATION METHODS IN FLUID MECHANICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Rational & irrational apprx, perturb techniques; asymptotic representation, convergence, limit processes; singular perturb. problems: inner & outer expansions, high & low Reynolds number problems: multiple scale techniques. Variable length pendulum, Strum-Liouville problems, WKBJ method and comparison.

AE 625 **TRANSITION AND TURBULENCE**
L-T-P-D-[C]
3-0-3-0-[5]

Elements of viscous flows and thin shear layer approximation. Different types of TSL flows. Instabilities in flows. Rayleigh-Taylor, Kelvin-Helmholtz mechanisms. Thin shear layer instabilities: for parallel and nonparallel flows. Temporal and spatial instabilities in boundary layers. convective/absolute, local/global instabilities of boundary layers, wakes, jets and free shear layers. Primary and secondary instabilities and relationship of instability theories to transition. Receptivity of shear layers for 2- and 3-D flows. Bypass transition in different flows.

Classified views of trubulent flows. Scales, spectra and closure of turbulent flows. Vorticity dynamics and other kinematic tools of turbulence. Role of stretching and dispersion in small scale turbulence. Route to turbulence: Chaos via non-linearity, instabilities and bifurcation. Coherent structures in turbulence: Universality of transitional and turbulent flows. Study of turbulence via chaos dynamics ans proper orthogonal decomposition (POD). DNS, LES and other closure schemes of turbulence.

AE 627 **ADVANCES IN TURBULENT SHEAR FLOWS**
L-T-P-D-[C]
3-0-0-0-[4]

Origin & nature of turb, statistical descrpn, turb transport of momentum and heat; kinetic energy of the mean flow & turb, vorticity dynamics, temp fluctuations; 1D & 3D spectra, spectral energy cascades in 2D & 3D turb, spectrum of turb, effects of production and dissipation, spectra of passive scalar contaminants; Lagrangian description of turb, dispersion of contaminants; experimental techniques.

AE 628 **CONTINUUM HYPERSONIC AERODYNAMICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Continuum hypersonics in entry flight. Gen features, Mach no. Small disturb theory, similitude. Large diflecn similitude; wedge, cone, wing. Unified similitude. Lighthill & other piston analogies, Newton-Busemann theory, thin shock layers, viscous-inviscid interaction. Real gas. Frozen flow. Non-equilibrium flow.

AE 629 **ADVANCES IN WIND ENERGY CONVERSION** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Earths atmosphere & rotation, Coriolis force, geostrophic winds. Terrain, met theories, measuring technique. Wind power site. Atmosph BL. Aerodyn in wind power. Sails, airscrews. Vertical & horizontal axis wind turbines. Actuator disc, momentum, and vortex theories. Control of wind turbines.

AE 632 **ADVANCED DYNAMIC STABILITY** **Prereq. AE 610**
L-T-P-D-[C]
3-0-0-0-[4]

General eqns of unsteady motion of airplane; longitudinal and lateral stability derivatives, stability of uncontrolled motion in longitudinal and lateral modes; stick fixed and stick free analysis. Airplane response. Root loci and sensitivity analysis; handling quality requirements, introduction to automatic flight control systems. Frequency-domain analysis.

AE 641 **SPACE DYNAMICS-I**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction, performance of single and multistage rockets, central force motion, two-body problem, ballistic trajectories, trajectory transfer, rendezvous and interception, Eulers eqns, satellite attitude dynamics, stabilization through gravity gradient, spin and dual spin, effect of energy dissipation on stability.

AE 642 **SPACE DYNAMICS-II** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction, n-body problem, general eqns. of motion, integrals of motion, restricted 3-body problem, trajectory transfer in multi-force field. Hamiltons eqns, canonical transformation and the Hamilton-Jacobi eqn; general theory of orbital perturbations, effect of environmental forces on satellite attitude dynamics and stability.

AE 644 L-T-P-D-[C] 3-0-0-0-[4]

INTRODUCTION TO HYPERSONIC & TRANS-ATMOSPHERIC FLIGHT

Prereq. #

Introduction to hypersonic flow, Newtonian theory, viscosity interaction, high-temperature effects, equilibrium & non-equilibrium flow, rarefied flow. Aerothermodynamic modelling, empirical correlations, computational fluid dynamics. Trans-atmospheric flight, general motion, Keplerian motion, gliding & maneuvering re-entry mechanics, angular motion, inertial guidance. Design considerations, propulsion & materials.

AE 646 L-T-P-D-[C] 3-0-0-0-[4]

CONTROL THEORY **Prereq. #**

Basics of classical control theory , components and their transfer functions, time and frequency domain analysis of control systems (C.S.), synthesis of C.S., modern control theory; state-space representation of C.S., sensitivity analysis, controllability and observability; Lyapunov criteria of stability and its application to C.S.; optimization.

AE 647 L-T-P-D-[C] 3-0-0-0-[4]

FLIGHT DYNAMICS **Prereq. #**

Fundamentals of vectors. Transformation of coordinates. Particle kinematics. Rigid body kinematics. Force equations in a moving frame. Moment equations in a moving frame. Atmospheric flight Dynamics. Space flight dynamics. Gyrodynamics.

AE 648 L-T-P-D-[C] 3-0-0-0-[4]

FLIGHT STABILITY AND CONTROL **Prereq. #**

Linearized equations of aircraft motion for small perturbations in stability axes. Stability analysis of linearized equations of motion. Airplane longitudinal motion. Airplane lateral motion. Airplane handling qualities. Missile and launch vehicle stability and control. Qualitative discussion of automatic flight control systems

AE 650 L-T-P-D-[C] 3-0-0-0-[4]

FUNDAMENTALS OF AEROSPACE PROPULSION **Prereq. #**

Introduction to propulsion, conservation equations, basic thermodynamics, dynamics and thermodynamics of 1 D flows, 1 D isentropic flows, normal and oblique shocks, compressible flows, Rayleigh flow, Fanno flow, elements of combustion, thermochemistry , adiabatic flame temperature, premixed flames, diffusion flames, rocket propulsion, thrust equation, solid rockets, liquid rockets, hybrid rockets, gas turbine cycles.

AE 651 L-T-P-D-[C] 3-0-0-0-[3]

APPLIED COMBUSTION **Prereq. #**

Review of Thermodynamics, Chemistry of Combustion, Physics of Combustion, Premixed Flame, Diffusion Flame, Droplet Combustion, Gas Turbine Combustion:

Fuel Atomization, Flame Holders, Ignition; Rocket Combustion: Solid Propellant Combustion, Liquid Propellant Combustion.

AE 652 **AIRCRAFT PROPULSION** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Gas turbine engines, performance analysis, subsonic and supersonic diffusers, centrifugal and axial compressors, stage dynamics, compressor stall, axial turbines, compressor-turbine matching, gas turbine combustors and afterburners, nozzles, ramjets, scramjets.

AE 653 **THERMAL TURBO MACHINERY** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Axial compressors, stage dynamics, degree of reaction, pressure rise limitations, secondary flows, performance: design and off-design, starting problems, centrifugal compressors; inlet flow, slip, sweep, diffuser design. Axial turbines: stage dynamics, three dimensional flows, loss estimation, blade cooling.

AE 654 **COMBUSTION PROBLEMS IN ROCKET PROPULSION**
L-T-P-D-[C]
3-0-0-0-[4]

Review of chemical reaction kinetics. Derivation of conservation equations for multicomponent reacting gaseous mixtures; transport phenomena for a multicomponent system. Special approximations. Diffusion flames. Burning of fuel droplet. Laminar flame theory, flammability limits. Combustion instabilities. Monopropellant droplet burning. Chemical reactions in boundary layers.

AE 655 **SELECTED TOPICS IN TURBO- MACHINES** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Cascades, matrix and time marching techniques for potential flow analysis of cascades, inlet turbulence effects on cascade performance. Flow in cascades with transonic regimes. Meridional flow. Streamline curvature and matrix through flow methods of analysis. Loss models. Boundary Layer problems in turbomachines. Annulus boundary layers, secondary flows.

AE 656 **HIGH SPEED INTERNAL FLOW PROBLEMS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Convergent-divergent nozzles; sonic line; power series solution. Dual flow nozzles, real gas effects; effects of boundary layer on mass flow rate, thrust and heat transfer. Supersonic compressors; three dimensional mixed-flows: problems of blade cooling. Supersonic combustion.

AE 657 **AIRBREATHING MISSILE PROPULSION**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction and overview. Comparison of ramjet propulsion with other types of missile propulsion. Types of ram propulsion. Specific impulse. Propellants.

Ramjet air induction system for missile application. Ducted rocket performance with single and multiple inlet systems. Engine and airframe integration for ramjet and ram rocket powered missiles. Ramjet with solid fuel. Solid propellant ram rockets. Supersonic combustion ramjet. Inlet, combustor and nozzle analysis.

AE 659 **TRANSONIC AERODYNAMICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Governing Eqns. Transonic Small Disturbance (TSD) Eqn. Conservative form vs. Nonconservative form. Transonic full Potential Eqn; FPE in strong conservation form in body-conforming grid. Viscous-Inviscid Coupling. Design of transonic airfoil shapes; computations of inviscid rotational flows.

AE 670 **AEROSPACE STRUCTURAL ANALYSIS-I** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Free body diagram, equilibrium equations, examples from three dimensional truss problems; bending moment, shear force. Introduction to theory of elasticity, stress, strain, stress-strain relations, constitutive relations, basic equations of elasticity. Bending of beams, symmetrical and unsymmetrical sections, temperature effects, nonhomogeneous materials, modulus weighted sectional properties, thin walled sections. Deflection of beams.Torsion of circular and noncircular sections, thin walled sections, single and multiple closed cell sections. Shear in thin walled sections, shear center, single and multiple cell sections, combined bending and torsion. Plane strain and plane stress problems in elasticity. Euler's buckling of columns.

AE 672 **SOLID MECHANICS**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction. Material behaviour of idealized bodies, mathematical preliminaries, tensor analysis, partial derivatives, etc. Analysis of stress and strain measures. Laws of conservation, eqn. of motion, conservation of energy. Thermodynamic and mechanical equilibrium. Constitutive laws : viscoelastic materials.

AE 673 **ROCKET AND MISSILE STRUCTURES** **Prereq. AE 670**
L-T-P-D-[C]
3-0-0-0-[4]

Mission analysis, design approaches, analytical techniques, rocket grain analysis, structural types and optimization, honeycomb and sandwich construction, structural materials, aeroelasticity of cylindrical and conical shells, re-entry problems, ablation analysis, design examples, future trends, inflatable and expandable structure.

AE 674 **ADVANCED AIRCRAFT STRUCTURAL ANALYSIS** **Prereq. AE 670**
L-T-P-D-[C]
3-0-0-0-[4]

Energy theorem review; fundamentals of FEM; idealism of a structure, idealization of an aircraft. Force-displacement relations; flexibility & stiffness; continuum elements; triangular, rectangular & bar. Stiffness coefficient evaluation. Castiglianos theorem. Matrix force method; element flexibilities, redundant structures, load transformation matrices, wing, cutout & fuselage analysis.

AE 675 **INTRODUCTION TO FINITE ELEMENT METHODS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Discussion on mathematical models, reliability of computer aided engineering analysis. Model problem of linear elastostatics in one-dimension, principle of minimum potential energy, beam bending problem. Finite element discretisation in one-dimension. One-dimensional h/p code, Finite Element Formulation and development of two-dimensional code. Convergence analysis in two dimensions. Characterizational of solution smoothness, rate of convergence in energy norm, a posteriori error estimation. Direct computation of stresses and strains, postprocessing, superconver-gent extraction techniques, nonlinear and time dependent problems.

AE 676 **AEROELASTICITY** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Influence coefficients and function. Formulation of static and dynamic aeroelastic equations. Static aeroelasticity; divergence, aileron reversal & control effectiveness, solutions by matrix and energy methods. Unsteady aerodynamics, oscillating airfoil in incompressible flow, experimental methods, Dynamic aero-elasticity, flutter calculation, panel flutter.

AE 677 **VIBRATION CONTROL** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Factors affecting level of vibration. Effects of vibration: harmful & useful, effects on human beings. Reduction at the source. Control by structural redesign, selection of materials, artificial damping, viscoelastic laminator & high damping inserts. Dynamic vibration absorbers, optimum tuning and damping. Vibration isolation. Application of optimum absorbers to engineering problems.

AE 678 **THEORY OF VIBRATIONS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Introd. Hamiltons principles, Lagranges eqn, Eigenvalue problem (EVP), discrete & continuous system. Boundary value problem formulation. General EVP, positive definite system, self adjoint property. Vibration of strings, rods, beams, membranes and plates. Rayleighs quotient. Integral formulation of EVP, natural modes of vibration, approximate methods. Response to excitation.

AE 679 **NON-LINEAR OSCILLATIONS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to Method of averaging, development of asymptotic solutions by Krylov. Bogollubov-Mitroipolskys method, phase-plane and state-space methods of analysis, stability analysis and Lyapunov methods.

AE 680 L-T-P-D-[C] 3-0-0-0-[4]

RELIABILITY ANALYSIS OF ENGINEERING SYSTEM **Prereq. #**

Introduction, basic statistical concepts. Basic stochastic processes concept. Failure categories and mortality models. Sub-system and system reliability. Reliability based design and maintenance policies.

AE 681 L-T-P-D-[C] 3-0-0-0-[4]

COMPOSITE MATERIALS **Prereq. #**

Introduction, Definition, classification, behaviors of unidirectional composites: prediction of strength, stiffness, factors influencing strength & stiffness, failure modes, analysis of lamina; constitutive classical laminate theory, thermal stresses. Design consideration, analysis of laminates after initial failure, interlaminar stresses, fracture mechanics, joints, experimental characterization. Performance under adverse environment.

AE 682 L-T-P-D-[C] 3-0-0-0-[4]

ANALYSIS OF COMPOSITE STRUCTURES **Prereq. #**

Mechanical properties of composite materials; Analysis of composite laminated beams, thin walled composite beams. Buckling of laminated thin walled columns. Buckling of open sections. Bending of plates. Composite sheet-stiffener combinations. Analysis of shells. Vibration of beams and plates. Optimization studies.

AE 683 L-T-P-D-[C] 3-0-0-0-[4]

RANDOM VIBRATIONS **Prereq. #**

Intro. to probability theory, random process. Excitation response relations for stationary random processes-single and multidegree of freedom system with linear and non-linear characteristics, continuous systems. Failure due to random vibration, application to aero, civil & mechanical systems.

AE 684 L-T-P-D-[C] 3-0-0-0-[4]

AIRCRAFT MATERIALS AND PROCESSES **Prereq. #**

Definition of various terms used for classification of materials. Mechanical properties. Testing of aircraft materials. Classification of alloys of aluminium, steel, titanium etc. High temperature problems; aerodynamic heating, design considerations, ceramic coating etc. Plastics, fibre-reinforced composites, transparent materials.

AE 685 L-T-P-D-[C] 3-0-0-0-[4]

DETERMINISTIC & RANDOM VIBRATION **Prereq. #**

Free and forced vibration of discrete multidegree of freedom systems with and without viscous damping; impulse and frequency response methods. Continuous systems; natural modes, free & forced vibration. Random vibrations: intro. to probability theory, random variables & processes, properties of random processes, response of system to random excitations.

AE 686 **HELICOPTER THEORY : DYNAMICS AND AEROELASTICITY** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Historical development, configurations of helicopters, rotor system, flight control mechanism, momentum theory and blade element theory in hover, vertical flight and forward flight. Idealization of rotor blades, Flap-lag and torsional dynamics of the blade. Trim and equilibrium analysis, aeroelastic stability of rotor blades. Flap-pitch, lag-pitch and flap-lag coupling, simple model of rotor fuselage dynamics, longitudinal and lateral stability and control of helicopters.

AE 687 **AEROSPACE STRUCTURAL ANALYSIS-II** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

General loads on aircraft, load factor, V-n diagram, effect of gust loading. Energy principles, potential and complementary potential; deflection analysis, indeterminate structures. Analysis of plates, Kirchhoff and first order shear deformation plate theories, buckling of plates, buckling of stiffened plates, local buckling of composite shapes.

AE 688 **DYNAMICS AND VIBRATION** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Rigid body dynamics: Newton's second law, impulse and momentum, moment of a force and angular momentum, work and energy, system of particles, rigid bodies, Euler's equations. Analytical mechanics: degrees of freedom, generalized coordinates, virtual work, Hamilton's principle, Lagrange's equations. Linear system theory: frequency response, transform methods, transfer function, transition matrix, Eigen value problem, Modal analysis. Lumped parameter systems: single degree of freedom system, two degrees of freedom system, multiple degrees of freedom system. Continuous system: introduction, longitudinal, transverse and torsional vibrations of slender members.

AE 689 **INTRODUCTION TO THE THEORY OF SMART STRUCTURES**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction to smart materials, piezo, pyro and ferro electric effects; hysteresis effects:electric field in solids: fundamentals of continuum mechanics; basic conservation laws; thermodynamic principles; constitutive modelling for smart materials; electro-thermo-elastic formulation and analysis of smart structures; control of smart structures; applications to aerospace vehicles.

AE 690 **HIGH TEMPERATURE GAS DYNAMICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Nature of high temperature flows, perfect and real gas, Gibbs free energy and entropy production, microscopic description of gases, thermodynamic properties, equilibirum properties kinetic theory, inviscid high temp. equilibrium and non-equilibrium flow, transport properties.

AE 691 **APPLIED MATHEMATICS FOR ENGINEERS**

L-T-P-D-[C]
3-0-0-0-[4]

ODE: Singular points and their classification. PDE: general classification, complex analysis: analytic functions; singular points & Laurent series. Fourier and Laplace transforms; basic theorems & examples. Discrete transforms. Perturbation methods: regular and singular perturbation theory. Multiple scale analysis, linear algebra. Linear least square problem. Eigenvalues & eigen vectors. Approx. theory.

AE 696 **INSTRUMENTATION, MEASUREMENT AND EXPERIMENTS IN FLUIDS- Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Need and objective, fundamentals of fluid mechanics, wind tunnels, visualization, HWA, pressure and noise measurements, temperature, wall shear stress, flow measurements, geophysical flows, spin up and spin down, data acquisition and processing, uncertainty analysis.

AE 698 **INTRODUCTION TO VIRTUAL INSTRUMENTATION**

L-T-P-D-[C]
2-0-3-0-[4]

Introduction to VI, typical applications, functional systems, graphical programming, data flow techniques, advantages of VI techniques. VI programming techniques; VIs and sub-VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, string and file I/O, DAQ methods, code interface nodes and DLL links. Sensors, transducers and signal conditioning; common transducers for displacement, temperature, load, pressure, flow etc. Single ended, floating and differential inputs, grounding, noise and filtering. Data acquisition basics; AD DAC, DIO, counters and timers, PC Hardware structure, timing, interrupts, DMA, operating system, PCI buses. Bus based instrumentation; instrumentation buses, GPIB, RS232C.

AE 699 **M. TECH. THESIS**

Units : As arranged

AE701/ ME724 **NONLINER FINITE ELEMENT METHOD (OPEN ELECTIVE)**

Prereq. : AE675, ME623 or equivalent

L-T-P-D-[C]
3-0-0-0-[4]

- Overview of nonlinear problems in structural analysis geometric and material nonlinearities, non linear forces and boundary conditions; nature of force-deflection curves, critical points. • Single degree of freedom system with geometric non linearity Incremental solution, iterative solution using direct and Newton- Raphson approaches; combined incremental and iterative solution with full or modified Newton- Raphson or initial stress method. • One- dimensional continuum problem: Axial bar under compression, various strain measures, weak and variational formulations based on Green strain measure. • I- D Finite element formulation : Total and Updated Lagrangian approaches : derivation of stiffness and tangent stiffness matrices, limit point and bifurcation; traversal of critical points.• Two dimensional problems : Strain measures in two- and three - dimensions, stress measures (Cauchy and Piola- Kirchhoff), objectivity, Updated Lagrangian formulation stress increments. • 2-D Incremental formulation with updates, derivation of stiffness and tangent stiffness matrices. • Advanced Solution Procedures: Line search, arc length quasi - Newton and Secant methods. • Nonlinear Dynamics: Direct Integration techniques : explicit and implicit solution techniques. Stability of time integration schemes. Newmark's scheme. The α method; energy conserving and automatic time stepping methods.

AE 747 **MOLECULAR GAS DYNAMICS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

The molecular model; binary elastic collisions: basic kinetic theory; reference states & boundary conditions; collisionless flow; transition regime flows. Direct simulation Monte Carlo method. One dimensional flows of a simple monatomic gas. Measurements in low density flows.

AE 751 **FUNDAMENTALS OF LIQUID ATOMIZATION** **Prereq. #**

L-T-P-D-[C]
3-0-0-4-[4]

Introduction to atomization, Physical processes in atomization, Types of atomizers, Classical Theories of atomization, Numerical modeling of atomization process, Theory of multi-phase flows, Atomizer design: Single Fluid and Twin- Fluid, Spray Characterization Measurement techniques in Spray Characterization, Applications of Atomizers Metal forming Chemical Industry Combustion.

AE 752 **PRINCIPLES OF ACOUSTICS** **Prereq. #**

L-T-P-D-[C]
3-0-0-4-[4]

Wave theory of sound : Plane waves, Harmonic waves and complex Algebra Speed of sound, Energy, Intensity and Power, Spherical waves. **Quantitative measurement of sound :** Frequency content and bnands, Decibel scale, Multiple frequency signals, coherence, Frequency domain representation of transient signals. **Propagation of Plane waves :** Reflection from a rigid surface, Propagation in a Tube, Radiation due to waves on the wall, Oblique reflection and transmission at a planar interface. **Radiation from Vibrating Bodies :** Oscillating spheres, Monopoles and Multi-poles.

AE 753 **THEORY OF COMBUSTION**

L-T-P-D-[C]
3-0-0-4-[4]

Introduction to combustion : Types of flames, role of chemical kinetics

Chemical Kinetics : Formulation of chemical kinetics equations, reaction mechanisms, steady state approximation, Arrhenius Law : Formulation of Arrhenius law, Microscopic consideration of reaction rates. Explosions : Thermal explosions, Chain branching explosions, Chemical equilibrium Conservation equations for reacting flows : Shvab Zeldovich formulation. Laminar premixed combustion : Flame speed - Thermal theory (Mallard and Le Chatellier), Diffusion Theory (Zeldovich, Frank- Kamenstakii and Semenov), Flame stabilization, Quenchingt and Flammability limits micro- combustion. Detonation and Deflagration : Chapman- Hugoniot relations, Chapman Jouguet points Liminar non- premixed conbustion: Burke- Schuman Analysis, Phenomenological Analysis Ignition, Extinction and Flammability. Turbulet premixed combustion : Theories, Time and length scales, thin flame approach, stirred reactor. Turbulent non-premixed combustion : Conserved scalar approach, two variable approach, flamelet model, direct closure.

AE 799 Ph.D. THESIS

Units : As arranged

BIOLOGICAL SCIENCES AND BIOENGINEERING

PROFESSOR

Sinha P (Head)	pradips	4027	4019

ASSOCIATE PROFESSOR

Ashok Kumar	ashokkum	4051	4052
Balaji Prakash	bprakash	4013	4024
Ganesh S	sganesh	4040	4041
Sankararamakrishnan R	rsankar	4014	4025
Subramaniam K	subbu	4043	4044

ASSISTANT PROFESSORS

Katti DS	dsk	4028	4029
Pal A	apal	4066	4058
Bandyopadhyaya A.	abandopa	4055	4057
Sen J	jonaki	4054	4057

Convenor, DUGC :	Subramanian K	subbu	4033
Convenor, DPGC :	Katti DS	dsk	4028
Faculty Counsellor:			

E-mails : head_bsbe@iitk.ac.in   Tel Nos : +91-512-259 4009

The Department of Biological Sciences and Bioengineering, (BSBE) was established in September 2001 with the aim of providing a multidisciplinary research and teaching programme in modern Biology and Bioengineering. The young and dynamic faculty of the department conduct research in diverse areas of basic and applied branches of Biology and Bioengineering. This includes genomics, developmental biology, structural biology, human molecular genetics, computational biology, bioinformatics, bioremediation, tissue engineering and bioprocess engineering. Research of the department is supported by funding from National and International agencies (DBT, DST, MHRD, CSIR and Wellcome Trust). The department has also developed extensive research facility and infrastructure.

The postgraduate program (M.Tech., BSBE) of the department is designed to provide both introductory and advanced levels of teaching in the areas mentioned earlier. Design of program allows students without any previous training in biology to rapidly adapt to these new fields of study. Theory lectures, supported by laboratory exercises, impart a comprehensive training to the student during the first two semesters. The third and fourth semesters of the M.Tech program would be primarily dedicated to research. The program is open to students in all disciplines of sciences, engineering, pharmacy and medicine without any precondition of prior training in biology.

A new B.Tech program in biological sciences and bioengineering has been introduced from the year 2004. The program provides a unique fusion of biology with other basic and engineering sciences. **No prerequisite of biology** at school level is insisted upon for admission to this program. The goal of this program is to prepare the students, both in theory and practice, for leadership in the globally competitive fields of Life Science, Pharmaceutical, Biotechnology industry, academia and research. Program has been developed to meet the increasing demand in these fields of industry and research. Students of this program would find unique opportunities of employment and research in the areas of biomedical engineering, drug design, bioinformatics, biotechnology, nano-biotechnology, genomics etc. The course is designed to introduce biology as an experimental science, in contrast to the commonly perceived notion of it as a descriptive subject. The students will also find the application of a wide range of techniques in physical, chemical and mathematical sciences for designing, executing and interpreting experiments in biology.

The B.Tech. students of BSBE will take courses common with all other branches of science and engineering in the first year. During their second year, they will take foundation and elective courses in basic biology and bioengineering topics, besides developing their interest and excitement in biological experimentations and discoveries. Concepts in biology will be sharply focused on to provide a holistic view and to facilitate integration of these with the fundamental principles of physics, chemistry, mathematics and engineering.The final two years of the program will see the development of professional competence of the students on a broad spectrum of topics. Major emphasis during the final semesters will be on research and development along with the development of entrepreneurial skills. Students would also compete for 'Joy Gill Endowment" scholarship for R&D intership in Bio-pharma and Biotech industries besides participating in Bio-business plan competitions.

CURRENT COURSE STRUCTURE FOR B.TECH. STUDENTS

BIOLOGICAL SCIENCES & BIOLOGICAL ENGINEERING

	SEMESTER							
	FIRST	SECOND	THIRD	FOURTH	FIFTH	SIXTH	SEVENTH	EIGHTH
C O U R S	CHM101 HSS1 ESC101 MTH101 PHY101 PHY102 PE101	BSE101 ESC 102 PHY103 MTH102 TA101 PE102	CHM201 ESO-1 ESO219 MTH203 BSE212	ESOII BSE216 TA201 BSE292 HSS1	BSB341 BSE391 BSE352 BSE322 * *	BSE392 BSE314 * * * *	BSE498 BSE491 * * *	BSE-499 * * * *

To be chosen from the following options :

DE

OE

HSS2

SE

DO BSE 100	Introduction to Biological Sciences & Bioengineering
D1 ESO219	Introduction to Biology
D2 BSE216	Biochemistry
BSE 292	BSBE Lab 1 : Molecular Biology
D3 BSE314	Biochemical Engineering
BSE 391	BSBE Lab II : Biochemistry and Biochemical Engineering
D4 BSE 352	Biomaterials
D5 BSE 322	Structural Biology and Bioinformatics
BSE 392	BSBE Lab III : Structural Biology and Bioinformatics
D6 BSE 314	Biomechanics
D7 BSE 498	Project I
BSE 491	BSBE Lab IV : Biomechanics and Biomaterials
D8 BSE 499	Project II
DE	BSBE Departmental Elective

BSE 100 **INTRODUCTION TO BIOLOGICAL SCIENCES AND BIOENGINEERING**

L-T-P-D-[C]
1-0-0-0-[0]

Biology in the 21st Century – The brave new world in the post genome era. Past, present and future of our society, industry and life style: impact of discoveries and technological innovations in biology. Challenges and excitement of research in biology and bioengineering. Bioengineering as an emerging science at the intersection of biology, engineering, physics and chemistry. Career opportunities in biotechnology, biomedical engineering, pharmaceutical industry, agro-biotechnology and in the diverse areas of basic science and medical research. Emerging trends of collaboration between industry and academia for development of entrepreneurship in biotechnology. Lab tours.

BSE 212 **MOLECULAR BIOLOGY**

L-T-P-D-[C]
3-0-0-0-[4]

Genome as the store house of information, DNA as the carrier of encoded messages. Genomic diversity across organisms as a source of embedded intelligence in nature. Intra-cellular transmission of genetic messages and their cellular translation; Cell-cell communication and feedback; Selective transmission of genetic messages - regulation of gene expression; logic of building body plans–developmental translation of encoded messages. Techniques of DNA manipulation and engineering.

BSE 216 **BIOCHEMISTRY**

L-T-P-D-[C]
3-1-0-0-[4]

Properties of water, Acids, Bases and Buffers. First and Second law of thermodynamics; Free energy as an indicator of spontaneity; Chemical Equilibria. Amino Acids of Proteins; Optical Activity. Primary Structure Determination; Three-Dimensional Structures of Proteins: Secondary Structure; Fibrous Proteins; Globular Proteins; Quaternary Structure. Polysaccharides; Glyco-proteins. Lipids and Membranes; Mechanisms of enzyme action; Substrate Specificity; Coenzymes; Regulation of Enzymatic Activity: enzyme kinetics, inhibition; effects of pH. Catalytic mechanisms, Biosynthesis of amino acids, lipids and nucleotides.

BSE 292 **BSBE LAB I – MOLECULAR BIOLOGY**

L-T-P-D-[C]
0-0-4-0-[2]

Use of Transgenic organisms in the study of gene expression methodology to obtain high affinity antibodies.

BSE 314 **BIOMECHANICS**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to biomechanics. Bio-sensors, actuators and control. Analysis of bio-system as a flexible structure. Aerodynamics, hydro-dynamics and locomotion. Bio-statics and Bio-dynamics I – Mechanics of motion, friction, fracture. Biodynamics II – Work, energy and power. Bio-dynamics III. Fluid Mechanics - Examples of Archimedes principles, Pascal Law, Bernoulli's theory and the living world, Viscosity and turbulence, Human circulatory system.

BSE 322 **STRUCTURAL BIOLOGY AND BIOINFORMATICS** **Prereq : BSE 216**

L-T-P-D-[C]
3-0-0-0-[4]

Biological Databases; Global and local alignment; pair wise and multiple sequence alignment; Pattern searching in DNA & Protein sequences; Alignment tools, BLAST, FASTA, phylogenetic prediction, evolutionary tree construction, gene prediction in prokaryotes, eukaryotes; Protein structure classification; Structure prediction from sequence features, Comparative genomics.

BSE 323 **PROTEIN STRUCTURE & ENGINEERING** **Prereq : BSE 216 BSE 322**

L-T-P-D-[C]
3-0-0-0-[4]

Purification of proteins, Chromatography principles, methods to estimate the concentration & purity, Principles of Protein Structure, Methods to determine 3D-Structures. X-ray crystallography and Nuclear Magnetic Resonance methods, Biological Membranes; Membrane Assembly and Protein Targeting; Signal transduction; Receptors and hormones; antigen-antibody relationship. Protein dynamics, Protein Folding, Dynamics and Structural Evolution. Elementary ideas of bonding and structure, stereochemistry; spectroscopic techniques. Protein Engineering*:* Proteins design and engineering, Random, site directed mutagenesis; Strategies to alter catalytic efficiency; structure prediction and modeling proteins; Molecular graphics in protein engineering; Dynamics and mechanics; Drug-protein interactions and Design; applications of engineered proteins.

BSE 341 **BIOCHEMICAL ENGINEERING**

L-T-P-D-[C]
3-0-0-0-[4]

Fundamentals of Biochemical engineering: Stoichiometry and energetics of microbial metabolism, Transport phenomena, Enzyme catalyzed reactions and processes, Bioreactor design and applications, Sterilization, Instrumentation and control, Bioseparations and bio-processes: Downstream processing – characteristics of biological materials, pretreatment methods; separation of cell biomass, adsorption, filteration, reverse osmosis, isoelectroc focusing, affinity –based separation, polishing-crystallization, drying, case studies; Process integration– Bioprocess integration for efficient production and recovery, scale-up consideration, process monitoring and process economics; Environmental bioprocesses – Interaction of mixed microbial population, applications, biological wastewater treatment, anaerobic, digesters, bioremediation.

BSE 391 **BSBE LAB II – BIOCHEMISTRY AND BIOCHEMICAL ENGINEERING**

L-T-P-D-[C]
0-0-9-0-[5]

Estimation of proteins by UV, Bradford and Lowry methods. SDS-PAGE separation of proteins Enzyme Kinetics- Salivary amylase- different pH buffers and temperature Chromatography- Ion exchange/ HPLC/ GC/affinity Determination of molecular weights by Gel chromatography. Estimation of sugars/blood cholesterol Respiration of mitochondria and oxidative phosphorylation. Bioreactors and bioprocess engineering – use computer simulation to explore mass transfer phenomena and cell growth kinetics. Bioseparation using smart polymers. Yeast antibody library screening- use state-of-art combinatorial library screening methodology to obtain high affinity antibodies.

BSE 392 **BSBE LAB III – STRUCTURAL BIOLOGY & BIOINFORMATICS** **Prereg : BSE 322**

L-T-P-D-[C]
0-0-4-0-[2]

De novo protein design and artificial proteins: approaches used in designing and constructing novel proteins. Structure based drug design: Virtual screening techniques, designing pharmacaphore models, scoring function and their relevance in downsizing hit lists. Determination of Protein structure by X-ray crystallography: protein purification, current methods in protein crystallization. Evaluating the quality of crystals, crystal freezing at low temperature for data collection. A demonstration session on X-ray diffraction data collection and processing.

Bioinformatics – Training with Insight Molecular modeling package, Exercises involving homology modeling of protein structures, Pairwise and multiple sequence alignments using tools such as BLAST, FASTA, CLUSTAL and from GCG suite of programs.

BSE 441 **EVOLUTION OF BIOLOGICAL MACHINES, 3-0-0-0-4**

Living body as an examples of finest designs for diverse activities, functions e.g., flying, swimming, reproduction, sensing, eating, etc. Evolution and natural selection as the means of optimization of biological machines at diverse scales: molecular, cellular, organismal and population. Principles of micro and macro evolution. Theories of evolution and Darwanian selection. Principles of generating diverse body plan and design in nature.

BSE 452 **BIOMATERIALS**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to Materials Science: Bulk and surface properties of materials; Polymeric materials; synthesis, char-acterization, and fabrication methods–Inert, biodegradable, hydrogels, Natural, Genetically engineered and Bioactive; Ceramics and glasses; Metals; Surface modification techniques. Biocompatibility of Biomaterials: Protein structure, interaction of proteins with synthetic materials;

Characterization of cell-material interactions; inflammatory responses; acute inflammation, chronic inflammation, foreign body response, assessment of material performance.

BSE 454 **INTRODUCTION TO TISSUE ENGINEERING**

L-T-P-D-[C]
3-0-0-0-[4]

What is tissue engineering? Scope and objective of tissue engineering; Principles of tissue engineering; Essential components of tissue engineering; Materials Science/Engineering aspects (degradable materials); Design and characterization of scaffolds (porosity, mechanical strength and 3-D architecture); Cell Biology aspects (choice of cell type, progenitor cells and cell differentiations); Molecular biology aspects (cell signaling molecules-growth factors, cell attachment-integrins); Drug delivery in tissue engineering; Commercial developments of tissue engineering; Future of tissue engineering.

BSE 491 **BSBE LAB IV- BIOMECHANICS AND BIOMATERIALS**

L-T-P-D-[C]
0-0-4-0-[2]

Biomechanics: Human body motion analysis. Control of artificial arms/legs using biological principles. Rehabilitation applications of biomechanics. Bio-sensors and MEMS: Development of sensors for measuring pressure, temperature, force at the fingertips and soles of the feet. Polymer spinners and micro lithography. Testing of synthetic materials

Biomaterials: Biodegradable polymers - synthesis, fabrication test their characteristic, computational simulation of biomaterial for their mechanical strength, tissue compatibility and prosthetic devices. Modeling natural material like wood, bamboo, fish-bone, plant stem etc.. Modeling human tissue and tissue biomaterial interactions.

BSE 611 **INTRODUCTION TO MODERN BIOLOGY** **Prereq.**

L-T-P-D-[C]
3-0-0-0-[4]

Meant for students without previous training/degree in biological sciences at the graduate level

Concepts and Methods in Biology :- Energy and life's organization, Evolutionary view of diversity, Nature of biological inquiry - observations, hypothesis and tests. Principles of Cellular Life, Chemical Foundation for cells, Carbon compounds in cells, Cell structure and function, ground rules for metabolism, source of energy for cells. Principles of inheritance: Cell division, patterns of inheritance, chromosomes and genetics. DNA to protein - Nature of the genetic material, transcription and translation. Fundamentals of protein structure, Principles of evolution: Microevolution, speciation, macro-evolutionary puzzle. Evolution and diversity: Origin and evolution of life, prokaryotic and eukaryotic life forms. Plant structure and function: Plant tissues, nutrition and transport.

Animal structure and function: Tissues and organs, sensory reception, endocrine control, circulation, immunity, respiration, digestion and nutrition, reproduction and development - sexual versus asexual reproduction stages of reproduction, cell differentiation, morphogenesis, and pattern formation. Nature of Ecosystems- Primary productivity, ecological pyramids, biological cycles, Ecology and behavior Population ecology, ecosystem, biosphere, human impact on biosphere, and evolutionary view of behavior- heritable aspects of behaviour, learn behavior, communication signals, social behavior.

BSE 612 **MATHEMATICS AND STATISTICS FOR BIOLOGISTS** **Prereq.**

L-T-P-D-[C]

3-0-0-0-[4]

Meant for students with training/degree in biological sciences at the graduate level

Review of basic mathematics, Introduction to statistics and probability, Data representation, mean, mode/ median/standard deviation etc., Histogram, Scatter plot, Distributions (binomial, poission and normal), Tests of significance (x2 and t).

regression and correlation, Analysis of variance, Matrices, 3-d geometry, Numerical methods and Vector analysis

BSE 613 **CELL AND MOLECULAR BIOLOGY** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Cell cycle, Cellular and tissue architecture: cell membrane, nuclear envelope, cyto-skeleton, cell cycle, mitotic and meiotic cell division, cell organelles and chromosome structure, Cell motility and shape, Cell- Cell signaling. Recombinant DNA technology: Isolation and characterization of DNA and RNA, DNA cloning, sequencing, and mutagenesis, transformation and targeted mutagenesis, polymerase chain reaction. Immunology: immunoassays, preparation of monoclonal antibodies, polyclonal antisera, and antipeptide antibodies, determination of antibody specificity. DNA-Protein Interactions: Mobility shift DNA binding assay, Methylation and Uracil Interference Assays, DNAse I foot printing, UV cross linking of proteins to nucleic acids, purification of DNA binding proteins, Yeast one-hybrid screening for DNA-protein interaction. Protein Expression: expression of protein in E.coli, insect cell, and in mammalian cells. Analysis of protein-protein interactions: interaction trap/two hybrid system, affinity purification using GST binding fusion proteins, page based expression cloning, coprecipitation, far western analysis. Manipulating the Mouse Genome: overview, homologous recombination, mouse ES cells, chimeric mouse and knockout mouse.

BSE 614 **GENETICS** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Essential Principles of genetics: The principles of inheritance and selection of experimental models. Extension of Mendelism: Gene action (genotype to phenotype) Gene interaction. The genetic basis of phenotypic variation. Epistatsis. Linkage recombination and gene mapping, X linked inheritance, Sex determination, Doses compensation. Evolution of concept of the gene: one gene one enzyme hypothesis, defining gene by Complementation test Genetic code. Genetics of prokaryotes: Genetics of viruses/phage, mapping of phage genotype, Genetic analysis bacteria, Transformation, conjugation and Transduction. Generation of genetic diversity: Mutation, recombination, transposition, extra chromosomal inheritance. Techniques of genetic analysis/Genetic dissection of biological process/ discovery of pathways. Morphological/molecular markers, Mutagenesis, Reporter genes, Mitotic recombination, Deletion mapping, Cytological mapping, Identification of a gene: phenotype to cloning.

BSE 615 **MODERN INSTRUMENTAL METHODS IN BIOLOGICAL SCIENCES** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Applications of spectroscopic and other techniques to the study of biomolecules: UV-Vis spectroscopy, Circular dichroism, Fluorescence, NMR, Mass, IR and Raman spectroscopy, X-Ray diffraction. Cellular Imaging Techniques: Microscopy: Phase contrast Nomarsky, Fluorescence, Atomic Force and confocal. Biophysical techniques to purify and study proteins. Dialysis, salting out and precipitaion by organic solvents, Ion exchange, gel filtration, reversed phase, affinity chromatography, ultracentrifugation, gel electrophoresis. Analysis of Proteins: Electrophoretic separation of proteins (single dimension native and denaturing gels, 2D and digital electrophoretic analysis), detection (staining, blotting and immuno-detection) and purification (various chromatograpy, HPLC, immunoprecipitation) of proteins, and specialized applications (in vitro synthesis of protein, labeling, microsequence analysis, and Mas spectrometry)

BSE 615 **IMMUNOLOGY** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to Immunology, Cells involved in immune response, Antigen receptor molecules, Generation of Diversity, Antigen recognition, Cell mediated immune reactions, Regulation of immune response, complement, Immunity to viruses, bacteria, fungi, protozoa and worms, Tumor Immunology, Immunodeficiency, Hypersensitivity, transplantation and rejection, Autoimmunity and autoimmune disease, Immunological techniques.

BSE 616 **BIOCHEMICAL ENGINEERING AND BIO NANOTECHNOLOGY** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Nanotechnology: Cellular Architecture - Structure and mechanics of cytoskeleton, Self assembly of cryoskeletal polymers, Force generation by poymerization. Motor proteins and nanotechnology. Types of Motor proteins: Linear and Rotary motors, Structure of Motor proteins, Motility properties of motors, ATP hydrolysis mechanism of various Motor proteins: comparison of kinetics Steps and force production by motors, chemo-mechanical coupling of motors: single molecule approaches. DNA as a polymer and DNA-based motors basics of DNA structure, Hairpin loops and helices: reciprocal exchange and stability of DNA structure, Base pairing, motifs used in DNA nanotechnology. RNA polymerase and DNA helicase as motors, Single molecule mechanics and DNA dynamics.

Biochemical Engineering: Overview of biotechnology, Enzyme Catalysis and immobilized biocatalysts (principles of enzyme catalysis; kinetics of single substrate reactions: enzyme inhibition, denaturation and inactivation; methods of immobilizations; Electrostatic, external and internal mass transfer effects or immobilized kinetics. Microbial growth (stoichiometry and energetics; unstructured and structured models. transport and Reactor Process (continuous stirred tank, plug flow and packed bed bioreactors; gas-liquid mass transfer; mass balance for two phase reactors; power requirements; sterilization). Downstream processing - Product recovery and purification (Centrifugation; ultrafiltration; preci-pation; chromotography; electrophoresis and crystallization; solvent mediated sparation. Concepts and dynamics of microbial interactions in mixed populations. Bioproducts & economics.

BSE 629 **Neurobiology** **Prereq #**

L-T-P-D-[C]
3-0-0-0-[4]

Cell and molecular biology of neurons. Membrane potential, local signaling and generation of action potential. Mechanism of synaptic transmission. Sensory pereception : Vision, hearing, taste, touch and smell. Movements : The motor systems, reflexes, Voluntary control of motion etc. Functions of hypothalamus limbic system and the Cerebral cortex learning and memory, sleep and dream.

BSE 631 **DEVELOPMENTAL BIOLOGY** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Basic concepts and historical account. Model systems. Animal body plan: Axes and germ layers. Organizers. Morphogenesis. Cell fate determination and cell differentiation. Cell-cell communication during development. Genes and development: gene expression and their regulation. Regeneration and aging. Environmental regulation of animal development.

BSE 632 **STRUCTURAL BIOLOGY AND BIOPHYSICS** **Prereq. none**

L-T-P-D-[C]
3-0-0-0-[4]

Conformational studies of biomolecules, protein secondary structure, 3D-structures of proteins, DNA structures, membrane proteins. X-ray and NMR techniques, electron crystallography, other spectroscopic techniques used to deduce structural information (CD, IR, FTIR, Raman, Solid State NMR, ESR etc.), Homology modeling, computational studies to understand the structure-function relationships of proteins, molecular mechanics and dynamics, force fields, biomolecular simulation programs. Structural genomics, high-throughput structure determination.

BSE 633 **BIOINFORMATICS AND COMPUTATIONAL BIOLOGY** **Prereq.# BSE 632**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction to Molecular Genetics, The Human Genome Project, Biological databases, Gene prediction, Analysis of genomic sequences, Pair wise and multiple sequence alignments, Bioinformatics tools, Hidden Markov Models, Conformational studies of biomolecules, Globular and membrane proteins, Protein folding problem, Homology modeling, Simulation studies of proteins and nucleic acids.

BSE 634 **FUNCTIONAL GENOMICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction; The impact of genomics on biological research; Identification of a large set of genes involved in a biological process; High-throughput expression analysis; Genome-wide search for interacting partners; Identification of alternatively spliced genes; Sequence variations and disease susceptibility; Pharmacogenomics; Proteomics; Functional genomics in model organisms; High-throughput phenotypic analysis; Recent developments in genomics.

BSE 636 **HUMAN MOLECULAR GENETICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Simple Mendelian traits; Loss-of-function mutations; Gain-of-function mutations; Gene interactions; Dynamic mutations; Genetics of neoplasia; Genomic imprinting and human disease; X-inactivation and DNA methylation; Gene mapping and positional cloning; Mutifactorial inheritance; Genetics of behavioral disorders; Pharmacogenetics and biochemical genetics; Animal models in human genetics: Methods used for diagnosis and detection of gene mutations; Gene Therapy.

ESO 219 **Introduction to Biology** **Prereq : none**
L-T-P-D-[C]
3-0-0-0-[4]

Chemical Foundation for Cells : Carbon Compounds in Cells, Cell Structure and Function. Principles of Cell structure and function : Cell Division and Mitosis, Meiosis. Flow of information : Chromosome and DNA, DNA to protein, Control of genes, recombinant DNA and genetic engineering Tissue, Organs and Homeostasis Nervous Systems, Sensory Reception, Endocrine Control, Protection, Support, and Movement, Circulation, Immunity, Respiration, Digestion and Human Nutrition, Reproduction and Development. Round Rules of Metabolism, How Cells Acquire Energy, and How Cells release stored energy.

CHEMICAL ENGINEERING

PROFESSORS

Bhattacharya PK (Head)	pkbhatta	7093	7817
Chhabra RP	rpc	7393	7607
Deo G	goutam	7363	7881
Gupta JP	jpg	7175	
Gupta SK	skgupta	7031	7127
Khanna A	akhanna	7117	
Kumar A	anilk	7195	
Kunzru D	dkunzru	7193	7811
Sharma A	ashutos	7026	7406
Verma N	nishith	7704	

ASSOCIATE PROFESSOR

Kaistha N	nkaistha	7513	7136
Panda S	spanda	6146	6065
Shankar V	vshankar	7377	7827

ASSISTANT PROFESSORS

Apte P	papte	7457	
Garg S	sgarg	7736	7860
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Singh JK	Jayantks	7017	

Convenor, DUGC :	Joshi YM	joshi	7993
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The Department of Chemical Engineering offers academic programmes leading to B.Tech., M.Tech. and Ph. D. degrees in Chemical Engineering.

The Department imparts graduate education with emphasis on chemical engineering fundamentals and prepares students for a high level of competence in the use of modern engineering methods, CAD and microprocessors based instrumentation, etc. Most of the graduate courses have a strong engineering science and modern orientation. They are primarily intended to prepare students for teaching and R&D careers in computer aided process design, simulation and controls, interfacial phenomena, process safety; complex fluid flow modeling etc. Our students find employment in renowned industrial and academic organisations in India and abroad.

The department has a young and dynamic faculty who are recognised both nationally and internationally, who have received numerous awards and honours for excellence in fundamental research for process development (e.g., Shanti Swarup Bhatnagar; Herdillia, Amar Dye-Chem and NOCIL awards of IIChE; Fellowships of Academy of Sciences and Engineering, etc.) Their research in diverse areas of Chemical Engineering is published in prestigious international journals with high impact factors.

The departmental faculty has also authored nearly 30 textbooks and research monographs through reputed publishers in India and abroad which reflects the faculty's commitment to teaching. There are a number of completed and ongoing projects sponsored by various national funding agencies including the Department of Science and Technology, Ministry of Human Resource Development, CSIR, ARDB, DBT, etc. The department enjoys an excellent rapport and professional interaction with various industrial organizations. Faculty members engage in high level consultancy work in industry during summers, whereas some others have sponsored projects funded by industry (e.g., IPCL Baroda, GSFC Baroda, Duncan Industries Ltd., UP State Agro Industries, Engineers India Ltd., GAIL, BPCL, CHT, Hindustan Lever, etc.).

CURRENT COURSE STRUCTURE FOR B.TECH. STUDENTS
CHEMICAL ENGINEERING

COURSE	SEMESTER							
	FIRST	**SECOND**	**THIRD**	**FOURTH**	**FIFTH**	**SIXTH**	**SEVENTH**	**EIGHTH**
	CHM101	TA101	MTH203	HSS-I-2	SE-1	HSS-II-1	HSS-II-2	SE-2
	PHY101	PHY103	CHM201	TA201	CHE312	CHE313	CHE452	CHE453
	PHY102	MTH102	ESO202	ESO218	CHE331	CHE362	CHE492	CHE463
	MTH101	ESC102	ESO212	CHE211	CHE361	CHE381	CHE494	DEL-2
	HSS-I-1/	CHE100	CHE251	CHE221	OE-1	CHE391	CHE495	DEL-3
	ENG112N	PE102				OE-2	DEL-1	
	ESC101						OE-3	
	PE101							

ChE 100 Intro. to Chemical Engineering
ChE 211 Fluid Mechanics
ChE 221 Chem. Engg. Thermodynamics
ChE 251 Chemical Process Calculations
HSS-I
ChE 312 Heat and MassTransfer
ChE 313 Separation Processes
ChE 331 Chemical Reaction Engineering
ChE 361 Chemical Process Industries
OE-I Open Elective-I
SE-I Sc Elective-I
ChE 362 Biochemical Engineering
ChE 381 Process Dynamics and Control
ChE 391 Unit Opn. Lab I
OE-II Open Elective-II
HSS-II
ChE 452 Computer Applications in Chemical Engineering
ChE 492 Unit Opn. Lab II
ChE 494 Summer In-Plant Training
ChE 495 Project
DE-I Departmental Elective - I
OE-II Open Elective - III
HSS-II
ChE 453 Chem. Engg. Design
ChE 463 Electronic, Polymeric & Ceramic Materials & Processing
DE-II, DE-III Departmental Elective - II, III
SE-II Sc Elective -II

COURSE DESCRIPTION

ChE 100 **INTRODUCTION TO CHEMICAL ENGINEERING**

L-T-P-D-[C]
2-0-0-0-[0]

What is engineering vis-à-vis basic Science? What is Chemical Engineering? What do Chemical Engineers do? Diversity of employment opportunities; Intimate connections with other physico-chemical sciences, biological and biomedical sciences, and other engineerings: case studies and examples; Historical perspectives and needs, e.g., petrochemical industries, pulp and paper, textiles; Concerns of chemical engineering: traditional areas, environment, energy, new materials, bioengineering and biotechnology, food, health; Safety, IPR, Professional ethics; Frontiers: role and future of Chemical Engineering in the computer/information revolution; biomolecular revolution (e.g., nanodevices); Basic tools of Chemical Engineering: physico-chemical, mathematical and biological sciences, transport phenomena, thermodynamics, kinetics and reactors, design; Concept of unit operations and descriptions of important unit operations; Concepts of scale-up, modeling and simulation: from molecular to terrestrial (e.g., ecology) scales; Visit to research laboratories of the department and other specially chosen laboratories in the Institute to introduce chemical engineering concerns; Simple laboratory demonstrations; Screening of educational videos from AIChE and I Chem E, as well as from Indian industries; Plant visits.

ChE 211 **FLUID MECHANICS** **Prereq. ESO 212**

L-T-P-D-[C]
3-0-0-1-[4]

Review of Navier-Stokes' (NS) equations; non-dimensionalization of NS equations; introduction to turbulence; analogies; correlations for fluid flow Short introduction to non-Newtonian flows, Engineering Bernoulli Equation; f vs. N_{Re} charts; K factors and equivalent lengths for various fittings; hydraulic diameter; Head vs. Q plots of centrifugal pumps; NPSH, cavitation and priming; pipeline system design including pseudo-steady state approximation; flow measurements; compressors and blowers. Compressible flows in conduits, *Mixing and Agitation:* Power consumption; mixing times; scale-up, Characterization of solids; fundamentals of two-phase flow; flow through packed beds and in fluidized beds (pressure drops, loading and flooding); pneumatic and hydraulic transportation. Filtration, Centrifuges and cyclones (including some recent models).

ChE 221 **CHEMICAL ENGINEERING THERMODYNAMICS** **Prereq. ESO 202**

L-T-P-D-[C]
3-0-0-1-[4]

Review of I and II Laws of Thermodynamics, P–V–T Relations of Pure Fluids Graphical,Tabular and Mathematical representaion; Generalized compressibility chart; Generalized EOS; Thermodynamic Potentials; Maxwell Relations, Thermodynamic Property Relations, Thermodynamic properties of real gases, Multicomponent mixtures, Properties of solutions, Phase Equilibrium (VLE, LLE, VLLE), Review of Thermochemistry; Chemical reaction equilibria.

ChE 251 **CHEMICAL PROCESS CALCULATIONS** **Prereq. None**

L-T-P-D-[C]
3-0-0-1-[4]

Guidelines for Problem Solving; Review of Basic concepts – Process variables & properties, Degree of Freedom, Steady State Material Balances – in non-reacting systems and reacting system, Recycle & purge, elemental vs. species balance, combustion of fossil fuels, Steady State Material balances in Multiphase systems, Steady State Energy Balances – in non-reacting & reacting systems, De-Coupled & coupled mass & energy balances, Calculations for network of units with recycle & bypass, Process Flow sheeting with sequential modular calculations, Unsteady State Balances.

ChE 312 **HEAT AND MASS TRANSFER** **Prereq. ESO 212, ChE 221**

L-T-P-D-[C]
3-0-0-1-[4]

Heat conduction, Molecular diffusion, Convective heat transfer (laminar & turbulent), convective mass transfer (laminar & Turbulent), simultaneous heat and mass transfer, wet-bulb and adiabatic saturation, Interface mass transfer; Boiling: pool and convective boiling, correlations, Condensation: film-wise and drop-wise condensation, correlations, Radiation: thermal radiation, radiation properties, view factors, heat exchange between surfaces, Heat exchanger design: Shell-and-tube, compact exchangers, reboiler, and condenser, Evaporators: type of equipment, single and multiple effect evaporators, Crystallization: phase equilibria, crystal growth, types of equipment, design, Aspen/Matlab should be used wherever possible.

ChE 313 **SEPARATION PROCESSES** **Prereq. ChE 221, ChE 312**

L-T-P-D-[C]
3-0-0-1-[4]

Mass transfer equipment: continuous contact and staged contact units for absorption, extraction, distillation, adsorption, humidification, drying, Phase equilibria: phase diagrams, V-L-E, G-L-E, S-L-E; estimation of binary and multicomponent phase equilibria, Single stage (steady state): binary and multicomponent, Single stage unsteady state: (distillation, drying, adsorption [blow down]), Separations without reflux: isothermal cases: stage contactor: McCabe -Thiele method, stage efficiency, matrix method, Thomas method for solution, continuous contact (HTU, NTU), Separations without reflux: non-isothermal cases (absorption, adsorption, drying, humidification): McCabe-Thiele method, numerical solutions, Separations with reflux: distillation, extraction and adsorption, McCabe-Thiele and matrix method; continuous contact, Membrane separation processes: fundamentals, introduction, different types of processes, Design of gas-liquid, liquid-liquid contactor; staged and continuous contact, Estimation of stage efficiencies, Short-cut methods for distillation. Aspen should be used as much as possible.

ChE 331 — **CHEMICAL REACTION ENGINEERING** — **Prereq. ChE 221**

L-T-P-D-[C]
3-0-0-1-[4]

Introduction, Basic Concepts in Chemical Kinetics, Collection and Analysis of Rate Data, Nonelementary Homogeneous Reactions, Isothermal Reactor Design, Design for Multiple Reactions in Isothermal Reactors, Nonisothermal Reactors, Nonideal flow, Catalysis, Kinetics of Catalytic Reactions , Diffusion and Reaction in Porous Catalysts.

ChE 361 — **CHEMICAL PROCESS INDUSTRIES** — **Prereq. ChE 251**

L-T-P-D-[C]
3-0-0-1-[4]

Role of Chemical Engineer, Elementary Process Flowsheeting P & I diagrams, Inorganic Industry–Fertilizers, Chlor alkalies, Natural Products –Pulp & Paper, Oils, Soaps, Herbs, Petroleum & Petrochemicals: Refining/Crude Distillation; FCC, Catalytic Reforming; Alkylation, Amination, Hydrocracking, Aromatic Extraction, Plastics, Intermediates, dyes & paints, Pharmaceuticals, Environmental Pollution & Waste Treatment.

ChE 362 — **BIOCHEMICAL ENGINEERING** — **Prereq. ESO 212, ChE 331**

L-T-P-D-[C]
3-0-0-1-[4]

Cell Structure and Cell Types, Chemicals of Life (RNA, DNA, enzymes etc.), Kinetics of Enzyme Reactions, Applied Enzyme Catalysis, Metabolic Stoichiometric and Energetics, Molecular Genetics and Control, Biomass Production, Transport Phenomena in Biosystems, Design and Analysis of Biological Reactors, Fermentors, Downstream Product Recovery and Purification, Interaction of Mixed Microbial Populations, Biological Wastewater Treatment.

ChE 381 — **PROCESS DYNAMICS AND CONTROL** — **Prereq. MTH 203**

L-T-P-D-[C]
3-0-0-1-[4]

Introduction, Process models, Linearization, Laplace transforms. Process dynamics, Time delay, Feedback control, Instrumentation, Stability (Routh array & root locus), Frequency response analysis (Bode and Nyquist plots), Design of feedback controllers, High level control (Cascade, Smith predictor, feedforward, adaptive, inferential, ratio, override etc.), MIMO systems, Digital control.

ChE 391 — **UNIT OPERATION LAB. I** — **Prereq. ChE 251, 211, 312, 331**

L-T-P-D-[C]
0-0-6-1-[4]

Fluid flow, Fluid particle systems, Thermodynamics, Heat transfer, Mass transfer.

ChE 452 — **COMPUTER APPLICATIONS IN CHEMICAL ENGINEERING**

L-T-P-D-[C]
3-0-0-1-[4]

Artificial Intelligence and Networks in Chemical Engineering, Expert Systems (CONPHYDE, KBS) and Tools (KEE, ART), Artificial Neural Network, Learning and Training, Process Plant Diagnosis, Safety Analysis, Process Modelling, Interfacial properties, Fault Diagnosis and Trouble Shooting, Data Base Management and

Qualitative Interpretation of Process Data, Simulation Packages, ASPEN PLUS, Batch Processing Packages (SUPERPRO), FLUENT

ChE 453 **CHEMICAL ENGINEERING DESIGN** **Prereq. ChE 251, 452**
L-T-P-D-[C]
3-0-0-1-[4]

Introduction to Design – Process Development, process alternatives, Process Flowsheeting and simulation using ASPEN PLUS, Conceptual Process Synthesis, Conceptual design of reactors, pressure vessels, distillation/adsorption columns, storage vessels, Synthesis of Separation Trains, Cost Estimation & profitability analysis, Heat Exchange Network Analysis, Scale-up & pilot plant studies, HAZOP and Safety in design, Batch process Design for sequential processing using SUPERPRO, Continuous plant design (group term projects).

ChE 463 **ELECTRONIC, POLYMERIC & CERAMIC MATERIALS & PROCESSING** **Prereq. ChE 312**
L-T-P-D-[C]
3-0-0-1-[4]

Atomic structure, semiconductor materials, solar cells, Transistors and Process Sequence of Fabrication, Control of Microcontamination, Microlithography, Doping, Etching, Oxidation, Chemical Vapour Deposition and Reactor Design, Classification and Electrical, Mechanical Properties of Polymer, Polymer Catalysis and Molecular Chemistry, Flow Behaviour and Polymer Processing, Polymer Blends and Composites, Applications of Polymers (Exchange Resin etc.), Ceramic Raw Materials and Characterization, Ceramic Processing Additives, Ceramic Beneficiation Process, Ceramic Forming Processes (Sol-gel, Casting etc.), Zeolites, Ceramic Drying, Surface Processing and Shaping.

ChE 492 **UNIT OPERATION LAB II** **Prereq. ChE 312, 313, 331, 381**
L-T-P-D-[C]
0-0-6-1-[4]

Mass Transfer, Heat transfer, chemical reactors, Computer aided data acquisition and on-line analysis, Process dynamics and control.

ChE 494 **SUMMER IN-PLANT TRAINING**
L-T-P-D-[C]
0-0-4-0-[2]

A written report and an oral presentation/interview after successful completion of an 8-week industrial in-plant training with a chemical industry.

DEPARTMENT ELECTIVES

ChE 495 **PROJECT** **Prereq. #**
L-T-P-D-[C]
0-0-8-0-[0]

Student will work on design/research projects to carry out theoretical/experimental work on problems in chemical engineering as assigned by the project advisor.

DEPARTMENT ELECTIVES

ChE 600 **RESEARCH METHODS AND SKILLS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Definition and nature of research, Motivation for research, different types and styles of research in sciences, role of serendipity, scientific temperament, Is science necessary? Working of some of the great minds from all walks of life-scientists, artists, writers,etc.Tools for thinking, critical and positive thinking, creativity and innovation, mind mapping; Development of problem solving skills, scaling and orders of magnitude analysis, role of simple models in thinking and in developing an understanding. Scientific and critical reasoning skills, art of reading and understanding scientific papers and critical evaluation of the underlying premises and assumptions, literature reviews. Professional attitudes and goals, concept of excellence, ethics in science and engineering, some famous frauds in science. Scientific communication, Organisation of ideas, writing scientific papers, reports and thesis; Making scientific presentations at conferences; Presenting popular lectures to semi-technical and or/non-technical audience/ participating in public debates on scientific issues.

ChE 611 **TRANSPORT PHENOMENA** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Kinematics, Transport theorem, constitutive relations, Equations of motion and their solutions, Boundary layer theory, Turbulence; Energy equation and its exact solutions, Continuity equation for multicomponent systems, constitutive relations, Interphase transport of momentum, energy and mass and macroscopic balances.

ChE 616 **MODELLING AND SIMULATION OF SEPARATION PROCESSES** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Advanced topics in multicomponent staged separation processes such as distillation, absorption, extraction. General design methods flash separation short-cut and rigorous methods.

ChE 618 **NEW SEPARATION PROCESSES** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Separation Factors for Rate Governed Separation Processes, Membrane Characterization; Reverse Osmosis: Models of Solvent and Solute Transport, Concentration Polarization; Ultrafiltration: Types of Transport through UF Membranes, Fouling and Concentration Polarization in UF, Osmaotic Pressure Model utization; Diafiltration: Process Design; Dialysis: Solute Transport analysis of dialyzer operation, Mode of Dialysis; Electro-dialysis: Types of Electro- dialysis - Ion Transport Fundamentals, Concept of Limiting Current Density, Concentration Polarization; Liquid Membrane; Permeation of Gases through Membranes and Pervaporation.

ChE 621 **THERMODYNAMICS I** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Postulational Thermodynamics: Postulates; Equilibrium criteria; Gibbs Duhem relation; Energy minimum principle; Thermodynamic potentials; Stability and phase Transition. Statistical Thermodynamics: Statistical mechanics of ensembles;

Estimation of Thermodynamic properties in Ideal gases, Estimation of equilibrium constant in reacting systems.

ChE 622 **INTRODUCTION TO MOLECULAR SIMULATION** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Theory methods, and application of molecular simulation. Elementary satistical mechanics. Molecular modeling. Basic Monte Carlo and molecular dynamics techniques and ensemble averaging. Evaluation of free energies, phase equilibria, interfacial properties, and transport and rate coefficients. Applications to simple and complex fluids and solids. Commercial simulation software.

ChE 623 **THERMODYNAMICS OF FLUIDS AND FLUID MIXTURES** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Classical thermodynamics of phase equilibria: Thermodynamic properties from volumetric data: Nature of intermolecular forces, Theory of corresponding states; Fugacities in gas mixtures and liquid solutions; gas solubilities; High pressure equilibria.

ChE 631 **CHEMICAL REACTION ENGINEERING** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Behaviour of chemical reactions; Behaviour of chemical reactors: ideal and non-ideal flow, non-isothermal reactor performance, reactor stability; Heterogeneous reactions: interphase and intraphase heat and mass transfer effects; Fluid-Solid non-catalytic reactions; Heterogeneous catalytic reactions.

ChE 633 **PRINCIPLES OF HETEROGENEOUS CATALYSIS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Adsorption; Energetics; Isotherms and Rates: Experimental aspects of adsorption and allied phenomena on catalyst surfaces; Pore structure and surface area estimation and their significance; Important catalysts, Promoters and Carriers; Mechanisms of some typical heterogeneous catalytic reactions, e.g., Oxidation.

ChE 641 **MATHEMATICAL METHODS IN CHEMICAL ENGINEERING** **Prereq.** #
L-T-P-D-[C]
3-0-0-0-[4]

Modelling, Vector Spaces, Matrices, Linear Operators, Initial Value Problem, Partial Differential Equation, Sturm Louiville Theory, Separation of Variables, Greens Functions, Transform Techniques, Nonlinear Equations, Continuation Methods, Bifurcation and Chaos.

ChE 642 **NUMERICAL METHODS IN CHEMICAL ENGINEERING** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Systems of Linear and Non-Linear Algebraic Equations: Successive Substitution, Newton-Raphson, Eigenvalues and Eigenvectors of Matrices, Interpolation, Solutions of ODEs (IVP): Runge Kutta, Multistep Methods, Gear's algorithm, Stiffness and Stability of algorithms, ODE (BVPs) and PDEs: Finite Difference, Finite Elements, Shooting Methods.

ChE 645 L-T-P-D-[C] 3-0-0-0-[4]

MODELING AND SIMULATION IN CHEMICAL ENGINEERING **Prereq. #**

Mathematical Model and its Necessity: Model Development principles: Synthesis of sub-models, Experimental facts, Hypothesis, Dimensional Analysis, Scaling, Reduction of equations.

Classification of Models: Deterministic and stochastic - Example from thermal diffusion, Lumped and Distributed parameter - Example from stirred tank and plug flow, Additional examples from transport processes and chemical kinetics.

Modelling and Simulation Techniques: Length and time scale analysis in multiscale systems, Population balance models - Fundamentals, Examples from Crystallization, coagulation, Microbial population, Monte Carlo methods - Basics of Random No. and Probabbility distribution, Time and event driven methods, Stochastic models - Poisson Process, Markov process, Birth-death process, Non-linear dynamics and Chaos- Principles, Application in mixing, reaction, stirred tank, fludized bed, Fractal models - Diffusion and reaction limited growth, Aggregate structure.

Solution and analysis of results: Parameter estimation, Asymptotes, Moments, Phase plane, Time series.

ChE 647 L-T-P-D-[C] 3-0-0-0-[4]

APPLIED STATISTICS FOR CHEMICAL ENGINEERS **Prereq.** #

Elementary concepts of statistics; Significance tests: linear regression; Hypothesis testing; Analysis of variance; Design of experiments; Non-linear parameter estimation: Model building and model discrimination.

ChE 652 L-T-P-D-[C] 3-0-0-0-[4]

OPTIMIZATION **Prereq.** #

Mathematical formulation of optimization problems; single variable problems: search techniques; Multivariable problems without constraints: direct methods, first and second order methods; Multivariable problems with constraints: Calculus of variations; Pontryagin's maximum principle; Dynamic Programming.

ChE 654 L-T-P-D-[C] 3-0-0-0-[4]

PROCESS ENGINEERING **Prereq. #**

Introduction to the elements of process design, process development, process evaluation ; flow sheeting; Pilot plant; Optimization and economic considerations, process design engineering, project engineering, practical considerations; safety considerations and successful plant operations, case studies.

ChE 658 **CHEMICAL PLANT SAFETY AND HAZARD ASSESSMENT** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Hazardous properties of chemicals; Site selection; Risk assessment method; Vapour release models; Fire and explosions; Boiling Liquid Expanding Vapour Explosions (BLEVE); Safety audit; Emergency planning and disaster management; Inherently safer design; Process intensification; Plant Security.

ChE 659 **PROCESS ENGINEERING PRINCIPLES IN MICROELECTRONIC FABRICATION** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Micro-electronic material processing techniques covering aspects through transport mechanism, reaction kinetics and design : silicon crystal growth, oxidation, ion implantation, chemical and physical vapor deposition, rapid thermal processing, epitaxy, lithography, plasma processing (deposition and etch), electrochemical deposition, chemical mechanical planarization. Clean room technology: particulate deposition and filtration aspect.

ChE 662 **PETROLEUM REFINERY ENGINEERING** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Petroleum refining in India; refinery tests and crude oil evaluation ; crude distillation column design; Delayed Coking; Catalytic cracking; Catalytic reforming; Catalytic isomerization; Alkylation; Polymerization; Hydrocracking; Hydrotreating.

ChE 666 **PARTICULATE SCIENCE & TECHNOLOGY** **Prereq.** #
L-T-P-D-[C]
3-0-0-0-[4]

Particle characterization; particle mechanics; discharge of particulate bulk solids; particles in fluids; process in applications.

ChE 670 **INTRODUCTION TO POLYMER SCIENCE & TECHNOLOGY** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Polymer Fundamentals: Chemistry of Polymer synthesis, Polymer Reaction Kinetics: Step-growth polymerization, free-radical chain growth polymerization, Emulsion Polymerization, Ionic and cationic polymerization. Chain statistics and rubber elasticity. Physical properties and characterization of polymers.

ChE 671 **REACTION ENGINEERING OF POLYMERS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Kinetics and mechanisms of polymerization: condensation, free radical, ionic, stereo-regular, copolymerization. Techniques of polymerization: bulk, suspension, emulsion, dispersion, interfacial in both semi-batch and multiphase reactors. Molecular weight distribution and control: simulation of some industrial reactors.

ChE 672 **PRINCIPLES OF POLYMER, PROCESSING** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Review of equations of motion, constitutive equations; Calendaring, extrusion; molding; mixing; fibre spinning.

ChE 673 **ENVIRONMENTAL POLLUTION: CONTROL, DESIGN AND MODELLING**

L-T-P-D-[C] **Prereq. #**

3-0-0-0-[4]

Air Pollution - Atmospheric Pollutants: Photochemical smog in troposphere; O_3 depletion in stratosphere; Acid Rain, Chemical equibiliria, *Aerosols*: Atmospheric deposition, nucleation, *Troposphere Energy Balance*: Pressure & Temperature relationship; Stability criteria: Stack plume rise, Puff and Plume dispersion, *Control of Pollutents*: Absorption; Adsorption: Break through Analysis, *Particles:* Mechanism of Particles capture; Water Pollution - Organic/Inorganic/Biological; Waste Water Treatment; Aerobic and Anerobic digesters, Dissolved O_2 model, Activated sludge process reactor design, Bio-tower reactor design.

ChE 676 **ENGINEERING APPLICATIONS OF RHEOLOGY** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Classification of fluid behaviour: Constitutive relations; Rheometry: Flow of non-Newtonian fluids in closed conduits: Flow in complex geometries: Fixed and fluidized beds; two phase flows, Mixing and agitation: requirements; Dimensional analysis; heat and mass transfer processes in non-Newtonian systems.

ChE 677 **INTRODUCTION TO POLYMER PHYSICS AND RHEOLOGY**

L-T-P-D-[C]

3-0-0-0-[4]

Introduction; Mathematical Preliminaries; Review of thermodynamics and statistical mechanics; Description and statistical properties of a single polymer chain (ideal and real chains); Excluded-volume effects; Thermodynamics of polymer solutions and blends; Flory-Huggins theory; Continuum aspects of rheology; Experimental measures of rheological response; Polymer dynamics: General theory of Brownian motion; Molecular theories for polymer dynamics and rheology; Rouse & Zimm theories; Tube model and Reptation theory.

ChE 678 **MECHANICS OF SOFT MATTER** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Fundamental Equations: The strain tensor; The stress tensor; Thermodynamics of deformation; Hooke's law; Homogeneous deformations; Stress equilibrium relations in Cartesian, cylindrical and polar coordinates. Equilibrium of an elastic medium bounded by a plane; Solid bodies in contact with and without interactions. Saint Venant's principle.

Equilibrium of rods and plates: Equations of equilibrium of rods; Bending and torsion of rods. Euler's buckling instability. Twisting instability of rods. Equation of equilibrium for a bent plate; The energy of a bent plate; Application of bending plate geometry for solving problems related to Adhesion.

Nonlinear elasticity: Molecular approach to rubber; strain energy theory; specific forms of strain energy; Neo-Hookean elasticity. Shearing of an compressible elastic material. Cavitation in crosslinked networks.

Mechanics of cell wall: Elasticity of cellular filaments; soft networks in cell; biomembranes, membrane undulations.

ChE 679 **SPECIAL TOPICS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Course contents vary from time to time.

ChE 681 **ADVANCED PROCESS DYNAMICS AND CONTROL** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Process Identification Techniques for SISO & MIMO systems - off line & on line; Generalized Predictive Control (GPC); Model Predictive Control (MPC): Dynamic Matrix Control (DMC), Internal Model Control for SISO & MIMO systems; Optimal Control; Multivariable Control; Control Design for Complete Plants; Case Studies using MATLAB & SIMULINK software.

ChE 683 **COMPUTER-AIDED PROCESS CONTROL** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Hardware: Analog and digital interfacing, sensors and transducers. System software: realtime programming, Application software: data logging, filtering, Digital Control: Z-transforms, discrete time dynamic systems, adaptive control, introduction to MIMO control systems. Laboratory exercises.

ChE 688 **FUNDAMENTALS OF COLLOID AND INTERFACE SCIENCE & TECHNOLOGY** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Capillarity, interfacial thermodynamics, surflactants, stability of muliphase systems, foam, emulsion, multiphase reactors, wetting and adhesion, catalyst sintering/redispersion; Stability and coagulation of colloids, nucleation and growth: Colloids in chemical engineering, in separation processes, bio-science.

ChE 699 **M. TECH. THESIS**

ChE 701/702 **GRADUATE SEMINAR (M.TECH.)**

ChE 799 **PH. D. THESIS**

ChE 801/802 **GRADUATE SEMINAR (PH. D.)**

CHEMISTRY

PROFESSORS

Bharadwaj PK	pkb	7034	7340
Chakraborty T (On leave)	tapasc	7772	7357
Chandra A	amalen	7976	7241
Chandrashekar V	vc	7259	7617
Chandrasekhar TK (On leave)	tkc	7282	7426
Gajbhiye NS	nsg	7080	7423
Gupta BD	bdg	7046	7730
Gupta Bhaya P	pinaki	7372	
Khan FA	faiz	7864	7394
Manogaran S	sm	7303	7340
Moorthy JN	moorthy	7438	
Mukherjee RN	rnm	7437	7708
Sarkar S	abya	7265	7386
Sathyamurthy N (On leave)	nsath	7367	7390
Singh VK	vinodks	7291	7774
Sundar Manoharan S	ssunder	7425	6043
Vankar YD (Head)	vankar	7492	7169
Verma S	sverma	7643	7962
Yadav VK	vijendra	7439	7939

ASSOCIATE PROFESSORS

Bera JK	jbera	7336	
Ghorai MK	mkghorai	7518	7539
Gurunath R	gurunath	7417	6039
Goswami D	dgoswami	7520	7187
Rao Maddali LN	maddali	7532	7163
Srihari K	srihari	7043	7469

ASSISTANT PROFESSORS

Anantha Raman G	garaman	7517	
Ranganathan M	madhavn	6037	
Rath SP	sprath	7251	6069

Convenor, DUGC :	Ghorai MK	mkghorai	7518
Convenor, DPGC :	Rao MLN	maddali	7163/7532
Faculty Counsellor:	Bera JK	jbera	7336

The Department of Chemistry has an undergraduate programme leading to Master's (M.Sc.) degree and a postgraduate programme leading to Doctorate (Ph. D.) degree. The Department offers a two-year M.Sc. programme through a nationwide entrance test called JAM to those with a Bachelor's degree from other Institutions. In addition, there is a five-year integrated M. Sc. programme for students who have completed their higher secondary or intermediate education in science. Admission to this programme is through the IIT JEE examination. The Ph.D. programme attempts to instil the spirit of research. It includes an integrated sequence of course work and research in various branches of chemistry such as inorganic, organic and physical chemistry, including bio-related areas.

The Department strives to provide undergraduates majoring in various Engineering and Science subjects, a basic understanding of the principles of chemistry and an awareness of its technological importance. A course in General Chemistry with laboratory content on experimental methods in chemistry is compulsory for all undergraduate students. The courses on physical and industrial organic chemistry are taken by those undergraduate students who have a particular interest in them.

Laboratory Facilities

Adequate laboratory facilities exist in the Department for teaching both undergraduate and graduate students. We have a well developed undergraduate laboratory to carry out experiments in inorganic, organic and physical areas. M.Sc. students work on research projects with faculty members in their research laboratories which are well equipped for Ph.D. and postdoctoral research in almost every field of chemistry. The Department believes that the training of chemists to a high level of professional competence can best be done in an environment of active and significant research. Accordingly, research forms one of the major activities of the Department. The research interests of the Faculty include analytical chemistry, applied chemistry, biophysical chemistry, chemical reaction dynamics, computer simulation of liquids, chemistry of natural products, fullerene chemistry, magnetic resonance (NMR and ESR), mass spectrometry, molecular beams and clusters, laser spectroscopy, mechanistic organic chemistry, organo-metallic chemistry, physical photochemistry, Organic photochemistry, polymer chemistry, solid state chemistry, synthetic main group chemistry, structural studies using X-ray diffraction, synthetic organic chemistry, theoretical chemistry, transition metal chemistry, bio-inorganic chemistry, bio-organic chemistry and enzyme chemistry and supramolecular chemistry.

STRUCTURE OF THE PROGRAMME M. Sc. (2-year)

SEM. I	SEM. II	SEM. III	SEM. IV
CHM 401	CHM 402	CHM 503	CHM 700
CHM 421	CHM 422	CHM 611	CHM 800
CHM 423	CHM 442	CHM 621	CHM 801
CHM 441	CHM 443	CHM 664	DE - 4
CHM 521	CHM 481	DE - 2	DE - 5
	DE - 1	DE - 3	

CHM 401	Organic Chemistry	I	Departmental Elective	DE - I
CHM 402	Organic Chemistry	II		DE - II
CHM 421	Physical Chemistry	I		DE - III
CHM 422	Physical Chemistry	II		DE - IV
CHM 423	Physical Chemistry	Lab.		DE - V
CHM 441	Inorganic Chemistry	I		
CHM 442	Inorganic Chemistry	II		
CHM 443	Inorganic Chemistry	Lab.		
CHM 481	Biosystems			
CHM 503	Organic Preparations	Lab.		
CHM 521	Mathematics for Chemistry			
CHM 611	Physical Organic Chemistry			
CHM 621	Chemical Binding			
CHM 664	Modern Phy. Methods in Chemistry			
CHM 700	Project			
CHM 800	General Seminar			
CHM 801	Special Seminar			

CURRENT COURSE STRUCTURE FOR M.Sc. [5-YEAR] STUDENTS

CHEMISTRY

	SEMESTER				
	FIRST	SECOND	THIRD	FOURTH	FIFTH
COURSE	CHM101 PHY101 PHY102 MTH101 ESC101 PE101 HSS-I-1/ ENG112	TA101 PHY103 MTH102 ESC102 CHM100 PE102	MTH203 CHM201 ESO-1 ESO-2 CHM301	HSS-I-2 TA201 CHM222 CHM302 CHM341 CHM404	HSS-II-1 CHM401 CHM421 CHM441 CHM503 OE-1

	SEMESTER				
	SIXTH	SEVENTH	EIGHTH	NINTH	TENTH
COURSE	CHM343 CHM402 CHM422 CHM442 OE-2	CHM423 CHM611 CHM621 CHM664 OE-3 DE-1	CHM443 CHM481 DE-2 DE-3 OE-4 NDE-1	HSS-II-2 CHM700 OE-5 OE-6	CHM700 NDE-2 CHM800 CHM801

CHM 201N			
CHM 222	Basic Physical Chemistry		ESO I
CHM 301	Basic Organic Chemistry		ESO II
CHM 302	Basic Organic Chemistry-II	MTH 203N	Mathematics III
CHM 341	Basic Inorganic Chemistry	OE-I	Open Elective-I
CHM 343	Inorganic Chemistry Lab.	OE-II	Open Elective-II
CHM 401	Organic Chemistry I	OE-III	Open Elective-III
CHM 402	Organic Chemistry II	DE-I	Departmental Elective-I
CHM 404	Organic Chemistry Lab.	DE-II	Departmental Elective-II
CHM 421	Physical Chemistry I	DE-III	
CHM 422	Physical Chemistry II		
CHM 423	Physical Chemistry Lab		
CHM 441	Inorganic Chemistry I		
CHM 442	Inorganic Chemistry II	NDE-1	Non Departmental Elective-1
CHM 443	Inorganic Chemistry Lab.	NDE-2	Non Departmental Elective-2
CHM 481	Biosystems		
CHM 503	Organic Preparation Lab.		
CHM 611	Physical Organic Chemistry		
CHM 621	Chemical Binding		
CHM 664	Modern Phy. Methods in Chemistry		
CHM 700			
CHM 800			

COURSE DESCRIPTIONS

CHM 101 **GENERAL CHEMISTRY LABORATORY**

Experiments related to general, organic, physical and inorganic chemistry.

CHM 201 **GENERAL CHEMISTRY**

L-T-P-D-[C]
3-1-0-1-[4]

Chemistry, man and matter, Experimental methods of structure determination, System at finite temperature, Molecular reaction of Transition Metal ion chemistry, Organometallic chemistry, 18-electron rule, simple ligands such as CO, ethylene, triphenyl phosphine etc.,' Homogeneous catalysis, Green chemistry, Structures of organic molecules. Conformations of ethane, butane, cyclohexane and monosaccharides such as glucose and fructose. Anomeric effect. E and Z configurations (inter conversions between E and Z). Optical activity, R and S (in brief), importance of optical activity in drug synthesis and biological activity, Synthesis of organic molecules, Photochemistry of organic and biomolecules, Chemistry of life processes, Biotechnology and Biomedical applications.

CHM 205/ SE 333 **INDUSTRIAL ORGANIC CHEMISTRY** **[Prereq. CHM 201]**

L-T-P-D-[C]
3-0-0-0-[4]

Various aspects of the energy and raw material supply: Coal, oil, natural gas, nuclear, and biomass as energy sources; Basic products of industrial synthesis: synthesis gas, methanol, formaldehyde, halogen derivatives of methane, chlorofluorohydrocarbons; Olefins:Historical perspective, cracking of hydrocarbons, ethylene, butanes, higher olefins, unbranched higher olefins and their use in metathesis reactions,

Acetylene: Significance and manufacturing process for acetylene, manufacture through calcium carbide, thermal process, applications of acetylene, 1,3-Dioolefins:1,3-Butadiene, industrial manufacture from cracking, dehydrogenation, applications of butadiene,

Synthesis using carbon monoxide: Hydroformylation, industrial operations, utilization of oxo products, carbonylation of olefins;

Oxidation products of ethylene: Ethylene oxide, process operation, ethylene glycol, ethylene glycol ethers, acetaldehyde, acetic acid, acetic anhydride,

Alcohols: Ethanol, propanol, butanols, amyl alcohols, aldol synthesis, polyhydric alcohols, neopentyl glycol.

Vinyl-halogen and oxygen compounds: Vinyl chloride, vinylidene chloride vinylacetate, binyl ethers;

Polyamides: Adipic acid, hexamethy-lenediamine, adiponitrile, lactams;

Propene conversion products; Propylene oxide, acetone, acrolein, allylchloride, acrylonitrile.;

Aromatics: Source of feedstocks, coking of hard coal, isolation, special separation techniques, condensed aromatics, naphthalene, anthracene, hydrodealkylation.

Benzene derivatives; Styrene, cumene, cyclohexane, phenol, maleic anhydride, nitrobenzene, aniline, diisocyanates. Oxidation products of xylene and naphthalene; Phthalic anhydride, esters of phthalic acid and derivatives, terephthalic acid.

CHM 222 **BASIC PHYSICAL CHEMISTRY** **[Prereq. CHM 201]**

L-T-P-D-[C]
3-1-0-0-[4]

States of matter and properties of gases, Thermodynamics, Chemical Kinetics.

CHM 301 / SE 332 **BASIC ORGANIC CHEMISTRY-I**

L-T-P-D-[C]
3-1-0-0-[4]

Nomenclature of organic molecules Structure and bonding, Stereochemistry, Reactive Intermediates, Substitution and Elimination Reactions, Molecular Rearrangements, Photochemistry.

CHM 302 **BASIC ORGANIC CHEMISTRY-II** **[Prereq. CHM 301]**

L-T-P-D-[C]
3-1-0-0-[4]

Oxidation, Reduction, C-C Bond Formations, Syhthesis of Polynuclear Hydrocarbons, Carbohydrates, Nucleotides, Amino Acids and Peptides.

CHM 310 / SE 336 **PHOTONS, MOLECULES 7 CHEMICAL DYNAMICS [Prereq. CHM 201]**

L-T-P-D-[C]
3-1-0-0-[4]

Molecular basis of elementary chemical reactions, relation between the microscopic and macroscopic observables, initial state selection and final state analysis with and without lasers, potential energy surfaces and reaction dynamics, computer simulation of chemical reactions, multiphoton processes and bond-selective chemistry.

CHM 341 **BASIC INORGANIC CHEMISTRY** **[Prereq. CHM 201]**

L-T-P-D-[C]
3-0-0-0-[4]

Vector model of the atom (Russell-Saunders Coupling), the molecule and molecular ions, periodicity of the elements, shielding, the size of the atoms, ionization energy, electron affinity, inorganic solid state, Covalent bonding, Heteronuclear bonds, Types of chemical forces, Effects of chemical forces, Hard and soft acids and bases: Classification, acids and bases, Optical activity, Experimental evidence for metal-ligand orbital overlap.

CHM 343 **INORGANIC CHEMISTRY LAB** **0-0-6-0-4**

CHM 401 **ORGANIC CHEMISTRY-I** **[Prereq. CHM 301, CHM 302 or**
eqv. for **MSc (Int.) students]**
L-T-P-D-[C]
3-0-0-0-[4]

Stereochemistry, Dynamic stereochemistry, Mechanistic and Stereochemical aspects, Reactive Intermediates: Carbenes, Nitrenes, Radicals, Carbo-cations.

Chm 402 **ORGANIC CHEMISTRY-II** **[Prereq. CHM 401]**
L-T-P-D-[C]
3-0-0-0-[4]

Oxidations, Reductions, C-C Bond formations.

CHM 404 **ORGANIC QUALITATIVE AND QUANTATIVE ANALYSIS**
L-T-P-D-[C]
0-0-6-0-[4]

Analysis of organic compounds (qualitative and quantitative) using both chemical and instrumental methods with emphasis on principles of organic reactions.

CHM 421 **PHYSICAL CHEMISTRY-I** **[Prereq. CHM 201, CHM 222 or M.Sc. (Int.) students]**
L-T-P-D-[C]
3-0-0-0-[4]

Atomic Structure, chemical binding and molecular structure. Elements of molecular spectroscopy.

CHM 422 **PHYSICAL CHEMISTRY** **[Prereq. CHM 421]**
L-T-P-D-[C]
3-0-0-0-[4]

Thermodynamics, Statistical Thermodynamics, Chemical kinetics.

CHM 423 **PHYSICAL CHEMISTRY, LALBORATORY**
L-T-P-D-[C]
0-0-8-0-[4]

A Laboratory course designed to illustrate principles of physical chemistry.

CHM 441 **INORGANIC CHEMISTRY-I** **[Prereq. CHM 341 for M.Sc. (Int.) students]**
L-T-P-D-[C]
3-0-0-0-[4]

Principles of modern inorganic chemistry, discussion of the chemistry of non-transition elements.

CHM 442 **INORGANIC CHEMISTRY-II** **[Prereq. CHM 441]**
L-T-P-D-[C]
3-0-0-0-[4]

Coordination Chemistry:- Bonding, Spectra, Magnetism, Structure and Reaction Mechanism, Supramolecular Chemistry, Molecular Magnetism, Organometallic Chemistry, Inorganic Chemistry of Biological systems.

CHM 443 **INORGANIC CHEMISTRY LABORATORY**
L-T-P-D-[C]
0-0-6-0-[4]

CHM 481/ SE 334 **BIOSYSTEMS** **[Prereq. CHM 201 (For M.Sc. (Int.)/B.Tech.)]**

Proteins, Nucleic acid, carbohydrates, and Glycoproteins, Metabolism, Enzymes and their kinetics. Biophysical techniques to purify and study Proteins. Nucleic acids: A,B and Z-DNA structures, Method of replication; sequencing of nucleic acids electrophoresis.

CHM 503 **ORGANIC PREPARATIONS LABORATORY**
L-T-P-D-[C]
0-0-6-0-[4]

Preparations of various organic compounds employing different reactions will be carried out, with a view to give the student sufficient training in synthetic organic chemistry.

CHM/521 CHM 600 **MATHEMATICS FOR CHEMISTRY**
L-T-P-D-[C]
3-0-0-0-[4]

Error Analysis, Scalars, vectors, curl, divergence and gradient, ordinary 3-0-0-0[4] differential equations, symmetry and group theory, matrices, etc.

CHM 602 **ADVANCED ORGANIC CHEMISTRY-II** **[Prereq. CHM 402]**
L-T-P-D-[C]
3-0-0-0-[4]

The course deals with concise and critical evaluation of many reactions of synthetic importance.

CHM 609 **PRINCIPLES OF ORGANIC CHEMISTRY** **[For Ph.D. Students only]**
L-T-P-D-[C]
3-0-0-0-[4]

Stereochemistry, mechanisms of selected reactions, Reactive intermediates, oxidation, Reduction, C-C bond formations, synthesis of some useful natural products.

CHM 611 **PHYSICAL ORGANIC CHEMISTRY**
[Prereq. CHM 402 for MSc Students]]
L-T-P-D-[C]
3-0-0-0-[4]

Orbital Symmetry and Frontier Orbitals, Stereoelectronic Effects in Organic Chemistry, Chemical Equilibria and Chemical Reactivity, Reactive Intermediates, Chemical Kinetics, Captodative Effect, Hammond's Postulate, Thermodynamic and Kinetic Control.

CHM 612 **FRONTIERS IN ORGANIC CHEMISTRY**
[[Prereq. CHM 402 for MSc students]
L-T-P-D-[C]
3-0-0-0-[4]

Developing facets of organic chemistry will be discussed. Special emphasis will be made relating to the stereo-chemistry involved.

CHM 614 **ORGANIC PHOTOCHEMISTRY** **[Prereq. CHM 402 or equiv.]**
L-T-P-D-[C]
3-0-0-0-[4]

Organic molecular transformations that are brought about by light will be discussed.

CHM 615 **ELECTROCYCLIC REACTIONS** **[Prereq. CHM 402 or equiv.]**
L-T-P-D-[C]
3-0-0-0-[4]

Aspects of concerted process will be discussed

CHM 616 **CHEMISTRY OF ORGANOMETALLIC COMPOUNDS** **[Prereq. CHM 442]**
L-T-P-D-[C]
3-0-0-0-[4]

The preparation of transformations of organometallic compounds will be discussed.

CHM 621 **CHEMICAL BINDING**
L-T-P-D-[C]
3-0-0-0-[4]

Intoroduction, The origin of quantum numbers, some 'constant potential' problems, commutation relationships, the atomic 'self-consistent-field' (SCF), Hartree and Hartree Fock methods. Screening effects Stater's rules and electron correlation overlap-hybridisation and examples thereof. Directed valence in space. Observable features of the chemical bond 'Chemical Binding'.

CHM 622 **CHEMICAL KINETICS** **Consent of Instructor**
L-T-P-D-[C]
3-0-0-0-[4]

Discussion of reaction rate theory, kinetics and mechanism of various types of reactions and catalysis.

CHM 626 **SOLID STATE CHEMISTRY**
L-T-P-D-[C]
3-0-0-0-[4]

Crystallography, X-ray method, chemistry of the defect solid state, electrical and thermal properties of solids.

CHM 629 **PRINCIPLES OF PHYSICAL CHEMISTRY** **[For Ph.D. Students only]**
L-T-P-D-[C]
3-0-0-0-[4]

Atomic and Molecular structure, Molecular Spectroscopy, Concepts of Statistical Thermodynamics, Electrochemistry, Chemical Kinetics, Photochemistry.

CHM 631 **APPLICATIONS OF MODERN INSTRUMENTAL METHODS**
[Prereq. CHM 402, chm 442]
L-T-P-D-[C]
3-0-0-0-[4]

Applications of multinuclear NMR (^{1}H, ^{13}C, ^{29}Si, ^{31}P, ^{19}F, ^{11}B, ^{119}Sn etc.). ESR, ENDOR (Electron Nuclear Double Resonance), Mossbauer and photoelectron spectroscopy towards structure elucidation of inorganic, organic and biologically important compounds .

CHM 632 **ENZYME REACTIONS MECHANISM AND ENZYME KINETICS**

L-T-P-D-[C] **[Prereq. CHM 481]**

3-0-0-0-[4]

Nomenclature of enzyme, Three dimensional structure of enzymes, families of enzymes, structure of enzyme substrate complex and methods of examining them, basic equations of enzyme kinetics, enzyme inhibition.

CHM 636 **PHYSICAL PHOTOCHEMISTRY**

L-T-P-D-[C]

3-0-0-0-[4]

Theory of electronic absorption spectra, fluorescence and phosphorescence spectra, internal conversion and intersystem crossing, solvent effects on absorption and emission spectra, exciplexes and eximers, energy transfer.

CHM 637 **MOLECULAR SPECTROSCOPY**

L-T-P-D-[C]

3-0-0-0-[4]

Molecular Symmetry and Group Theory, Matrix Methods, Time dependent states and spectroscopy of vibration and rotation of diatomic molecules, rotation of polyatomic molecules, vibration of polyatomic molecules, electronic spectroscopy.

CHM 641 **ADVANCED INORGANIC CHEMISTRY-I** **[Prereq. CHM 442]**

L-T-P-D-[C]

3-0-0-0-[4]

An advanced course on the physical principles of inorganic chemistry with illustrations from the chemistry of transition and non-transition elements.

CHM 642 **ADVANCED INORGANIC CHEMISTRY-I** **[Prereq. CHM 442]**

L-T-P-D-[C]

3-0-0-0-[4]

Mechanisms of inorganic reactions and ligand field theory.

CHM 646 **BIO-INORGANIC CHEMISTRY**

L-T-P-D-[C]

3-0-0-0-[4]

Studies of metallo-biomolecules in relation to electron transfer, atom transfer, electron and oxygen carrier reactions using transition metals and model systems.

CHM 647 **MACROCYCLES, RINGS AND POLYMERS** **[Prereq. CHM 442]**

L-T-P-D-[C]

3-0-0-0-[4]

Basic Concepts; Molecular forces and Chemical bonding; Molecular weight; testing and analysis; polymerization reactions, Ziegler-Natta Catalysis, Inorganic rings and polymers, Ferrocene and organometallic macromolecules, sulfur-nitrogen polymers, polysilane, poly-silazane, B-N polymers, precursors for ceramics, Phthalocyanins, conducting polymers, Host-Guest complexation, Supramolecular Chemistry.

CHM 648 L-T-P-D-[C] 3-0-0-0-[4]

THE CHEMISTRY OF METAL CARBON BOND: STRUCTURE, REACTIVITY AND APPLICATIONS **[Prereq. CHM 442]**

Study of bonding in compounds with M-C bond and with M-M bond. Applications of these compounds in Catalysis and in Organic Synthesis.

CHM 649 L-T-P-D-[C] 3-0-0-0-[4]

PRINCIPLES OF INORGANIC CHEMISTRY **[For Ph.D. Students only]**

Principles of modern inorganic chemistry discussion of the chemistry of non transition elements, Coordination Chemistry, organometallic chemistry, Inorganic chemistry of biological systems.

CHM 650 L-T-P-D-[C] 3-0-0-0-[4]

STATISTICAL MECHANICS AND ITS APPLICATIONS TO CHEMISTRTY

Principles of classical and quantum statistical mechanics and their applications to chemical problems.

CHM 651 L-T-P-D-[C] 3-0-0-0-[4]

CRYSTAL AND MOLECULAR STRUCTURE DETERMINATION

Bragg's law, reciprocal lattice concept, space group and geometrical crystallography, the phase problem, Patterson Fourier synthesis, Harkar-Kasper inequalities, refinement of crystal structures, modern X-ray diffraction techniques.

CHM 654 L-T-P-D-[C] 3-0-0-0-[4]

SUPRAMOLECULAR CHEMISTRY

Concepts and language of supramolecular chemistry, molecular recognition, quantification of non-covalent forces, energetics of supramolecular complexes, Macro-cycles and macro-polycycles, Catenands and dendrimers, Self-assembly of organic and hybrid inorganic-organic systems, Supramolecular catalysis, Molecular machines, molecular and supramolelcular devices.

CHM 662 L-T-P-D-[C] 3-0-0-0-[4]

CHEMISTRY OF NATURAL PRODUCTS **[Prereq. CHM 402]**

The isolation, structure and reactions of natural products will be discussed.

CHM 664 L-T-P-D-[C] 3-0-0-0-[4]

MODERN PHYSICAL METHODS IN CHEMISTRY **[Prereq. CHM 422]**

Applications of spectroscopic methods, dipole moments, magnetism, magnetic resonance, and other methods in analysis and elucidation of molecular structure will be discussed.

CHM 668 L-T-P-D-[C] 3-0-0-0-[4]

ADVANCED MAIN GROUP CHEMISTRY **[Prereq. CHM 441]**

General Introduction to main group chemistry, Homo and Heteroclusters of main group elements, chemistry of main group homo and heterocycles, polymers of main group elements, main group organometallic Chemistry.

CHM 670 **SCIENTIFIC INSTRUMENTATION**

L-T-P-D-[C]
3-0-0-0-[4]

Network theorems, Resonance Circuits, BJT and FET devices, Amplifier basics, Operational Amplifiers, Power Supplies, Basic digital gates, Bistable, Monostable, and Astable multi-vibrators, A/D and D/A convertors. 8-bit Microprocessor basics. Electronics in scientific instrumentation. Examples of scientific instruments.

CHM 679 **INTRODUCTION TO BIONANOTECHNOLOGY**

L-T-P-D-[C]
3-0-0-0-[4]

CHM 679 **MOLECULAR REACTION DYNAMICS**

L-T-P-D-[C]
3-0-0-0-[4]

Molecular reaction dynamics and chemical reaction cross-section, rate constant and activation energy, reactive scattering using molecular beams, potential energy surfaces, probing the transition state, unimolecular reactions, state-selective photochemistry.

CHM 681 **BASIC BIOLOGICAL CHEMISTRY** **[Prereq. CHM 481]**

L-T-P-D-[C]
3-0-0-0-[4]

Purine and pyrimidine bases. Watson-Crick and Hoogsteen hydrogen bonds. DNA double helix, RNA folding, Nucleic acid synthesis. Genetic code and gene expression, Transcription. Post-transcriptional modification of RNA, Reverse transcription: HIV-I replication cycle. Amino acids and proteins. Ribosomal translation. DNA triple helical motifs, Triplexes in biological context, Triplexes for targeted delivery of drugs , DNA superstructures. Polymerase chain reactions, In vitro mutagenesis, DNA sequencing. RNA self-splicing, Group I and group II introns, Ribozymes: Catalytic mechanism, and applications, Artifical evolution. Antisense oligonucleotides: Mechanism and control of gene expression. Molecular basis of carcinogenesis, Prions, Genetic diseases. Approaches in drug design and discovery, Drug metabolism.

CHM 685 **MOLECULE-RADIATION INTERACTION**

L-T-P-D-[C]
3-0-0-0-[4]

Electromagnetic fields and their quantization, quantum mechanics of interaction radiation and atoms, optical activity, Raman scattering, Rayleigh scattering, spontaneous emission.

CHM 687 L-T-P-D-[C] 3-0-0-0-[4]

CHEMISTRY OF POLYHEDRAL CLUSTERS AND METAL-METAL MULTIPL BONDED COMPOUNDS **[Prereq. CHM 442]**

Non-transition element polyhedral compounds, Transition metal clusters (structure and bonding). Synthesis of transition metal carbonyl clusters, Ligand substitution reactions, Cluster assigned ligand transformation, Polyhedral rearrangements, Fragmentation reactions, Clusters in homogeneous catalysis, Metal metal multiple bonds.

CHM 689 L-T-P-D-[C] 3-0-0-0-[4]

NUCLEAR MAGNETIC RESONANCE

Physical basis of NMR spectroscopy; Chemical shift; Indirect spin-spin coupling; Computer simulation of NMR spectra; Double Resonance experiments; relaxation; Multipulse experiments; Nuclear Overhauser effect and NOESY experiments; Applications, Chemical and Biochemical; Dynamic NMR, Theory and Applications; Application to Solids, NMR Imaging.

CHM 691 L-T-P-D-[C] 3-0-0-0-[4]

FRONTIERS IN INORGANIC CHEMISTRY **[Prereq. CHM 442]**

Developing facets of inorganic chemistry: i) Oxidative generation of the O-O bond from water during photosynthesis and its importance from the standpoint of non-conventional energy research and ii) reductive cleavage of the dioxygen O-O bond and the chemistry thereof (various novel organic transformations including methane to methanol of biotechnological importance), performed by a large number of metalloenzymes and synthetic catalysts. The course is intended to be attractive not only to the students having aptitude for inorganic chemistry but also to those who are interested in chemistry of relevance to biology and industry.

CHM 693 L-T-P-D-[C] 3-0-0-0-[4]

CHEMICAL SYNTHETIC STRATEGY OF ADVANCED MATERIALS

Chemical methods of synthesis play a crucial role in designing materials, discovering novel materials, metastable phases, nanomaterials and provide less cumbersome routes for the known materials. Chemical ingenuity is important for the synthesis of solid materials with desired structure and properties. Keeping in mind the multidisciplinary nature of the subject, a rational approach to the synthesis of materials is evolved. Indeed, soft chemistry routes/techniques are pursued with greater vigour. These include precursor technique, sol-gel, hydrothermal, non-aqueous liquid phase reactions, polymer pyrolysis, gas phase reactions, plasma reactions, electron beam evaporation, freeze drying, spray drying, topochemical reactions, intercalation, electrochemical methods, CVD laser ablation, arc-method, molten salt method, intergrown structures. Solid state reactivity, working knowledge of characterization techniques and conventional techniques.

CHM 695 **MOLECULAR MODELLING IN CHEMISTRY**

L-T-P-D-[C]
3-0-0-0-[4]

Basic principles of quantum mechanics of atoms and molecules, potential energy surfaces, modeling of water and small organic molecules, molecular modeling of macromolecules, simple applications of molecular modeling, study of an assembly of atoms or molecules.

CHM 696 **QUANTUM COMPUTING**

L-T-P-D-[C]
3-0-0-0-[4]

The main objective of this course is to provide an overview of the interdisciplinary field of quantum Computing and demystify the concept of quantum while linking it to computation and information science. It is aimed to bring out the concepts of quantum mechanics through linear algebra and matrix manipulation, which connects it to conventional computer science. The main advantages of quantum computing are demonstrated through reversibility and parallel processing while the difficulties in implementation and alghorithm development are treated with care.

CHM 698 **CHEMISTRY OF DRUG DESIGN AND METABOLISM**

[Prereq.CHM 481]

L-T-P-D-[C]
3-0-0-0-[4]

Physicochemical principles of drug action, principles of drug design, neuroactive drugs, anticancer, antiviral, antimalarial and cardiovascular drugs, biopharmaceuticals, drug delivery and drug metabolism, induction and inhibition of drug metabolism.

CHM 699 **LASERS IN CHEMISTRY AND BIOLOGY 3-2-3-5**

L-T-P-D-[C]
3-2-3-0-[5]

Fundamentals of Lasers, laser-induced fluorescence and multiphoton ionization processes of molelcules, probing IVR and dynamics of chemical reactions in liquid and molecular beam, spectroscopy of single molecule, probing of proton dynamics, optical trapping and manipulations of biological macromolecules and organelles, confocal microscopy and fluorescence correlation spectroscopy, applications to diagnostics and biotechnology.

CHM 700 **(M.Sc. 2-yr), 0-0-12-0-12**

CHM 700 **(M.Sc. Integ.) 0-0-8-0-8 (IX semester), 0-0-12-0-12 (X Semester)**

CHM 800 **GENERAL SEMINAR**

CHM 801 **GRADUATE SEMINAR**

CIVIL ENGINEERING

PROFESSORS

Basudhar P.K.	pkbd	7029
Bose Purnendu	pbose	7403
Chakrabarti S.K.	chakra	7173
Chandra Sarvesh	sarv	7667
Chakroborty Partha	partha	7037
Dikshit Onkar	onkar	7937
Datta Bithin	bithin	7027
Gupta V.K.	vinaykg	7118
Jain Sudhir K.	skjain	7867
Kumar Ashwini	ashwini	7756
Misra Sudhir	sud	7346
Murty C.V.R.	cvrm	7267
Sharma Mukesh	mukesh	7759
Sinha Rajiv	rsinha	7317
Srivastava Rajesh	rajeshs	7755
Tare Vinod	vinod	7792

ASSOCIATE PROFESSORS

Das Animesh	adas	7477
Guha Saumyen	sguha	7917
Jain Ashu	ashujain	7411
Lohani Bharat	blohani	7623
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Civil Engineering deals with natural and man-made built environment - their planning, design, construction and management. The profession encompasses many disciplines including Structural Engineering, Geotechnical Engineering, Hydraulics & Water Resources Engineering, Environmental Engineering, Transportation Engineering, Geoinformatics, and Engineering Geosciences. It is responsible for the largest quantum of resource allocation and utilization in activities ranging from defence and industrial development to social welfare, food production and economic growth.

The undergraduate Civil Engineering professional education at IIT Kanpur starts at the second year level in the four-year B.Tech. and five year B.Tech.-M.Tech. degree programmes. Recognizing the modern pace of development in Civil Engineering, the programme provides basic education in physical sciences including solid, fluid & soil mechanics, materials, earth sciences and geoinformatics, that leads to the planning, design and construction of bridges, buildings, hydraulic structures, environmental systems, and transportation systems including highways, railways, airports, etc. Besides these broad training, students are given the option to pursue electives in any particular area of Civil Engineering. A two-semester project during the fourth year of the B.Tech. degree programme is intended to synthesize their education in several areas. As a student proceeds along the program, the emphasis shifts from analysis to design, and from skill development theoretical to the problem-solving approach.

The objective of the post-graduate program in Civil Engineering at IIT Kanpur is the education of engineers with a deep understanding of scientific principles underlying their specialisation so that they can make fundamental contributions to the field through research and development of advanced technology. Currently, research facilities are available for advanced work in the areas of hydraulics and water resources engineering, environmental engineering, geotechnical engineering, structural engineering, transportation systems engineering, engineering geosciences, and geoinformatics. The five year B.Tech.-M.Tech. Dual Degree students and the two year M.Tech. Degree students undertake research work during the last year of their programme. Facilities are provided for both analytical and experimental research work in well-developed laboratories having modern equipment. Along with courses and research in the major area, students also take courses from other Departments in related fields and basic sciences.

The Department also administers a two year M.Tech. interdisciplinary programme in Environmental Engineering and Management. Details of this programme are given elsewhere in this bulletin.

The Ph.D. programme offers training to the students in four areas : coursework, experimental techniques, independent analytical study, and written & oral presentation.

CURRENT COURSE STRUCTURE FOR B.TECH. STUDENTS

FOUR YEAR B.TECH. PROGRAMME

	SEMESTER			
	FIRST	**SECOND**	**THIRD**	**FOURTH**
COURSE	PHY102 MTH101 HSS-I-1/ ENG112N TA101 ESC102 PE101	PHY101 CHM101 PHY103 MTH102 ESC101 CE100 PE102	MTH203 CHM201 ESO204 ESO212 CE251	HSS-I-2 ESO218 TA201 CE222 CE242
	SEMESTER			
	FIFTH	**SIXTH**	**SEVENTH**	**EIGHTH**
COURSE	CE331 CE321 CE361 CE371 CE311	CE322 CE312 CE332 CE362 CE373 CE382	CE451 CE491	CE492

In addition to above, the student must complete the following credits :

DE	12 Credits
OE	12 Credits
HSS-2	08 Credits
SE	08 Credits

The above template is valid for Y6 and Y7 batch students or students joining later in CE. The students of other batches must contact the DUGC Convener, CE for their course templates.

FIVE YEAR B.TECH.-M.TECH. DUAL DEGREE PROGRAMME

SEMESTER				
FIRST	SECOND	THIRD	FOURTH	FIFTH
PHY102 MTH101 HSS-I-1/ ENG112N TA101 ESC102 PE101	PHY101 CHM101 PHY103 MTH102 ESC101 CE100 PE102	MTH203 CHM201 ESO204 ESO212 CE251	HSS-I-2 ESO218 TA201 CE222 CE242	CE321 CE331 CE361 CE371 CE311

	SEMESTER				
SIXTH	SEVENTH	EIGHTH	SUMMER I	NINTH	TENTH
CE 312 CE322 CE332 CE 362 CE373 CE382	CE451 DE-PG-1 DE-PG-2	DE-PG-3 DE-PG-4 DE-PG-5 DE-PG-6 CE699 (4 Credits)	CE 699 (4 Credits)	DE-PG-7 CE699 12 Credits	CE699 16 Credits

PE - 4 Credits; SE – 4 Credits; HSS-II - 8 Credits; in 5th - 8th Semester

Two Year M.Tech. Programme

SEMESTER			
FIRST	SECOND	THIRD	FOURTH
PG-1 **PG-2** **PG-3** **PG-4**	**PG-5** **PG-6** **PG-7** **PG-8**	**CE-699** **16 Credits**	**CE-999** **16 Credits**

Ph.D. Programme

SEMESTER					
FIRST	SECOND	THIRD	FOURTH	FIFTH	SIXTH
PG-1 **PG-2** **PG-3** **PG-4**	**CE-799** **16 Credits**	**CE-799** **16 Credits**	**CE-799** **16 Credits**	**CE-799** **16 Credits**	**CE-799** **16 Credits**

COURSE DESCRIPTIONS

UNDERGRADUATE COURSES

CE 100 **INTRODUCTION TO CIVIL ENGINEERING**

L-T-P-D-[C]
1-0-2-0-[0]

Overview of Civil Engineering: Civil Engineering Landmarks: Impact (social, economic, environmental) of Civil Engineering on Society; Future directions: Job opportunities in Civil Engineering; Case studies: Hands-on projects, demonstrations, and Field visit.

CE 222 **STRUCTURAL ANALYSIS** **Prereq. ESO 204**

L-T-P-D-[C]
3-1-0-1-[4]

Stability and Determinacy of Structures, Analysis of Statically Determinate Structures, Review of shear force and bending moment diagrams in beams and frames, Plane trusses: Deflection of trusses: Deflection of beams and frames: Influence line diagrams and moving loads, Analysis of Statically Indeterminate Structures, Force and stiffness methods of analysis, Plane trusses by using method of consistent deformations, Beams and frames: Plane trusses by using direct stiffness method

CE 242 **ENGINEERING GEOSCIENCES**

L-T-P-D-[C]
3-0-2-1-[4]

Earth System: Lithosphere, Hydrosphere, Cryosphere and atmosphere and their iinteractions

Solid Earth : Shape, size, interior of the solid earth. Geological materials: rocks, soils, minerals (clay mineralogy), Engineering and Genetic classification of soils, rocks, rock cycle, rock-water interaction. Earth Processes and their consequences, Geomorphological features, structures (folds, faults)

Earthquakes: Causes, classification, magnitude, intensity, Historical earthquakes, Seismic hazards zoning, strong ground motion, earthquake prediction

Landslides and Subsidence: Causes, classification and monitoring;
Groundwater: Groundwater resources and quality of ground water

Geology of India : Physiographic and fectonic divisions; Minral resources.

Geophysical mapping: seismic, resistivity, radar, geotomography, logging

Remote sensing, GIS and GPS : Basic principles and their applications in monitoring Lithosphere, Hydrosphere, Cryo-sphere and Atmosphere**; Criteria** for site selections for Dam, tunnels, waste/radioactive disposal sites

CE 251 L-T-P-D-[C] 3-0-2-1-[4]

CONSTRUCTION MATERIALS

Introduction and overview of course: Constituents of concrete (Cement, Aggregates): Proportioning of concrete, Fresh concrete, Hardened concrete, Quality control (Sampling, Acceptance, etc.), Transportation and placing , Testing of concrete (including NDT), Admixtures (Chemical, mineral), Concrete and environment; Steel: Manufacture, different types of steel, Steel in Civil Engineering (Structural, reinforcing bars, wires); Bitumen and bituminous mixes: Source, composition, characterization, Various forms, Tests on bitumen Preparation/characterization of bituminous mixes. Mix design, Tests - Dynamic modulus, fatigue, creep and stability;

Bricks and brick masonry: Manufacture, Properties, classification and specifications, Brick masonry and principles of design of masonry structures;

Other materials: Timber, geotextiles, FRPs, Epoxy-coated bar.

CE311 L-T-P-D-[C] 3-1-0-0-[4]

Engineering Hydrology (prerequisite – none) :

Precipitation, Infiltration and Evapotranspiration : Forms of precipitation, measurement, depth-duration and intensity- duration frequency relations, Evaporation – process, measurement, and estimation, Infiltration process, measurement, and estimation. Evapotranspiration measurement and estimation; Runoff and Hydrographs : Rainfall Runoff correlations, Flow duration cureve. Mass curve, Droughts and floods, Factors affecting flow hydrograph, Unit hydrograph, its analysis and S-curve hydrograph, Synthetic and instantaneous unit hydrographs ; Statistical analysis : Hydrologic Routing, Risk, reliability, and safety factor, Flood frequency studies ; Flood forecasting : Rational method Time Area curves, Desing flood ; Channel and flood routing ; Groundwater hydrology : Flow equations Confined and unconfined flow, Well hydraulics, Steady and unsteady flow, Well losses, Specific capacity ; Irrigation Engineering

CE 312 L-T-P-D-[C] 2-1-2-0-[4]

Hydraulic Engineering (Prerequisite- ESO212)

Pipe Flow : Boundary Layer Concepts, Turbulent Flwo, Pipe Networks : Open channel Flow : Uniform Flow, Critical Flow, Gradually Varied Flow, Rapidly Varied Flow, spatially Varied flow ; Unsteady flow : Pipes , Open Channels ; Flow measurement : Viscosity, Pressure , Velocity and turbulence measurements; Forces on immersed Bodies : Drag and lift.

CE 321 **DESIGN OF STEEL STRUCTURES** **Prereq. ESO 204**

L-T-P-D-[C]
3-2-0-1-[4]

Introduction to Design: Design Loads and Load Combinations, Working Stress Design, Plastic Design, LRFD Methods, Introduction to Steel and Steel Structures, Design of tension members, Design of structural fasteners: rivets, bolts and welds, Design of compression members, Design of flexure members: Beams-rolled sections, built-up sections, Plate Girders – riveted/bolted and welded, Design of eccentric connections: riveted/bolted and welded, Design of beam-columns and column bases, Design of steel industrial sheds, Wind Design, Introduction to inelastic actions and plastic hinges: Application of PD and LRFD

CE 322 **DESIGN OF REINFORCED CONCRETE STRUCTURES** **Prereq. ESO 204**

L-T-P-D-[C]
3-2-0-1-[4]

Introduction: Structural Systems, Materials, Loadings and Structural Analysis, Introduction to Design of Concrete Structures, Working Stress Design, Ultimate Load Design, Limit Sate Design, Working Stress Design: For Bending Moment and Shear Force - Rectangular Beams, Limit State Design: For Compression - Columns, For Bending Moment and Shear Force - Beams, For Torsion- Beams, For Combined Compression and Flexure – Beam-Columns, Slabs – One-way; Two-way, Connections (Joints), Design of RC Frame Buildings, Earthquake Design, Ductile Detailing, (Introduction to Capacity Design Concept), Design of Other Structural Components, Flat Slabs; Footings; Walls; Stair Cases.

CE 331 **SOIL MECHANICS** **Prereq. CE 242**

L-T-P-D-[C]
3-0-2-1-[4]

Preview of Geotechnical Problems in Civil Engineering and Infrastructure Development, Description of soil, Engineering geology of soils and their formation, earthquakes and their effects, Stresses within a soil, effective stress principle, stress point and stress path, Soil - water systems- capillarity, flow, Darcy's law, permeability, and tests for its determination, different heads, piping, quicksand condition, seepage, flownets, flow through dams, filters, Compressibility and consolidation characteristics, maximum past stress, OCR, determination of coefficients of consolidation and secondary compression (creep), consolidation under construction loading, Strength and direct and triaxial shear tests, Mohr - Coulomb strength criterion, drained, consolidated undrained and undrained tests, strength of loose and dense sands, NC and OC soils, dilation, pore pressures, Skempton's coefficients, etc. Compaction characteristics, water content - dry unit weight relationships, OMC, max. dry unit weight, field compaction control, etc. Introduction to Geosynthetics, classification, functions, properties - physical, mechanical, hydraulic, environmental, etc. Stability of slopes, limit equilibrium methods, ordinary methods of slices and simplified Bishop method, factors of safety.

CE 332 **GEOTECHNICAL ENGINEERING** **Prereq. CE 331**

L-T-P-D-[C]
2-1-2-1-[4]

Introduction, examples of foundation problems - case studies, Characterisation of ground, site investigations, methods of drilling, sampling, in situ test - SPT, CPT, plate load and dynamic tests, groundwater level, etc. Bearing capacity, general, local and punching shear failures, corrections for size, shape, depth, water table, compressibility, etc., ultimate and allowable stresses, methods based on in situ tests, Settlements of foundations, stress in soils (Boussinesq, Westergaard, Mindlin solutions), one and two dimensional cases, immediate, consolidation and creep settlements, methods based on in situ tests, Limit State Design, stability and serviceability states, load and strength factors, Types of foundations - shallow/deep, isolated, combined, mat, etc., contact pressure distributions, soil - foundation interactions, basics of structural design, Ground Improvement Techniques, methods for difficult or problematic ground conditions-soft soils, loose sands, seismic conditions, expansive or collapsible soils, etc., preloading, vertical drains, stone columns, heavy tamping, grouting, etc. Earth Pressure theories, Coulomb and Rankine approaches, c-f soils, smooth and rough walls, inclined backfill, depth of tension crack, Retaining structures, gravity, cantilever, counterfort, reinforced earth, etc., design and checks for stability, Deep foundations, piles, pile groups, well foundations, under-reamed piles, pre-cast, driven cast in situ and bored piles, shaft and base resistances, downdrag, pile load tests, Selected Topics-machine foundations/introduction to environmental geotechnique/application of geosynthe-tics, etc.

CE 342 **ENGINEERING APPLICATIONS OF GEOLOGIC STRUCTURES** **Prereq. CE 242**

L-T-P-D-[C]
3-0-0-0-[4]

Rock deformation in nature, Recognition and classification of folds: Faults, Joints, Unconformities; Rock decay and weathering, Interpretation of Geologic maps, Stereograms, airphotos, Satellite imageries; Geophysical methods; Techniques of Field measurement, Applications in foundations, Building Materials, Tunnelling, Underground structures, Landslides, Slope stability, Earthquakes, Mineral exploration, Ground water pollution, Case histories.

CE 354 **COMPUTER AIDED DESIGN IN CIVIL ENGINEERING**

L-T-P-D-[C]
3-0-0-0-[4]

Engineering design principles, interactive design using workstations, and software tools. Programming languages, data structures and their design, Computer graphics, introduction to GKS, Starbase Libraries. Computer aided drafting, data base management system, simulation and optimization. Applications in Civil Engineering, structural design.

CE 361 **ENVIRONMENTAL QUALITY AND POLLUTION**

L-T-P-D-[C]
3-0-2-1-[4]

Introduction and Scope, Ecology and Environment, Environmental Quality and Pollution, Pollutants, Wastes, Disposal of Wastes, Solid Waste Management, Hazardous Waste: Definition; Measurement; Control measures; Management, Air Pollution Control, Noise Pollution, Environmental Impact, Environmental Audit, Laboratory Experiments.

CE 362N **WATER SUPPLY AND WASTE-WATER ENGINEERING** **Prereq. CE 361**

L-T-P-D-[C]
3-0-0-1-[4]

Water and Wastewater Quantity Estimation, Water Distribution and Sewerage Systems, Elements of Water Supply Scheme, Water/Wastewater Quality Enhancement, Physicochemical Processes, Surface and Ground Water Treatment, Biological Processes for Water and Wastewater Quality Enhancement, Elements of Wastewater Disposal Schemes, Rural Water Supply and Sanitation, Visit to Water and Wastewater Effluent Treatment Plants.

CE 371 **GEOINFORMATICS**

L-T-P-D-[C]
3-0-3-1-[4]

Introduction to surveying, Linear measurements, Compass surveying, Levelling and Contouring, Plane Tabling (PT), Theodolites, Tacheometric surveys, Errors and adjustments, Triangulation, Introduction to photogrammetry and remote sensing, EDM/Total Station/GPS.

CE 373 **SURVEY AND GEOLOGY CAMP, 4 UNITS** **Prereq. CE 242, CE 371**

Survey Camp: Reconnaissance and establishing the stations; Base line measurements, Triangulation readings on various stations; computation and preparation of triangulation map; contouring; preparation of map; preparation of report.

Geology Camp: Reconnaissance of the area; Elementary geological field mapping of rock formations and structural details; Geomorphic processes Preparation of report.

CE 382 **TRANSPORTATION ENGINEERING** **Prereq. CE251, CE331**

L-T-P-D-[C]
3-0-3-1-[4]

Analysis of Traffic Flow, Design of Traffic facilities, Pavement Analysis, Pavement Design, Highway Construction, Highway Maintenance.

CE 412 **HYDRAULIC MACHINES**

L-T-P-D-[C]
3-0-0-0-[4]

Fundamentals of hydraulic turbine theory; Turbine performance characteristics and selection of turbines; Design of radial flow and axial flow turbines and Pelton turbines; Fundamentals of Rotodynamic pumps; Centrifugal and axial flow pumps; special duty pumps; cavitation in hydraulic machines.

CE 414 **RIVER ENGINEERING**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction; Sediment load; Resistance to flow; Regime theories, River training; River modelling; Social and Environmental impacts.

CE 421 **STRUCTURAL DESIGN III** **PREREQ. CE 322**
L-T-P-D-[C]
3-0-0-0-[4]

Design of prestressed concrete structures: limit state design of beams and ties, introduction to miscellaneous structures; design of simple bridges and liquid retaining structures; introduction to design of masonary structures.

CE 422 **ADVANCED STRUCTURAL MECHANICS** **PREREQ. CE 222**
L-T-P-D-[C]
3-0-0-0-[4]

Matrix structural analysis: displacement and force methods; stress analysis: general state of stress, failure criterion, stress concentration, fatigue failure; analysis of simple problems of plates and shells.

CE 423 **INTRODUCTION TO EARTHQUAKE ENGINEERING** **PREREQ. ESO 204**
L-T-P-D-[C]
3-0-0-0-[4]

Causes of earthquakes and seismic waves, Magnitude, intensity and energy release, Charecteristics of earthquakes, Seismic risk; EQ response of structures, Single-degree-of freedom dynamics, Concept of response spectra and introduction to multi-degree-of-freedom systems; Design response spectrum, Idealization of structures, Response spectrum analysis, Equivalent lateral Force concepts; Philosophy of earthquake resistant design, Ductility, Redundancy & over-strength, Damping, Supplemented damping, Base Isolation, Code provisions; Seismic behaviour of concrete, steel and masonary structures, Material properties, Behaviour and analysis of members under cyclic loads, Seismic detailing provisions, Review of damage in past earthquakes.

CE 424 **SPECIAL TOPICS IN STRUCTURAL DESIGN** **PREREQ. CE 321, CE 322**
L-T-P-D-[C]
3-0-0-0-[4]

Detailed engineering design of two to three of the following structures: multistorey buildings, industrial buildings, steel towers, bridges, retaining structures, chimneys.

CE 432 **GROUND IMPROVEMENT TECHNIQUES**
L-T-P-D-[C]
3-1-0-0-[4]

Need for improvement, Compaction, Preloading, dewatering, admixtures, grouting, heat treatment, ground freezing, inclusion, anchorage, micropiles, stone columns, heavy tamping Electro-kinematic stablization, Physical and Chemical improvement. Soil reinforcement, Principles, geosynthetics. Vertical drains, Ground anchorage, rock bolting, soil nailing, Deep mixing with lime cement. Emerging trends.

CE 434 **CONSTITUTIVE MODELLING OF SOILS**

L-T-P-D-[C]

3-1-0-0-[4]

Stress, Strain, elasticity, plasticity. Introduction to the Mechanics of Soils - Critical State Soil Mechanics. Behaviour of soil before failure. Evaluation of Model Parameters.

CE 436 **MACHINE FOUNDATION DESIGN**

L-T-P-D-[C]

3-0-0-0-[4]

Principles of dynamics and vibrations, Single degree and Multi degree of freedom systems - free and forced vibrations, Introductions to vibration of continuous systems - wave propagation in soil media, Laboratory and In-situ determination of dynamic soil properties, Introduction to machine foundations and its practical considerations for construction, IS code of practice, Examples.

CE 442 **PHYSICAL AND ENVIRONMENTAL GEOLOGY** **PREREQ. CE 242**

L-T-P-D-[C]

3-0-0-0-[4]

The Dynamic earth systems, Classification of Geologic materials, Weathering and soil formation, Surface water, Ground water, Oceans and coastlines, Atmospheric and Oceanographic Processes, Techniques of Terrain evaluation, Exploration and utilization of Natural Resources, Man's role in environmental changes, Geologic studies for pollution Abatement, Summary of field and experimental Data.

CE 451 **SYSTEMS ANALYSIS IN CIVIL ENGINEERING**

L-T-P-D-[C]

3-0-0-1-[4]

Introduction to the course and its importance, Optimization methods:-Introduction, Problem formulation, Introduction to mathematical principles in optimization, Solution techniques for linear and integer problems, Introduction to non-linear problems, Civil Engineering Case Studies. Project scheduling, PERT, Inventory and crew scheduling, Decision-making in uncertain environment, Recapitulation of probability theory, Introduction to Game theory, Model Calibration:-Parameter Estimation (point and interval), Hypothesis testing. Examples using Software Packages.

CE 452 **PRINCIPLES OF CONSTRUCTION MANAGEMENT**

L-T-P-D-[C]

3-0-0-1-[4]

Introduction to construction management, Life Cycle of a construction project; Construction equipment and technology; Analysis for technical feasibility; Environmenta l impact, Economic feasibility; Capital budgeting and investment analysis; Risk analysis in construction projects; Building, Industrial and infrastructure construction-interdiciplinary nature of construction projects; Specifications and quality control; Types of contracts, (Lump Sum, Unit rate, BOT, BOLT, etc.); Estimation of quantities, Legal Issues-construction by-laws, Arbitration; Safety issues in construction projects; Case studies.

CE 454
L-T-P-D-[C]
2-1-0-0-[3]

CONCRETE ENGINEERING

Fundamental concrete science (Mixing, transportation, placing and curing of concrete, properties of fresh and hardened concrete. Using chemical and mineral admixtures); Special concretes, (Mass concrete, hot and cold weather concrete; self compacting, fibre reinforced, and high strength concretes); special construction methods (Mechanized construction, Roller compaction and shotcreting, preplaced aggregate and antiwashout concretes); Special reinforcing materials (Epoxy-coated reinforcing bars, Fiber reinforced plastics); Case studies.

Laboratory studies: Effect of addition of chemical admixtures on properties of paste and mortar. (flow table and setting time measurement). Properties of cement grouts (flow through funnel and bleeding); compare performance of hand-mixed and machine-mixed mortar and concrete; Properties of concrete and some non-destructive tests, Laboratory demonstrations.

CE 455
L-T-P-D-[C]
3-0-0-0-[4]

VIBRATION OF ELASTIC SYSTEM

Concepts of dynamics and Vibrations; Discrete and continuous systems;Damped and undamped systems; Single and Multidegre of Freedom systems; Analytical methods; Transform Methods, Impulse and Earthquake response; Earthquake response spectra, Response of multidegree of freedom systems; Numerical Methods for free and forced Vibration Analysis; Continuous systems; Vibration Control.

CE 462
L-T-P-D-[C]
2-0-0-0-[3]

ENVIRONMENTAL MANAGEMENT IN INDUSTRIES **PREREQ. CE 361**

Sources and types of wastes: solid, Liquid, and gaseous wastes; Control and Removal of specific pollutants in Industrial wastewaters: eg. Oil and grease. cynide, Flouride, Toxic organics, Heavy metals, Radioactivity etc.; Solid and Hazardous wates: definitions, concepts and managemnt aspects; Control of gaseous emissions: Identification of chimney and fugitive sources, their quantification, fuel quality, combustion processes. Particulate and gaseous pollutant control; Recent trends in Industrial waste management: Cradle to Grave concept, life cycle analysis and clean technologies; Case studies of various industries: Dairy, Fertilizer, Distillary, Sugar, Pulp and paper, Iron and Steel, Metal plating, Thermal power plants, etc.; Environmental audit: Definitions and concepts, environmental audit vs. accounts audit, compliance audit relevant methodologies, regulations; Introduction to ISO and ISO 14000, Preparation and implementation of environmental Management Plans.

CE 463 **ENVIRONMENTAL IMPACT AND RISK ASSESSMENT**
L-T-P-D-[C]
3-0-0-0-[4]

PREREQ. CE 361 & CE 362

Environmental legislations and international treaties, Environmental systems and their interactions, global/regional environmental issues, Environmental Impact Assessment (EIA), definitions, methodologies and concept of sustainable development, Environmental toxicology, Risk Assessment, in environmental management, Principles of risk assessment, pollutant exposure assessment, conceptual models and ecological risk.

CE 472 **PRINCIPLES OF REMOTE SENSING**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction; Energy source and radiation principles; Remote sensing systems, Multispectral scanners (MSS); Thermal infrared line scanner, sideways looking airbourne radar; Spectral pattern recognition - visual and digital techniques; Classification; Data acquisition from LANDSAT, SPOT, ERS, IRS; Analysis of digital data products from MSS and TM; Digital enhancement techniques (LAB); Application of remote sensing in resource evaluation.

CE 491 **PROJECT I,**
L-T-P-D-[C]
0-0-4-0-[2]

CE 492 **PROJECT II**
L-T-P-D-[C]
0-0-6-0-[3]

Topics should preferably be design, development, design aid type and interdisciplinary. The project should aim at training the students in going through all important phases of project studies starting from establishing the need through collection of data, analysis, design, development, drawing, cost estimates and project reports. Wherever appropriate some alternatives which meet the same needs should also be considered and evaluated using appropriate evaluation criteria.

POSTGRADUATE COURSES

CE 602 **ADVANCED MATHEMATICS FOR CIVIL ENGINEERS**
L-T-P-D-[C]
3-0-0-0-[4]

Linear differential equations; Fourier integrals and transforms; Partial differential equations; Numerical methods in general; Numerical methods for differential equations; Linear algebra; Numerical methods in linear algebra; Data analysis, Probability theory; Mathematical statistics.

CE 610 **HYDRAULIC STRUCTURES**
L-T-P-D-[C]
3-0-0-0-[4]

Advanced topics in the design and construction of dams: spillways, stilling basin

Intake works, tunnels and penstocks, gates, surge tanks, power house structures, etc.

CE 611 **ENGINEERING HYDRAULICS (3-0-0-4)**
L-T-P-D-[C]
3-0-0-0-[4]

Basics: dimensional analysis, equations of continuity, motion, and energy, irrotational flow, drag and lift of immersed bodies; Pipe flow: laminar flow, turbulent flow, boundary layer theory, wall turbulent shear flow, free turbulent shear flow; Open Channel flow: energy-depth relationships, uniform flow, gradually varied flow, hydraulic jump, rapidly varied flow, spatially varied flow, unsteady flow.

CE 612 **FLUID MECHANICS LABORATORY**
L-T-P-D-[C]
2-0-2-0-[4]

Verification of momentum equation; Friction loss in pipes; Rainfall-runoff relationship; Flow over sharp crested weir; Flow in pipe networks; Bernoulli theorem; Fall velocity of objects; Point velocity measurement by ADV; Reynolds' apparatus; Venturimeter and orifice meter; Energy loss in bends; Ground water flow/ well abstraction; Hydrogen bubble flow visualization; Hydraulic jump; Flow past a cylinder

CE 613 **SEDIMENT TRANSPORTATION (3-0-0-4)**
L-T-P-D-[C]
3-0-0-0-[4]

Properties of sediment, incipient motion, bed load, suspended load, total load, sediment measurements, regime concept, bed form mechanics, plan form and stream bed variations of rivers, reservoir sedimentation, erosion and deposition, sediment control, sediment transport in pipes.

CE 614 **HYDROLOGIC ANALYSIS AND DESIGN**
L-T-P-D-[C]
3-0-0-0-[4]

The hydrologic processes: precipitation, evaporation, infiltration, groundwater, and stream flow; Hydrologic measurements and networks; Analysis of discrete and continuous hydrologic data: harmonic analysis, statistical analysis including frequency analysis, correlation, and regression analysis and multivariate analysis, time series analysis and its applications; System analysis and synthesis; Linear and non - linear, lumped and distributed parameter systems; Queing models, simulation analysis; Hydrologic design of water resources systems.

CE 617 **GROUNDWATER SYSTEMS ANALYSIS** **Prereq. CE 614**
L-T-P-D-[C]
3-0-0-0-[4]

Digital simulation models for groundwater development, application of finite difference and finite element methods for solving problems in groundwater development and management; Analog methods: direct electric analog, viscous flow analog and other analogs; Optimisation methods, models for conjunctive development of surface and groundwater; Special problems in ground-water development and management; Artificial recharge, ground subsidence, salt water intrusion and others.

CE 619 **WATER RESOURCES ENGINEERING**

L-T-P-D-[C]
3-0-0-0-[4]

Water resources systems: components of the system, objectives of water resources development, development, planning, and design, construction and operation of water resources systems; System demands, geographic and geological aspects; Hydrological implications, economic, social and political consideration in system development; Benefits and costs; Economic objectives: mathematical and econometric principles in optimal system design, numerical and digital computer methods in hydraulic and water resources engineering.

CE 620 **STRUCTURAL DYNAMICS (3-0-0-4)**

L-T-P-D-[C]
3-0-0-0-[4]

Loading: nature of dynamic loading, harmonic, random, types of dynamic loading; Continuous systems: rods (axial vibrations), beams (shear, axial and axial-shear-flexural vibrations); Discrete mass systems: SDOF (free and forced vibrations), MDOF (generalized coordinates, eigenvalue analysis, matrix and modal time history analysis); Introduction of random vibration: stochastic processes, stochastic analysis of linear dynamical systems to Gaussian inputs, SDOF, MDOF.

CE 621 **ENGINEERING MECHANICS**

L-T-P-D-[C]
3-0-0-0-[4]

Stress analysis: forces and moments, theory of stress, principal stresses and stress invariants, compatibility equations, equilibrium equations; Strain: deformation and velocity gradients, Lagrangian and Eulerian description and finite strain, small deformation theory, principal strains and strain invariants, compatibility conditions; Fundamental physical principles: conservation of mass, linear momentum, angular momentum, and energy, second law of thermodynamics; Constitutive theory: St. Venant's principal, linear elasticity and generalized Hook's law, Stokesian and Newtonian fluids, Navier-Stokes equations, Bernoulli equation, linear viscoelasticity, yield criteria; Applications: Airy stress function, two-dimensional elastostatics problems, torsion.

CE 622 **STABILITY OF STRUCTURES**

L-T-P-D-[C]
3-0-0-0-[4]

Criteria for design of structures: stability, strength, and stiffness; Classical concept of stability; Stability of discrete systems: linear and nonlinear behaviour; Stability of continuous systems: stability of columns: axial–flexural buckling, lateral bracing of columns, combined axial-flexural-torsion buckling; Stability of frames: member buckling versus global buckling, slenderness ratio of frame members; Stability of beams: lateral-torsion buckling; Stability of plates: axial-flexural buckling, shear flexural buckling, buckling under combined loads; Introduction to inelastic buckling and dynamic stability.

CE 623 **EXPERTIMENTAL METHODS IN STRUCTURAL ENGINEERING**

L-T-P-D-[C]
1-0-2-3-[4]

Similitude and structural models: dimensional analysis, Buckingham's Pi theorem, scale factors and dynamic similitude; Uses and applications of models: types of model investigation, indirect and direct models, elastic and inelastic models (steel, concrete and masonry), size effects; Analysis of experimental data: error and uncertainty in experiment, measurement systems, accuracy in models and reliability of results; Test planning, design and implementation: testing sequence and experimental plan, loading systems, devices, actuators and their control; Instrumentation: mechanical, electrical, electronic system and their calibration, various types of sensors for displacement, velocity, acceleration, pressure, loads, strains, full-field measurements; Data acquisition system and data processing: analog systems, digital systems using personal computers, dynamic measurement, numerical and graphical data processing and archiving; Lab exercises: experiments to illustrate buckling of structural members; load-deformation behaviour of beams, columns, joints, and frames under various loads, mode shapes, natural frequency, damping factors from free and forced vibrations, shake table tests.

CE 624 **ADVANCED STRUCTURAL ANALYSIS**

L-T-P-D-[C]
3-0-0-0-[4]

Basics of structural analysis: static & dynamic loading, linear & nonlinear structural behaviour, geometric & material nonlinearity, hysteretic behaviour; Classical linear analysis of frames and trusses: displacement method, slope deflection equations & matrix displacement method, effect of foundation settlement and temperature; Geometric nonlinear analysis of frames and trusses: displacement method, nonlinear slope-deflection equations & nonlinear behaviour, linearized iterative matrix displacement method, geometric stiffness matrix, tangent stiffness matrix, P- Ä effect, buckling of frames, tension structures; Material nonlinear analysis of frames: basics of plasticity, distributed plasticity & lumped plasticity, incremental nonlinear analysis.

CE 625 **MASONARY STRUCTURES**

L-T-P-D-[C]
3-0-0-0-[4]

Properties of constituents: units - burnt clay, concrete blocks, mortar, grout, reinforcement; Masonry bonds and properties: patterns, shrinkage, differential movement, masonry properties - compression strength ; Stresses in masonry walls: **v**ertical loads, vertical loads and moments – eccentricity & kern distance, lateral loads - in-plane, out-of-plane; Behaviour of masonry walls and piers: axial and flexure, axial- shear and flexure, Behaviour of Masonry Buildings: unreinforced masonry buildings - importance of bands and corner & vertical reinforcement, reinforced masonry buildings - cyclic loading & ductility of masonry walls; Behaviour of masonry infills in RC frames: strut action; Structural design of masonry in buildings: methods of design – WSD, USD, seismic design - seismic loads, code provisions, infills, connectors, ties; Seismic evaluation and strengthening of masonry buildings: methods - in-situ, non-destructive testing; Construction practices and new materials.

CE 626 **ADVANCED DESIGN OF REINFORCED CONCRETE STRUCTURES**

L-T-P-D-[C]
3-0-0-0-[4]

Design of reinforced concrete structures: methods of design - WSD, LSD, ULD, LRFD, review of LSD - flexure, axial-flexure, shear, torsion; Strut and Tie Models: basics - B and D Regions, modeling of P, V, M, T, P-V-M, supports and load points; Capacity design concept**:** flexure design, shear design, strong-column weak-beam philosophy; Beam-column Joints: loading, effects under seismic loading, beam bar anchorage, transverse reinforcement; Collapse Mechanisms: basics - beam, storey and sway mechanisms, progressive versus gradual collapse, demand-capacity ratios - incremental DCRs & pushover analysis, Ductility of Reinforced Concrete Structures: material ductility- steel & concrete, section ductility, member ductility, structural ductility.

CE 627 **ADVANCED DESIGN OF STEEL STRUCTURES**

L-T-P-D-[C]
3-0-0-0-[4]

Properties of steel: mechanical properties, hysteresis, ductility; Hot-Rolled Sections: compactness and non-compactness, slenderness, residual stresses; Design of steel structures: inelastic bending – curvature, plastic moments, design criteria - stability , strength, drift; Stability criteria: stability of beams - local buckling of compression flange & web, lateral-torsional buckling, stability of columns - slenderness ratio of columns, local buckling of flanges and web, bracing of column about weak axis, method of design - allowable stress design, plastic design, load and resistance factor design; Strength Criteria: beams – flexure, shear, torsion, columns - moment magnification factor, effective length, P-M interaction, bi-axial bending, joint panel zones; Drift criteria: P-Ä effect, deformation-based design; Connections**:** types – welded, bolted, location - beam-column, column-foundation, splices.

CE 628 **DURABILITY OF CONCRETE STRUCTURES**

L-T-P-D-[C]
3-0-0-0-[4]

Concrete and the environment: interaction; Overview of concrete deterioration: alkali-aggregate reaction, corrosion, carbonation; Permeability of concrete and its measurement: penetration of carbon dioxide and chlorides into concrete, corrosion of steel in concrete - electrochemistry of corrosion, micro and macro cell corrosion, corrosion cells and currents, role of concrete, prevention of corrosion; Corrosion induced longitudinal cracks: nature and properties of corrosion products; Alkali aggregate reaction: reactive minerals, mechanism of deterioration, identification and tests; Codal provisions for durability; Nondestructive testing; repair/rehabilitation of structures.

CE 629 **EARTHQUAKE ANALYSIS AND DESIGN OF STRUCTURES**

L-T-P-D-[C]
3-0-0-4-[4]

Characteristics of earthquakes; Earthquake response of structures; Concept of earthquake resistant design; Code provisions of design of buildings; Design of liquid storage tanks; Liquefaction; Non-engineered construction; Special topics: bridges, dams, strengthening of existing buildings.

CE 630 **ROCK MECHANICS**

L-T-P-D-[C]
3-0-0-0-[4]

Physical properties and classification of intact rock and rock masses, rock exploration, engineering properties of rock, stresses in rock near underground openings; Rock tunneling, rock slope stability, bolting, blasting, grouting and rock foundation design.

CE 631 **ADVANCED GEOTECHNICAL ENGINEERING**

L-T-P-D-[C]
3-0-0-0-[4]

Soil composition and soil structure; Steady State flow, 2D and 3D seepage, transient flow; Compressibility and rate of consolidation, one, two, and three dimensional consolidation theories; Shear strength and stress-strain relationships of soils; Stability of slopes; Arching effects; Buried Structures

CE 632 **FOUNDATION ANALYSIS AND DESIGN**

L-T-P-D-[C]
3-0-0-0-[4]

Settlement and bearing capacity: shallow spread footings, mats, and deep foundations; Foundation models, contact pressure distribution for footings, rafts, piles; Retaining Structures; Soil-structure interaction studies; Case studies.

CE 633 **REINFORCED EARTH STRUCTURES**

L-T-P-D-[C]
3-0-0-0-[4]

Reinforcing materials; Advantage of RE; Behaviour of Reinforced earth walls; Soil reinforcement interaction internal and external stability condition; Field application of RE; Randomly reinforced earth and analysis of reinforced soils; Testing of soil reinforcements; Development, fabrication, design, and applications of geotextiles, geogrids, geonets, and geomembranes.

CE 634 **GROUND IMPROVEMENT TECHNIQUES**

L-T-P-D-[C]
3-0-0-0-[4]

Engineering properties of soft, weak and compressible deposits; Principles of treatment-loading (static and Dynamic); Accelerated flow; Reinforcement; Drainage and filters, Injections, thermal, electrical and Chemical Methods; Preloading; Dynamic Consolidation; Vertical drains; Granular piles; Soil nailing; Anchors; Design methods and case studies.

CE 635 **FOUNDATION DYNAMICS**

L-T-P-D-[C]
3-0-0-0-[4]

Dynamics of elastic systems; Single and multi-degrees of freedom systems; Empirical and semi-empirical approaches to the theory of soil dynamics; Elastic theories of soil dynamics; Wave propagation; Dynamic soil properties; Design of machine foundations; Vibration isolation; Pile dynamics.

CE 636 **GEOTECHNICAL EARTHQUAKE ENGINEERING**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction; Seismic Hazards: Mitigation of Seismic Hazards, seismology and earthquakes, strong ground motion, seismic hazard analysis; Wave propagation in unbounded media: in semi-infinite bodies, in layered soils and attenuation of stress waves; Dynamic soil properties; Ground response analysis; Effect of local site conditions on ground motion; Liquefaction: evaluation of liquefaction hazards, effects of liquefaction; Case studies.

CE 637 **CONSTITUTIVE MODELING OF FRICTIONAL MATERIALS**

L-T-P-D-[C]
3-0-0-0-[4]

Role of constitutive modeling; Importance of laboratory testing with relation to constitutive modeling; Elasticity: linear, quasilinear, anisotropic; Plasticity basics: yield criteria, flow rule, plastic potential, hardening/softening; Rate Independent Plasticity: mohr-Coulomb, non-linear failure criteria, Drucker-Prager, and cap models; Critical state soil mechanics: critical state concept, cam-clay models, simulation of single element test using cam-clay, consolidation, drained and undrained triaxial test; Stress-dilatancy theory; Work hardening plasticity theory: formulation and implementation; Applications of elasto-plastic models; Special Topics: hypoelasticity-plasticity, disturbed state concept.

CE 638 **GEOTECHNICAL INVESTIGATIONS FOR CE PROJECTS (1-0-3-3)**

L-T-P-D-[C]
1-0-3-3-[4]

Subsurface exploration planning, drilling and sampling techniques, field and laboratory tests, instrumentation and monitoring of field data, report preparation.

CE 639 **ANALYTICAL AND NUMERICAL METHODS IN GEOMECHANICS**

L-T-P-D-[C]
3-0-0-0-[4]

Finite difference, finite element and other analytical methods of solution to (i) Elasticity and stability problems in Geomechanics, (ii) Analysis of response of soil media to applied loads, (iii) Limiting equilibrium, Failure theories, Method of characteristics, (iv) Limit analysis, etc.

CE 640 **EARTH SYSTEM PROCESSES**

L-T-P-D-[C]
3-0-0-4-[4]

Introduction; Controls of earth system processes, geomorphic systems, threshold and equilibrium, scale of analysis; Endogenic processes and landforms, global morphology and plate margin landforms; Exogenic processes and landforms, fluvial, coastal, aeolian and lacustrine processes & landforms; Endogenic-exogenic interactions; Long-term landscape development; Interaction between lithosphere, hydrosphere, atmosphere and cryosphere.

CE 641 **ENVIRONMENTAL GEOLOGY**

L-T-P-D-[C]
3-0-0-0-[4]

Earth-environment interaction; Fundamental concepts of environmental geology, Environment of water, sediments and soils, Weathering, soil formation and erosion; Water quality controls in nature; Environmental impact of resource exploration and use; Land use management; Geological considerations of toxic and radioactive waste disposal; Environment vs. development.

CE 642 **GEOLOGICAL HAZARDS**

L-T-P-D-[C]
3-0-0-0-[4]

Geological hazards and environmental impact; Landslides: cause, classification, zonation and protection; Earthquakes: historical seismicity, classification, interplate and intraplate earthquakes, effect on ground structures, magnitude and intensity scales, seismic zonation; Floods: hydrology and types of floods, nature and extent of flood hazard, flood hazard zoning, flood control and protection; Land subsidence; Snow avalanches; Rock bursts; Mapping, monitoring and management of geological hazards.

CE 643 **RESOURCE EXPLORATION TECHNIQUES**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to earth, ocean and snow and their environments; Various resources (water, hydrocarbon, minerals) and their occurrences, nature and characteristics; Physical and engineering properties of various resources; Airborne, ground and borehole techniques: seismic, electrical, electromagnetic, radar, gravity, magnetic, self-potential, radioactive geotomography and logging techniques; Estimation of resources; Impact of growing population on earth, ocean and snow resources.

CE 644 **SATELLITE REMOTE SENSING AND GIS FOR GEO-RESOURCE EVALUATION**

L-T-P-D-[C]
3-0-0-0-[4]

Basic principles of image interpretation and GIS; Interpretation of regional geological and geomorphological features; River basin studies; Identification of groundwater potential zones; Lake and wetland studies; Water quality mapping; Vegetation Mapping and forestry applications; Applications in glaciology and snow hydrology; Applications in oceanography and coastal zone mapping; Mineral resources evaluation; Microwave remote sensing and its application in monitoring earth resources, snow surface, ocean and atmosphere; Application of thermal infrared data for mapping surface moisture and rock types and environmental studies.

CE 645 L-T-P-D-[C] 3-0-0-0-[4]

PHOTOGEOLOGY IN TERRAIN EVALUATION

Introduction to physical and structural geology; Landforms and drainage patterns; Elements of photogeology; Stereoscopy; Elementary photogrammetry; Photographic systems, types of cameras, films and filters; Photo-interpretation key; Quantitative interpretation of toposheets and airphotos; Applications in engineering geology, landuse, land wastage, hydrogeology, mineral exploration and change detection.

CE 646 L-T-P-D-[C] 3-0-0-0-[4]

GLOBAL CLIMATE CHANGE

Introduction to global climate; Global climatic models; Methods of reconstructing climate; Quaternary climates, sea level changes, glacial/interglacial cycles; Geological records of climate change, sedimentology, stable isotopes, geochemistry; Geochronology – relative and numerical methods; Vegetation dynamics, migration history, response of vegetation to climatic reversals; Pre-quaternary climates, evolution of climate through geological time.

CE 647 L-T-P-D-[C] 3-0-0-0-[4]

PALEOSEISMOLOGY AND TECTONIC GEOMORPHOLOGY

Plate tectonic and its relation to earthquakes; Historical and modern seismicity; Mapping of active tectonic landforms in different tectonic environments; Field techniques in paleoseismology, identification of old (prehistoric) earthquake by trenching, estimation of magnitude, slip rates, and recurrence interval of faults, prediction of future earthquake, identification of paleo-liquefaction features; Dating techniques; Correlation of paleoseismic data with existing geodetic and geophysical data; Delineation of seismogenic faults and their related seismic hazard; Seismic hazard assessment (SHA).

CE 648 L-T-P-D-[C] 1-0-4-4-[4]

LABORATORY PRACTICES IN GEOSCIENCE

Remote sensing applications: features extractions from remote sensing data, reflectance and NDVI calculations and change analysis; Resistivity survey: determination of layered parameters (resistivity and thickness of layers); Shallow seismic survey: determination of layered parameters (seismic velocity and thickness of overburden); Ground penetrating radar: identification of sub-surface utility, data acquisition and processing, mapping of shallow sub-surface sedimentary sequence, mapping of shallow sub-surface deformation; GPS: measurement of location with the help of GPS geo-referencing of the satellite data, determination of crustal movements using GPS; Core logging: facies characterization and stratigraphic mapping from sediment cores; Grain size analysis: grading of sediments; Magnetic susceptibility: measurement of susceptibity of sediments and rocks samples.

CE 650 **DIGITAL SIMULATION**

L-T-P-D-[C]
2-1-0-4-[4]

Methodology of system simulation; Mathematical modelling of systems and processes including analysis and interpretation of data; Verification of models; Data generation and validation; Sample size and variance reduction; Special Simulation Languages like SIMULA: design of Computer Simulation Experiments; Response surface analysis; Analysis of Simulated data. Case studies from different fields. A project on a specific problem.

CE 671 **INTRODUCTION TO REMOTE SENSING**

L-T-P-D-[C]
3-0-2-5-[4]

Remote sensing system; Physics of remote sensing, EMR characteristics and interaction in atmosphere and with ground objects; Sensor types characteristics: types of resolution, FOV, IFOV, PSF; RS satellites and data products; Image processing, interpretation elements; Classification; Geometric and radiometric distortions, Geo-referencing, resampling methods; Atmospheric errors and removal; Satellite orbits and characteristics; Applications of optical and microwave remote sensing techniques in Civil Engineering.

CE 672 **MACHINE PROCESSING OF REMOTELY SENSED DATA**

L-T-P-D-[C]
3-0-0-0-[4]

Image processing system; Preprocessing of remotely sensed data; Radiometric and Geometric distortions and corrections; Image enhancement; Image transformations; Pattern recognition.

CE 673 **INSTRUMENTATION, LABORATORY AND FIELD PRACTICES IN GEOINFORMATICS (3 CREDITS)**

Use of automatic and digital levels, electronic theodolites, total stations, plane tabling; Control surveys using GPS, Total station and triangulation methods (adjustment and computations of coordinates); Cartography and report writing.

CE 674 **GLOBAL POSITIONING SYSTEM**

L-T-P-D-[C]
2-0-2-4-[4]

Basic concepts: pseudo range and carrier phase measurements; Signal structure; GPS coordinate systems: WGS-84, GPS time; GPS Errors and biases; GPS orbital Geometry and Navigational solution; Surveying with GPS; Planning and field observations; Data post-processing; GIS and GPS integration; Other satellite based navigational systems: GLONASS, GALILEO, modernization plans of navigational satellites.

CE 675 **GEOGRAPHICAL INFORMATION SYSTEM**

L-T-P-D-[C]
2-0-2-4-[4]

Introduction; GIS data: spatial and non-spatial, spatial data model: raster, tessellation, vector, 2.5D model; Topology and topological models; Spatial referencing using coordinates and geographic identifiers, metadata; Spatial data acquisition; Attribute data sources; Spatial and attribute data input; Data storage, RDBMS, database operations; Spatial and non-spatial data editing functions; Quality of spatial data; GIS analysis functions: Retrieval, classification, measurement, neighborhood, topographic, interpolation, overlay, buffering, spatial join and query, connectivity, network functions, watershed analysis, viewshed analysis, spatial pattern analysis, spatial autocorrelation, trend surface analysis; GIS presentation functions: Visual communication theory, design theory, data visualization methods, exporting data; Modern trends: Internet GIS, 3D GIS, physical modeling under GIS environment.

CE 676 **PRECISION REMOTE SENSING**

L-T-P-D-[C]
2-0-3-4-[4]

Altimetric LiDAR: Physics of laser, spectral characteristics of laser, laser interaction with objects; Airborne Altimetric LiDAR: principle: topographic and bathymetric LiDAR, multiple return, full wave digitization; Components of a LiDAR system, INS technology, INS-GPS integration, measurement of laser range, calibration; Flight planning; LiDAR geolocation models; Accuracy of various components of LiDAR and error propagation, error analysis of data and error removal; Data classification techniques, raw data to bald earth DEM processing, uses of return intensity and full waveform in information extraction, LiDAR data integration with spectral data; LiDAR applications: building, tree, power line extraction; LiDAR data visualization; Photogrammetry: metric and non-metric cameras; Geometry of near vertical and tilted photographs, heights and tilt distortions; Rectification and orthophotographs; Stereoscopy, parallax equation and stereo measurements for height determination; Orientation- interior, exterior, relative, and absolute, Mathematical model relating image, model and object space; Collinearity and coplanarity conditions, DLT; Image matching techniques; Strip and block triangulation and adjustment; Automatic DTM and Orthophoto production.

CE 677 **GEOSPATIAL DATA PROCESSING**

L-T-P-D-[C]
3-0-0-0-[4]

Geodetic reference systems: ICRF and ITRF, Geodetic datums, Earth ellipsoid; basic geometric geodesy; Coordinate systems and transformation; Map projections, geoid and geoidal heights and undulations; Observations and mathematical model, precision and accuracy, rejection of observations, weights and cofactors, correlation and covariance, propagation of errors and variance-covariance; Least squares adjustment computations; Sequential processing and Kalman Filtering; Variance-covariance of adjusted data, error ellipse and error ellipsoid; Statistical analysis of adjusted data; Introduction to GPS; Code and phase measurements; Models for single point positioning and relative positioning using code and phase data; Methods of interpolation; Geostatistical tools: variogram and krigging.

CE 680 **TRAFFIC FLOW MODELLING AND SIMULATION**

L-T-P-D-[C]
3-0-0-0-[4]

Traffic flow characteristics; deterministic and stochastic models of stream flows; Car following models, stability and diffusion phenomena in traffic; Boltzmann models. Signalized and unsignalized intersections, Coordination and optimization of network of signalized intersections; pedestrian flow problems. Fundamentals of traffic simulation modeling. Simulation methodologies and model design. Simulation languages, Study of large scale simulation models such as VTI, Transyt, Sigop, etc.

CE 681 **ANALYSIS AND DESIGN OF PAVEMENT SYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Subsystems of Pavement Design; Basis of Pavement Design; Development of various design methods for highway and airport pavements; Pavement support conditions, Properties of components and design tests; Materials of Construction and Construction procedures for different types; Soil Stabilizations methods; Quality control and tolerance; Mathematical models for pavement systems; Landing gears; vehicle pavement interaction; Computer Programming for various pavement analysis and design methods; pavement management process, pavement evaluation and performance; Design alternatives-Analysis, Evaluation and Selection.

CE 682 **ANALYSIS AND DESIGN OF TRANSPORTATION INFRASTRUCTURE**

L-T-P-D-[C]
4-0-0-5-[4]

Introduction to supply and demand sides of transportation engineering, analysis of transportation demand (including topics such as category analysis, gravity model, entropy models, choice models, user equilibrium models, etc.). Introduction to public transportation. Designing efficient public transport systems (including topics such as route development, schedule development, pricing strategies, etc.). Concept of structural, functional and drainage design of pavement structure. Design of flexible and rigid pavement – various approaches. Cost and reliability considerations. Pavement maintenance issues. Pavement distresses, distress evaluation, maintenance measures, and network level maintenance strategy.

CE 683 **TRAFFICENGINEERING**

L-T-P-D-[C]
3-0-0-0-[4]

Microscopic and macroscopic traffic parameters, traffic flow models, car-following models, capacity and level of service analysis, design of traffic facilities like unsignalized and signalized intersections, inter changes, expressways, traffic signs, parking areas etc., simulation of traffic streams.

CE 684 L-T-P-D-[C] 3-0-0-0-[4]

URBAN TRANSPORTATION SYSTEM

Dimensions of the widening role of urban transportation system planning; the planning process; land use and transport system models; comparison and evaluation of various models; transportation impact study methodologies; strategies for the evaluation of alternative transportation plans and plan implementation; Regional analysis and plan implementation; Regional Analysis and development concepts; the role of transportation planning in the overall regional system; methodology and models for regional transportation system planning; implementation framework and case studies.

CE 685 L-T-P-D-[C] 3-0-0-0-[4]

RAIL TRANSPORTATION SYSTEMS PLANNING AND DESIGN

Rail Transportation System; Demand analysis and forecasting for passenger and freight traffic costing and pricing principles, project analysis and design; project interdependencies and programming techniques; systems analysis and systems planning; macroeconomic transportation simulator; case studies and implementation strategies.

CE 688 L-T-P-D-[C] 3-0-0-0-[4]

AIRPORT SYSTEMS PLANNING AND DESIGN

Air Transport-structure and organization, the challenges and the issues, Forecasting air travel demand-trend forecasts and analytical methods; Air freight demand, Characteristics of the aircraft as they affect airport; Airport planning-requirements: site selection, layout plan and financial plan; Air traffic control lighting and signing; Airport capacity and configuration; Geometric design of runway, taxiway and aprons; passenger terminal functions, passenger and baggage flow, design concepts, analysis of flow through terminals, parking configurations and apron facilities; Air cargo facilities-flow through cargo terminals, unitized systems; Airport drainage and pavement design; Airport access problem; Environmental impact of airports.

CE 689 L-T-P-D-[C] 1-0-4-4-[4]

CHARACTERIZATION OF PAVEMENT MATERIALS AND ANALYSIS OF PAVEMENTS

Components of a pavement structure. Experimental characterization of pavement materials – bituminous mix, aggregates, subgrade, cemented material. Material modeling – visco-elastic, visco-plastic behaviour. Load stresses in pavements, generalized multi-layer solution – Burmister layer, slab, foundation models. Static and dynamic analysis. Fatigue and rutting modeling and calibration. Temperature stresses in pavements. Estimation of cumulative damage.

CE 690 L-T-P-D-[C] 0-0-6-3-[4]

LABORATORY COURSE IN TRANSPORTATION ENGINEERING (0-0-6-3)

Experiments to characterize pavement materials like, viscosity tests, ageing tests, skid tests, etc. Experiments to characterize bituminous mixes, like mix design related experiments, moisture sensitivity related experiments, etc. Experiments related to traffic data collections on speed, volume, travel time, delay, etc. Traffic studio (students will learn to use geometric design software and video data analysis software). Demonstrations of various equipments including possible visits to advanced labs and road systems.

CE 699 **M.TECH. THESIS (CREDIT MAX. 16 UNITS)**

CE 710 **INTRODUCTION TO AI TECHNIQUES**

L-T-P-D-[C]

3-0-0-0-[4]

Expert Systems (ES): history of ES, basic concepts of ES, definition and components of ES, inference engines and reasoning mechanisms e.g. forward reasoning, backward reasoning, and mixed reasoning, knowledge representation methods and development of the rule based knowledge base, dealing with uncertainty, and selected case studies of ES applications to engineering and sciences; Artificial Neural Networks (ANNs): background and history of ANNs, definitions and basic concepts of ANNs, biological and artificial neural networks, feed-forward and feed-back networks, supervised and unsupervised learning methods–standard back-propagation (BP), conjugate gradients BP, self organizing networks, etc., development of ANN models for specific problems and selected case studies; Genetic Algorithms (GAs): fundamentals and preliminary concepts of evolution and GA, preliminaries of optimization, genetic operators-selection, crossover, and mutation, binary and real-coded GAs, constraint handling in GAs, and selected case studies involving GA applications to engineering.

CE 712 **TRANSIENTS IN PIPES**

L-T-P-D-[C]

3-0-0-0-[4]

Causes of transients; Governing Equations; Method of characteristics; Transients in pumping schemes and hydro electric schemes; Transient bubble flow; Transient control.

CE 713 **UNSTEADY OPEN-CHANNEL FLOW**

L-T-P-D-[C]

3-0-0-0-[4]

Review of basic equations; 2 D Shallow water flow equations: Boussinesq equations, Finite - difference solutions: explicit and implicit methods; Dambreak flow analysis; Supercritical flow computation; Sediment routing models.

CE 714 **STOCHASTIC HYDROLOGY**

L-T-P-D-[C]

3-0-0-0-[4]

Statistical methods in hydrology, probability distribution of hydrologic variables, hypothesis testing and goodness of fit, flood frequency analysis, single and multiple regression analysis, classification of time series, characteristics of hydrologic time series, statistical principles and techniques for hydrologic time series modelling, time series modelling of annual and periodic hydrologic time series (including AR, ARMA, ARIMA, and DARMA models), multivariate modelling of hydrologic time series, practical considerations in time series modelling applications.

CE 715 **WATER RESOURCES SYSTEMS ENGG. AND MANAGEMENT**

L-T-P-D-[C]
3-0-0-0-[4]

Economics of water resources systems: principles of engineering economics; Microeconomics and efficient resource allocation, conditions of project optimality; Planning for multipurpose water resource projects; Introduction to mathematical optimization techniques; Multiobjective optimization; Application of optimization techniques; Water resources planning under uncertainty; Stochastic planning models; Application of simulation models.

CE 716 **MANAGEMENT AND MODELLING OF ENVIRONMENTAL SYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Human - environment relationship, normative criteria, descriptive and prescriptive models, limits of growth; Environmental and natural resources economics, pollution control policy, growth in a finite environment; Environmental protection laws; Numerical/mathematical modelling of environmental systems, subsystems, and pollutant transport processes; Planning and management of environmental systems: optimization techniques, stochastic modelling, statistical inferences; Large scale systems; Optimal monitoring network design, identification of sources; Risk reliability and uncertainty in environmental systems; Topics in groundwater and surface water quality management.

CE 717 **GROUNDWATER HYDROLOGY AND POLLUTANT TRANSPORT**

L-T-P-D-[C]
3-0-0-0-[4]

Groundwater as a resource, general problems of chemical contamination in groundwater; Fluid potential, hetrogenity and anisotropy; Aquifiers, aquitrads and general geology, well hydraulics, parameter estimation; Steady and transient flow equations, unsaturated flow equation; Pollutant transport in groundwater, chemical and transport processes, numerical modeling and solution, break through curves; Seawater intrusion in coastal aquifiers; Modelling of pollutant transport in the unsaturated zone; Optimization models for management of groundwater quantity and quality; Optimal monitoring network design; Multiple objective management; Conjective management of surface and groundwater; Special topics.

CE 721 **RANDOM VIBRATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Random processes; Stochastic response of linear structural systems: normal mode approach; Level crossing; Peak and envelop statistics; Application to wind and earthquake engineering; Non-stationary processes; Nonlinear random vibrations.

CE 722 L-T-P-D-[C] 3-0-0-0-[4]

THEORY OF PLATES AND SHELLS

Some results from differential geometry: curves in 3D space - parameterized equation for curves, arc length as a parameter; surfaces - parametric description, curvilinear co-ordinates, first and second fundamental forms, principal curvature co-ordinates, derivatives of unit vectors, equations of Gauss and Codazzi; Membrane theory of shells: equilibrium equations, applications to shells of revolution under axisymmetric loads, applications to cylindrical shells under asymmetric loads, strain-displacement relations , application in calculation of displacements; Bending theory of shells: kinematic assumptions and strain-displacement relations, stress measures and equilibrium equations, constitutive relations, cylindrical shell under axi-symmetric loads, bending of cylindrical shells; Bending theory of flat plates: thin plates, Kirchoff theory - strain displacement relations, stresses and stress resultants, constitutive equations, equilibrium equations, boundary conditions, derivation of theory from principle of virtual work, rectangular plates-solution by double Fourier series, circular plates, edge effects, anisotropic and layered plates, thick plates-Reissner-Mindlin-Naghadi type theories, moderate deflection analysis and buckling of plates.

CE 730 L-T-P-D-[C] 3-0-0-0-[4]

SOIL STRUCTURE INTERACTION

Contact pressure distribution, foundation models, Limit analysis of rafts and foundations; Soil structure interaction studies pertaining to buried structures; Analysis and design of deep foundations; Modern trends in the design of earth retaining structures.

CE 733 L-T-P-D-[C] 3-0-0-0-[4]

GEOENVIRONMENTAL DESIGN ASPECTS OF SOLID WASTE MANAGE-MENT

Identification, characterization and regulatory requirements for disposal of hazardous, nonhazardous and domestic wastes. Waste Management-Recycling, com-posting, incineration and various disposal methods. Site selection and Geo-environmental investigations. Natural attenuation process and mechanism of attenuation. Design practices of solid wastes. Tailing dams for disposal of flyash, coal, copper, iron and other metal wastes. Single and double lined landfill design, linear material clay, geosynthetics amended soils and other admixtures. Leachate collection and detection system. Landfill construction. Construction quality control and per-formance monitoring. Application of geosynthetics in waste disposal design.

CE 751 **ADVANCED STATISTICAL METHODS FOR CIVIL ENGINEERS**

L-T-P-D-[C]
3-0-0-0-[4]

Basics of Probability, its distributions, experimental error and its characteristics, adjustment computations, sampling theory, theory of point and interval estimation, hypotheses testing, regression analysis, robust estimators and certain other statistical tests.

CE 752 **FUZZY SYSTEMS: THEORY AND APPLICATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Fuzzy sets, fuzzy numbers, fuzzy relations, fuzzy measures, fuzzy logic and the theory of uncertainty and information; applications of the theory to inference and control, clustering, image processing and data handling.

CE 799 **PH.D. THESIS (CREDIT MAX. 16 UNITS)**

COMPUTER SCIENCES AND ENGINEERING

PROFESSORS

Agrawal M (Head)	manindra	7338	
Aggarwal SK	ska	7614	
Biswas S	sb	7574	
Dhande S G (joint appointment with M.E.)	sgd	7170	
Ghosh RK	rkg	7645	
Gupta P	pg	7647	
Jain A	ajain	7642	
Jalote P	jalote	7619	
Karnick H	hk	7601	
Moona R	moona	7652	
Mukherjee A	amit	7489	
Prabhakar TV	tvp	7618	7608
Sanghi D	dheeraj	7077	
Saxena S	ssax	7611	
Sinha RMK (Joint appointment with E.E.)	rmk	7174	
Ganguly S	sganguly	7231	
Mehta SK	skmehta	7829	

ASSOCIATE PROFESSORS

Seth A	seth	7231

ASSISTANT PROFESSORS

Chaudhuri M	mainakc	7890
Piyush P. Kurur	ppk	7584
Baswana S.	sbaswana	6074
Bhattacharya A.	arnabb	7650

Convenor, DUGC :	Mukherjee A	amit	7489
Convenor, DPGC :	Mehta S. K.	skmehta	7829
Faculty Counsellor :	Karnick H	hk	7601

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IIT Kanpur has one of the most established programmes in Computer Science and Engineering in the country functioning since 1971. Starting as an Interdisciplinary Programme, it became a full-fledged department in 1984.

The Department admits every year around 35 students in the B.Tech. prog-ramme, 40 students in the M.Tech. program and 27 students in the dual degree programme. There are about 10 Ph.D. students registered at a time. It has a faculty of 22 whose interests span almost the entire area of Computer Science. Besides, it also has software engineers and project research engineers.

The recent research activities of the Department include :

IITK CSE department is actively involved in research in various fields of computer Science. The faculty is involved with both theoretical as well as experimental research. The domain of research range from abstract theory to down-to-earth problem of immediate interest to the industry.

Major Breakthrough in Theory: One of the major outstanding problems in the area of computational number theory has been solved by one of the faculty members in the year 2002. The problem pertained to whether a number could be tested for primality in polynomial time. This is considered the most important research result during the last 15 years in the area of Theoretical Computer science.

Smart Card Technology Development: A standard for smart card operating system has been developed which is used by the Government of India for all its smart card based applications. A smart card operating system has also been implemented which is compliant to this standard. This technology is in the process of being commercialised.

Computer System Security: Recently a center on computer system security has been set up. The center aims to promote research in all aspects of computer security. The Department has already made several contributions in this area including design of new private key cryptosystems, packet filtering system, etc.

Language technology: Development of Indian Language technology has been one of our major thrust activities at IIT Kanpur. Some path-breaking contributions have been made in Indian Language Coding (ISCII), keyboard design, transliteration, OCR, machine translation, Linuxware, NLP, Indian scripts on Linux, web content creation and search. Some of our landmark achievements are: GIST multilingual technology, ANGLABHARTI & ANUBHARTI machine aided translation strategies and popular web-sites such as Gita-supersite. First version of Angla Hindi, an unconstrained machine-aided translation system from English to Hindi based on Anglabharti approach has been released and the technology has been transferred to the industry. Angla Hindi is available on web at *http://anglahindi.iitk.ac.in*

Wireless Networking: Wireless Networking research aims at making telecom affordable to rural areas that cannot be served profitably by conventional wireless technologies. A large scale outdoor experiment is being conducted to assess viability of using IEEE 802.11b technology for this purpose. Work in progress includes wireless network monitoring, MAC and routing protocol design, and novel applications for wireless networks. This is the largest outdoor multihop system anywhere in the country.

The following are the major research areas in the Department.

Software Engineering; Programming Languages; Computer Architecture; Operating systems; Information Systems; Computer Security; Algorithm; Theoretical Computer Science, Computer graphics and CAD, Artificial Intelligence, VLSI and Hardware Design, Networks and Mobile Computing.

CURRENT COURSE STRUCTURE FOR B.TECH. STUDENTS

COMPUTER SCIENCE & ENGINEERING

	S E M E S T E R							
	FIRST	**SECOND**	**THIRD**	**FOURTH**	**FIFTH**	**SIXTH**	**SEVENTH**	**EIGHTH**
C	CHM101	TA101	MTH203	HSS-I-2	SE-1	HSS-II-1	HSS-II-2	SE-2
O	PHY101	PHY103	CHM201	TA201	CS330	CS335	CS498	CS499
U	PHY102	MTH102	CS220	CS201	CS340	CS345	DEL-1	DEL-3
R	MTH101	ESC102	ESO-1	CS355	OE-2	OE-3	OE-4	OE-5
S	HSS-I-1/	CS100	ESO211	OE-1	**ONE OUT**	**ONE OUT**	DEL-2	OE-6
	ENG112N	PE102			**OF**	**OF**		
	ESC101				CS350,	CS315,		
	PE101				CS425,	CS365,		
					CS455	CS422		

CS 100	Introduction to Profession
CS 201	Discrete Mathematics
ESO 211	Data Structures and Algorithms
CS 220	Intro. to Computer Organisation
CS 315	Principles of Data base Systems
CS 330	Operating Systems
CS 335	Compiler Design
CS 340	Theory of Computation
CS 245	Design and Analysis of Algorithms
CS 350	Principles of Programming Languages
CS 255	Programming Tool & Techniques
CS 360	Introduction to Computer Graphics and Simulation
CS 422	Computer Architecture
CS 425	Computer Networks
CS 455	Intoduction to Software Eng.
CS 498	B.Tech. Project
CS 499	B.Tech. Project

Notes :

Those students who have taken ENG121 in 1st Semester will have to do one HSS level extra in EL Slot.

A student is required to take 4 ESO/BSO courses, with the condition that 2 of these must be ESO.

COURSE DESCRIPTION

CS 201 **DISCRETE MATHEMATICS**

L-T-P-D-[C]
3-0-0-0-[4]

Notion of proof: proof by counter-example, the contrapositive, proof by contradiction, inductive proofs, Algebra: Motivation of algebraic structures; review of basic group theory with emphasis to finite groups: subgroups and group homomorphism, Lagrange's theorem. Commutative rings, ideals, Finite fields and their elementary properties. Some CS applications (e.g., RSA, error correcting codes), Combinatorics: Basic counting techniques, pigeon-hole principle, recurrence relations, generating functions, Polya's counting theorem. Basics of graph theory. Introduction to probabilistic method in combinatorics. Formal logic: Propositional logic: proof system, semantics, completeness, compactness. First order logic: models, proof system, compactness, Examples of formal proofs in, say, number theory or group theory. Some advanced topics. E.g., CS application of logic, introduction to modal and temporal logics, Or, formal number theory including incompleteness theorem.

CS 220 **INTRODUCTION TO COMPUTER ORGANIZATION** **Prereq. ESC 102**

L-T-P-D-[C]
3-0-2-0-[4]

Introduction, Overview of basic digital building blocks; truth tables; basic structure of a digital computer, Number representation, Integer -unsigned, signed (sign magnitude, 1's complement, 2's complement, r's complement); Characters-ASCII coding, other coding schemes; Real numbers-fixed and floating point, IEEE754, Assembly language programming for some processor, Basic building blocks for the ALU, Adder, Subtractor, Shifter, Multiplication and division circuits, CPU Subblock, Datapath - ALU, registers, CPU buses; Control path microprogramming (only the idea), hardwired, logic; External interface, Memory Subblock, Memory organization; Technology-ROM, RAM, EPROM, Flash etc. Cache; Cache coherence protocol for uniprocessor (simple), I/O Subblock, I/O techniques -interrupts, polling, DMA; Synchronous vs. Asynchronous I/O; Controllers, Peripherals, Disk drives; Printers- impact, dot matrix, ink jet, laser; Plotters; Keyboards; Monitors; Advanced Concepts, Pipelining; Introduction to Advanced Processors.

CS 315 **PRINCIPLES OF DATA BASE SYSTEMS** **Prereq. ESC 101, ESO 211**

L-T-P-D-[C]
3-0-0-0-[4]

Overview of file organisation techniques: sequential, direct, indexed, hashed, inverted, B-trees, Data models: relational, network, hierarchical, Relational model: algebra, calculus, normal forms. Implementation of query languages, security and protection of data recovery methods, Concurrent operations on data bases, introduction to distributed data base systems, case studies.

CS 330 **OPERATING SYSTEMS** **Prereq. ESC 101, ESO 211, CS 220**

L-T-P-D-[C]
3-0-2-0-[4]

Introduction: Role of operating System; System Calls; Processes and Threads Concepts of Processes, Threads; Process Control BLock. CPU Scheduling: Examples from contemporary OSes (UNIX and NT). Inter-Process Communication Message Passing, Mailboxes, Pipes; Examples from contemporary OSes (Unix and NT).

Process Synchronization Critical Section Problem; Hardware Mechanism for synchronization; Semaphores and Mutex objects; Classical Problems (Producer Consumer, dining philosophers etc.); Monitors; Examples of synchronization mechanisms such as from Java and Pthreads. Deadlocks and Detection, Prevention and avoidance mechanisms.

Virtual Memory: Address binding process (compilation and linking); Dynamic Linking; Segmentation; Paging Protection; Demand Paging; Page Replacement policies - Thrashing, pre-paging and other issues; swapping; examples from contemporary OSes (Linux, NT)

Files and Directories: File organization in directories; File attributes; Operations on files; Directory attributes and operations on directories; Directory organizations; File and directory protections.

File system implementation Concepts of mounting; Allocation mechanisms - Contiguous, linked and indexed allocations; Free space management; caching; Examples of files systems from one or more of DOS, BSD, Linux, HPFS and NTFS;

Device Drivers: Storage management Disk scheduling; Disk Management; Swap and swap management.

Security and Protection Mechanisms: Password based protection; Encryption and Decryption; System Threats — Viruses, Wormholes, Trojan Horses etc.

CS 335 **COMPILER DESIGN** **Prereq. ESC 101, ESO 211, CS 220**

L-T-P-D-[C]
3-0-4-0-[4]

Compiler structure: analysis-synthesis model of compilation, various phases of a compiler, tool based approach to compiler construction.

Lexical analysis: interface with input, parser and symbol table, token, lexeme and patterns. Difficulties in lexical analysis. Error reporting. Implementation. Regular definition, Transition diagrams, LEX Syntax analysis: CFGs, ambiguity, associativity, precedence, top down parsing, recursive descent parsing, transformation on the grammars, predictive parsing, bottom up parsing, LR parsers (SLR, LALR, LR), YACC

Syntax directed definitions: inherited and synthesized attributes, dependency graph, evaluation order, bottom up and top down evaluation of attributes, L- and S-attributed definitions

Type checking: type system, type expressions, structural and name equivalence of types, type conversion, overloaded functions and operators, polymorphic functions, type checking in OO languages

Run time system: storage organization, activation tree, activation record, parameter passing, symbol table, dynamic storage allocation, garbage collection

Intermediate code generation: intermediate representations, translation of declarations, assignments, control flow, boolean expressions and procedure calls. Implementation issues

Code generation and instruction selection: issues, basic blocks and flow graphs, register allocation, code generation, DAG representation of programs, code generation from DAG, peep hole optimization, code generator generators, specifications of machine

Code optimization: Introduction to Code optimization, data-flow analysis

CS 340 **THEORY OF COMPUTATION** **Prereq. ESO 211**

L-T-P-D-[C]
3-0-0-0-[4]

Scope and motivation for theory of computation; informal introduction to computability and complexity; set membership problem as idealization of computing problems; alphabets, strings, languages, automata; deterministic finite automata; nonde-terminism; equivalence of DFAs and NFAs; regular expressions and their equivalence with finite automata; pumping lemma; some applications of FAs (e.g., text pattern matching); decision properties of regular languages; Myhill-Nerode theorem; minimization of DFAs, Grammars as generative devices; context-free grammars, derivation, and parse trees; pushdown automata; equivalence with CFGs; normal forms of CFGs, pumping lemma for context-free languages; decision and closure properties; some applications (e.g., YACC, markup languages, XML and document type definition, etc.), Why consider Turing machines?; basic TM model and its extensions; NDTMs, TM configurations; robustness of TM as a computing model; universal TM, Recursive and r.e. languages; notion of undecidability; undecidability of halting problem; reducibility; other undecidable problems; Rice's theorem; separation of r.e. and recursive languages; existence of non r.e. languages; self-reference, recursion theorem; decidability of logical theories; implication to automated theorem proving, Motivation for examining feasibility/infeasibility distinction; definition of time and space complexity classes; P and NP, and their importance; polynomial time reducibility; definition of NP-completeness, and NP-hardness; Cook-Levin theorem; some other NP-complete problems, Brief review of the notion of randomized algorithms; probabilistic TMs; classes RP, BPP, and ZPP; relationships to P and NP; proof of inclusion of BPP in P/poly.

CS 345 **ALGORITHMS-II** **Prereq. CS 201, ESO 211**

L-T-P-D-[C]
3-0-2-0-[4]

Max Flows: Max Flows (Ford-Fulkerson and bipartite matching), Linear Algebra: LUP decomposition, inverting matrices, Fast Fourier Transform. Polynomial multiplication, integer multiplication and division, Number Theoretic Algorithms: gcd, modulo arithmetic, Chinese remaindering, RSA, Linear Programming: formulation, simplex, primal-dual, Geometric algorithms: convex hull, closest pair, intersection of line segments, polygon triangulation, Randomized Algorithms: identity testing, primality and min-cut, Approximation Algorithms: max-cut, tsp, vertex-cover etc, Backtracking, Other topics. These may include string matching,parallel algorithms, amortized analysis etc.

CS 350 **PRINCIPLES OF PROGRAMMING LANGUAGES** **Prereq. ESO 211**

L-T-P-D-[C]
3-0-2-0-[4]

Brief history of development of programming languages, Introduction - imperative programming, functional programming, logic programming and object oriented programming, Values and types, Notion of variables, Lifetime of variables-local, global and heap variables, Bindings and environments, bindables, scope-block structure, static and dynamic scoping, Abstraction - procedural and function abstractions, Type systems - monomorphic type systems. Introduction to polymorphism, Types of polymorphism - overloading, parametric polymorphism, polymorphic types, Type checking and type inference – inference rules for monomorphic types, introduction to polymorphic type inference, Functional programming, Logic Programming, Object oriented programming.

CS 355 **PROGRAMMING TOOLS AND TECHNIQUES** **Prereq. ESC 101**

L-T-P-D-[C]
1-0-4-0-[4]

Software management tools, CVS, Scripting tools, GUI programming tools, Language processing tools, Web programming tools.

CS 360 **INTRODUCTION TO COMPUTER GRAPHICS AND SIMULATION**
Prereq. ESO 211

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to Picture Synthesis and Analysis. Conceptual Framework of an Interactive Graphical Simulation System, Graphics hardware. Basic Raster Graphics Algorithms. Introduction to Simple Raster, Graphics Package (SRGP), Graphics Entities. Geometric Transformations. Object hierarchy. Segmentation. Interaction Techniques, Geometric Modeling in 3-D. Viewing in 3-D. Concept of Synthetic Camera. Dialogue Design. Graphics User Interfaces. Windowing Systems Graphi -cal Modeling of Discrete events. Simulation of Discrete Event Displays. Animation Techniques. Basic Rules for Animation. Graphical Simulation of continuous motion. Role of Virtual Reality in Graphical Simulation.

CS 365 **ARTIFICIAL INTELLIGENCE** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Introduction to AI. Agents and environments. Problem solving by search; uninformed search, informed ("heuristic") search, constrained satisfaction problems, adversarial search, Knowledge representation and reasoning; rule based representations, logical formalisms, frames or object oriented systems, network based approaches and mixed representations. Theorem-proving. Knowledge bases and expert systems. Overview of LISP and PROLOG. Reasoning in uncertain environments. Planning communication and multiagent systems. Learning Vision, NLP.

CS 397 **SPECIAL TOPICS IN COMPUTER SCIENCE** **Prereq. #**

L-T-P-D-[C]

0-0-0-0-[4]

This course is meant for a 3rd year BTech (CSE) student to study a topic of their interest, somewhat independently. A student may also carry out a project in this course. In this course, there will be a faculty member associated with each student whose responsibility will be to suggest reading material, hold discussion sessions, monitor the progress of the student, examine the student, and give a grade at the end of the semester.

CS 422 **COMPUTER ARCHITECTURE** **Prereq. CS 220**

L-T-P-D-[C]

3-0-0-0-[4]

Introduction: Overview of Computer Architecture, Performance evaluation of processors, Pipelining, Super-pipelines, Advanced pipelines, static and dynamic scheduling, Instruction level parallelism, loop unrolling, VLIW and Super scalar processors, Vector processing and array processing, Memory: bandwidth issues, memory organization, cache coherence, Symmetric multiprocessors (SMP), NUMA-MPs, Massively parallel processors, Cache coherence protocols, Interconnection networks, I/O processing, parallel programming, Examples of contemporary architectures, AS (Reliability, Availability, Scalability) features.

CS 425 **COMPUTER NETWORKS** **Prereq. #**

L-T-P-D-[C]

3-0-2-0-[4]

Introduction: Advantages of computer networks, LAN vs. WAN, ISO/OSI seven-layer architecture, networks topologies, Physical Layer: transmission media, data encoding, Data Link Layer: Framing, Error detection and correction, Stop-and-wait protocol, Sliding window protocols, MAC Layer: Aloha protocols, CSMA/CD; Ethernet. Other examples of MAC protocols, Network Layer: Inter-networking – Tunneling, Encapsulation, Fragmentation. Internet Protocol (IP) –Header structure, addresses, options, etc. Routing Algorithms and Routing protocols. Other related protocols, for example, ICMP, ARP, RARP, BOOTP, DHCP, Transport Layer: Transmission Control Protocol – header, services, connection management, congestion control, sliding window, timers. User Datagram Protocol. Domain Name Service, Unix network programming, socket abstraction. client-server architecture, Session, Presentation, Application Layers. Example protocols: Email (SMTP), Telnet, FTP, etc.

CS 455 **INTRODUCTION TO SOFTWARE ENGINEERING** **Prereq. #**

L-T-P-D-[C]
3-0-2-0-[4]

Introduction - industrial strength software, problem of software development, problem of scale, basic process-based approach, etc. Software Process Models - concept of processes, ETVX model for process specification, different process models and when they are useful, Requirement analysis and specification - the basic problem, the sub- phases in the phase, analysis techniques (structured analysis), specification, validation, function point analysis, Project planning - effort, schedule, quality, project monitoring, and basic CM, Design principles and structured design methodology - partitioning, top- down and bottom-up, step-wise refinement, coupling and cohesion, Coding - style, structured programming, verification concepts. Testing - testing purpose, levels of testing, black box testing, white box testing, different test case generation approaches, Other topics - object oriented, metrics, standards, industrial practices.

CS 498 **B. TECH. PROJECT- I**

L-T-P-D-[C]
0-0-12-0-[6]

CS 601 **COMPUTER SYSTEMS LAB** **Prereq. #**

L-T-P-D-[C]
0-1-3-0-[3]

Programming utilities, lab exercise for developing large system and application programs.

CS 602 **FUNDAMENTALS OF COMPUTER SYSTEMS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Basic concepts of operating systems, compilers, and data base management systems.

CS 603 **FUNDAMENTALS OF THEORETICAL COMPUTER SCIENCE** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Logic: basics of propositional and first order logic, completeness and compactness results. Some applications to computer science. (e.g., theorem proving, logic programming). Theory of computation: Church's thesis, undecidability. Computational complexity: time and tape bounds, time and tape bounded simulations, notion of complexity classes, classes P and NP, NP-completeness, some natural NP-complete problems.

CS 617 **DATABASE QUERIES** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Optimization and evaluation of relational queries: conjunctive query optimization, optimization of queries involving union and difference operators, algorithms for performing joins. Limitations of relational algebra as a query language. Fixed-point queries and Horn-clause queries. Optimization and evaluation of Horn-clause queries; filtering data flow method, magic set and generalized counting methods, clause and literal deletion problems. The boundedness problem, reducing the complexity of recursion, Duplicate clause removal. Incorporating functions, sets and negations into Horn-clause queries.

CS 618 **INDEXING AND SEARCHING TECHNIQUES IN DATABASES** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Index structures - R-tree, M-tree, VA-file, etc., Space-partitioning versus data-partitioning methods; Similarity queries - Range search, k-NN search, Self-join; Retrieval techniques - Fagin's Algorithm, Threshold Algorithm, Probabilistic Fagin's; Vector Space - embedding, properties; Dimensionality reduction - SVD, PCA, FastMap, Wavelets, Fourier transform, etc.; Distance measures - Lp norm, Mahalanobis distance, Kullback-Leibler divergence measure, Earth Mover's Distance, etc.; Data compression - Wavelets, Fourier, V-optimal histograms;

CS 619 **ADVANCES IN DBMS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

User interfaces: forms, graphics, semi-graphics, spread sheet, natural language. Query optimization: techniques like query modification; Object oriented databases: notion of abstract data type, object oriented systems, object oriented db design. Expert data bases: use of rules of deduction in data bases, recursive rules. Fuzzy data bases: fuzzy set and fuzzy logic, use of fuzzy techniques to define inexact and incomplete data bases.

CS 621 **TOPICS IN CONTEMPORARY MICROARCHITECTURE** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Performance as well as non-performance issues in current microarchitecture research and development. Modern techniques to fight control dependence (advanced branch predictors), and data dependence (perfecting algorithms, data speculation techniques), and techniques to scale microarchitectures for supporting large number of in-flight instructions. Design of microprocessors for low power, reliability, and security. Power/performance trade-offs and metrics, transient fault detection and recovery, designs for reliability and hardware level security (memory integrity and code pointer protection).

CS 622 L-T-P-D-[C] 3-0-0-0-[4]

ADVANCED COMPUTER ARCHITECTURE **Prereq. #**

Single-threaded execution, traditional microprocessors, DLP, ILP, TLP, memory wall, Parallel programming and performance issues, Shared memory multiprocessors, Synchronization, small-scale symmetric multiprocessors on a snoopy bus, cache coherence on snoopy buses, Scalable multiprocessors, Directory-based cache coherence, Interconnection network, Memory consistency models, Software distributed shared memory, multithreading in hardware, Chip multiprocessing, Current research and future trends.

CS 623 L-T-P-D-[C] 3-0-0-0-[4]

VLSI DESIGN FOR PARALLEL ARCHITECTURES **Prereq. #**

Introduction to hierarchical structural design. Role of CAD in VLSI design process. Techniques and algorithms for symbolic layout and routing. CMOS processing technology, CMOS building block. Use of pipelining and parallelism, self-synchronized designs, VLSI computing structures. Introduction to systolic arrays, mapping algorithms on systolic arrays, design of systolic arrays, system examples and design exercises

CS 624 L-T-P-D-[C] 3-0-0-0-[4]

TOPICS IN EMBEDDED SYSTEMS **Prereq. #**

Current topics in the design, specifications and analysis of embedded systems. Contemporary topics such as specifications of embedded systems, analysis of embedded systems, interface to the real-time operating systems, design case studies, design methodologies, etc. Other topics may include verification of embedded systems like formal verification, co-simulation, etc., estimation of hardware and software costs, partitioning, synthesis (hardware, software, memory, bus), retargetable usage of the software, specification and verification of the OS schedules, hard and soft real-time operating systems, and fault tolerant systems.

CS 625 L-T-P-D-[C] 3-0-0-0-[4]

ADVANCED COMPUTER NETWORKS **Prereq. #**

Introduction: Overview of computer networks, seven-layer architecture, TCP/IP suite of protocols, etc. MAC protocols for high-speed LANs, MANs, and wireless LANs. (for example, FDDI, DQDB, HIPPI, Gigabit Ethernet, Wireless ethernet, etc.) Fast access technologies. (For example, ADSL, Cable Modem, etc.) ATM Networks. ATM layer. ATM Adaptation Layers. Congestion control. Signalling, Routing, QoS support, Neighbour-disconery, Auto-configuration. Changes to other protocols. Application Programming Interface for IPv6. Mobility in networks. Mobile IP. Security related issues. IP Multicasting. Multicast routing protocols, adderss assignments, session discovery, etc. TCP extensions for high-speed networks, transaction-oriented applications. Other new options in TCP. Network security at various layers. Secure-HTTP, SSL, ESP, Authentication header, Key distribution protocols. Digital signatures, digital certificates.

CS 626 **FAULT TOLERANT COMPUTING SYSTEMS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

The course will discuss the principles and practice of fault tolerance in software and distributed systems. Some of the topics to be covered in the class are: system model - error, failure, faults, software fault tolerance, Byzantine agreement, fail- stop processors, stable storage, reliable and atomic broadcasting, process resiliency, data resiliency and recovery, commit protocols, reliability modeling & performance evaluation, crash recovery in databases, and voting methods.

CS 628 **COMPUTERS SYSTEM SECURITY** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction: need and basic goals for computer security, security threats etc.

Cryptographic building blocks: Symmetric and asymmetric key cryptography, cryptographic hash functions, digital signature schemes etc., with representative applications for each. Operating System Security: Low-level protection mechanisms, access control: models for access control, some confidentiality, integrity, and hybrid models of access control such as Bell-La Padula, Biba, Chinese Wall etc., discretionary v/s mandatory access control.

Case studies: Java access control policy specifications, SELinux security model and implementation. Program flaws: Bugs which have security implications such as buffer overflows, race conditions etc. Malicious code: Viruses, worms, Trojan horses; how they work and how to defend against them.

Network Security: problems in network security; kinds of attacks, PKI, key exchange protocols, example protocols such as PGP, Kerberos, IPSEC/VPN, SSL, S/MIME etc. Protocol vulnerabilities: examples of protocol vulnerabilities such as in TCP/IP, denial of service attacks etc. Tools for network security such as firewalls and intrusion detection systems.

References :

CS 632 **TOPICS IN DISTRIBUTED SYSTEMS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Local area networks, concurrency control and recovery, distributed languages and communication primitives, file servers, case studies of distributed systems.

CS 633 **PARALLEL COMPUTING** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction: Paradigms of parallel computing: Synchronous - vector/array, SIMD, Systolic; Asynchronous - MIMD, reduction paradigm. Hardware taxonomy: Flynn's classifications, Handler's classifications. Software taxonomy: Kung's taxonomy, SPMD. Abstract parallel computational models: Combinational circuits, Sorting network, PRAM models, Interconnection RAMs. Parallelism approaches - data parallelism, control parallelism. Performance Metrics: Laws governing performance measurements. Metrics - speedups, efficiency, utilization, communication overheads, single/multiple program performances, bench marks. Parallel Processors: Taxonomy and topology-shared memory mutli-processors, distributed memory networks. Processor organization - Static and dynamic interconnections. Embeddings and simulations. Parallel Programming: Shared memory programming, distributed memory programming, object oriented programming, data parallel programming, functional and dataflow programming. Scheduling and Parallelization: Scheduling parallel programs. Loop scheduling. Parallelization of sequential programs. Parallel programming support environments.

CS 634 **MOBILE COMPUTING** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction: Mobile computing a vision for future, ubiquitous computing versus virtual reality, software models for mobile computing. Data management Issues. Distributed algorithms and mobility: structuring distributed algorithms for mobile computing environments, token ring algorithm. Publishing and accessing data in the air: pull and push based data transfers, data dissemination by broadcast, treating air as cache, energy efficient indexing in air. Handoff management: handoff detection, failures, channel assignments. Location Management: two-tier HLR-VLR scheme, mobile IP, hierarchical tree based scheme, regional directories, distributed location management. Approximate query processing: concept hierarchy, summary database, updates and view maintenance, approximate query processing. Mobile Transaction Models. Mobile Computing: technological prospective: 1-G, 2-G and 3-G network and services, the Internet, mobile computing and cellular telephony, voice and data services on 3G networks, battery problem and power dissipation, low energy processors. File system support for mobile computing: Coda and Bayou file systems. Ad-hoc network routing protocols: DSDV, GSR, FSR, DSR, AODV.

CS 640 **COMPUTATIONAL COMPLEXITY** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Complexity Classes. NP and co-NP, Results on structure of NP-complete sets, Sparse NP-hard sets, Basic Inclusions and Separations, Nondeterministic Space Classes, Logarithmic Space, A PSPACE complete problem, Polynomial Hierarchy, PH through Alternating Quantifiers, Universal Relations, Probabilistic Classes, Schwartz-Zippel Lemma and BPP, BPP and its relationship with other Complexity Classes

CS 641 **MODERN CRYPTOLOGY** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Basics of finite fields. Private and Public-key cryptography, existing cryptosystems and their security. Cryptanalysis of existing systems. Zero-knowledge protocols, One-way functions. Advanced protocols for different applications, e.g. e-cheque, e-cash etc. Network and System level security issues.

CS 642 **CIRCUIT COMPLEXITY THEORY** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

The course aims at a comprehensive overview of results on the circuit complexity classes and their relationship with the Turing based classes. The topics to be covered in the course are as follows: The class NC and its properties. Characterization of class P by circuits. The classes DLOG, NLOG, LogCFL and their properties. The class SC, proof of the relationship RL is a subset of SC. The class NC1 and its characterizations. The class TC0 and its characterizations. The class ACC and its characterizations. The class AC0 and its charecterizations. Lower bounds for AC0, for AC0[m] where m is a prime power and for TC02.

CS 643 **ABSTRACT STATE MACHINES: THEORY AND PRACTICE** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Examples of sequential abstract state machines (ASMs, for short) specifying some familiar algorithms. Proof of sequential ASM thesis which states that all sequential algorithms can be captured by sequential ASMs. Computations with abstract structures, choiceless polynomial time. ASM specification of parallel and distributed algorithms. ASM methodology for specifying semantics of programming languages, and for verification. Comparison of ASM approach with other existing methodologies for specification and verification. ASM defined fine complexity classes. ASMs and meta-finite models.

CS 644 **FINITE AUTOMATA ON INFINITE INPUTS** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Finite automata on infinite words and trees: Complementation, determinization and algorithms for checking emptiness.

Connections with logic: Finite automata and monadic second order (MSO) logic on words and trees. Decidability of MSO theory of various infinite graphs, methods of interpretation and unfolding.

Applications: Decision procedures for temporal logics. Modelling, verification and synthesis of systems. Effective theory of infinite games.

CS 645 **TOPICS IN DESIGN AND ANALYSIS OF ALGORITHMS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction. Disjoint set Union-Find algorithms. Red-black trees. Selection algorithms and application to convex hull. Planar graph separators. Priority queues. Fusion trees and their applications to integer sorting. F-heaps, R-heaps, Q-heaps and AF-heaps and general shortest paths and minimum spanning trees algorithms. Polynomial time algorithms for matching.

CS 646 **PARALLEL ALGORITHMS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Complexity measure for parallel algorithms. Parallel combinatorial algorithms: permutations with and without repetitions, combinations, derangements. Parallel searching algorithms: maximum/minimum, median, K-th largest/smallest element. Parallel sorting algorithms. Parallel graph algorithms: parallel graph search and tree traversal algorithms, parallel algorithms for connectivity problems, parallel algorithms for path problems.

CS 647 **ADVANCED TOPICS IN ALGORITHMS AND DATA STRUCTURES** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

The course intends to deal with advanced aspects of algorithm: design and analysis including data structures, analysis and lower bound proofs, amortized complexity of algorithms. Fibonacci heaps and self-adjusting search trees, Splay trees, linking and cutting trees. State-of-the-art algorithms for minimum spanning trees, shortest path problem. Network flows - preflow-push algorithms, max flow algorithm, and scaling algorithms. Matching, blossoms, Micali-Vazirani algorithm. Lower bound theory for parallel computations.

CS 648 **RANDOMISED ALGORITHMS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Review of discrete probability; Notion of randomized algorithms, motivating examples; Markov, Chebyshev inequalities, Chernoff bounds; Probabilistic method; Hashing, fingerprinting; Random walks and Markov chains. Program checkers; Polynomial identities; Randomized complexity classes, Probabilistically checkable proofs; some number theoretic problems; Approximate counting.

CS 649 **LOGIC IN COMPUTER SCIENCE** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

The aim of this course will be to provide introduction to some applications of logic in computer science. Following are some possible topics. At least three of these will be covered in some detail. Communication and Concurrency: Processes as transition systems, operations on these processes (composition, hiding etc.). Bisimulation and observational equivalences. Calculus of mobile systems: pi-calculus. Some theory related to pi calculus. Logics to reason about transition systems, LTL, CTL* and modal mu calculus. Reasoning about Knowledge: Knowledge as modality, axioms of knowledge. Common knowledge, distributed agents exchanging messages, agreeing to disagree. Logical omniscience. Finite Model Theory: Expressiveness of FO and its extensions on finite structures. Games for lower bounds. Connections with complexity classes, role of order on the domain. Feasible Proofs: Propositional proof systems for tautologies. Simulation and lower bounds on length of proofs for specific systems (e.g. PHP requires superpolynomial length using resolution). Theories of weak arithmetic, provably total functions and relations to complexity theory. Full Abstraction problem for PCF: PCF as an extension of lambda calculus. Operational and denotational semantics and the full abstraction problem. Solutions to the full abstraction problem. Games semantics.

CS 650 **TOPICS IN LAMBDA CALCULUS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Optimal reductions in lambda calculus: Levy's formalization of the problem, Lamping's algorithm and its correctness. Connections to linear logic and geometry of interaction. Inherent complexity of implementing optimal reductions.

Categorical semantics of lambda calculus: Introduction to category theory. Cartesian closed categories and typed lambda calculus. Relation to deductive systems. Categories with reflexive elements, a construction by D. Scott.

Games semantics: Games semantics for lambda calculus. Solution to full abstraction problem via games. PCF, an extension of typed lambda calculus.

CS 653 **FUNCTIONAL PROGRAMMING** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

ML (CAML dialect); X-calculus and combinators; abstraction and higher order functions; lazy and eager evaluation; types, polymorphism and type inference; Equations and pattern matching; SECD machine; denotational semantics of functional languages; implementing functional languages.

CS 654 **SOFTWARE ARCHITECTURE** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

In this course we study, typical software system structures (architectural styles), techniques for designing and implementing these structures, models for characterizing and reasoning about architectures, and tools for architectural modelling. Role of architecture in Software engineering; Enterprise Architectures, Zachman's Framework; Architectural Styles, Design Patterns; Architecture Description Languages; Product-line architectures; Component based development.

CS 655 L-T-P-D-[C] 3-0-0-0-[4]

OBJECT ORIENTED SOFTWARE MODELING **Prereq. #**

Unified Modeling Language, (UML), Use case modeling, Methodologies for object-oriented analysis and design (OOAD), Design patterns, CASE tool support for OOAD and automatic code generation, Precise modelling (using OCL-Object Constraint Language) and analysis of software models, Model-driven architecture (MDA), Modeling language design:metamodeling, UML Profiles, Advanced modeling topics: Aspect oriented modeling, Modeling non functional properties, round-trip engineering, model-based testing, open research questions.

CS 660 L-T-P-D-[C] 3-0-0-0-[4]

FUNDAMENTALS OF INTERACTIVE COMPUTER GRAPHICS **Prereq. #**

Overview of the programmer's model of interactive graphics. Computer graphics and image processing and techniques. Implementation of a simple graphics package. Geometric transformations, viewing transformations, advanced display architecture. Raster algorithms and software. Techniques of visual realism. Algorithms for hidden edge and surface removal. Shading models, colour displays and concepts of shadows.

CS 663 L-T-P-D-[C] 3-0-0-0-[4]

COMPUTATIONAL GEOMETRY **Prereq. #**

Historical perspective: complexity notions in classical geometry. Towards computational geometry, geometric preliminaries, models of computation. Geometric searching: point location problems, location of a point in a planar subdivision, the slab method, the chain method, range - searching problems. Convex hulls: problem statement and lower bounds. Graham's scan, Jarvis's march, quick hull technique, convex hulls in more than one dimension, extension and applications. Proximity: divide and conquer approach, locus approach; the Voronoi diagram, lower bounds, variants and generalizations. Intersections, hidden-line and hidden surface problem. The geometry of rectangles: application of the geometry of rectangles, measure and perimeter of a union of rectangles, intersection of rectangles and related problems.

CS 664 L-T-P-D-[C] 3-0-0-0-[4]

ALGORITHMS IN COMBINATORIAL GEOMETRY **Prereq. #**

Basics: fundamental concepts in combinatorial geometry, permutation tables, semispaces of configurations, dissection of point sets, zones in arrangement, the complexity of families of cells. Fundamental algorithms: constructing arrangements, skeletons in arrangements, linear programming, planar point location search. Applications: problems for configurations and arrangements, separation and intersection in the plane.

CS 665 **ARTIFICIAL INTELLIGENCE** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Approaches to artificial intelligence. Search: state space, and/or and game tree search. Production systems: design, implementation and limitations, case studies. Knowledge representation: semantic networks, predicate calculus, structural/causal networks. Current issues: inference control, theorem proving, deduction, truth maintenance, planning. Case study of one or more examples from natural language processing, question answering, vision, expert systems, etc. Philosophical issues.

CS 671 **INTRODUCTION TO NATURAL LANGUAGE PROCESSING** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

A computational framework for natural language. A framework such as LFG, GPSG or Panini in some depth. Partial description of English or an Indian language in the frame work, lexicon, algorithms and data structures for implementation of the framework. Introduction to semantics and knowledge representation. Some applications like machine translation, database interface.

CS 672 **NATURAL LANGUAGE PROCESSING SEMANTICS** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Introduction to semantics, semantic interpretation, knowledge representation, context and world knowledge, plans and actions, discourse structure, belief models, speech acts. Selected applications.

CS 673 **MACHINE TRANSLATION** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Overview of Natural Language Processing; Syntax, semantics, context and world of knowledge; Strategies for machine translation, Direct, Transfer and Interlingua approaches; Rule based, Example based on Hybrid Methodologies; Construction of lexical data-base, Text generation, Machine-aided translation, user interfaces; Examples of English-Hindi and Hindi-English machine translation.

CS 674 **MACHINE LEARNING AND KNOWLEDGE DISCOVERY** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

This course will explore different machine learning, knowledge discovery and data mining approaches and techniques: Concept Learning, Decision Tree Learning, Clustering and instance based learning, Rule induction and inductive learning, Bayesian networks and causality, Neural networks, Genetic algorithms, Reinforcement learning, Analytical, learning.

CS 676 **COMPUTER VISION AND IMAGE PROCESSING** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Human and Computer Visioon, Image Representation and Modelling, Line and Edge detection, labeling, Image Segmentation. Pattern Recognition: Statistical, Structural, Neural and Hybrid Techniques. Training and Classification. Document Analysis and Optical Charecter Recognition. Object Recognition Scene Matching and Analysis, Robotic Vision. Role of Knowledge.

CS 678 **LEARNING WITH KERNELS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Course Contents :

Kernel based methods in machine learning have become a major paradigm in machine learning in the last decade. The methods have also found widespread application in pattern classification problems. This course aims to fist discuss the basic principles of kernel based learning methods and then branch off into some areas of current research like : techniques for finding optimal kernels, error bound analysis novelty detection etc.

CS 680 **CATEGORY THEORY AND APPLICATIONS IN COMPUTING** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction: Basic definition and diagram; sources and sinks; monicity and epicity; isomorphisms of objects and morphisms; duality; Universal Structures: Initial terminal and zero; Category of sources and sinks; product; equalizer; regular epicity and monicity; pullback; completeness; kernel; Normal Categories: Normal hierarchy; extension of categories; factorization; chains and exactness; Morphism algebra: Biproduct; semi-additive category; Additive category; Functors: Natural transformation; categories on natural transformation; property preserving and reflecting functors; Diagram isomorphism; Similar categories; generalization of limit and colimit; H-reflection morphism and adjoint functor; Representable functors Category in context of another category; Application to Logic (Topoi); application to Programming Languages.

CS 681 **COMPUTATIONAL ALGEBRA AND NUMBER THEORY** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Elementary operations: the complexity of basic operations like additions, multiplications for integers and polynomials. Polynomials: The complexity of factorization, irreducibility testing, ideal membership etc for polynomials over finite fields. Motivating example: Reed-soloman codes. Integer Lattices: the complexity of finding a short vector in an integer lattice. Motivating example; polynomial factorization. Integers: The complexity of factorization, primality testing, discrete log computation etc for integers. Motivating examples: RSA and El Gamal cryptosystems. Elliptic curves: the complexity of addition, point counting etc. for elliptic curves. Motivating examples: Elliptic curve cryptosystems and integer factoring.

CS 699 **M. TECH. THESIS**

L-T-P-D-[C]
0-0-0-0-[4]

CS 697 **SPECIAL TOPICS IN COMPUTER SCIENCE & ENGINEERING** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Special and advanced topics in different areas of Computer Science and Engineering will be covered under this course.

CS 698G **PERFOMANCE AND AVAILABILITY OF COMPUTER**

Prereq. # Instructor's Consent

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to probability and stochostic processes in Computer science and engineering applications, exposure to methods of reliability and performance analysis of hardware and software systems. Analytical methods including fault trees, Markov chains, Markov reward models, stochastic Petri nets and queuing networks; Specifying and solving analytical models using SHARPE (Symbolic Hierarchical Automated Reliability and Performance Evaluator) software package.

CS 698T **WIRELESS NETWORKING: PRINCIPLES AND PRACTICE**

Prereq. # EM theory for EE students, Computer Networks for CSE Students

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to wireless communication; RF signal propagation, overview of modulation techniques, basics of equlization, diversity and channel coding, Multiple access techniques; Case studies related to IEEE 802.11, Bluetooth and GSM. Special Topics such as Antennas, Mobile Cellular Telephony, Mobile IP: Mobility and the internet.

CS 719 **INTRODUCTION TO DATA STREAMS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Motivating applications: network monitoring, sensor networks, need for highly efficient processing of high speed and high volume data streams, Space and time efficient randomized algorithms as a candidate solution, models of data streams. Basics of randomization: elementary probability theory, expectation, linearity of expectation, variance, Markov and Chebychev's inequality, Chernoff and Hoeffding (CH) tail inequalities, hash functions, limited independence, CH-bounds for limited independence.

Finding frequent items in data streams, Estimating distinct item queries, Estimating frequency moments, estimating join sizes, Approximate histograms over data streams, Transforms over data streams, wavelets, fourier and DCT clustering over data streams, Applications to graphs.

CS 720 **VLSI TESTING AND FAULT-TOLERANCE** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

The course is primarily intended to familiarize students with the problem of testing large and complex electronic circuits. Various techniques to solve this problem and concepts of design for easy testability (DFT) will be discussed. Topics related to fault-modeling and fault-simulation to evaluate the fault-coverage of test vectors will be covered in detail. The problem of reduced yield and reliability of circuits in presence of faults will be discussed and techniques to improve the yield and reliability of these circuits by introducing fault-tolerance measures will also be covered.

Various redundancy techniques like structural, time, information and software redundancy will also be discussed in detail.

CS 725 **TOPICS IN NETWORKING** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Recent developments in various fields in networking, including but not limited to, routing, flow control, performance evaluation, transport protocols, application protocols, real-time protocols, and network architectures. Emerging technologies such as, ATM, SMDS, Frame-relay, SONET, ISDN. Issues in Gigabit networking. Network related issues in development of multi-media applications.

CS 726 **TOPICS IN MULTIMEDIA** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Multimedia systems - requirements, technology. Coding and compression standards - JPEG, MPEG, etc. Architecture issues in multimedia. Desk area networks. Operating Systems Issues in multimedia - real-time OS issues, synchronization, interrupt handling, etc. Database issuses in multimedia - indexing and storing multimedia data, disk placement, disk scheduling, searching for a multimedia document. Networkng issues in multimedia - Quality-of-service guarantees, resource reservation, traffic specification, shaping, and monitoring, admission control, etc. Multicasting issues. Session directories. Protocols for controlling sessions. Security issues in multimedia - digital watermarking, partial encryption schemes for video streams. Multimedia applications - audio and video conferencing, video on demand, voice over IP, etc. Latest developments in the field of multimedia.

CS 727 **TOPICS IN INTERNET TECHNOLOGIES** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Today the Internet is being used for myriad of applications - electronic publishing, electronic commerce, distance education, collaborative working, etc. This course intends to investigate the underlying principles and practices that support these applications. Introduction to computer networks; Content preparation- HTML, DHTML, VRML, SGML, XML and other markup schemes; Images - compression, formats; Audio - compression, formats; Content Delivery - protocols - HTTP and variants, Internet servers, proxy servers; Search engines; Data on the web; Content Display - browsers, plugins, helper applications; Interactivity - Java, Active-X; Component technologies, Javabeans, CORBA;

Security, Electronic payment systems, Firewalls, Encryption, Watermarks; Performance, Benchmarking the Web.

CS 728 **TOPICS IN GRID COMPUTING** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Overview: definition of grid; basic building blocks; issues in management of grid models; evolution of grid models.

Grid architecture: requirements concerning abstractions, behaviors, resources, connectivity, and protocols; Open grid service architectures. Environment: Overview of GCE; programming models; middleware for building grid computing environments; tools based on RCP, RMI, web service and P2P models; language support (MPI-G, MPI-G2, etc.) for grid computing; other grid programming support (I/O, fault tolerance, programming meta models for grid programming); security. Application case studies: Seti project, Sun grid engine, Skyserver and some national grid projects. Monitoring and debugging: scheduling; performance tuning; debugging and performance diagnostic issues.

CS 730 **TOPICS IN OPERATING SYSTEMS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

This course will cover some advanced topics in Operating Systems, such as, issues in multiprocessor operating systems, real-time operating systems, advanced file system topics, and distributed systems.

CS 738 **ADVANCED COMPILER OPTIMIZATIONS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction to Advanced topics, Compiler Algorithms Notation, Symbol table structure, Intermediate representation, Run time support, Producing code generators automatically, Control flow analysis, Data flow analysis, Dependence analysis and dependence graphs, Alias analysis, Introduction to optimizations, Early optimizations, Redundancy elimination, Loop optimizations, procedure optimizations, Register allocation, Code scheduling, control flow and low level optimizations, Inter procedural Analysis and optimizations, Optimization for memory hierarchy, Case studies.

CS 740 **TOPICS IN LOGIC AND COMPUTATION** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Curry-Howard isomorphism between typed terms of formal systems representing computable functions and deductions in certain logics. Simply typed lambda calculus, Gödel's system T and Girard's system F. Strong normalization. Semantics. Expressibility of these — how higher order functions and polymorphism add to expressibility. Connection with provably recursive functions in systems of arithmetic. Polynomial time logic.

CS 741 **STRUCTURAL COMPLEXITY** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Survey of basic background: models of computations and resource bounded computations. Central complexity classes, notion of complete problems in a class, polynomial time reducibilities and how these relate to each other.

Structure of NP complete sets, p-isomorphism conjecture. Sparse sets in NP. Self reducibility. Relativised classes. Nonuniform complexity. Uniform diagonalization. Polynomial time hierarchy. Interactive proof systems.

CS 742 **PARALLEL COMPLEXITY AND SUB-LOGARITHMIC TIME ALGORITHMS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

VLSI theory of complexity. Theory of log-space completeness. Structure of NC. Unbounded fan-in circuits. CRAM model and allocated PRAM models. Sublogarithmic time algorithms for Parallel symmetry breaking, parallel prefix computation, ordered chaining, nearest largers, Delaunay triangulation and convex hull. Optimal NC algorithms for deterministic list ranking triconnectivity and task Scheduling.

CS 743 **ADVANCED GRAPH ALGORITHMS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Review of important sequential graph algorithms. Introduction to parallel models for computation. General techniques for fast parallel computations on vectors and lists and their applications to design of efficient parallel graph algorithms. Parallel dynamic programming and its applications to expression graphs. State-of-art algorithms for depth first search of directed and undirected graphs. NC-algorithms for ST-numbering and open ear decomposition. Parallel algorithms for graph optimization problems. Algorithms for graph coloring. Decomposition of graph into simpler subgraphs. Equivalence relations and classes in graphs. Parallel planarity testing.

CS 744 **PSEUDO-RANDOM GENERATORS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Pseudo-random generators are efficiently computable functions that stretch and input random string to a much bigger sized string such that the output string appears random to resource-bounded computations. These functions have become one of the fundamental objects to study in complexity theory because of their utility. They are used to derandomize randomized algorithms, formalize notions of cryptographic security, obtain lower bounds on the complexity of problems etc. (unfortunately, as of now very few constructions of pseudo-random generators are provably known although many are conjectured). In this course, we study pseudo-random generators and their connections in depth. The topics covered in the course are as follows :

Pseudo-random generators: definitions and Existence. Pseudo-random generators of small stretch: Definitions of cryptographic security, Equivalence of one-way functions and pseudo-random generators, Some functions conjectured to be one-way functions, Pseudo-random function generators.

Pseudo-random generators of large stretch: Equivalence of lower bounds and pseudo-random generators, Known pseudo-random generators against small depth circuits and small space classes, Extractors and pseudo-random generators.

Pseudo-random generators against arithmetic circuits: Equivalence of lower bounds and pseudo-random generators, A function conjectured to be pseudo-random.

CS 755 **TOPICS IN SOFTWARE ENGINEERING** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

This is a research-oriented, seminar type course which will focus on the state-of-the-art in various areas of Software Engineering–Software project management, Metrics and measurement, Software configuration management, Software risk management, Requirements engineering, Software quality assurance, Software reliability models, Object oriented design, Object oriented programming (with C++), Formal specifications, Formal verification of programs, lackson method for design, CASE tools and technology, Cleanroom method for software development, Information system design, Real-time software specification and design.

CS 781 **COGNITION: MEMORY** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Types of memory, Features (esp. behavioural) of memory, Experimental evidence from: Psychology (human/animal subjects), nerophysiology, neurochemistry and imaging, brain lesions and damage in human animals, Models: Schema, Sparse distributed memory, pandemonium, Copy cat, Society of mind, matrix, SAM, TODAM, connectionist.

CS 782 **COGNITIVE SEMANTICS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Cognitive Semantics seeks to relate linguistic expressions to conceptual structures in the context of a speech act. The objective of this course is to explore the cognition-language mappings.

CS 784 **LANGUAGE ACQUISITION** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Part A: Child Language Acquisition: Methodology: Diary studies, Large sample studies, Longitudinal studies. Developmental stages: Prelinguistic development: Onset of perception, Phonological development. Linguistic development: Lexicon, holophrasis, under/overextensions; Morphology and syntax (Grammar), telegraphic speech, compositionality, syntax in lexical development; universals and parameter setting, Discourse organization, deictic reference, discourse dependencies, speech acts and implicature. Bilingual language development: Syntactic and semantic processing; Differentiation, transfer and decay. Non-normal language develop.ment: Phonological, grammatical and pragmatic impairments.

Part B: Artificial life, agent based and evolutionary approaches to language acQuisition. Some topics from the following will be discussed. 1. Communicative aspects of language. Origins and use of signs, symbols, words, compositional structures in communication. Origins of a lexicon in multiple agent systems, simulation experiments. Emergence/evolution of syntax in multiple agent systems, simulation experiments. Learning mechanisms and constraints from computational learning theory. Emergence/evolution of language universals. Grounding of linguistic entities. Emergence/evolution of intentional and semantic aspects of language. Optimality theory and optimality arguments.

CS 789 **SPECIAL TOPICS IN LANGUAGE ACQUISITION AND ORIGINS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Child's acquisition of phonology, lexicon, syntax, semantics, pragmatics, and mappings; Grounding issues in language acquisition; Origin and evolution of speech sounds, lexicon, syntax, semantics, intentional use, Agent and population models, Bootstrapping, Modularity-nonmodularity debate; Critical periods; Rules vs connectionist approaches; Sign language, synchronic and diachronic change, creolization.

CS 797 **SPECIAL ADVANCE TOPICS IN COMPUTER SCIENCE** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

CS 799 **Ph. D. THESIS**

CORE PROGRAMME

For Students of B.Tech., B.Tech.-M.Tech. (Dual Degree) and M.Sc. (Integrated) Programmes

		Structure A	Structure B
FIRST YEAR	**Semester I**	**CHM 101 + PHY 101** **ESC 101** **ENG 112** **MTH 101** **PHY 102** **PE 101**	**ESC 102** **TA 101** **HSS-I** **MTH 101** **PHY 102** **PE 101**
	Semester II	**ESC 102** **TA 101** **HSS-I** **MTH 102** **PHY 103** **PE 102**	**CHM 101 + PHY 101** **ESC 101** **ENG 112** **MTH 102** **PHY 103** **PE 102**
SECOND YEAR	**Semester III**	**CHM 201** **COM 200** **D-1** **MTH 201** **ESO-I** **ESO-II**	**CHM 201** **COM 200** **D-1** **MTH 201** **ESO-I** **TA 201**
	Semester IV	**D-2** **D-3** **HSS-I** **EL** **ESO-I** **TA 201**	**D-2** **D-3** **HSS-I** **EL** **ESO-I** **ESO-II**
One half of the batch is assigned Structure A and the other half is assigned Structure B			

CHM 101 PHY 101
ESC 102 Introduction to Electronics
CHM 101 Chemistry Lab.
PHY 101 Physics Lab.
ENG 112/HSS-I
ENG 112 English Language and Composition
HSS-I Level I Course in Humanities and Social Sciences
ESC 101 Fundamentals of Computing
TA 101 Engineering Graphics
MTH 101 Mathematics - I
PHY 102 Physics - I
PE 101 Physical Exercises I
CHM 101 Chemistry Lab. and PHY 101 Physics Lab
ESc 102 Introduction to Electronics
ESC 101 Fundamentals of Computing
TA 101 Engineering Graphics
D 100 Introduction to Profession

MTH 102 Mathematics - II
PHY 103 Slow Pace
PHY 103 Physics - II
PE 102 Physical Exercises II
CHM 201 Chemistry
Com-S 200 Communication Skills
D 1 Departmental course
ESO - I Engineering Science I
ESO - II Engineering Science II
MTH 203 Mathematics - III
TA 201 Introduction to Manufacturing Processes
HSS - I Level I course in HSS
ESO - I Engineering Science I
ESO - II Engineering Science II
D2 & D3 Departmental Courses
EL - I Open Elective
TA 201 Introduction to Manufacturing Processes

CORE COURSES

CHM 101 **CHEMISTRY LABORATORY**

L-T-P-D-[C]
0-1-3-0-[2]

Permanganometric Titrations, Acid - Base titrations, Iodometric titrations, Complexometric titrations, Dichrometric titrations, Recycling of aluminium, Preparation and analysis of a metal complex, Polynuclear metal complexes with multidentate briding ligands, Chromatography of natural pigments, Viscosity of solutions, Chemical kinetics, Heterogeneous equilibrium, Photochemical oxidation - reduction, Application of free electron model, Spectrophotometric estimation, Synthesis of antioxidants used as food preservatives, Preparation of polymer films, Preparation of azo-dyes and dyeing, Resolution of commercial Ibuprofen.

CHM 201 **CHEMISTRY**

L-T-P-D-[C]
3-1-0-1-[4]

Physical Principles: Experimental methods of structure determination, Systems at finite temperature, Molecular reaction dynamics. Chemistry of Molecules: Introduction to molecules, Principles and applications of Transition Metal ion chemistry, Organometallic chemistry, Green chemistry, Structure of organic molecules, Synthesis of organic molecules, Photochemistry of organic and biomolecules, Chemistry of life processes, Biotechnology and Biomedical applications.

ESC 101 **FUNDAMENTALS OF COMPUTING**

L-T-P-D-[C]
3-1-3-0-[5]

introduction to Linux, the programming environment, write and execute the first program, introduction to the object oriented (OO) approach-classes, objects, state through member variables, interface through member functions/ methods. Give many examples of (OO) approaches to problem solving in science and engineering, Procedural programming, Introduction to basic input-output - Assignment and expressions, Control: if, if-then-else, case, go, continue, break, Loops, interators, enumerations examples form algebraic equation solving, Function as a procedural abstraction, argument passing, references, Basic containers: Array, Vector, examples from solving systems of linear equations, Recursion, Object-oriented aspects, Programming using classes and objects, Scope, encapsulation, visibility, Inheritance, subtypes, static-dynamic binding, Primitive types, classes as types, wrapper classes for primitive types

Java i/o system, More container classes-list, hashtable, set, sortedset, algorithms which use these classes, Interfaces.

ESC 102 **INTRODUCTION TO ELECTRONICS**

L-T-P-D-[C]
3-1-3-1-[5]

Passive components, Signal sources, DC circuit analysis, Time domain response of RC and RL circuits, Discrete electronic devices, Sinusoidal steady state response, phasor, impedance, Two port network, basic feedback theory, frequency response, transfer function, DC Power supply, BJT biasing, Simple transistor amplifier, differential amplifier, Op-amp, Circuits using op-amp, Waveform generators, 555 timer, Simple active filters, Logic gates, multiplexers, combinatorial circuits, Combinatorial circuit design, K-map, Sequential circuits, Flip-flops, Counters, shift registers, sequence generators, DA converters, AD converters, Basic micro-computer architecture.

Laboratory Experiments : Familiarization with passive components, function generator and oscilloscope, Step and frequency response of RC and RL circuits, Some electronic components and their characteristics, DC power supply, Voltage amplifiers using op-amp, Comparators, Schmitt trigger and Active filters, Waveform generators using op-amp and 555 timer, Combinatorial circuits, Sequential circuits, Digital-to-analog converters and analog-to-digital converters.

ESO 202 **THERMODYNAMICS**

L-T-P-D-[C]
3-1-0-1-[4]

Definitions & concepts: SI Units; System; Property; Energy; Thermodynamic Equilibrium; Work, State Postulate; Zeroth Law of Thermodynamics; Temperature Scale, Thermodynamic Properties of Fluids: Mathematical, Tabular and Graphical representation of data; Ideal gas Van der Waals Equation of state; Compressibility chart; Thermodynamic Diagrams including Mollier diagram; Steam Tables, First law of Thermodynamics & its applications to Non flow processes, Applications of First Law of Thermodynamics of Flow Processes; Steady state Steady flow and Transient flow processes, Applications of First Law of Thermodynamics to Chemically Reacting Systems Second Law of Thermodynamics & its Applications, Thermodynamic Potentials, Maxwells Relations; Thermodynamic Relations and Availability, Power Cycles, Refrigeration Cycles; SI Units, Definitions & Concepts: System, Property, Energy, Thermodynamic Equilibrium, Work interaction & various modes of work, Heat, State Postulate, Zeroeth Law of Thermodynamics, Temperature Scale, IPTS.

Thermodynamic Properties of Fluids: Pure substance. Phase, Simple compressible substance, Ideal gas Equation of state, van der Waals Equation of State; Law of corresponding states, Compressibility chart, Pressure-volume; Temperature-volume and Phase diagrams; Mollier diagram and Steam tables.

First Law of Thermodynamics & its consequences, Applications of First Law for elementary processes, First Law analysis of Non-flow processes; Use of steam tables & Mollier diagram, Application of First Law of Thermodynamics for Flow Process-Steady state, steady flow processes, Throttling process; Transient Flow Processes-Charging & discharging of tanks.

First Law Applications to Chemically Reacting Systems: Fuels & Combustion, Theoretical Air/Fuel ratio, Standard heat of Reaction and effect of temperature on standard heat of reaction, Adiabatic flame temperature.

Second Law of Thermodynamics & its Applications: Limitations of the First Law of Thermodynamics, Heat Engine, Heat Pump/Refrigerator. Second Law of Thermodynamics - Kelvin Planck and Clausius statements & their equivalence, Reversible & irreversible processes, Criterion of reversibility, Carnot cycle & Carnot principles, Thermodynamic Temperature scale, Clausius inequality, Entropy, Calculations of entropy change, Principle of entropy increase, T- S diagram, II Law analysis of Control volume.

Thermodynamic Potentials; Maxwell relations; Available energy, Availability; Second law efficiency. Thermodynamic relations, Jacobian methods, Clapeyron and Kirchoff equations, Phase rule.

Power Cycles: Rankine cycle- Ideal, Reheat and Regenerative Rankine cycles. Gas Power Cycles: Otto cycle, Diesel cycle, Dual cycle and Brayton cycle, Refrigeration Cycles: Vapor compression refrigeration, Absorption refrigeration and Gas refrigeration Cycles.

ESO 204 **MECHANICS OF SOLIDS, 3-1-0-1-4**

L-T-P-D-[C]
3-1-0-1-[4]

Free body diagram, Modelling of supports, Conditions for Equilibrium, Friction Force-deformation relationship and geometric compatibility (for small deformations) with illustrations through simple problems on axially loaded members and thin-walled pressure vessels, Force analysis (axial force, shear force, bending moment, and twisting moment diagrams) of slender members *(singularity functions not to be used*), Concept of stress at a point, Transformation of stresses at a point, Principal stresses, Mohr’s circle (only for plane stress case), Displacement field, Concept of strain at a point, Transformation of strain at a point, Principal strains, Mohr’s circle (only for plane strain case), Strain Rosette, Modelling of problem as a plane stress or plane strain problem, Discussion of experimental results on 1-D material behaviour, Concepts of elasticity, plasticity, strain-hardening, failure (fracture/yielding), idealization of 1-D stress-strain curve, Concepts of isotropy, orthotropy, anisotropy, Generalized Hooke’s law (without and with thermal strains), Complete equations of elasticity, Torsion of circular shafts and thin-walled tubes (*plastic analysis and rectangular shafts not to be discussed*), Bending of beams with symmetric cross-section (normal and shear stresses) (*shear centre and plastic analysis not to be discussed*), Combined stresses, Yield criteria, Deflection due to bending, Integration of the moment-curvature relationship for simple boundary conditions, Superposition principle (*singularity functions not to be used*), Concepts of strain energy and complementary strain energy for simple structural elements (those under axial load, shear force, bending moment, and torsion), Castigliano's theorems for deflection analysis and indeterminate problems, Concept of elastic instability, Introduction to column buckling, Euler's formula (*post-buckling behaviour not to be covered*)

ESO 208 **EARTH SCIENCE**
L-T-P-D-[C]
2-1-2-0-[4]

EARTH AS PLANET IN THE SOLAR SYSTEM: Introduction; Earth in relation to moon, meteorites and other members of the solar system; Comparison of internal structures; origin;

ATMOSPHERE AND OCEANS: Origin and evolution; Atmosphere-ocean interaction; Air pollution, Green house effect, Ozone layer; Ocean currents and waves

SOLID EARTH AND EARTH MATERIALS: Interior of the earth; Magmas, volcanoes and igneous rocks; Sediments and sedimentary rocks; Metamorphism and metamorphic rocks; Rock forming minerals; Crystal structure; Crystallographic methods; Optical properties; Radiometric age; Geological time scale.

PROCESSES THAT SHAPE THE EARTH'S SURFACE: Geomorphic processes and landforms; Weathering and soils; Streams and drainage pattern; Ground water, wind; Glacier; Shore processes; Impact of human activity; Natural hazards.

THE EVOLVING EARTH: Crustal deformation; Geologic structures and their representation; Applications of remote sensing; Isostasy; Continental drift; Sea-floor spreading; Paleo-magnetism, Plate tectonics; MINERAL RESOURCES: Ore-forming processes; Metallic and non-metallic deposits; Fossil fuels; Mineral resources of the sea; Geology of India and distribution of economic mineral deposits; *Tutorials*, *Laboratory Sessions*.

ESO 209 **PROBABILITY AND STATISTICS, 3-1-0-1-4** **Prereq. MTH 101**
L-T-P-D-[C]
3-1-0-1-[4]

Probability, Axiomatic Definition, Properties, Conditional probability, Bayes rule and Independence of Events, Random variables, Distribution function, Probability mass and density functions, Expectation, Moments, Moment generating function, Chebyshev's inequality; Special distributions: Bernoulli, Binomial, Geometric, Negative Binomial, Hypergeometric, Poisson, Uniform, Exponential, Gamma, Normal, Joint Distributions, Marginal and Conditional Distributions, Moments, Independence of random variables, Covariance, Correlation, Functions of random variables, Weak law of large numbers, P.levy's Central limit theorem (i.i.d. finite variance case), Normal and Poisson approximations to Binomial; *STATISTICS: Introduction*: Population, sample, parameters; *Point Estimation*: Method of moments, MLE, Unbiasedness, Consistency, Comparing two estimators (Relative MSE), Confidence Interval, Estimation for mean, difference of means, variance, proportions. Sample size problem. *Tests of Hypotheses*: N-P Lemma, examples of MP and UMP tests, p-value, Likelihood ratio test, Tests for means, variance, two sample problems, Test for proportions, Relation between confidence intervals and tests of hypotheses, Chi-Square goodness of fit tests, contingency tables, SPRT *Regression Problem:* Scatter diagram, Simple linear regression, Least squares estimation; Tests for slope and correlation, prediction problem, Graphical residual analysis, Q-Q plot to test for normality of residuals, Multiple Regression; Analysis of Variance: Completely randomised design and Randomised block design, Quality Control, Shewhart control charts and Cusum charts

ESO 210 **INTRODUCTION TO ELECTRICAL ENGINEERING**

L-T-P-D-[C]
3-1-2-0-[5]

Introduction to Single-Phase Circuits, Power Calculations, Magnetic Circuits, Mutually Coupled Circuits, Transformers, Equivalent Circuit and Performance, Analysis of Three-Phase Circuits, *Direct-Current Machines*: Construction, Equivalent Circuit, Torque-Speed Characteristics, Applications; *Induction Machines*: Construction Equivalent Circuit, Torque-speed Characteristics, Speed Control, Starting, Applications *Synchronous Machines*: Construction, Equivalent Circuit, Generator & Motor Operation Power Angle Characteristics, Hunting, Pull-Out, Stepper Motors and controls, Principles of Industrial Power Distribution.

ESO 211 **DATA STRUCTURES AND ALGORITHMS-I**

L-T-P-D-[C]
3-0-0-0-[4]

Order Analysis: Objectives of time analysis of algorithms; Big-oh and Theta notations, Data Structures:- Arrays, Linked lists, Stacks (example: expression evaluation), Binary search trees, Red-Black trees, Hash tables, Sorting and Divide and Conquer Strategy:- Merge-sort; D-and-C with Matrix Multiplication as another example, Quick-sort with average case analysis, Heaps and heap-sort, Lower bound on comparison-based sorting and Counting sort, Radix sort, B-trees, Dynamic Programming: methodology and examples (Fibonacci numbers, matrix sequence, multiplication, longest common subsequence, convex polygon triangulation), Greedy Method: Methodology, examples (lecture scheduling, process scheduling) and comparison with DP (more examples to come later in graph algorithms), Graph Algorithms:- Basics of graphs and their representations, BFS, DFS, Topological sorting, Minimum spanning trees (Kruskal and Prim's algorithms and brief discussions of disjoint set and Fibonacci heap data structures), Shortest Paths (Dijkstra, Bellman-Ford, Floyd-Warshall).

ESO 212 **FLUID MECHANICS AND RATE PROCESSES**

L-T-P-D-[C]
3-1-0-1-[4]

FLUID MECHANICS: Introduction to fluids, Fluid statics; pressure as a scalar, manometry, forces on submerged surfaces (NO moments NOR center of pressure), Description of flows; field approach, Euler acceleration formula, streamlines, streaklines, etc., Reynolds' transport theorem Conservation of mass; stream function, Linear (NOT angular) Momentum balance, Navier-Stokes' (NS) equation; *elementary* derivation; application; Poiseuille flow, Couette flow, Energy equation-Bernoulli equation, applications including flow measurement (Pitot tube, Orifice meters); Pipe flows and losses in fittings; Similitude and modelling: using non-dimensionali-zation of N-S equations and boundary conditions, simplifications for cases without free surfaces and without cavitation (scale factor approach should NOT be done); High Re flow: Prandtl's approximation; basic inviscid flow; need for boundary layer; Magnus effect (mathematical derivations be avoided), Boundary layers-elementary *results* for flat plates. Separation, flow past immersed bodies (bluff, streamlined); physics of ball-games (qualitative) *Heat Transfer:* Introduction, rate law and conservation law, Conduction equation; non-dimensionalization, various approximations, Steady state conduction-concept of resistances in series and of critical thickness of insulation, Unsteady conduction; significance of Biot and Fourier numbers, Heissler charts; Low Bi case; penetration depth, Essential nature of convection: transpiration cooling; writing energy equation without dissipation and pressure terms; one example (heat transfer to fluid flowing in a tube); non-dimen-sionalization, Nusselt number and correlations; *MASS TRANSFER*: Simple ideas of mass transfer; definitions (mass basis only), similarity with heat transfer. Use of steady 'conduction' concepts to solve simple steady cases in dilute solutions as well as in stationary solids, only.

Boundary conditions, Illustrative example: One example involving all three transport phenomena should be discussed, possibly from the bio-world or from microelectronics processing.

ESO 214 **Nature and Properties of Materials**

L-T-P-D-[C]
3-1-3-1-[5]

Examples of materials highlighting Structure-Processing-Property-performance relations. 14 space lattices, unit cells, cubic and HCP structures, Miller indices, Packing, interstitials, different ceramic structures; Non-crystalline/nanocrys-talline materials-definitions, concept of Tg, local order, different polymer structures.

Structure determination using X-ray diffraction (Bragg's diffraction and structure factor for cubic lattices); Point defects, edge and screw dislocations-their notation and concepts, energy of a dislocation, stacking fault, grains and grain boundaries, bulk defects;

PHASE EVOLUTION: Definition of diffusivity, concept of activation energy, examples of diffusion process; Definition of a phase, phase rule, unary and binary (eutectic, eutectic with terminal solid solutions) systems and examples, phase diagrams of important metal and ceramic systems, Nucleation and growth (homogeneous and heterogeneous), Introduction to TTT curves, examples of various transformations;

MECHANICAL BEHAVIOUR: Measures of mechanical response (fundamental measurable mechanical properties), engineering and true stress-true strain response, concept of yield point and Elastic modulus (composite materials) viscoelesticity, fracture toughness, stress intensity factor, fracture energy, comparison of these properties for different engineering materials.

Deformation of single and polycrystalline materials, slip systems, critical resolved shear stress, mechanisms of slip and twinning; Fatigue and creep properties of materials with suitable examples, Strengthening mechanisms, Fracture in ductile and brittle (Griffith's Theory) solids, ductile to brittle transition,

ELECTRONIC PROPERTIES: Drude theory of metals, free electron theory (density of states, Fermi energy, Fermi-Dirac statistics, band theory of solids, existence of metals and insulators, Brillouin zones), Semiconductors (structures of elements and compounds), equilibrium properties of semiconductors, conductivity as a function of temperature, measurement of band gap, doping, law of mass action, Hall effect, carrier concentration of mobility of non-generate semiconductors, Excess carrier generation, optical properties of semiconductors, concept of lifetime, I-V characteristics of p-n junction and their applications as LEDs, lasers and solar cells, Introduction to semiconductor crystal growth and processing modern methods of expitaxy (brief introduction to quantum wells and superlattices, if time permits), Dia-, para-ferro- and ferri magnetism; soft/hard magnetic materials.

Dielectric and ferroelectric materials ($BaTiO_3$ as an example); linear and non-linear behaviour.

ESO 216 **SIGNAL PROCESSING AND INSTRUMENTATION** **Prereq. ESc 101**

L-T-P-D-[C]
3-1-0-1-[4]

Physical quantities and their measurement. Different grades of measurability, scales and scale-invariant properties. Errors, precision (resolution), accuracy and calibration standards. Study of quantities; mechanical (position, force, velocity, acceleration (electrical voltage, current, position, frequency, time), chemical (flow, pressure, temperature, pH), psychophysical (brightness, loudness) etc., Sensors (e.g. stain guages, pH electrodes, photodiodes, accelerometers, etc), actuators (eg. Relays, solenoids, valves, stepper motors), sources (eg. Voltage, current, light sources), Introduction to the study of signals and their processing. Familiarization and use of Virtual Instrumentation software, Signals and noise; signal representation and noise characterisation. Analog and digital signals; signal sampling and quantisation. The Fourier series and the Fourier Transform; magnitude and phase spectra; the DFT; Signal and noise filtering; noise reduction techniques; windowing, boxcar intergration, lock-in amplifiers, multipoint averaging; Signal conversion: A/D and D/A conversion techniques. Multiplexing; Basic instrumentation: meters, guages, milli and micro voltmeters. Various bridges for impedance and frequency measurement. Examples of advanced instrumentation: oscilloscopes and spectrum analyzers. NMR.

Data Acquisition and computer control. Interfacing with microcontrollers and personal computers. Virtual (Software) instrumentation.

ESO 218 **COMPUTATIONAL METHODS IN ENGINEERING**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction, Engineering Systems, Physical and Mathematical Modeling, Error Analysis - Approximations and round off and Truncation errors, Roots of Equations- single variable -Method of Bisection, Method of Interpolation, Secant Method, One point Methods, Newton Raphson method, Secant Method, Multiple roots, Solution of Linear Simultaneous Equations-Direct Methods-Gauss Elimination, Gauss-Jordan, LU decomposition; Iterative Methods-Gauss-Seidel, Conjugate Gradient, Banded and Sparse systems, Solution of Nonlinear Simultaneous Equations, Curve Fitting-Least Square regression, Interpolation including splines, Fast Fourier Transforms, Regression Analysis for Multivariable, Eigen Values and Eigen Vectors- Power method, Relaxation Method, Diagonalization method. Numerical Differentiation and Integration-High-Accuracy Differentiation Formulas, Derivatives of Unequal Spaced Data. The trapezoidal Rule, Simpson's rule, Integration with unequal segments, Open Integration Formulas, Ordinary Differential Equations- Finite Difference method, Method of Weighted Residuals, Analytical versus Numerical Methods, Initial Value and Boundary Value Problems-Euler's method, Improvement of Euler's method, Runge-Kutta Method, Multiple Steps Method, Partial Differential Equations-Elliptic and parabolic Equations, Explicit and Implicit Methods, Crank Nicholson Method, ADI method; Introduction to Finite Element Method, Applications.

MTH 101 **MATHEMATICS - I**

L-T-P-D-[C]
3-1-0-1-[4]

Real numbers; Sequences; Series; Power series, Limit, Continuity; Differentiability, Mean value theorems and applications; Linear Approximation, Newton and Picard method; Taylor's theorem (one variable), Approximation by polynomials Critical points, convexity, Curve tracing; Riemann Integral; fundamental theorems of integral calculus Improper integrals; Trapezoidal and Simpson's rule; error bounds; Space coordinates, lines and planes, Polar coordinates, Graphs of polar equations, Cylinders, Quadric surfaces; Volume, Area, length; Continuity, Differentiability of vector functions, arc length, Curvature, torsion, Serret-Frenet formulas, Functions of two or more variables, partial derivatives. Statement only, of Taylor's theorem and criteria for maxima/minima/saddle points; Double, triple integrals, Jacobians; Surfaces, integrals, Vector Calculus, Green, Gauss, Stokes Theorems

MTH 102 **MATHEMATICS - II** **Prereq. : MTH 101**

L-T-P-D-[C]
3-1-0-1-[4]

Matrices; Matrix Operations (Addition, Scalar Multiplication, Multiplication, Transpose, Adjoint) and their properties; Special types of matrices (Null, Identity, Diagonal, Triangular, Symmetric, Skew-Symmetric, Hermitian, Skew-Hermitian, Orthogonal, Unitary, Normal), Solution of the matrix EquationAx=b; Row-reduced Echelon Form; Determinants and their properties, Vector Space R^n (R); Subspaces; Linear Dependence / Independence; Basis; Standard Basis of R^n; Dimension; Co-ordinates with respect to a basis; Complementary Subspaces; Standard Inner product; Norm; Gram-Schmidt Orthogonalisation Process; Generalisation to the vector space C^n (C), Linear Transformation from R^n to R^m (motivation, X - AX); Image of a basis identifies the linear transformation; Range Space and Rank; Null Space and Nullity; Matrix Representation of a linear transformation; Structure of the solutions of the matrix equation Ax = b, Linear Operators on R^n and their representation as square matrices; Similar Matrices and linear operators; Invertible linear operators; Inverse of a non-singular matrix; Cramer's method to solve the matrix equation Ax=b, Eigenvalues and eigenvectors of a linear operator; Characteristic Equation; Bounds on eigenvalues; Diagonalisability of a linear operator; Properties of eigenvalues and eigenvectors of Hermitian, skew-Hermitian, Unitary, and Normal matrices (including Symmetric, Skew-Symmetric, and Orthogonal matrices), Implication of diagonalisability of the matrix $A + A^r$ in the real Quadratic form $X^T AX$; Positive Definite and Semi-Positive Definite Matrices, Complex Numbers, geometric representation, powers and roots of complex numbers, Functions of a complex variable, Analytic functions, Cauchy-Riemann equations; elementary functions, Conformal mapping (for linear transformation) Contours and contour integration, Cauchy's theorem, Cauchy integral formula, Power Series, term by term differentiation, Taylor series, Laurent series, Zeros, singularities, poles, essential singularities, Residue theorem, Evaluation of real integrals and improper integrals.

MTH 203 **MATHEMATICS - III** **Prereq. : MTH 102**

L-T-P-D-[C]
3-1-0-1-[4]

Introduction & Motivation to Differential Eqns., First Order ODE, y'=f(x,y)- geometrical interpretation of solution, Eqns. reducible to separable form, Exact Eqns., integrating factor, Linear Eqns., Orthogonal trajectories, Picard's Thm. for IVP (without proof) & Picard's iteration method, Euler's Method, Improved Euler's Method, Elementary types of eqns. F(x,y,y')=0: not solved for derivative; Second Order Linear differential eqns: fundamental system of solns. and general soln. of homogeneous eqn, Use of known soln. to find another, Existence and uniqueness of soln. of IVP, Wronskian and general soln of nonhomogeneous eqns. Euler-Cauchy Eqn., extensions of the results to higher order linear eqns., Power Series Method - application to Legendre Eqn., Legendre Polynomials, Frobenius Method, Bessel eqn. Prop of Bessel functions, Sturm Liouville BVP, Orthogonal functions, Sturm comparison Thm., Laplace transform, Fourier Series and Integrals, Introduction to PDE, basic concepts, Linear and quasi-linear first order PDE, 2nd order PDE and classification of 2nd order semi-linear PDE (Canonical form), D'Alemberts formula and Duhamel's principle for one dimensional wave eqn., Laplace and Poisson's eqn., maximum principle with application, Fourier Method for IBV problem for wave and heat equation, rectangular region, Fourier method for Laplace equation in 3 dimensions, Numerical Methods for Laplace and Poisson's eqn.

PHY 101 **PHYSICS LABORATORY**

L-T-P-D-[C]
0-0-3-0-[2]

Introduction to Error Analysis and Graph Drawing; Spring Oscillation Apparatus; Trajectory of a Projectile on an inclined plane; Moment of Inertia of a bicycle wheel; Bar Pendulum; Torsional Pendulum; Coupled Pendulum; Study of collisions on an Air Track; Gyroscope; Current Balance; Measurement of Capacitance using Galvanometer; Charging of a plate capacitor; Electromagnetic Induction; Prism Spectrometer; Fraunhofer Diffraction using He-Ne laser; Magnetic Field in Helmholtz Coil; Resonance in Electrical Circuits.

PHY 102 **PHYSICS-I**

L-T-P-D-[C]
3-1-0-1-[4]

Coordinate Systems, elements of vector algebra in plane polar, cylindrical, spherical polar coordinate systems, Dimensional Analysis; Solutions for 1 dimensional equation of motion in various forms, Frames of reference, relative velocity and accelerations; Newton's laws and applications (to include friction, constraint equations, rough pulleys), Line integrals, gradient, curl, conservative forces, potential, Work-Energy theorems, Energy diagrams; Conservation of linear momentum and collisions, variable mass problems; Central forces, Gravitation, Kepler's law, hyperbolic, elliptic and parabolic orbits, Forced Oscillations, damping, resonance; Waves: Motion in Non-inertial frames, centrifugal and Coriolis forces; Conservation of Angular Momentum and elementary rigid body dynamics; Special Theory of Relativity.

PHY 103 **PHYSICS-II**

L-T-P-D-[C]

3-1-0-1-[4]

Vector Calculus; Electrostatics; Gauss law and applications, electrostatic potential and Curl of E; Work and energy in electrostatics, Laplace's Equation and (first) uniqueness theorem, method of images, multipoles (introduction), force and torque on dipoles; Polarization, bound charges, Electric displacement and boundary conditions, Linear dielectrics, force on dielectrics. Motion of charges in electric & magnetic fields; Magneto-statics: Current Density, Curl and divergence of B, Ampere's law and applications, magnetization, bound currents and bound pole densities, Magnetic field H, Magnetic susceptibility, Ferro, para and diamagnetism, Boundary conditions on, B and H Faraday's law, Energy in magnetic field, Displacement current, Maxwell's equations in Media, Poyntings Theorem, E.M. Waves: Wave equation, plane waves, polarization and types of polarization, Energy and momentum of plane E.M. waves. Propagation through linear media and conductors. Reflection and transmission at normal incidence from dielectric and metal interfaces. Magnetism as a relativistic phenomenon. Relativistic transformations of E B fields (simple illustrations only), Diffraction, Quantum Mechanics,* Photons, Uncertainty Principle, Electron diffraction experiments, De Broglie Hypothesis, Born interpretation, Schrodinger-Equation and application to 1-D box problem.

TA 101 **ENGINEERING GRAPHICS**

L-T-P-D-[C]

2-0-3-1-[4]

Orthographic projections; lines, planes and objects; Principles of dimensioning, sectional views. Machine part assemblies, auxillary views, Space geometry; lines and planes, true lengths and shapes, properties of parallelism, perpendicularity and intersections of lines and planes, simple intersections of solids and development of lateral surfaces of simple solids, Isometric views. Introduction to computer graphics.

TA 201 **INTRODUCTION TO MANUFACTURING PROCESSES**

L-T-P-D-[C]

2-0-6-0-[5]

Introduction to Manufacturing, Historical perspective; Importance of manufacturing; Classification of manufacturing processes, Engineering materials, Casting, Fundamentals of casting, Sand casting, Permanent mold casting including pressure die casting, Shell, investment & centrifugal casting processes, Continuous casting, Casting defects, Metal Forming, Basic concepts of plastic deformation, Hot & cold working, Common bulk deformation processes (Rolling, Forging, Extrusion and Drawing), Common sheet metal forming processes, Machining, Chip formation and generation of machined surfaces, Tool geometry, tool material, tool wear and practical machining operations (turning, milling and drilling), Grinding processes, Finishing processes, Introduction to unconventional machining processes (EDM, ECM, UCM, CHM, LBM) etc., Welding & Other Joining Processes, Fundamentals of welding & classification of welding processes, Gas and arc welding, Brazing and soldering, Adhesive bonding, Mechanical fastening, Heat Treatment, Principles of heat treating; annealing, normalizing, hardening and tempering, Manufacturing of Polymer and Powder Products, Classification of polymers, Introduction to extrusion, injection molding, blow molding, compression and transfer molding , Green compacts from powders including slip casting of ceramics, Sintering, Modern Trends in Manufacturing.

DESIGN PROGRAMME

PROFESSORS

Dhande SG (Head)	sgd	7220	
Chatterjee J.	jayanta	7858	

ASSISTANT PROFESSORS

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Bhushan Braj	brajb	7024	
Jha Munmua	mjha	7615	
Roy Satyaki	satyaki	4060	4030

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Raghuram V	vraghu	7434	
Chatterjee A	achat	7170	7380
Kulkarni Anjali K	anjalik	7995	
KKS Pandiyan	klandian	8431	

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Design Programme at IIT Kanpur, is conceived as a centre for creative minds, which stimulates the students to bring in synthesis of varied knowledge domains for creative problem solving. The students, through their practical projects, are taught to address social issues by developing and providing innovative design solutions through a multi-disciplinary approach. Not only it encourages new and radical concepts, but also it facilitates the "concepts to function" transition. The Programme acts as a hub which fosters interactivity among students, faculty and industry to create a complete learning experience.

Candidates with a undergraduate background of engineering, design or architecture are eligible for the programme.

STRUCTURE OF THE (M.DES.) PROGRAMME

Semester I	Semester II	Semester III	Semester IV
DES 601[1]	**DES 603[4]**	**DES 699[7]**	**DES 699[8]**
DES 602[2]	**DES 682[5]**	**TE**	
DES 681[3]	**DES 699[6]**		
OE	**OE**		

DES 601	Design Theory[1]	DES 602	Design Practice -I[2]
DES 681	Design Project -I[3]	One elective	(4 Units)
DES 603	Design Practice -II[4]	DES 682	Design Project -II[5]
DES 699	M.Des. Thesis (4 Units)[6]	One elective	(4 Units)
DES 699	M.Des. Thesis (8 Units)[7]	Two Electives	(8 Units)
DES 699	M.Des. Thesis (16 Units)[8]		

COURSE DESCRIPTION

DES 601 **DESIGN THEORY**
L-T-P-D-[C]
2-0-2-0-[4]

Design Philosophy, Art (aesthetics) in ID, History of Design, Human Experience in Design, Design Elements, Design Principles, Theory of Colour, Colour Aesthetics, Subject of Colour, Design Paradigm, Art Design & Society, Indian Tradition and Products.

Studio: Form, Space and Texture; 2D and 3D Form Analysis, Colour and Texture in 2-D and 3D surface; Colour Aesthetics; Product Analysis and Ergonomics, Product Design and Developments.

DES 602 **DESIGN PRACTICE-I**
L-T-P-D-[C]
3-0-0-0-[4]

Stages of a Product and Concurrent Engineering; Problem Formulation, Specifications and Constraints; Creating Forms; Configuration Optimisation; Coupled, Decoupled and Uncoupled designs; Product of Static and Dynamic Societies; Material Experimentation; Construction Technique; Model Building; Decision Making, Addressing Failures and Courage to Create; Interpersonal Skills; Robust Design, Incubation; Economic Considerations; Micro and Macro Designs; Introduction to Electronics; Laboratory on Problem Formulation, Innovation, Decision Making, Inter-personal Skills, etc., through Group Discussion, Case studies, Books and Journals Review.

DES 603 **DESIGN PRACTICE-II**
L-T-P-D-[C]
2-0-2-0-[4]

Construction of Forms, Geometrical Transformations; Surface Modeling; Representation of 3D Shapes; Solid Modeling; Simulation in CAED, Rapid Prototyping & Tooling; Strength and Stiffness of Structural Elements and Mechanisms; Introduction to Control; Electronics Signal Processing; Sensors and Actuators; Micro Electro-Mechanical Systems; Mechatronics; Design of Embedded Systems; Intelligent Product Design.

Laboratory: 2D-3D Modeling, Operation of Rapid Tooling and Prototyping Instruments, Development of Simple Sensors and Actuators, Design of Products with Embedded Sensors etc.

DES 621 **CREATIVE VISUALIZATION**
L-T-P-D-[C]
2-0-2-0-[4]

Theory: Art movements and design : Principles of style in art, product design, architecture and graphic design : Photography : Design and performing art : Art and perception : Methodology of criticism and appreciation.

Studio: Short workshops, projects, and field trips in the above mentioned areas (photography, film making, lights, stage craft, script writing, editing, product development) to emphasize visualization powers in an attempt to build a personal vision.

DES 622 **2D AND 3D VISUAL DESIGN**

L-T-P-D-[C]
2-0-4-0-[4]

The objective of this course is to make a complete realization of visual language through theoretical knowledge and practical exercises in the related domain of 2D and 3D Design applications. Some of the topics that will be dealt with are - Types of 2D and 3D Visual Media, Visual Grammar, Application in Visual Design, Visual Perception and Analysis, Visual Forms & Concepts, Design and Development of Form, Communication through Visual Modes of Application.

DES 623 **TOPICS IN MOTION PICTURES**

L-T-P-D-[C]
2-0-4-0-[4]

Topics in motion pictures require a combined practical and theoretical approach for realizing the creative media in its totality. The proposed course would offer students the opportunity to acquire a range of transferable and practical skills in film and television productions.

Concise and brief history of motion pictures; Analysis and a general approach to the criticism of film and television media; Approach and methods in these forms of media productions; Overview of the digital media arts field with an emphasis on technological developments and their integration in art research and production.

Students would be introduced to contemporary and historical directions, key concepts and methodologies through seminar lectures, research presentations, practical exercises and a final project. Classes would be supplemented with viewing a range of productions, individual and group critiques, presentations, demonstrations and practical exercises to explore traditional and modern methods and explore both technical and creative approaches to the medium.

The course will also include short workshops supported by specialized professionals in the related fields.

DES 624 **ELEMENTS AND PRINCIPAL OF DESIGN**

L-T-P-D-[C]
2-0-2-4-[4]

The course intends to develop the following areas-

(i) Elements of Design- value, color, form, shape, line and texture. Each elenment is to be examined theoretically along with studio exercises and evaluated through consumer products (2D & 3D).

(ii) Principal of Design would evaluate contrast, rhythm, unity, emphasis, pattern, movement, and balance on the basis of Design Elements. The course proposes to develop through understanding of the elements and principles of design and their co-relationship.

The course intends in developing understanding on the above issues and executes projects to examine elements and principles of design. Students are expected to develop knowledge and practical skill through theoretical and practical training. Students are required to develop products, give seminars and submit research paper on chosen topics.

DES-625 **STUDIES IN FORM AND STYLE**

L-T-P-D-[C]
2-0-2-0-[4]

Theory : Form envelops and assists function and in the process creates a 'network of values' that is termed as Style. 'Studies in form and style' concerns the conceptualization, exploration, and development of form and style in both product design and Visual commnication. The course will explore various bases for creative visualization like Fantasy. Metaphors, Cultural connotations and Bionics in the context of form- making.

From analysis - Analysis of principles of form in relation with society study of evolution of forms in products 2D and 3D space analysis Dominant - sub - dominant - subordinate relationship, Recall of forms Tensile design Motion and form, Light- space analysis

For Visual communication form will ne explored in the context of concept-communication and the application of information theory to visual structures. This will include case studies of advertisement campaigns like Amul Silk - cunt etc.

The course evaluates patterns of aesthetic, ergonomic and market behavior towards forms.

Studio: Form development assignments in both Product and visual communications will deal with the evolution of form in relation with exploration and function. Each assignment will complete the design process and its various stages from conceptualization, comparative studies, and usability issues to market trends as related to the study of Form. The study of the design process will help in understanding the shifts between analytical and creative phases in different stages of design that is conceptualizattion and manufacturability gaps.

Various visual structures and alternative display formats wiill be explored through the assignments.

The course is envisaged in collaboration with assignments from the industry wherever possible in which the primary work will take place in the Lab and the critical evaluatiion in the industry. The course requires extensive field study for usability and market trends.

DES 626 **INTERACTION DESIGN**

L-T-P-D-[C]
2-0-2-0-[4]

Interaction Design defines behavioral pattern and builds the performance level of technical, environmental, biological and organizational systems i.e. software, products, mobile devices, environments, services, wearable, and even organizations themselves to name a few. The behavior or the "interaction" of a manufactured article or a scheme in response to its user-group is the primary concern of this topic in design. Students are expected to collect information through user research following the various user research methodologies, generate interactive scenarios and strategies, design stressing upon behaviour as well as form, and consider the evaluation process of design in terms of usability and emotional factors and propose solutions for the ease of use in physical or virtual products or a system. Interactive objects, spaces and services are concieved taking into consideration the different design concerns as well as by exploiting Information and Communication Technogy (ICT) potentialities as term projects.

DES 627 **MANAGEMENT OF DESIGN AND INNOVATION**

L-T-P-D-[C]
2-0-2-0-[4]

Identification of Opportunities and the creative mind, Problem Based ideation, Creative Problem solving, Market Innovation and Brands, Strategy and Organization for the Creative Business, Networks and Collaboration for Design Innovation and cultural Industries, Competitive Design performance Management for the Design Business over the Life Cycle.

DES 628 **DESIGN, CULTURE AND SOCIETY**

L-T-P-D-[C]
2-0-2-0-[4]

Understanding the Dynamics of Indian Society : Social Units and Institutions, Cultural Adaptations, Exploring Culture : Attributes, Cultural Practices, Cultural Growth and Cultural Integration , Methods of cultural Inquiry : Comparative Methods, Fieldwork, Ethnographic Study, and Perspective on Design trends, Indigenous Design Culture : Proletarian Design Innovations, Role of Design within Societal Structure and Cultural Framework and Understanding Users, User Experience Design : UE Research Tecniques, Trend Mapping : Research Methodology-assessing, scoping, digging and refining the data, information, knowledge and insight layers ; Cultural triangulation-how observation, interrogation and intuition add the key and core vital layer to understanding the data assessed, the knowledge acquired and the insights delivered; Quantitative sampling; Visual and trend mapping techniques turning insights into market strategies; Using forecasting to develop products and new brand directions.

DES 629 **INTRODUCTION TO CRITICAL ART APPRECIATION**
L-T-P-D-[C]
2-0-2-0-[4]

Contemporary Art- Theory & Practice, Art and its implications –Society & Culture, Role of Art and Artist in Socio Cultural Framework, Understanding Visual Culture –Historical and Global Perspective, Methodology for Critical Thinking in the context of Art Appreciation, Principles and Norms of Art, Communication in Visual Arts, Relative studies in diverse cultural expressions.

DES 681 **DESIGN PROJECT-I**
L-T-P-D-[C]
0-0-6-0-[4]

Introduction to Graphics, Introduction to Graphics Software, Introduction to Style, Introduction to Multimedia Application, Introduction to CAD Application, User Consumer Interaction Study, Media Communication, Ergonomics, Material Exploration.

DES 682 **DESIGN PROJECT-II**
L-T-P-D-[C]
2-0-3-0-[4]

Manufacturability Studies, Embedded products, Product styling, Package Designing, Information design, HCI, GUI, Animation, Film appreciation, Print Making.

DES 689 **TOPICS IN DESIGN, 2-0-3-0-4**
L-T-P-D-[C]
2-0-3-0-[4]

Lectures and Workshops on Various Topics in Design like Ergonomics, Graphic Design and Typography, Design Management, Visual Image Design, Composition and Media Art, Aesthetics and Forms, Role of Design in ICT, Auto Design, Product Simulation, Packaging Design, Sustainable Design through Practical Exercises, Studio Projects, Field Trips.

DES 698 **SPECIAL STUDIES / PROJECT COURSE IN DESIGN**
L-T-P-D-[C]
0-0-0-0-[4]

Cognitive Design; Design Management; Human factors in Ergonomics Design; Usability & User-centric Design; Axiomatic Design; Human Computer Interface Design (HCI), etc.

DES 699 **M. DES. THESIS**

DEPARTMENT OF ELECTRICAL ENGINEERING

PROFESSORS

Bansal RK	rkb	7075	
Biswas A	abiswas	7319	7137
Chaturvedi AK	akc	7613	
Das SP	spdas	7106	
Das U	utpal	7150	7360
Dutta A	aloke	7661	
Ghosh AK	anjn	7105	
Gupta Sumana	sumana	7310	
John J	jjohn	7088	7733
Joshi A	ajoshi	7233	
Kalra PK (Head)	kalra	7810	7034
Mazhari B	baquer	7924	
Qureshi S	qureshi	7339	7133
Sachidananda M	sachi	7131	
Sharma G	govind	7922	
Singh SN	snsingh	7009	
Sinha RMK (Joint appointment with CSE)	rmk	7154	
Sircar P	sircar	7063	
Srivastava SC	scs	7625	7299
Umesh S	sumesh	7855	

ASSOCIATE PROFESSORS

Behera L	lbehera	7198
Singh YN	ynsingh	7944
Harish AR	arh	7569
Iyer SSK	sskiyer	7820
Vasudevan K	vasu	7109
Venkatesh KS	venkats	7468

ASSISTANT PROFESSORS

Banerjee A	adrish	7991
Gupta Nandini	ngupta	7511
Hedge RM	rhegde	6248
Mishra SK	santanum	6249
Potluri RP	potluri	6093
Sensarma P	sensarma	7076

EMERITUS FELLOW

Arora R	rarora	7665	7850

Convenor, DUGC :	A Biswas	abiswas	7319, 7137
Convenor, DPGC :	S Umesh	sumesh	7855
Faculty Counsellor:	S. P. Das	spdas	7106

E-mails : _____@iitk.ac.in Tel Nos : +91-512-259 _______

At the UG level, the department offers a 4 year B. Tech. programme in Electrical Engineering. While most of the courses in the first four semesters are compulsory, those in the final four semesters are electives. Once the fundamentals underlying different areas of electrical engineering have been taught, students are free to specialise in areas of their interest, beginning in the sixth semester. The

B.Tech. curriculum emphasises laboratory courses throughout. The project in the final year, which lays stress on independent design, is a culmination of the skills imparted in the laboratory courses. The department also offers dual degree (B. Tech. & M. Tech.) programme.

At the PG level, the department offers M. Tech. and Ph. D. programmes in various areas of Electrical Engineering.

Specialisation in the M. Tech. Programme in Electrical Engineering is presently available in the following broad areas: Systems, Power Electronics & drives and Control systems, Power and Controls (including Power Microwaves & Photonics; Information Systems (including Signal Processing, Communications & Telecom Networks) Microelectronics, VLSI & Display Technology.

Considerable flexibility is available in the selection of courses in PG programmes. The postgraduate committee of the department plans the study programme for individual PG students. Faculty advisors counsel students in choosing a course package out of a number of possibilities based upon his/her interest and background.

In the Master's programme, a student has to complete eight courses. Certain number of courses out of the required total forms a package of compulsory courses. These are from the area of specialisation of the student. The rest are electives to be chosen in accordance with one's interests as well as thesis requirements. The programme culminates in a thesis which is normally in the area of specialisation of the student and has to be defended before the end of the programme.

The most important part of the doctoral programme is research culminating in a thesis. The research should represent an original investigation on the part of the student and is expected to make a significant contribution to knowledge in the subject. Publications in good journals and international conferences are encouraged.

Sponsored research and development activities are pursued in the Advanced Centre for Electronic Systems (ACES), which is the R&D wing of the department. Work on problems of current relevance in Electrical Engineering involving latest technologies are carried out under these sponsored projects. Students can take up thesis problems which have relevance to these activities, thus enabling them to use some of the sophisticated facilities available in the Centre.

The academic atmosphere is informal and this is borne out by the freedom the students have to discuss issues with the faculty members. Research students are encouraged to generate their research problems through discussion with faculty both in and out of the classroom. They have the freedom to choose their thesis supervisors from among the faculty members of the department and sometimes even from outside the department.

CURRENT COURSE STRUCTURE FOR B.TECH.-M.TECH. (DUAL DEGREE) STUDENTS
ELECTRICAL ENGINEERING

	SEMESTER									
	FIRST	**SECOND**	**THIRD**	**FOURTH**	**FIFTH**	**SIXTH**	**SEVENTH**	**EIGHTH**	**SUMM.**	**NINTH**	**TENTH**
C	PHY102	PHY101	MTH203	HSS-I-2	HSS-II-1	SE-1	DEL-1	OE-PG-3/	DE-PG-1		
O								DEL-2			
U	MTH101	CHM101	CHM201	ESO209	EE320	EE340	HSS-II-2	OE-PG-4			
R	HSS-I-1/	PHY103	TA201	ESO210	EE330	EE381	OE-PG-1	OE-PG-5	EE699	EE699	EE699
S	ENG112N	MTH102	EE200	EE210	EE370	**3 OUT**	OE-PG-2	DEL-3	4	12	16
	TA101	ESC101	ESO202	EE250	EE380	OF	OE-PG-3/	EE699	Credits	Credits	Credits
	ESC102	EE100	OR		OE-1	EE301		4			
	PE101	PE102	ESO214			EE311		Credits			
						EE321					
						EE60					

CHM 201	Chemistry
Com-S 200	Communication Skills
ESO 202	Thermodynamics or
ESO 214	Nature & Properties of Materials
EE 200	Signals, Systems and Networks
TA 201	Introduction to Manufacturing
MTH 203	Mathematics III
ESO 209	Probability & Statistics
ESO 210	Introduction to Electrical Engg.
EE 210	Microelectronics - I
EE 250	Control System Analysis
HSS	
EE 320	Principles of Communication
EE 330	Power Systems
EE 370	Digital Electronics & Micro-processor Technology
EE 380	Electrical Engineering Lab. - I
HSS	
OE	Open Elective
EE 340	Electromagnetic Theory
EE 381	Electrical Engineering Lab. - II
SE	Science Elective
	Three courses out of the following four:
EE 301	Digital Signal Processing
EE 311	Microelectronics II
EE 321	Communication Systems
EE 360	Power Electronics
SE	Science Elective
OE	Open Elective
DE	Department Elective
DE	Department Elective
EE 491	Project-I
HSS	
DE	Department Elective
OE	Open Elective
OE	Open Elective
EE 492	Project - II

Summer training and industrial tour are optional.

EE 200 **SIGNALS, SYSTEMS AND NETWORKS** **Prereq. ESc 102**

L-T-P-D-[C]
3-1-0-0-[4]

Continuous and discrete time signals; Fourier series, Fourier, Laplace and Z transform techniques; DFT. Sampling Theorem. LTI systems: I/O description, impulse response and system functions, pole/ zero plots, FIR and IIR systems. Analog and digital filters. Networks: topological description, network theorems,Two port analysis.

EE 210 **MICROELECTRONICS - I** **Prereq. ESc 102**

L-T-P-D-[C]
3-1-0-0-[4]

I-V characteristics of BJTs and MOSFETs, Basic amplifier configurations, Current sources and active loads, output stages, Op-amps, Feedback amplifiers, Stability and compensation, Noise in Electronic circuits, Signal processing: D/A and A/D converters, Non-linear electronic circuits.

EE 250 **CONTROL SYSTEM ANALYSIS** **Prereq. EE 200 or #**

L-T-P-D-[C]
3-1-0-0-[4]

Linear feedback control systems, frequency and time domain analysis, I/O relationships, transfer function, perfor-mance analysis, Routh-Hurwitz and Nyquist stability criteria, Bode diagrams, Nicholas chart, Root locus method, Feedback system design. Non-linear systems, phase-plane analysis, limit cycles, describing function.

EE 301 **DIGITAL SIGNAL PROCESSING** **Prereq. EE 200**

L-T-P-D-[C]
3-0-0-0-[4]

Review of discrete time signals and systems. Sampling of CT signals: aliasing, prefiltering, decimation and interpolation, A/D and D/A conversion, quantization noise. Filter design techniques. DFT Computation. Fourier analysis of signals using DFT. Finite register length effects. DSP hardware. Applications.

EE 311 **MICROELECTRONICS - II** **Prereq. EE 210**

L-T-P-D-[C]
3-0-0-0-[4]

Basics of semiconductor physics, p-n junction diodes, Metal-semiconductor contacts, BJTs, MOS capacitors, MOSFETs, optoelectronic devices, Advanced semiconductor devices: MESFETs, HBTs, HEMTs, MODFETs.

EE 320 **PRINCIPLES OF COMMUNICATION** **Prereq. EE 200**

L-T-P-D-[C]
3-1-0-0-[4]

Communication problem and system models. Representation of deterministic and stochastic signals. Analog and digital modulation systems, Receiver structures, SNR and error probability calculations, Frequency and time division multiplexing. Digital encoding of analog signals. Elements of information theory, Multiple access techniques and ISDN.

EE 321 **COMMUNICATION SYSTEMS** **Prereq. EE 320**

L-T-P-D-[C]
3-0-0-0-[4]

Information measures. Source coding. ISI & channel equalization, partial response signalling. M-ary modulation systems, error probability calculations. PLLs and FM threshold extension. Error control coding, block and convolution codes. Combined modulation and coding, trellis coded modulation. Spread spectrum systems.

EE 330 **POWER SYSTEMS** **Prereq. ESO 210**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction to generation, transmission and distribution systems, Substation arrangements. Mathematical modelling of power systems. Grounding in power systems. Power cables and lines - parameter calculations. Fault Calcula-tions. Current and voltage relations of lines and cables. Reactive power control. Switchgear and protection.

EE 340 **ELECTROMAGNETIC THEORY** **Prereq. PHY 103**

L-T-P-D-[C]
3-1-0-0-[4]

Basics of Static electric and magnetic fields, Energy in fields, Maxwell's equations, plane EM waves, Propagation in free space and in matter, Reflection and refraction, Guided EM waves, Transmission lines, Radiation of EM waves.

EE 360 **POWER ELECTRONICS** **Prereq. ESc 102**

L-T-P-D-[C]
3-0-3-0-[4]

Power semiconductor devices: structure and characteristics; snubber circuits, switching loss. Controlled rectifiers: full/half controlled converters, dual converters, sequence control. AC regulator circuits, reactive power compensators. dc-dc converters, switching dc power supplies. Inverters: square wave and pwm types, filters, inverters for induction heating and UPS.

EE 370 **DIGITAL ELECTRONICS & MICROPROCESSOR TECHNOLOGY** **Prereq. ESC 102**

L-T-P-D-[C]
3-1-0-0-[4]

Analysis of digital logic families: TTL, MOS, CMOS Inverters; interfacing between logic families; various logic functions and their implementation; Bistable circuits - R-S, J-K, D and PLA; Design of synchronous sequential circuits. Microprocessor based systems : Number systems, Arithmetic operations in integer and floating point systems; ASCII Code; General micro-processor organisation, Memory inter-facing, Assembly language and bus signals of 8085; interrrupts and their applications; Serial and parallel ports; DMA and its controller; 8253 timer; 8259 interrupt controller.

EE 380 **ELECTRICAL ENGINEERING LAB**

L-T-P-D-[C] **Prereq. ESc 102, ESO 210, EE 210, EE 250**

0-2-6-0-[4]

Experiments from various areas of electrical engineering with emphasis on electronic devices, circuits, control systems and machines.

EE 381 **ELECTRICAL ENGINEERING LAB I**

L-T-P-D-[C] **Prereq. EE 320 or #, EE 370 or #, EE 380**

0-2-6-0-[4]

Experiments from various areas of electrical engineering with emphasis on digital electronics, communications, machines, drives and power systems, and electromagnetics.

EE 403 **ADVANCED DIGITAL SIGNAL PROCESSING** **Prereq. EE 301**

L-T-P-D-[C]

3-0-0-0-[4]

Review of linear algebra; functional analysis, time-frequency representation; frequency scale and resolution; uncertainity principle, short-time Fourier transform, Multi-resolution concept and analysis, Wavelet transforms. Wigner-ville distributions. Multi-rate signal processing; discrete-time bases and filter banks; 2D signals and systems, 2D sampling in arbitrary lattices, 2D-linear transforms, 1D/2D signal compression; introduction to DSP architecture.

EE 413 **SEMICONDUCTOR DEVICES TECHNOLOGY** **Prereq. EE 210**

L-T-P-D-[C]

2-0-3-0-[4]

Semiconductor materials, Ultraclean technology, Single crystal growth, Thermal oxidation of silicon, Solid state diffusion, Ion implantation, Vacuum technology, Physical and chemical vapor deposition techniques, Wet and dry etching, Lithography techniques, VLSI/ULSI process integration, Fault diagnosis and characterization techniques.

EE 414 **LOW NOISE AMPLIFIERS** **Prereq. EE 320, EE 311**

L-T-P-D-[C]

3-0-0-0-[4]

Noise and its characterisation, Noise figure calculations, Noise in semiconductors, P-N junction, Metal semiconductor junctions, Tunnelling: Varactors and their application as parametric amplifiers and multipliers. Tunnel diode amplifiers, Schottky diode Mixers, Masers, Design aspects of low noise amplifiers and mixers.

EE 415 **LINEAR INTEGRATED CIRCUIT DESIGN** **Prereq. EE 311**

L-T-P-D-[C]

3-0-0-0-[4]

Bipolar and MOS technology. Voltage regulators. Analog delay lines. IC transducers. Analog switches, S/H circuits. Noise in ICs, Special function ICs. Switched capacitor circuits. Opto-electronic ICs and systems. MOS analog circuits-building blocks, subcircuits, opamps. BiCMOS circuit design. Low power/voltage circuit design. Mixed signal design issues.

EE 416 L-T-P-D-[C] 3-0-0-0-[4]

OPTO-ELECTRONICS **Prereq. EE 210, EE 340**

LEDs, semiconductor lasers, modulation of laser sources. Avalanche and PIN photodetectors and their characteristics. Solar cells. Optical fibers and their characteristics. Integrated optics. Fiber optic communication systems, system design consideration.

EE 417 L-T-P-D-[C] 3-0-0-0-[4]

INTRODUCTION TO VLSI DESIGN **Prereq. EE 210, EE 370 or #**

Review of MOS device operation; fabrication and layout; combinational and sequential logic design; verification and testing; arithmetic blocks, memory; architecture design; floor planning; design methodologies; example of a chip design; analysis and synthesis algorithms including circuit, switch and logic simulation, logic synthesis, layout synthesis and test generation; packaging.

EE 422 L-T-P-D-[C] 3-0-0-0-[4]

COMMUNICATION SYSTEM ENGINEERING **Prereq. EE 320**

Baseband signal characterisation-telegraphy, telephony, television and data; message channel objective; voice frequency transmission, radio wave propagation methods: random noise characterization in communication systems, intermodulation distortion : line of sight systems description and design; troposcattrer systems.

EE 431 L-T-P-D-[C] 3-0-0-0-[4]

ELECTRICAL MACHINES **Prereq. ESO 210**

Magnetic circuits and transformers including three-phase transformers. Electro-mechanical energy conversion. General principle of AC machines. Synchronous machines including power system interfacing. Induction machine including starting and speed control of motors.

EE 432 L-T-P-D-[C] 3-0-0-0-[4]

POWER GENERATION, 3-0-0-0-4 **Prereq. ESO 210**

Power generation from conventional sources; thermal, hydro, nuclear and gas power plants - their functions and control; types of prime movers, generators and excitation systems; Economic considerations in power systems. Alternate sources of power generation - solar, wind, geo-thermal, ocean-thermal, tidal, wave and MHD.

EE 437 L-T-P-D-[C] 3-0-2-0-[5]

FUNDAMENTALS OF HV ENGG & LABORATORY TECHNIQUES **Prereq. EE 330**

Electromagnetic fields, field control, Dielectrics used in HV and their properties, Standard voltage wave-forms, Generation and measurement of HV ac, dc and impulse voltages, Non-destructive testing, HV bushings & insulators, Overvoltage phenomena & insulation coordination

EE 441 L-T-P-D-[C] 3-0-0-0-[4] **MICROWAVES** **Prereq. EE 340**

Active devices: LHTs, klystrons, magnetrons, TWTs, BWOs, microwave transistors; point contact, tunnel, PIN, and GUNN diodes; Parametric amplifier masers. Microwave circuits-theory of guiding systems, scattering matrix impedance transformation and matching. Passive devices: ferrites & ferrite devices, microwave cavity.

EE 442 L-T-P-D-[C] 3-0-0-0-[4] **ANTENNAS AND PROPAGATION** **Prereq. EE 340**

Retarded potential, radiation from current element and dipole, radiation patterns, impedance, reciprocity. Various types of antennas, interferometers and multi-element arrays, Antenna Measurements. Ground wave propagation, terrain and earth curvature effects.Tropospheric propagation; fading, diffraction and scattering; Ionospheric Propagation-refractive index, critical frequencies, effects of magnetic field.

EE 443 L-T-P-D-[C] 3-0-0-0-[4] **RADAR SYSTEMS** **Prereq. EE 320**

Radar equation, CW and Frequency Modulated Radars, MTI and pulse Doppler radar, MTI delay line cancellors. MTI from moving platform, Tracking radars. Mono-pulse tracking in range/Doppler; Electronic scanning radars, Beam forming and Steering methods, Noise and Clutter; Ambiguity function; Radar signal processing; SAR.

EE 444 L-T-P-D-[C] 3-0-0-0-[4] **RADIO ASTRONOMY** **Prereq. EE 340**

Fundamentals of astronomy, Co-ordinate systems, Structure of the universe, Radio astronomy fundamentals, Electromagnetic wave propagation, Radio telescope Antennas, Reflector Antennas, Antenna arrays, Interferometry and aperture synthesis. Radio astronomy receivers, General principles, low noise amplifiers, digital auto-correlation receivers, Description of radio sources.

EE 451 L-T-P-D-[C] 3-0-0-0-[4] **ADVANCED CONTROL SYSTEMS** **Prereq. EE 250**

Modelling of physical systems, Concepts of state, state-space, Controllability and observability. Sensitivity and error analysis. Nonlinear systems, singular points, phase plane analysis, Lyapunov stability, describing functions, on-off and dual mode systems. Sampled Data Systems. Computer control systems.

EE 455 L-T-P-D-[C] 3-0-0-0-[4] **TRANSDUCERS AND INSTRUMENTATION** **Prereq. #**

Measurement process; scales of measurement; configuration and functional description of measurement systems; performance characteristics; sensing elements and transducers for measurement of motion, force, pressure, flow, temperature, light, vacuum, etc.; transducer interfacing; signal conditioning, transmission and recording; microprocessor based instrumentation.

EE 480 **ADVANCED ELECTRICAL ENGINEERING LABORATORY 1** **Prereq. EE480**
L-T-P-D-[C]
0-0-6-0-[4]

The purpose of this course is to allow students to do new and challenging experiment in emerging areas of Electrical Engineering under the guidance of an assigned department faculty member. This would also facilitate the task of developing new experiments for EE380/381 as well.

EE 481 **ADVANCED ELECTRICAL ENGINEERING LABORATORY 2** **Prereq. EE481**
L-T-P-D-[C]
0-0-6-0-[4]

The purpose of this course is to allow students to do new and challenging experiment in emerging areas of Electrical Engineering under the guidance of an assigned department faculty member. This would also facilitate the task of developing new experiments for EE380/381 as well.

EE 491 **PROJECT - I, 0-0-0-9-3, Fourth Year Standing EE 491**
PROJECT - II, 0-0-0-15-5, EE492 **Prereq. EE 491**

POST-GRADUATE COURSES

EE 600 **MATHEMATICAL STRUCTURES OF SIGNALS & SYSTEMS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Nature of definitions; Theory of measurement and scales; Symmetry, invariance and groups; Groups in signals and systems; Algebraic and relational structures of signal spaces and convolutional systems; Representation theory of groups, harmonic analysis and spectral theory for convolutional systems.

EE 601 **MATHEMATICAL METHODS IN SIGNAL PROCESSING** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Generalized inverses, regularization of ill-posed problems. Eigen and singular value decompositions, generalized problems. Interpolation and approximation by least squares and minimax error criteria. Optimization techniques for linear and nonlinear problems. Applications in various areas of signal processing.

EE 602 **STATISTICAL SIGNAL PROCESSING I**
L-T-P-D-[C]
3-0-0-0-[4]

Power Spectrum Estimation-Parametric and Maximum Entropy Methods, Wiener, Kalman Filtering, Levinson-Durban Algorithms Least Square Method, Adaptive Filtering, Nonstationary Signal Analysis, Wigner-Ville Distribution, Wavelet Analysis.

EE 603 **ADVANCED TOPICS IN DIGITAL FILTERING** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Multirate Processing of discrete Time Signals; Orthogonal Digital Filter Systems. Two-Dimensional Discrete Time Filters. VLSI Computing structures for Signal Processing.

EE 604 **IMAGE PROCESSING** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Human visual system and image perception, monochrome & colour vision models, colour representation ; image sampling & quantization; 2-D systems; image transforms; image coding; stochastic models for image representation; image enhancement, restoration & reconstruction. Image analysis using multiresolution techniques.

EE 605 **INTRODUCTION TO SIGNAL ANALYSIS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Discrete and Continuous time signals and systems, LTI systems, Convolution, Difference equations. Frequency domain representation: Fourier transform and its properties. Random discrete signals. Sampling and reconstruction: Change of sampling rate. Normed vector spaces, basis, linear independence, orthogonality. Linear systems of equations. Over- and Underdetermined systems. Row- and Column spaces, Null spaces. Least square and minimum norm solutions. Inverse and pseudo inverse, Symmetry transformations. Eigenvectors and eigenvalues. Hilbert transforms, band pass representations and complex envelope. Base band pulse transmission, matched filtering, ISI, equalization. Coherent and noncoherent detection.

EE 606 **ARCHITECTURE AND APPLICATIONS OF DIGITAL SIGNAL PROCESSORS,** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Review of DSP fundamentals. Issues involved in DSP processor design - speed, cost, accuracy, pipelining, parallelism, quantization error, etc. Key DSP hardware elements - Multiplier, ALU, Shifter, Address Generator, etc. TMS 320C55 X and TM 320C6X and 21000 family architecture and instruction set. Software development tools - assembler, linker and simulator. Applications using DSP Processor - spectral analysis, FIR/IIR filter, linear-predictive coding, etc.

EE 607 **WAVELET TRANSFORMS FOR SIGNAL AND IMAGE PROCESSING** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Basics of functional Analysis; Basics of Fourier Analysis; Spectral Theory; Time-Frequency representations; Nonstationary Processes; Continuous Wavelet Transforms; Discrete Time-Frequency Transforms; Multi resolution Analysis; Time-Frequency Localization; Signal Processing Applications; Image Processing Applications

EE 608 L-T-P-D-[C] 3-0-0-0-[4]

STATISTICAL SIGNAL PROCESSING II **Prereq. #**

Power Spectrum Estimation, model order selection, Prony, Pisarenko, MUSIC, ESPRIT algorithms, least square estimation, cholesky, LDU-OR, SV decomposition. Transversal & reasnic least square lattice filters, Signal Analysis with Higher order Spectra, Array processing, Beam foming, Time-delay estimation.

EE 609 L-T-P-D-[C] 3-0-0-0-[4]

BASICS OF BIOMEDICAL SIGNAL AND IMAGE PROCESSING **Prereq. #**

Speech and pathology of vocal tract/ cords, Perpetual coding of audio signal and data compression, Spatio-temporal nature of bioelectric signals, cardiac generator and its models, Specific digital technique for bioelectric signals, Modes of medical imaging.

EE 610 L-T-P-D-[C] 3-0-0-0-[4]

ANALOG/DIGITAL VLSI CIRCUITS **Prereq. #**

Analog MOS circuits, op-amps, frequency and transient responses, stability and compensation. Analog switches, sample-and-hold circuits, switched-capacitor circuits. MOS inverters and gate circuits, interfacing, transmission gates. MOS memory circuits. Digital building blocks - multiplexers, decoders, shift registers, etc. Gate array, standard cell, and PLA based designs. Digital -to-Analog and Analog-to-Digital converters.

EE 611 L-T-P-D-[C] 3-0-0-0-[4]

FLUCTUATION PHENOMENA IN MICROELECTRONICS **Prereq. #**

Stochastic variables of interest in physical electronics (e.g. carrier concentration, potential, barrier heights, mobility, diffusion constant, G-R time, avalanche coefficients etc.). Thermodynamic considerations. Manifestation of stochastic processes in physical electronics. Instrumentation.

EE 612 L-T-P-D-[C] 3-0-0-0-[4]

FIBER OPTIC SYSTEMS I **Prereq. #**

Review of semiconductor physics - radiative recombination. LEDs, optical cavity, DH and other lasers. P-I-N and APD detectors, detector noise. Optical fibers - ray and mode theories, multimode and single-mode fibers, attenuation, dispersion. Gaussian beams. Power coupling, splices and connectors.

EE 613 L-T-P-D-[C] 3-0-0-0-[4]

MEASUREMENTS, PARAMETER EXTRACTION AND SLSI TOOLS IN MICROELECTROMICS **Prereq. #**

Essentially a lab course aimed at imparting basic measurement, analysis and software skills relevant to microelectronics. Experiments related to BJT DC characteristics, MOS C-V measuremets, interface state density and DLTS. SPICE simulation of complex CMOS gate; full custom cell layout; logic simulation; multi-level logic minimization using VIEWLOGIC tools.

EE 614 L-T-P-D-[C] 3-0-0-0-[4]

SOLID STATE DEVICES I **Prereq. #**

Basic semiconductor physics. Diodes (P-N junction, Schottky, contact), Junction Transistors (BJT, HBT), Field Effect Transistors (JEFT, MESFET, MOSFET, HEMT). Other semiconductor devices.

EE 615 L-T-P-D-[C] 3-0-0-0-[4]

HIGH FREQUENCY SEMICONDUCTOR DEVICES AND CIRCUITS **Prereq. EE 614**

Review of Semiconductor properties - Crystal structure of semiconductors, band theory, occupation statistics, electrical properties, optical properties, recombination kinetics, avalanche process in semiconductors, photon statistics; MESFETs; Transport in low dimensional structures: HEMTs: Hetrojunction BJTs; Design of high frequency amplifiers and oscillators, Resonant tunneling structures, RTD oscillators; Intervalley scattering, Gunn diodes, IMPATT diodes; TRAPATTs; Mixer diodes; Step recovery diodes; Introduction to epitaxial growth for these structures; elements of device fabrication.

EE 616 L-T-P-D-[C] 3-0-0-0-[4]

SEMICONDUCTOR DEVICE MODELLING **Prereq. #**

Models for metal-semiconductor contacts and heterojunctions. MOSFET - quantum theory of 2DEG, gradual channel approximation, charge control models, BSIM model, second-order effects. MESFET-Shockley, velocity saturation and universal models. HEFT - Basic and universal models. SPICE and small-signal models.

EE 617 L-T-P-D-[C] 3-0-0-0-[4]

FIBER OPTIC SYSTEMS II **Prereq. #**

Fiber optic transmitter and receiver designs. Link analyses. Line Coding. Coherent optical communication systems. Multiplexing schemes. Local area networks, FDDI, SONET and SDH. Fiber optic sensors and signal processing. Optical Amplifiers. Photonic Switching. Solitons in optical fibers.

EE 618 L-T-P-D-[C] 3-0-0-0-[4]

INTEGRATED CIRCUIT TECHNOLOGY **Prereq. #**

IC components - their characterization and design. Anaysis and design of basic logic circuits. Linear ICs. Large Scale Integration. Computer simulation of ICs and layout design. High Voltage ICs. GaAs MESFET and GaAs ICs. Failure, reliability and yield of ICs. Fault modeling and testing.

EE 619 L-T-P-D-[C] 3-0-0-0-[4]

VLSI SYSTEM DESIGN **Prereq. #**

Emphasis on the synthesis based approach to VLSI Design. Relevant issues related to physical design automation such as placement, floor planning, routing and compaction are covered. Combinational & sequential logic synthesis issues and algotithms are discussed. Detailed coverage of HDLs and high level synthesis algorithms and issues.

EE 620 L-T-P-D-[C] 3-0-0-0-[4]

APPLICATION OF CDMA TO CELLULAR COMMUNICATIONS Prereq. EE 621

Spread spectrum concept. Basics of CDMA. Properties and generation of PN sequences. Basics of Cellular and Mobile communications. Applications of CDMA to cellular communication systems. Walsh and Harr functions. Second and third generation CDMA systems/standards. Multicarrier CDMA. Synchronization and demodulation issues. Diversity techniques and Rake receiver. Cell coverage and capacity issues. Convolution and turbo codes. CDMA optimization issues.

EE 621 L-T-P-D-[C] 3-0-0-0-[4]

REPRESENTATION AND ANALYSIS OF RANDOM SIGNALS Prereq. #

Review of probability, random variables, random processes; representation of narrow band signals. Transmission of signals through LTI systems; Estimation and detection with random sequences; BAYES, MMSE, MAP, ML schemes. K-L and sampling theorem representations, matched filter, ambiguity functions, Markov sequences, linear stochastic dynamical systems.

EE 622 L-T-P-D-[C] 3-0-0-0-[4]

COMMUNICATION THEORY Prereq. #

Rate Distortion Theory, Channel Coding Theorems, Digital Modulation Schemes, Trellis Coded Modulation, Digital Transmission over Bandlimited Channels, Fading Multipath Channels, Synchronization. Analog Modulation Schemes, Optimum/ Suboptimum Receivers; Diversity Combining; Cellular Mobile Communciation; Equalization.

EE 623 L-T-P-D-[C] 3-0-0-0-[4]

DETECTION & ESTIMATION THEORY Prereq. #

Classical Detection and Estimation Theory, Signal Representation, Detection of signals in Gaussian noise, Waveform estimation, Linear estimation problems, Wiener filtering, Kalman filtering.

EE 624 L-T-P-D-[C] 3-0-0-0-[4]

INFORMATION & CODING THEORY Prereq. #

Entropy and mutual information, rate distortion function, source coding, variable length coding, discrete memoryless channels, capacity cost functions, channel coding, linear block codes, cyclic codes. Convolutional codes, sequential and probabilistic decoding, majority logic decoding, burst error-correcting codes.

EE 625 L-T-P-D-[C] 3-0-0-0-[4]

SATELLITE COMMUNICATION **Prereq. #**

Introduction. Historical background and overall perspective; Satellite network modeling ; Link calculations; FM analysis; TV Transmission; Digital modulation; Error control; Multiple access; FDMA, TDMA, CDMA. Orbital considerations; Launching; Atmospheric effects; Transponders; Earth Stations; VSATs.

EE 626 L-T-P-D-[C] 3-0-0-0-[4]

TOPICS IN STOCHASTIC PROCESSES **Prereq. EE 621 or equiv. #**

Martingale convergence theorem, stopping times, sequential analysis. Ergodic Theory: Measure preserving transformations, stationary processes, mixing conditions, ergodic theorem, Shannon-Millan-Breiman theorem. Markov chains-asymptotic stationarity, indecomposability, ergodicity. Continuous time processes: Separability, continuity, measurability, stochastic integral.

EE 627 L-T-P-D-[C] 3-0-0-0-[4]

SPEECH SIGNAL PROCESSING **Prereq. #**

Spectral and non-spectral analysis techniques; Model-based coding techniques; Noise reduction and echo cancellation; Synthetic and coded speech quality assessment; Selection of recognition unit; Model-based recognition; Language modelling; Speaker Identification; Text analysis and text-to-speech synthesis.

EE 628 L-T-P-D-[C] 3-0-0-0-[4]

TOPICS IN CRYPTOGRAPHY AND CODING **Prereq. #**

Cryptography and error control coding in communication and computing systems. Stream and block ciphers; DES; public-key cryptosystems; key management, authentication and digital signatures. Codes as ideals in finite commutative rings and group algebras. Joint coding and cryptography.

EE 629 L-T-P-D-[C] 3-0-0-0-[4]

DIGITAL SWITCHING **Prereq. #**

Network Architecture; time division multiplexing; digital switching; space & time division switching, cross point and memory requirements; blocking probabilities. traffic Analysis, models for circuit and packet switched systems, performance comparison; ISDN.

EE 630 L-T-P-D-[C] 3-0-3-0-[5]

SIMULATION OF MODERN POWER SYSTEMS **Prereq. #**

Modern power systems operation and control, Power system deregulation; static and dynamic modeling; Load flow and stability studies; Electromagnetic phenomenon; Insulation and partial discharge.

EE 631 L-T-P-D-[C] 3-0-0-0-[4]

ADVANCED POWER SYSTEM STABILITY **Prereq. #**

Detailed machine modeling, Modeling of turbine-generator and associated systems, excitation systems and PSS, Transient stability and small signal stability for large systems, SSR and system modeling for SSR studies, Voltage stability: P-V and Q-V curves, static analysis, sensitivity and continuation method; Dynamic analysis, local and global bifurcations, Control area, Margin prediction, Stability of AC-DC systems.

EE 632 L-T-P-D-[C] 3-0-0-0-[4]

ECONOMIC OPERATION & CONTROL OF POWER SYSTEMS **Prereq. #**

Economic load dispatch, loss formula, introduction to mathematical programming, hydrothermal scheduling systems, power system security, optimal real and reactive power dispatch, state estimation, load frequency control, energy control center.

EE 633 L-T-P-D-[C] 3-0-0-0-[4]

ELECTRIC POWER SYSTEM OPERATION AND MANAGEMENT UNDER RESTRUCTURED ENVIRONMENT **Preq. #**

Fundamentals of deregulation: Privatization and deregulation, Motivations for Restructuring the Power industry; Restructuring models and Trading Arrangements: Components of restructured systems, Independent System Operator (ISO): Functions and responsibilities, Trading arrangements (Pool, bilateral & multilateral), Open Access Transmission Systems; Different models of deregulation: U K Model, California model, Australian and New Zealand models, Deregulation in Asia including India, Bidding strategies, Forward and Future market; Operation and control: Old vs New, Available Transfer Capability, Congestion management, Ancillary services; Wheeling charges and pricing: Wheeling methodologies, pricing strategies.

EE 634 L-T-P-D-[C] 3-0-0-0-[4]

ELECTRICAL INSULATION IN POWER APPARATUS AND SYSTEMS

- Properties of dielectrics and breakdown mechanisms ; composites and novel materials; insulators for outdoor applications.
- Issues in design of insulators and insulator systems.
- Overvoltages and insulation coordination in transmission networks.
- Generation and measurement of testing Voltages –DC, AC, impulse and pulsed.
- Testing and Evaluation : Procedures and standards, ageing studies.

- On- line and off- line condition monitoring of sub-station equipment.
- Advances in measurement and diagnostic technologies : partial discharge monitoring, space charge charge measurements, dielectric spectroscopy, etc.
- Lab demonstrations

EE 635 **HVDC TRANSMISSION AND FLEXIBLE AC TRANSMISSION SYSTEMS**
L-T-P-D-[C] **Prereq. None**
3-0-0-0-[4]

General aspects of DC transmission, converter circuits and their analysis, DC link controls, faults and abnormal operation and protection;Mechanism of active and reactive power flow contro; Basic FACTS controllers: SVC, STATCOM, TCSC, TCPAR, UPFC; Modeling of FACTS Controllers; System static performance improvement with FACTS controllers; System dynamic performance improvement with FACTS controllers

EE 636 **ADVANCED PROTECTIVE RELAYING** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Advanced protective relaying, basic protection schemes, relay terminology, relays as comparators, static relays, application of solid state devices, differential relaying systems, distance relaying schemes, protection of multiterminal lines, new types of relaying criteria, special problems, digital protection.

EE 638 **HIGH VOLTAGE ENGINEERING BEHAVIOUR OF DIELECTRICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Electric fields and their numerical estimation; avalanche, streamer and leader processes; breakdown mechanisms, arcs, breakdown characteristics of gases, liquids and solids; intrinsic and practical strengths of dielectrics; ageing of solids, liquids and gases; gas insulated systems; effects of corona.

EE 640 **COMPUTATIONAL ELECTRO-MAGNETICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Review of complex variables, conformal mappings, matrix calculus; Sturm Liouville equation; Eigenvalue problem; Guiding structures; Scattering media; Green's function approach; Variational formulation, FEM, Generalised scattering matrix and planar circuit approach.

EE 641 **ADVANCED ENGINEERING ELECTRO MAGNETICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Transmission line theory; Green's function and integral transform techniques; Wave propagation and polarization parameters; reflection and transmission across an interface; waveguides, cavity resonators, scattering by cylinders, wedges, spheres etc. Geometric theory of diffraction.

EE 642 **ANTENNA ANALYSIS & SYNTHESIS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Vector potential; antenna theorems and definitions; dipole, loop, slot radiators; aperture antennas; array theorems; pattern synthesis; self and mutual impedances; scanning antennas; signal processing antennas, travelling wave antennas; antenna measurements.

EE 643 **SMART ANTENNAS FOR MOBILE COMMUNICATIONS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Statistical signal processing concepts, Basics of mobile wireless communications. Radio-frequency signal modeling and channel characterization. Smart antennas and generalized array signal processing. Source localization problem. Joint angle and delay estimation. Smart antenna array configurations. Mobile communication systems with smart antennas.

EE 645 **MONOLITHIC MICROWAVE ICS** **Prereq. EE 340, EE 210**

L-T-P-D-[C]
3-0-0-0-[0]

Scattering parameters of n-ports, Conductor and dielectric losses in planar transmission lines, coupled lines, multi-conductor lines, discontinuities, GaAs MESFET fabrication devices, High electron mobility transistor, Heterojunction bipolar transistor fabrication and modeling, NMIC technology and design.

EE 646 **PHOTONIC NETWORKS AND SWITCHING** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Optical communications: Introduction to basic optical communications and devices. Optical multiplexing techniques - Wavelength division multiplexing, Optical frequency division multiplexing, time division multiplexing, code division multiplexing. Optical Networks: Conventional optical networks, SONET / SDH, FDDI, IEEE 802.3, DQDB, FCS, HIPPI etc. Multiple access optical networks, Topologies, Single channel networks, Multichannel networks, FTFR, FTTR, TTFR and TTTR, Single hop networks, Multihop networks, Multiaccess protocols for WDM networks, Switched optical networks. Optical amplification in all-optical networks. All-optical subscriber access networks. Design issues. Optical switching: Motivation, Spatial light modulator, Relational and non-relational switching devices, Fundamental limits on optical switching elements, Switching architectures, Free-space optical switching. Wavelength routed networks and other special topics. Soliton based networks, Optical networks management issues.

EE 647 **MICROWAVE MEASUREMENTS AND DESIGN** **Prereq. #**

L-T-P-D-[C]
2-0-2-0-[4]

Experiments in basic microwave measurements; passive and active circuit characterization using network analyser, spectrum analyser and noise figure meter; PC based automated microwave measurements; integration of measurement and design of microwave circuits.

EE 648 **MICROWAVE CIRCUITS** **Prereq. EE 340**
L-T-P-D-[C]
3-0-0-0-[4]

Transmission lines for microwave circuits; waveguides, stripline, microstrip, slot line; microwave circuit design principles; passive circuits; impedance transformers, filters, hybrids, isolators etc., active circuits using semiconductor devices and tubes, detection and measurement of microwave signals.

EE 649 **THE FINITE ELEMENT METHOD FOR ELECTRIC AND MAGNETIC FIELDS**
L-T-P-D-[C]
3-0-1-0-[4]

- Introduction : Review of Electromagnetic Theory.
- Introduction to the Finite Element Method using electrostatic fields : Galerkin 's method of weighted residuals, Minimum energy principle, Calculation of capacitance, electric field, electric forces from the potential solutions.
- Finite Element Concepts : Pre- processing, shape functions, isoparmetric elements, meshing, solvers, post- processing.
- finite Element Modeling : Conductive media, steady currents ; Magnetostatic fields, permanent Magnest, scalar and vector potentials ; Electromagnetic fields. eddy current problems, modeling of moving parts ; modeling of electrical circuits.

Laboratory :

Matlab and Femlab simulation

EE 650 **BASICS OF MODERN CONTROL SYSTEMS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Vector spaces, Linear systems, similarity transformations, Canonical forms, Controllability, Observability, Realisability etc. Minimal realization, Digital systems, Nonlinear systems, Phase-plane analysis, Poinca're theorems, Lyapunov theorem, Circle and Popov criterion; Robust control, Linear Quadratic Regulator (LQR), Linear Quadratic Gaussian (LQG) control, Loop Transfer Recovery (LTR), H-infinity control.

EE 651 **NONLINEAR SYSTEMS** **Prereq. EE 451**
L-T-P-D-[C]
3-0-0-0-[4]

Describing function, phase-plane analysis. Poincare's Index, Bendixson's theorem. Linearization. Lyapunov stability, stability theorems, variable-gradient technique and Krasovskii's method for generating Lyapunov functions, statement of Lur'e problem, circle criterion, Popov criterion, input-output stability.

EE 652 **LINEAR STOCHASTIC DYNAMI-CAL SYSTEMS** **Prereq. EE 621**

L-T-P-D-[C]

3-0-0-0-[4]

Wiener processes; Markov chains & processes; Filtering, prediction & smoothing. Least squares, Minimum variance, ML and Minimax estimates, error bounds. Kalman and Wiener filters. Optimal control in presence of uncertainty, Synthesis of regulators and terminal controllers, Effect of noisy components on optimal control law. Partially characterised systems.

EE 653 **DIGITAL CONTROL** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Discrete-time signals and systems, Z-transform, pulse transfer functions. Compensator design by root locus, error coefficients and frequency response. State-space models of discrete time systems, controllability, observability, stability, state estimation, Kalman filtering. Linear regulation. Parameter estimation.

EE 654 **ROBUST CONTROL SYSTEMS** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Linear Quadratic Regulators: return ratio & difference, sensitivity function. Kalman's optimality condition. Gain/phase margins, robustness to time delay and nonlinearity. Characterization of sensitivity. Kharitonov theorem robustness. Singular values - properties, application in stability, robustness and sensitivity. Robustness of discrete time LQR systems.

EE 655 **OPTIMAL CONTROL** **Prereq. EE 650**

L-T-P-D-[C]

3-0-0-0-[4]

Basic mathematical concepts. Conditions for optimality, variational calculus approach, Pontryagin's maximum principle and Hamilton Jacobi-Bellman theory. Structures and properties of optimal systems. Various types of constraints; singular solutions. Minimum time problems.

EE 656 **CONTROL SYSTEM DESIGN** **Prereq. #**

L-T-P-D-[C]

3-0-3-0-[5]

Linear multivariable control systems. Equivalence of internal and external stability of feedback control systems and the stabilization problem. Stable factorization approach for solving stabilization problem. Feedback system design. Solutions of H_2 and H_a problems. Robust stabilization, graph topology and graph metric.

EE 657 **MATHEMATICAL METHODS IN CONTROL SYSTEMS** **Prereq. #**

L-T-P-D-[C]

3-0-0-0-[4]

Real and complex Euclidean spaces, Infinite dimensional inner product, complete spaces, Linear functionals and operators, Eigenvalues and eign vectors, complete orthognal representations, Errors solutions to systems of linear equations, Matrix inversion, pivoting eigenvalue and eigen vector calculations, SVD, Non linear equations, probability theory, concepts, random variables, distribution functions, moments and statistics of multiple variables, MS estimations, stochastic processes.

EE 658 — **FUZZY SET, LOGIC & SYSTEMS AND APPLICATIONS** — **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction, Uncertainity, Imprecision and Vagueness, Fuzzy systems, Brief history of Fuzzy logic, Foundation of Fuzzy Theory, Fuzzy Sets and Systems, Fuzzy Systems in Commercial Products, Research Fields in Fuzzy Theory, Classical sets and Fuzzy sets, Classical Relations, Fuzzy relations, Membership Functions, Fuzzy to crisp conversions, Fuzzy arithmetic, Numbers, Vectors and the extension principle, Classical logic and Fuzzy logic, Mathematical background of Fuzzy Systems, Classical (Crisp) vs, Fuzzy sets, Representation of Fuzzy sets, Types of Membership Functions, Basic Concepts (support, singleton, height, a-cut projections), Fuzzy set operations, S-and T- Norms, Properties of Fuzzy sets, Sets as Points in Hypercube, Cartesian Product, Crisp and Fuzzy Relations, Examples, Liguistic variables and hedges, Membership function design. Basic Principles of Inference in Fuzzy Logic, Fuzzy IF-THEN Rules, Canonical Form, Fuzzy Systems and Algorithms, Approximate Reasoning, Forms of Fuzzy Implication, Fuzzy Inference Engines, Graphical Techniques of Inference, Fuzzyifications/ DeFuzzification, Fuzzy System Design and its Elements, Design options. Fuzzy Events, Fuzzy Measures, Possibility Distributions as Fuzzy Sets, Possibility vs, Probability, Fuzzy Systems as Universal Approximators, Additive Fuzzy Systems (standard additive model).

EE 660 — **BASICS OF POWER ELECTRONICS CONVERTERS** — **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Power semiconductor devices, BJT, MOSFET, IGBT, GTO and MCT: AC-DC Converters; Forced communication; synchronous link converters, DC-AC converters, buck, boost, buck-boost, cuk, flyback configuration, resonant converters, PWM inverters; active filters.

EE 661 — **POWER ELECTRONICS APPLICATIONS IN POWER SYSTEMS** — **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Basics of flexible AC transmission systems, Controlled rectifier and energy storage plants, Tap changers and phase shifters, Thyristor controlled VAR compensation and series compensation, Modern (synchronous link converter) VAR compensators, Unified power flow controller (UPFC) and Interline power flow controller, Power quality conditioners, Power electronics in power generation.

EE 662 — **CONTROL TECHNIQUES IN POWER ELECTRONICS** — **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

State space modeling and simulation of linear systems, Discrete time models, conventional controllers using small signal models, Fuzzy control, Variable structure control, Hysteresis controllers, Output and state feedback switching controllers

EE 663 **MODELING AND SIMULATION OF POWER ELECTRONIC SYSTEMS Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Machine modeling, DC, induction motor and synchronous machines; simulation of transients; simulation tools: SABER, PSPICE, and MATLAB-SIMULINK; Simulations of converters, inverters and cyclo-converters etc.

EE 664 **FUNDAMENTALS OF ELECTRIC DRIVES** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Motor load dynamics, starting, braking & speed control of dc and ac motors. DC drives: converter and chopper control. AC Drives: Operation of induction and synchronous motors from voltage and current inverters, slip power recovery, pump drives using ac line controller and self-controlled synchronous motor drives.

EE 665 **ADVANCED ELECTRIC DRIVES** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Closed loop control of solid state DC drives, Scalar and vector control of induction motor, Direct torque and flux control of induction motor, Self controlled synchronous motor drive, Vector control of synchronous motor, Switched reluctance motor drive, Brushless DC motor drive, Permanent magnet drives, Industrial drives.

EE 666 **SPECIAL TOPICS IN POWER ELECTRONICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

PWM inverters, Multilevel inverters, Neutral point controlled inverters, Soft switching converters: DC-DC resonant link inverters, Hybrid resonant link inverters, Quasi resonant link converters, Switched mode rectifiers, Synchronous link converters.

EE 671 **NEURAL NETWORKS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Theory of representation; Two computational pradigms; Multi-layer networks; Auto-associative and hetero-associative nets; Learning in neural nets: Supervised and unsupervised learning; Application of neural nets; Neural network simulators.

EE 672 **COMPUTER VISION AND DOCUMENT PROCESSING** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Human and computer vision, Image reprentation and modelling, Line and edge detection, Labeling, Image segmentation, Pattern recognition, Statistical, structural neural and hybrid techniques, Training & classification, Document analysis and optical character recognition, object recognition, Scene matching & analysis, Robotic version, Role of knowledge.

EE 673 **DIGITAL COMMUNICATION NETWORKS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

OSI model, queueing theory, physical layer, error detection and correction, data link layer, ARQ strategies, framing, media access layer, modelling and analysis of important media access control protocols, FDDI and DQDB MAC protocols for LANs and MANs, network layer, flow control & routing, TCP/IP protocols, ATM.

EE 674 **Architecture of advanced Microprocessors and Microcontrollers** **Prereq. EE 370**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to the general structure of advanced microprocessors and microcontrollers. Discussions on architectures, instruction sets, memory hierarchies, pipelining and RISC principles. Specific details of MC68HC11, MC68000 and Power PC 601. Laboratory based experiments and projects with these devices.

EE 675 **DIGITAL CIRCUIT DESIGN** **Prereq. EE 370**

L-T-P-D-[C]
3-0-0-0-[4]

Combinational circuit design; implemen-tation using programmable logic devices & field programmable gate arrays. Synchronous & asynchronous sequential circuits. Micro-programming and use of AMD 2909 micro-sequencer in sequential circuits. Issues related to fault detection, fault tolerance, and reliable design.

IEEE 488.2, serial interfacing - RS 232C, RS 422, RS 423, RS 485, CAMAC, VXI, SCXI, PXI, Sensors and transducers; Interfacing signal conditioning, Signal analysis techniques, Networking methods and their applications in instrumentation.

EE 676 **DIGITAL, MOBILE RADIO SYSTEMS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to Mobile Radio networks, channel description and analysis, Propagation Effects, Technologies, TDMA/CDMA Techniques, Architectures, Cellular Systems, GSM Systems, Mobile Satellite Communication, Wireless ATM, Third Generation Cellular, Universal Mobile Telecommunication Systems (UMTS).

EE 677 **KNOWLEDGE BASED MAN MACHINE SYSTEMS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Knowledge representation, state-space techniques, logic, semantic networks, frames, script. Production system, object oriented and ANN models. Applications in robotic vision and processing of documents, natural languages and speech. Course Project involving extensive programming is compulsory.

Combinational and sequential circuits, Logic families, Number systems, Arithmetic circuits using SSI/MSI chips. Basic microprocessor architecture, Essentials of a microcomputer system, Instruction sets, Machine cycles, Interrupt structures. Parallel /serial I/O, Analog I/O, DMA operation. Peripheral controllers.

EE 678 **NEURAL SYSTEMS AND NETWORKS, 2-0-3-4** **Prereq. #**

L-T-P-D-[C]
2-0-3-0-[4]

Memory: Eric Kandel's momery and its physiological basis, Explicit and Implicit memories, Short Term and Long Term potentiation (STP and LTP), Hopfield's Model of Associative Memories, its comparison with Kandel's model, Stability of Hopefield net, its use as CAM, Hamming's Model and comparision of number of weights, Learning: Supervised and Unsupervised nets, Learning Methods, Neural systems: Different types of neurons, dendrites, axons, role of Na^+ K^+ *AT* Pase and resting potentials, synaptic junctions and transmission of action potentials, Consciousness and its correlation with respiratory sinus arrythmia, a bioinstrumentation scheme for its measurement; Neural nets for technical applications: Bidirectional Associative Memories, (SAMs), Radial Basic, Function nets. Boltzmann machine, Wavelet nets, Cellular Neural Nets and Fuzzy nets.

EE 679 **QUEUEING SYSTEMS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Review of probability and stochastic processes, Markov chains, Little's theorem, modelling & analysis of M/M-/- queues, Burke's Theorem, Reversibility, Method of stages, Analysis of M/G/1 queues, Queues with vacations, Work conservation principle, Priority queues, Queues served in cyclic order, Fluid-flow and diffusion approximations.

EE 680 **INTELLIGENT INSTRUMENTATION**

L-T-P-D-[C]
2-0-3-0-[4]

Introduction, data flow and graphical programming techniques, Virtual instrumentation (VI), advantages, VIs and Sub-VIs, Data acquisition methods, DAQ hardware, PC hardware; Structure, Operating system, ISA, PCI, USB, PCMICA buses, Instrumentation buses. IEEE 488.1 and

EE 698 **Special Topics in Electrical Engineering,**

Courses contents will be decided by the instructor

EE 699 **M. Tech. Thesis**

EE 799 **Ph. D. Thesis**

DEPARTMENT OF ELECTRICAL ENGINEERING

PROFESSORS

Bansal RK	rkb	7075	
Biswas A	abiswas	7319	7137
Chaturvedi AK	akc	7613	
Das SP	spdas	7106	
Das U	utpal	7150	7360
Dutta A	aloke	7661	
Ghosh AK	anjn	7105	
Gupta Sumana	sumana	7310	
John J	jjohn	7088	7733
Joshi A	ajoshi	7233	
Kalra PK (Head)	kalra	7810	7034
Mazhari B	baquer	7924	
Qureshi S	qureshi	7339	7133
Sachidananda M	sachi	7131	
Sharma G	govind	7922	
Singh SN	snsingh	7009	
Sinha RMK (Joint appointment with CSE)	rmk	7154	
Sircar P	sircar	7063	
Srivastava SC	scs	7625	7299
Umesh S	sumesh	7855	

ASSOCIATE PROFESSORS

Behera L	lbehera	7198
Singh YN	ynsingh	7944
Harish AR	arh	7569
Iyer SSK	sskiyer	7820
Vasudevan K	vasu	7109
Venkatesh KS	venkats	7468

ASSISTANT PROFESSORS

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Gupta Nandini	ngupta	7511
Hedge RM	rhegde	6248
Mishra SK	santanum	6249
Potluri RP	potluri	6093
Sensarma P	sensarma	7076

EMERITUS FELLOW

Arora R	rarora	7665	7850

Convenor, DUGC :	A Biswas	abiswas	7319, 7137
Convenor, DPGC :	S Umesh	sumesh	7855
Faculty Counsellor:	S. P. Das	spdas	7106

E-mails : _____@iitk.ac.in Tel Nos : +91-512-259 _______

At the UG level, the department offers a 4 year B. Tech. programme in Electrical Engineering. While most of the courses in the first four semesters are compulsory, those in the final four semesters are electives. Once the fundamentals underlying different areas of electrical engineering have been taught, students are free to specialise in areas of their interest, beginning in the sixth semester. The

B.Tech. curriculum emphasises laboratory courses throughout. The project in the final year, which lays stress on independent design, is a culmination of the skills imparted in the laboratory courses. The department also offers dual degree (B. Tech. & M. Tech.) programme.

At the PG level, the department offers M. Tech. and Ph. D. programmes in various areas of Electrical Engineering.

Specialisation in the M. Tech. Programme in Electrical Engineering is presently available in the following broad areas: Systems, Power Electronics & drives and Control systems, Power and Controls (including Power Microwaves & Photonics; Information Systems (including Signal Processing, Communications & Telecom Networks) Microelectronics, VLSI & Display Technology.

Considerable flexibility is available in the selection of courses in PG programmes. The postgraduate committee of the department plans the study programme for individual PG students. Faculty advisors counsel students in choosing a course package out of a number of possibilities based upon his/her interest and background.

In the Master's programme, a student has to complete eight courses. Certain number of courses out of the required total forms a package of compulsory courses. These are from the area of specialisation of the student. The rest are electives to be chosen in accordance with one's interests as well as thesis requirements. The programme culminates in a thesis which is normally in the area of specialisation of the student and has to be defended before the end of the programme.

The most important part of the doctoral programme is research culminating in a thesis. The research should represent an original investigation on the part of the student and is expected to make a significant contribution to knowledge in the subject. Publications in good journals and international conferences are encouraged.

Sponsored research and development activities are pursued in the Advanced Centre for Electronic Systems (ACES), which is the R&D wing of the department. Work on problems of current relevance in Electrical Engineering involving latest technologies are carried out under these sponsored projects. Students can take up thesis problems which have relevance to these activities, thus enabling them to use some of the sophisticated facilities available in the Centre.

The academic atmosphere is informal and this is borne out by the freedom the students have to discuss issues with the faculty members. Research students are encouraged to generate their research problems through discussion with faculty both in and out of the classroom. They have the freedom to choose their thesis supervisors from among the faculty members of the department and sometimes even from outside the department.

CURRENT COURSE STRUCTURE FOR B.TECH.-M.TECH. (DUAL DEGREE) STUDENTS
ELECTRICAL ENGINEERING

	S E M E S T E R										
	FIRST	**SECOND**	**THIRD**	**FOURTH**	**FIFTH**	**SIXTH**	**SEVENTH**	**EIGHTH**	**SUMM.**	**NINTH**	**TENTH**
C	PHY102	PHY101	MTH203	HSS-I-2	HSS-II-1	SE-1	DEL-1	OE-PG-3/	DE-PG-1		
O								DEL-2			
U	MTH101	CHM101	CHM201	ESO209	EE320	EE340	HSS-II-2	OE-PG-4			
	HSS-I-1/	PHY103	TA201	ESO210	EE330	EE381	OE-PG-1	OE-PG-5	EE699	EE699	EE699
R	ENG112N	MTH102	EE200	EE210	EE370	**3 OUT**	OE-PG-2	DEL-3	4	12	16
S	TA101	ESC101	ESO202	EE250	EE380	OF	OE-PG-3/	EE699	Credits	Credits	Credits
	ESC102	EE100	OR		OE-1	EE301		4			
	PE101	PE102	ESO214			EE311		Credits			
						EE321					
						EE60					

CHM 201	Chemistry
Com-S 200	Communication Skills
ESO 202	Thermodynamics or
ESO 214	Nature & Properties of Materials
EE 200	Signals, Systems and Networks
TA 201	Introduction to Manufacturing
MTH 203	Mathematics III
ESO 209	Probability & Statistics
ESO 210	Introduction to Electrical Engg.
EE 210	Microelectronics - I
EE 250	Control System Analysis
HSS	
EE 320	Principles of Communication
EE 330	Power Systems
EE 370	Digital Electronics & Micro-processor Technology
EE 380	Electrical Engineering Lab. - I
HSS	
OE	Open Elective
EE 340	Electromagnetic Theory
EE 381	Electrical Engineering Lab. - II
SE	Science Elective
	Three courses out of the following four:
EE 301	Digital Signal Processing
EE 311	Microelectronics II
EE 321	Communication Systems
EE 360	Power Electronics
SE	Science Elective
OE	Open Elective
DE	Department Elective
DE	Department Elective
EE 491	Project-I
HSS	
DE	Department Elective
OE	Open Elective
OE	Open Elective
EE 492	Project - II

Summer training and industrial tour are optional.

EE 200 — **SIGNALS, SYSTEMS AND NETWORKS** — **Prereq. ESc 102**

L-T-P-D-[C]
3-1-0-0-[4]

Continuous and discrete time signals; Fourier series, Fourier, Laplace and Z transform techniques; DFT. Sampling Theorem. LTI systems: I/O description, impulse response and system functions, pole/ zero plots, FIR and IIR systems. Analog and digital filters. Networks: topological description, network theorems,Two port analysis.

EE 210 — **MICROELECTRONICS - I** — **Prereq. ESc 102**

L-T-P-D-[C]
3-1-0-0-[4]

I-V characteristics of BJTs and MOSFETs, Basic amplifier configurations, Current sources and active loads, output stages, Op-amps, Feedback amplifiers, Stability and compensation, Noise in Electronic circuits, Signal processing: D/A and A/D converters, Non-linear electronic circuits.

EE 250 — **CONTROL SYSTEM ANALYSIS** — **Prereq. EE 200 or #**

L-T-P-D-[C]
3-1-0-0-[4]

Linear feedback control systems, frequency and time domain analysis, I/O relationships, transfer function, perfor-mance analysis, Routh-Hurwitz and Nyquist stability criteria, Bode diagrams, Nicholas chart, Root locus method, Feedback system design. Non-linear systems, phase-plane analysis, limit cycles, describing function.

EE 301 — **DIGITAL SIGNAL PROCESSING** — **Prereq. EE 200**

L-T-P-D-[C]
3-0-0-0-[4]

Review of discrete time signals and systems. Sampling of CT signals: aliasing, prefiltering, decimation and interpolation, A/D and D/A conversion, quantization noise. Filter design techniques. DFT Computation. Fourier analysis of signals using DFT. Finite register length effects. DSP hardware. Applications.

EE 311 — **MICROELECTRONICS - II** — **Prereq. EE 210**

L-T-P-D-[C]
3-0-0-0-[4]

Basics of semiconductor physics, p-n junction diodes, Metal-semiconductor contacts, BJTs, MOS capacitors, MOSFETs, optoelectronic devices, Advanced semiconductor devices: MESFETs, HBTs, HEMTs, MODFETs.

EE 320 — **PRINCIPLES OF COMMUNICATION** — **Prereq. EE 200**

L-T-P-D-[C]
3-1-0-0-[4]

Communication problem and system models. Representation of deterministic and stochastic signals. Analog and digital modulation systems, Receiver structures, SNR and error probability calculations, Frequency and time division multiplexing. Digital encoding of analog signals. Elements of information theory, Multiple access techniques and ISDN.

EE 321 L-T-P-D-[C] 3-0-0-0-[4]

COMMUNICATION SYSTEMS **Prereq. EE 320**

Information measures. Source coding. ISI & channel equalization, partial response signalling. M-ary modulation systems, error probability calculations. PLLs and FM threshold extension. Error control coding, block and convolution codes. Combined modulation and coding, trellis coded modulation. Spread spectrum systems.

EE 330 L-T-P-D-[C] 3-1-0-0-[4]

POWER SYSTEMS **Prereq. ESO 210**

Introduction to generation, transmission and distribution systems, Substation arrangements. Mathematical modelling of power systems. Grounding in power systems. Power cables and lines - parameter calculations. Fault Calcula-tions. Current and voltage relations of lines and cables. Reactive power control. Switchgear and protection.

EE 340 L-T-P-D-[C] 3-1-0-0-[4]

ELECTROMAGNETIC THEORY **Prereq. PHY 103**

Basics of Static electric and magnetic fields, Energy in fields, Maxwell's equations, plane EM waves, Propagation in free space and in matter, Reflection and refraction, Guided EM waves, Transmission lines, Radiation of EM waves.

EE 360 L-T-P-D-[C] 3-0-3-0-[4]

POWER ELECTRONICS **Prereq. ESc 102**

Power semiconductor devices: structure and characteristics; snubber circuits, switching loss. Controlled rectifiers: full/half controlled converters, dual converters, sequence control. AC regulator circuits, reactive power compensators. dc-dc converters, switching dc power supplies. Inverters: square wave and pwm types, filters, inverters for induction heating and UPS.

EE 370 L-T-P-D-[C] 3-1-0-0-[4]

DIGITAL ELECTRONICS & MICROPROCESSOR TECHNOLOGY **Prereq. ESC 102**

Analysis of digital logic families: TTL, MOS, CMOS Inverters; interfacing between logic families; various logic functions and their implementation; Bistable circuits - R-S, J-K, D and PLA; Design of synchronous sequential circuits. Microprocessor based systems : Number systems, Arithmetic operations in integer and floating point systems; ASCII Code; General micro-processor organisation, Memory inter-facing, Assembly language and bus signals of 8085; interrrupts and their applications; Serial and parallel ports; DMA and its controller; 8253 timer; 8259 interrupt controller.

EE 380 **ELECTRICAL ENGINEERING LAB**

L-T-P-D-[C] **Prereq. ESc 102, ESO 210, EE 210, EE 250**

0-2-6-0-[4]

Experiments from various areas of electrical engineering with emphasis on electronic devices, circuits, control systems and machines.

EE 381 **ELECTRICAL ENGINEERING LAB I**

L-T-P-D-[C] **Prereq. EE 320 or #, EE 370 or #, EE 380**

0-2-6-0-[4]

Experiments from various areas of electrical engineering with emphasis on digital electronics, communications, machines, drives and power systems, and electromagnetics.

EE 403 **ADVANCED DIGITAL SIGNAL PROCESSING** **Prereq. EE 301**

L-T-P-D-[C]

3-0-0-0-[4]

Review of linear algebra; functional analysis, time-frequency representation; frequency scale and resolution; uncertainity principle, short-time Fourier transform, Multi-resolution concept and analysis, Wavelet transforms. Wigner-ville distributions. Multi-rate signal processing; discrete-time bases and filter banks; 2D signals and systems, 2D sampling in arbitrary lattices, 2D-linear transforms, 1D/2D signal compression; introduction to DSP architecture.

EE 413 **SEMICONDUCTOR DEVICES TECHNOLOGY** **Prereq. EE 210**

L-T-P-D-[C]

2-0-3-0-[4]

Semiconductor materials, Ultraclean technology, Single crystal growth, Thermal oxidation of silicon, Solid state diffusion, Ion implantation, Vacuum technology, Physical and chemical vapor deposition techniques, Wet and dry etching, Lithography techniques, VLSI/ULSI process integration, Fault diagnosis and characterization techniques.

EE 414 **LOW NOISE AMPLIFIERS** **Prereq. EE 320, EE 311**

L-T-P-D-[C]

3-0-0-0-[4]

Noise and its characterisation, Noise figure calculations, Noise in semiconductors, P-N junction, Metal semiconductor junctions, Tunnelling: Varactors and their application as parametric amplifiers and multipliers. Tunnel diode amplifiers, Schottky diode Mixers, Masers, Design aspects of low noise amplifiers and mixers.

EE 415 **LINEAR INTEGRATED CIRCUIT DESIGN** **Prereq. EE 311**

L-T-P-D-[C]

3-0-0-0-[4]

Bipolar and MOS technology. Voltage regulators. Analog delay lines. IC transducers. Analog switches, S/H circuits. Noise in ICs, Special function ICs. Switched capacitor circuits. Opto-electronic ICs and systems. MOS analog circuits-building blocks, subcircuits, opamps. BiCMOS circuit design. Low power/voltage circuit design. Mixed signal design issues.

EE 416 L-T-P-D-[C] 3-0-0-0-[4] **OPTO-ELECTRONICS** **Prereq. EE 210, EE 340**

LEDs, semiconductor lasers, modulation of laser sources. Avalanche and PIN photodetectors and their characteristics. Solar cells. Optical fibers and their characteristics. Integrated optics. Fiber optic communication systems, system design consideration.

EE 417 L-T-P-D-[C] 3-0-0-0-[4] **INTRODUCTION TO VLSI DESIGN** **Prereq. EE 210, EE 370 or #**

Review of MOS device operation; fabrication and layout; combinational and sequential logic design; verification and testing; arithmetic blocks, memory; architecture design; floor planning; design methodologies; example of a chip design; analysis and synthesis algorithms including circuit, switch and logic simulation, logic synthesis, layout synthesis and test generation; packaging.

EE 422 L-T-P-D-[C] 3-0-0-0-[4] **COMMUNICATION SYSTEM ENGINEERING** **Prereq. EE 320**

Baseband signal characterisation-telegraphy, telephony, television and data; message channel objective; voice frequency transmission, radio wave propagation methods: random noise characterization in communication systems, intermodulation distortion : line of sight systems description and design; troposcattrer systems.

EE 431 L-T-P-D-[C] 3-0-0-0-[4] **ELECTRICAL MACHINES** **Prereq. ESO 210**

Magnetic circuits and transformers including three-phase transformers. Electro-mechanical energy conversion. General principle of AC machines. Synchronous machines including power system interfacing. Induction machine including starting and speed control of motors.

EE 432 L-T-P-D-[C] 3-0-0-0-[4] **POWER GENERATION, 3-0-0-0-4** **Prereq. ESO 210**

Power generation from conventional sources; thermal, hydro, nuclear and gas power plants - their functions and control; types of prime movers, generators and excitation systems; Economic considerations in power systems. Alternate sources of power generation - solar, wind, geo-thermal, ocean-thermal, tidal, wave and MHD.

EE 437 L-T-P-D-[C] 3-0-2-0-[5] **FUNDAMENTALS OF HV ENGG & LABORATORY TECHNIQUES** **Prereq. EE 330**

Electromagnetic fields, field control, Dielectrics used in HV and their properties, Standard voltage wave-forms, Generation and measurement of HV ac, dc and impulse voltages, Non-destructive testing, HV bushings & insulators, Overvoltage phenomena & insulation coordination

EE 441 L-T-P-D-[C] 3-0-0-0-[4]

MICROWAVES **Prereq. EE 340**

Active devices: LHTs, klystrons, magnetrons, TWTs, BWOs, microwave transistors; point contact, tunnel, PIN, and GUNN diodes; Parametric amplifier masers. Microwave circuits-theory of guiding systems, scattering matrix impedance transformation and matching. Passive devices: ferrites & ferrite devices, microwave cavity.

EE 442 L-T-P-D-[C] 3-0-0-0-[4]

ANTENNAS AND PROPAGATION **Prereq. EE 340**

Retarded potential, radiation from current element and dipole, radiation patterns, impedance, reciprocity. Various types of antennas, interferometers and multi-element arrays, Antenna Measurements. Ground wave propagation, terrain and earth curvature effects.Tropospheric propagation; fading, diffraction and scattering; Ionospheric Propagation-refractive index, critical frequencies, effects of magnetic field.

EE 443 L-T-P-D-[C] 3-0-0-0-[4]

RADAR SYSTEMS **Prereq. EE 320**

Radar equation, CW and Frequency Modulated Radars, MTI and pulse Doppler radar, MTI delay line cancellors. MTI from moving platform, Tracking radars. Mono-pulse tracking in range/Doppler; Electronic scanning radars, Beam forming and Steering methods, Noise and Clutter; Ambiguity function; Radar signal processing; SAR.

EE 444 L-T-P-D-[C] 3-0-0-0-[4]

RADIO ASTRONOMY **Prereq. EE 340**

Fundamentals of astronomy, Co-ordinate systems, Structure of the universe, Radio astronomy fundamentals, Electromagnetic wave propagation, Radio telescope Antennas, Reflector Antennas, Antenna arrays, Interferometry and aperture synthesis. Radio astronomy receivers, General principles, low noise amplifiers, digital auto-correlation receivers, Description of radio sources.

EE 451 L-T-P-D-[C] 3-0-0-0-[4]

ADVANCED CONTROL SYSTEMS **Prereq. EE 250**

Modelling of physical systems, Concepts of state, state-space, Controllability and observability. Sensitivity and error analysis. Nonlinear systems, singular points, phase plane analysis, Lyapunov stability, describing functions, on-off and dual mode systems. Sampled Data Systems. Computer control systems.

EE 455 L-T-P-D-[C] 3-0-0-0-[4]

TRANSDUCERS AND INSTRUMENTATION **Prereq. #**

Measurement process; scales of measurement; configuration and functional description of measurement systems; performance characteristics; sensing elements and transducers for measurement of motion, force, pressure, flow, temperature, light, vacuum, etc.; transducer interfacing; signal conditioning, transmission and recording; microprocessor based instrumentation.

EE 480 L-T-P-D-[C] 0-0-6-0-[4]

ADVANCED ELECTRICAL ENGINEERING LABORATORY 1 Prereq. EE480

The purpose of this course is to allow students to do new and challenging experiment in emerging areas of Electrical Engineering under the guidance of an assigned department faculty member. This would also facilitate the task of developing new experiments for EE380/381 as well.

EE 481 L-T-P-D-[C] 0-0-6-0-[4]

ADVANCED ELECTRICAL ENGINEERING LABORATORY 2 Prereq. EE481

The purpose of this course is to allow students to do new and challenging experiment in emerging areas of Electrical Engineering under the guidance of an assigned department faculty member. This would also facilitate the task of developing new experiments for EE380/381 as well.

EE 491

PROJECT - I, 0-0-0-9-3, Fourth Year Standing EE 491
PROJECT - II, 0-0-0-15-5, EE492 Prereq. EE 491

POST-GRADUATE COURSES

EE 600 L-T-P-D-[C] 3-0-0-0-[4]

MATHEMATICAL STRUCTURES OF SIGNALS & SYSTEMS Prereq. #

Nature of definitions; Theory of measurement and scales; Symmetry, invariance and groups; Groups in signals and systems; Algebraic and relational structures of signal spaces and convolutional systems; Representation theory of groups, harmonic analysis and spectral theory for convolutional systems.

EE 601 L-T-P-D-[C] 3-0-0-0-[4]

MATHEMATICAL METHODS IN SIGNAL PROCESSING Prereq. #

Generalized inverses, regularization of ill-posed problems. Eigen and singular value decompositions, generalized problems. Interpolation and approximation by least squares and minimax error criteria. Optimization techniques for linear and nonlinear problems. Applications in various areas of signal processing.

EE 602 L-T-P-D-[C] 3-0-0-0-[4]

STATISTICAL SIGNAL PROCESSING I

Power Spectrum Estimation-Parametric and Maximum Entropy Methods, Wiener, Kalman Filtering, Levinson-Durban Algorithms Least Square Method, Adaptive Filtering, Nonstationary Signal Analysis, Wigner-Ville Distribution, Wavelet Analysis.

EE 603 **ADVANCED TOPICS IN DIGITAL FILTERING** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Multirate Processing of discrete Time Signals; Orthogonal Digital Filter Systems. Two-Dimensional Discrete Time Filters. VLSI Computing structures for Signal Processing.

EE 604 **IMAGE PROCESSING** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Human visual system and image perception, monochrome & colour vision models, colour representation ; image sampling & quantization; 2-D systems; image transforms; image coding; stochastic models for image representation; image enhancement, restoration & reconstruction. Image analysis using multiresolution techniques.

EE 605 **INTRODUCTION TO SIGNAL ANALYSIS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Discrete and Continuous time signals and systems, LTI systems, Convolution, Difference equations. Frequency domain representation: Fourier transform and its properties. Random discrete signals. Sampling and reconstruction: Change of sampling rate. Normed vector spaces, basis, linear independence, orthogonality. Linear systems of equations. Over- and Underdetermined systems. Row- and Column spaces, Null spaces. Least square and minimum norm solutions. Inverse and pseudo inverse, Symmetry transformations. Eigenvectors and eigenvalues. Hilbert transforms, band pass representations and complex envelope. Base band pulse transmission, matched filtering, ISI, equalization. Coherent and noncoherent detection.

EE 606 **ARCHITECTURE AND APPLICATIONS OF DIGITAL SIGNAL PROCESSORS,** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Review of DSP fundamentals. Issues involved in DSP processor design - speed, cost, accuracy, pipelining, parallelism, quantization error, etc. Key DSP hardware elements - Multiplier, ALU, Shifter, Address Generator, etc. TMS 320C55 X and TM 320C6X and 21000 family architecture and instruction set. Software development tools - assembler, linker and simulator. Applications using DSP Processor - spectral analysis, FIR/IIR filter, linear-predictive coding, etc.

EE 607 **WAVELET TRANSFORMS FOR SIGNAL AND IMAGE PROCESSING** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Basics of functional Analysis; Basics of Fourier Analysis; Spectral Theory; Time-Frequency representations; Nonstationary Processes; Continuous Wavelet Transforms; Discrete Time-Frequency Transforms; Multi resolution Analysis; Time-Frequency Localization; Signal Processing Applications; Image Processing Applications

EE 608 L-T-P-D-[C] 3-0-0-0-[4]

STATISTICAL SIGNAL PROCESSING II **Prereq. #**

Power Spectrum Estimation, model order selection, Prony, Pisarenko, MUSIC, ESPRIT algorithms, least square estimation, cholesky, LDU-OR, SV decomposition. Transversal & reasnic least square lattice filters, Signal Analysis with Higher order Spectra, Array processing, Beam foming, Time-delay estimation.

EE 609 L-T-P-D-[C] 3-0-0-0-[4]

BASICS OF BIOMEDICAL SIGNAL AND IMAGE PROCESSING **Prereq. #**

Speech and pathology of vocal tract/ cords, Perpetual coding of audio signal and data compression, Spatio-temporal nature of bioelectric signals, cardiac generator and its models, Specific digital technique for bioelectric signals, Modes of medical imaging.

EE 610 L-T-P-D-[C] 3-0-0-0-[4]

ANALOG/DIGITAL VLSI CIRCUITS **Prereq. #**

Analog MOS circuits, op-amps, frequency and transient responses, stability and compensation. Analog switches, sample-and-hold circuits, switched-capacitor circuits. MOS inverters and gate circuits, interfacing, transmission gates. MOS memory circuits. Digital building blocks - multiplexers, decoders, shift registers, etc. Gate array, standard cell, and PLA based designs. Digital -to-Analog and Analog-to-Digital converters.

EE 611 L-T-P-D-[C] 3-0-0-0-[4]

FLUCTUATION PHENOMENA IN MICROELECTRONICS **Prereq. #**

Stochastic variables of interest in physical electronics (e.g. carrier concentration, potential, barrier heights, mobility, diffusion constant, G-R time, avalanche coefficients etc.). Thermodynamic considerations. Manifestation of stochastic processes in physical electronics. Instrumentation.

EE 612 L-T-P-D-[C] 3-0-0-0-[4]

FIBER OPTIC SYSTEMS I **Prereq. #**

Review of semiconductor physics - radiative recombination. LEDs, optical cavity, DH and other lasers. P-I-N and APD detectors, detector noise. Optical fibers - ray and mode theories, multimode and single-mode fibers, attenuation, dispersion. Gaussian beams. Power coupling, splices and connectors.

EE 613 L-T-P-D-[C] 3-0-0-0-[4]

MEASUREMENTS, PARAMETER EXTRACTION AND SLSI TOOLS IN MICROELECTROMICS **Prereq. #**

Essentially a lab course aimed at imparting basic measurement, analysis and software skills relevant to microelectronics. Experiments related to BJT DC characteristics, MOS C-V measuremets, interface state density and DLTS. SPICE simulation of complex CMOS gate; full custom cell layout; logic simulation; multi-level logic minimization using VIEWLOGIC tools.

EE 614 **SOLID STATE DEVICES I** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Basic semiconductor physics. Diodes (P-N junction, Schottky, contact), Junction Transistors (BJT, HBT), Field Effect Transistors (JEFT, MESFET, MOSFET, HEMT). Other semiconductor devices.

EE 615 **HIGH FREQUENCY SEMICONDUCTOR DEVICES AND CIRCUITS** **Prereq. EE 614**

L-T-P-D-[C]
3-0-0-0-[4]

Review of Semiconductor properties - Crystal structure of semiconductors, band theory, occupation statistics, electrical properties, optical properties, recombination kinetics, avalanche process in semiconductors, photon statistics; MESFETs; Transport in low dimensional structures: HEMTs: Hetrojunction BJTs; Design of high frequency amplifiers and oscillators, Resonant tunneling structures, RTD oscillators; Intervalley scattering, Gunn diodes, IMPATT diodes; TRAPATTs; Mixer diodes; Step recovery diodes; Introduction to epitaxial growth for these structures; elements of device fabrication.

EE 616 **SEMICONDUCTOR DEVICE MODELLING** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Models for metal-semiconductor contacts and heterojunctions. MOSFET - quantum theory of 2DEG, gradual channel approximation, charge control models, BSIM model, second-order effects. MESFET-Shockley, velocity saturation and universal models. HEFT - Basic and universal models. SPICE and small-signal models.

EE 617 **FIBER OPTIC SYSTEMS II** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Fiber optic transmitter and receiver designs. Link analyses. Line Coding. Coherent optical communication systems. Multiplexing schemes. Local area networks, FDDI, SONET and SDH. Fiber optic sensors and signal processing. Optical Amplifiers. Photonic Switching. Solitons in optical fibers.

EE 618 **INTEGRATED CIRCUIT TECHNOLOGY** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

IC components - their characterization and design. Anaysis and design of basic logic circuits. Linear ICs. Large Scale Integration. Computer simulation of ICs and layout design. High Voltage ICs. GaAs MESFET and GaAs ICs. Failure, reliability and yield of ICs. Fault modeling and testing.

EE 619 **VLSI SYSTEM DESIGN** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Emphasis on the synthesis based approach to VLSI Design. Relevant issues related to physical design automation such as placement, floor planning, routing and compaction are covered. Combinational & sequential logic synthesis issues and algotithms are discussed. Detailed coverage of HDLs and high level synthesis algorithms and issues.

EE 620 L-T-P-D-[C] 3-0-0-0-[4]

APPLICATION OF CDMA TO CELLULAR COMMUNICATIONS Prereq. EE 621

Spread spectrum concept. Basics of CDMA. Properties and generation of PN sequences. Basics of Cellular and Mobile communications. Applications of CDMA to cellular communication systems. Walsh and Harr functions. Second and third generation CDMA systems/standards. Multicarrier CDMA. Synchronization and demodulation issues. Diversity techniques and Rake receiver. Cell coverage and capacity issues. Convolution and turbo codes. CDMA optimization issues.

EE 621 L-T-P-D-[C] 3-0-0-0-[4]

REPRESENTATION AND ANALYSIS OF RANDOM SIGNALS Prereq. #

Review of probability, random variables, random processes; representation of narrow band signals. Transmission of signals through LTI systems; Estimation and detection with random sequences; BAYES, MMSE, MAP, ML schemes. K-L and sampling theorem representations, matched filter, ambiguity functions, Markov sequences, linear stochastic dynamical systems.

EE 622 L-T-P-D-[C] 3-0-0-0-[4]

COMMUNICATION THEORY Prereq. #

Rate Distortion Theory, Channel Coding Theorems, Digital Modulation Schemes, Trellis Coded Modulation, Digital Transmission over Bandlimited Channels, Fading Multipath Channels, Synchronization. Analog Modulation Schemes, Optimum/ Suboptimum Receivers; Diversity Combining; Cellular Mobile Communciation; Equalization.

EE 623 L-T-P-D-[C] 3-0-0-0-[4]

DETECTION & ESTIMATION THEORY Prereq. #

Classical Detection and Estimation Theory, Signal Representation, Detection of signals in Gaussian noise, Waveform estimation, Linear estimation problems, Wiener filtering, Kalman filtering.

EE 624 L-T-P-D-[C] 3-0-0-0-[4]

INFORMATION & CODING THEORY Prereq. #

Entropy and mutual information, rate distortion function, source coding, variable length coding, discrete memoryless channels, capacity cost functions, channel coding, linear block codes, cyclic codes. Convolutional codes, sequential and probabilistic decoding, majority logic decoding, burst error-correcting codes.

EE 625 L-T-P-D-[C] 3-0-0-0-[4]

SATELLITE COMMUNICATION **Prereq. #**

Introduction. Historical background and overall perspective; Satellite network modeling ; Link calculations; FM analysis; TV Transmission; Digital modulation; Error control; Multiple access; FDMA, TDMA, CDMA. Orbital considerations; Launching; Atmospheric effects; Transponders; Earth Stations; VSATs.

EE 626 L-T-P-D-[C] 3-0-0-0-[4]

TOPICS IN STOCHASTIC PROCESSES **Prereq. EE 621 or equiv. #**

Martingale convergence theorem, stopping times, sequential analysis. Ergodic Theory: Measure preserving transformations, stationary processes, mixing conditions, ergodic theorem, Shannon-Millan-Breiman theorem. Markov chains-asymptotic stationarity, indecomposability, ergodicity. Continuous time processes: Separability, continuity, measurability, stochastic integral.

EE 627 L-T-P-D-[C] 3-0-0-0-[4]

SPEECH SIGNAL PROCESSING **Prereq. #**

Spectral and non-spectral analysis techniques; Model-based coding techniques; Noise reduction and echo cancellation; Synthetic and coded speech quality assessment; Selection of recognition unit; Model-based recognition; Language modelling; Speaker Identification; Text analysis and text-to-speech synthesis.

EE 628 L-T-P-D-[C] 3-0-0-0-[4]

TOPICS IN CRYPTOGRAPHY AND CODING **Prereq. #**

Cryptography and error control coding in communication and computing systems. Stream and block ciphers; DES; public-key cryptosystems; key management, authentication and digital signatures. Codes as ideals in finite commutative rings and group algebras. Joint coding and cryptography.

EE 629 L-T-P-D-[C] 3-0-0-0-[4]

DIGITAL SWITCHING **Prereq. #**

Network Architecture; time division multiplexing; digital switching; space & time division switching, cross point and memory requirements; blocking probabilities. traffic Analysis, models for circuit and packet switched systems, performance comparison; ISDN.

EE 630 L-T-P-D-[C] 3-0-3-0-[5]

SIMULATION OF MODERN POWER SYSTEMS **Prereq. #**

Modern power systems operation and control, Power system deregulation; static and dynamic modeling; Load flow and stability studies; Electromagnetic phenomenon; Insulation and partial discharge.

EE 631 L-T-P-D-[C] 3-0-0-0-[4]

ADVANCED POWER SYSTEM STABILITY **Prereq. #**

Detailed machine modeling, Modeling of turbine-generator and associated systems, excitation systems and PSS, Transient stability and small signal stability for large systems, SSR and system modeling for SSR studies, Voltage stability: P-V and Q-V curves, static analysis, sensitivity and continuation method; Dynamic analysis, local and global bifurcations, Control area, Margin prediction, Stability of AC-DC systems.

EE 632 L-T-P-D-[C] 3-0-0-0-[4]

ECONOMIC OPERATION & CONTROL OF POWER SYSTEMS **Prereq. #**

Economic load dispatch, loss formula, introduction to mathematical programming, hydrothermal scheduling systems, power system security, optimal real and reactive power dispatch, state estimation, load frequency control, energy control center.

EE 633 L-T-P-D-[C] 3-0-0-0-[4]

ELECTRIC POWER SYSTEM OPERATION AND MANAGEMENT UNDER RESTRUCTURED ENVIRONMENT **Preq. #**

Fundamentals of deregulation: Privatization and deregulation, Motivations for Restructuring the Power industry; Restructuring models and Trading Arrangements: Components of restructured systems, Independent System Operator (ISO): Functions and responsibilities, Trading arrangements (Pool, bilateral & multilateral), Open Access Transmission Systems; Different models of deregulation: U K Model, California model, Australian and New Zealand models, Deregulation in Asia including India, Bidding strategies, Forward and Future market; Operation and control: Old vs New, Available Transfer Capability, Congestion management, Ancillary services; Wheeling charges and pricing: Wheeling methodologies, pricing strategies.

EE 634 L-T-P-D-[C] 3-0-0-0-[4]

ELECTRICAL INSULATION IN POWER APPARATUS AND SYSTEMS

- Properties of dielectrics and breakdown mechanisms ; composites and novel materials; insulators for outdoor applications.
- Issues in design of insulators and insulator systems.
- Overvoltages and insulation coordination in transmission networks.
- Generation and measurement of testing Voltages –DC, AC, impulse and pulsed.
- Testing and Evaluation : Procedures and standards, ageing studies.

- On- line and off- line condition monitoring of sub-station equipment.
- Advances in measurement and diagnostic technologies : partial discharge monitoring, space charge charge measurements, dielectric spectroscopy, etc.
- Lab demonstrations

EE 635 **HVDC TRANSMISSION AND FLEXIBLE AC TRANSMISSION SYSTEMS** **Prereq. None**
L-T-P-D-[C]
3-0-0-0-[4]

General aspects of DC transmission, converter circuits and their analysis, DC link controls, faults and abnormal operation and protection;Mechanism of active and reactive power flow contro; Basic FACTS controllers: SVC, STATCOM, TCSC, TCPAR, UPFC; Modeling of FACTS Controllers; System static performance improvement with FACTS controllers; System dynamic performance improvement with FACTS controllers

EE 636 **ADVANCED PROTECTIVE RELAYING** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Advanced protective relaying, basic protection schemes, relay terminology, relays as comparators, static relays, application of solid state devices, differential relaying systems, distance relaying schemes, protection of multiterminal lines, new types of relaying criteria, special problems, digital protection.

EE 638 **HIGH VOLTAGE ENGINEERING BEHAVIOUR OF DIELECTRICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Electric fields and their numerical estimation; avalanche, streamer and leader processes; breakdown mechanisms, arcs, breakdown characteristics of gases, liquids and solids; intrinsic and practical strengths of dielectrics; ageing of solids, liquids and gases; gas insulated systems; effects of corona.

EE 640 **COMPUTATIONAL ELECTRO-MAGNETICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Review of complex variables, conformal mappings, matrix calculus; Sturm Liouville equation; Eigenvalue problem; Guiding structures; Scattering media; Green’s function approach; Variational formulation, FEM, Generalised scattering matrix and planar circuit approach.

EE 641 **ADVANCED ENGINEERING ELECTRO MAGNETICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Transmission line theory; Green’s function and integral transform techniques; Wave propagation and polarization parameters; reflection and transmission across an interface; waveguides, cavity resonators, scattering by cylinders, wedges, spheres etc. Geometric theory of diffraction.

EE 642 **ANTENNA ANALYSIS & SYNTHESIS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Vector potential; antenna theorems and definitions; dipole, loop, slot radiators; aperture antennas; array theorems; pattern synthesis; self and mutual impedances; scanning antennas; signal processing antennas, travelling wave antennas; antenna measurements.

EE 643 **SMART ANTENNAS FOR MOBILE COMMUNICATIONS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Statistical signal processing concepts, Basics of mobile wireless communications. Radio-frequency signal modeling and channel characterization. Smart antennas and generalized array signal processing. Source localization problem. Joint angle and delay estimation. Smart antenna array configurations. Mobile communication systems with smart antennas.

EE 645 **MONOLITHIC MICROWAVE ICS** **Prereq. EE 340, EE 210**
L-T-P-D-[C]
3-0-0-0-[0]

Scattering parameters of n-ports, Conductor and dielectric losses in planar transmission lines, coupled lines, multi-conductor lines, discontinuities, GaAs MESFET fabrication devices, High electron mobility transistor, Heterojunction bipolar transistor fabrication and modeling, NMIC technology and design.

EE 646 **PHOTONIC NETWORKS AND SWITCHING** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Optical communications: Introduction to basic optical communications and devices. Optical multiplexing techniques - Wavelength division multiplexing, Optical frequency division multiplexing, time division multiplexing, code division multiplexing. Optical Networks: Conventional optical networks, SONET / SDH, FDDI, IEEE 802.3, DQDB, FCS, HIPPI etc. Multiple access optical networks, Topologies, Single channel networks, Multichannel networks, FTFR, FTTR, TTFR and TTTR, Single hop networks, Multihop networks, Multiaccess protocols for WDM networks, Switched optical networks. Optical amplification in all-optical networks. All-optical subscriber access networks. Design issues. Optical switching: Motivation, Spatial light modulator, Relational and non-relational switching devices, Fundamental limits on optical switching elements, Switching architectures, Free-space optical switching. Wavelength routed networks and other special topics. Soliton based networks, Optical networks management issues.

EE 647 **MICROWAVE MEASUREMENTS AND DESIGN** **Prereq. #**
L-T-P-D-[C]
2-0-2-0-[4]

Experiments in basic microwave measurements; passive and active circuit characterization using network analyser, spectrum analyser and noise figure meter; PC based automated microwave measurements; integration of measurement and design of microwave circuits.

EE 648 **MICROWAVE CIRCUITS** **Prereq. EE 340**
L-T-P-D-[C]
3-0-0-0-[4]

Transmission lines for microwave circuits; waveguides, stripline, microstrip, slot line; microwave circuit design principles; passive circuits; impedance transformers, filters, hybrids, isolators etc., active circuits using semiconductor devices and tubes, detection and measurement of microwave signals.

EE 649 **THE FINITE ELEMENT METHOD FOR ELECTRIC AND MAGNETIC FIELDS**
L-T-P-D-[C]
3-0-1-0-[4]

- Introduction : Review of Electromagnetic Theory.

- Introduction to the Finite Element Method using electrostatic fields : Galerkin 's method of weighted residuals, Minimum energy principle, Calculation of capacitance, electric field, electric forces from the potential solutions.

- Finite Element Concepts : Pre- processing, shape functions, isoparmetric elements, meshing, solvers, post- processing.

- finite Element Modeling : Conductive media, steady currents ; Magnetostatic fields, permanent Magnest, scalar and vector potentials ; Electromagnetic fields. eddy current problems, modeling of moving parts ; modeling of electrical circuits.

Laboratory :

Matlab and Femlab simulation

EE 650 **BASICS OF MODERN CONTROL SYSTEMS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Vector spaces, Linear systems, similarity transformations, Canonical forms, Controllability, Observability, Realisability etc. Minimal realization, Digital systems, Nonlinear systems, Phase-plane analysis, Poinca're theorems, Lyapunov theorem, Circle and Popov criterion; Robust control, Linear Quadratic Regulator (LQR), Linear Quadratic Gaussian (LQG) control, Loop Transfer Recovery (LTR), H-infinity control.

EE 651 **NONLINEAR SYSTEMS** **Prereq. EE 451**
L-T-P-D-[C]
3-0-0-0-[4]

Describing function, phase-plane analysis. Poincare's Index, Bendixson's theorem. Linearization. Lyapunov stability, stability theorems, variable-gradient technique and Krasovskii's method for generating Lyapunov functions, statement of Lur'e problem, circle criterion, Popov criterion, input-output stability.

EE 652 **LINEAR STOCHASTIC DYNAMI-CAL SYSTEMS** **Prereq. EE 621**
L-T-P-D-[C]
3-0-0-0-[4]

Wiener processes; Markov chains & processes; Filtering, prediction & smoothing. Least squares, Minimum variance, ML and Minimax estimates, error bounds. Kalman and Wiener filters. Optimal control in presence of uncertainty, Synthesis of regulators and terminal controllers, Effect of noisy components on optimal control law. Partially characterised systems.

EE 653 **DIGITAL CONTROL** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Discrete-time signals and systems, Z-transform, pulse transfer functions. Compensator design by root locus, error coefficients and frequency response. State-space models of discrete time systems, controllability, observability, stability, state estimation, Kalman filtering. Linear regulation. Parameter estimation.

EE 654 **ROBUST CONTROL SYSTEMS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Linear Quadratic Regulators: return ratio & difference, sensitivity function. Kalman's optimality condition. Gain/phase margins, robustness to time delay and nonlinearity. Characterization of sensitivity. Kharitonov theorem robustness. Singular values - properties, application in stability, robustness and sensitivity. Robustness of discrete time LQR systems.

EE 655 **OPTIMAL CONTROL** **Prereq. EE 650**
L-T-P-D-[C]
3-0-0-0-[4]

Basic mathematical concepts. Conditions for optimality, variational calculus approach, Pontryagin's maximum principle and Hamilton Jacobi-Bellman theory. Structures and properties of optimal systems. Various types of constraints; singular solutions. Minimum time problems.

EE 656 **CONTROL SYSTEM DESIGN** **Prereq. #**
L-T-P-D-[C]
3-0-3-0-[5]

Linear multivariable control systems. Equivalence of internal and external stability of feedback control systems and the stabilization problem. Stable factorization approach for solving stabilization problem. Feedback system design. Solutions of H_2 and H_a problems. Robust stabilization, graph topology and graph metric.

EE 657 **MATHEMATICAL METHODS IN CONTROL SYSTEMS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Real and complex Euclidean spaces, Infinite dimensional inner product, complete spaces, Linear functionals and operators, Eigenvalues and eign vectors, complete orthognal representations, Errors solutions to systems of linear equations, Matrix inversion, pivoting eigenvalue and eigen vector calculations, SVD, Non linear equations, probability theory, concepts, random variables, distribution functions, moments and statistics of multiple variables, MS estimations, stochastic processes.

EE 658 **FUZZY SET, LOGIC & SYSTEMS AND APPLICATIONS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction, Uncertainity, Imprecision and Vagueness, Fuzzy systems, Brief history of Fuzzy logic, Foundation of Fuzzy Theory, Fuzzy Sets and Systems, Fuzzy Systems in Commercial Products, Research Fields in Fuzzy Theory, Classical sets and Fuzzy sets, Classical Relations, Fuzzy relations, Membership Functions, Fuzzy to crisp conversions, Fuzzy arithmetic, Numbers, Vectors and the extension principle, Classical logic and Fuzzy logic, Mathematical background of Fuzzy Systems, Classical (Crisp) vs, Fuzzy sets, Representation of Fuzzy sets, Types of Membership Functions, Basic Concepts (support, singleton, height, a-cut projections), Fuzzy set operations, S-and T- Norms, Properties of Fuzzy sets, Sets as Points in Hypercube, Cartesian Product, Crisp and Fuzzy Relations, Examples, Liguistic variables and hedges, Membership function design. Basic Principles of Inference in Fuzzy Logic, Fuzzy IF-THEN Rules, Canonical Form, Fuzzy Systems and Algorithms, Approximate Reasoning, Forms of Fuzzy Implication, Fuzzy Inference Engines, Graphical Techniques of Inference, Fuzzyifications/ DeFuzzification, Fuzzy System Design and its Elements, Design options. Fuzzy Events, Fuzzy Measures, Possibility Distributions as Fuzzy Sets, Possibility vs, Probability, Fuzzy Systems as Universal Approximators, Additive Fuzzy Systems (standard additive model).

EE 660 **BASICS OF POWER ELECTRONICS CONVERTERS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Power semiconductor devices, BJT, MOSFET, IGBT, GTO and MCT: AC-DC Converters; Forced communication; synchronous link converters, DC-AC converters, buck, boost, buck-boost, cuk, flyback configuration, resonant converters, PWM inverters; active filters.

EE 661 **POWER ELECTRONICS APPLICATIONS IN POWER SYSTEMS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Basics of flexible AC transmission systems, Controlled rectifier and energy storage plants, Tap changers and phase shifters, Thyristor controlled VAR compensation and series compensation, Modern (synchronous link converter) VAR compensators, Unified power flow controller (UPFC) and Interline power flow controller, Power quality conditioners, Power electronics in power generation.

EE 662 **CONTROL TECHNIQUES IN POWER ELECTRONICS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

State space modeling and simulation of linear systems, Discrete time models, conventional controllers using small signal models, Fuzzy control, Variable structure control, Hysteresis controllers, Output and state feedback switching controllers

EE 663 | **MODELING AND SIMULATION OF POWER ELECTRONIC SYSTEMS Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Machine modeling, DC, induction motor and synchronous machines; simulation of transients; simulation tools: SABER, PSPICE, and MATLAB-SIMULINK; Simulations of converters, inverters and cyclo-converters etc.

EE 664 | **FUNDAMENTALS OF ELECTRIC DRIVES** | **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Motor load dynamics, starting, braking & speed control of dc and ac motors. DC drives: converter and chopper control. AC Drives: Operation of induction and synchronous motors from voltage and current inverters, slip power recovery, pump drives using ac line controller and self-controlled synchronous motor drives.

EE 665 | **ADVANCED ELECTRIC DRIVES** | **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Closed loop control of solid state DC drives, Scalar and vector control of induction motor, Direct torque and flux control of induction motor, Self controlled synchronous motor drive, Vector control of synchronous motor, Switched reluctance motor drive, Brushless DC motor drive, Permanent magnet drives, Industrial drives.

EE 666 | **SPECIAL TOPICS IN POWER ELECTRONICS** | **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

PWM inverters, Multilevel inverters, Neutral point controlled inverters, Soft switching converters: DC-DC resonant link inverters, Hybrid resonant link inverters, Quasi resonant link converters, Switched mode rectifiers, Synchronous link converters.

EE 671 | **NEURAL NETWORKS** | **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Theory of representation; Two computational pradigms; Multi-layer networks; Auto-associative and hetero-associative nets; Learning in neural nets: Supervised and unsupervised learning; Application of neural nets; Neural network simulators.

EE 672 | **COMPUTER VISION AND DOCUMENT PROCESSING** | **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Human and computer vision, Image reprentation and modelling, Line and edge detection, Labeling, Image segmentation, Pattern recognition, Statistical, structural neural and hybrid techniques, Training & classification, Document analysis and optical character recognition, object recognition, Scene matching & analysis, Robotic version, Role of knowledge.

EE 673 **DIGITAL COMMUNICATION NETWORKS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

OSI model, queueing theory, physical layer, error detection and correction, data link layer, ARQ strategies, framing, media access layer, modelling and analysis of important media access control protocols, FDDI and DQDB MAC protocols for LANs and MANs, network layer, flow control & routing, TCP/IP protocols, ATM.

EE 674 **Architecture of advanced Microprocessors and Microcontrollers** **Prereq. EE 370**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to the general structure of advanced microprocessors and microcontrollers. Discussions on architectures, instruction sets, memory hierarchies, pipelining and RISC principles. Specific details of MC68HC11, MC68000 and Power PC 601. Laboratory based experiments and projects with these devices.

EE 675 **DIGITAL CIRCUIT DESIGN** **Prereq. EE 370**

L-T-P-D-[C]
3-0-0-0-[4]

Combinational circuit design; implemen-tation using programmable logic devices & field programmable gate arrays. Synchronous & asynchronous sequential circuits. Micro-programming and use of AMD 2909 micro-sequencer in sequential circuits. Issues related to fault detection, fault tolerance, and reliable design.

IEEE 488.2, serial interfacing - RS 232C, RS 422, RS 423, RS 485, CAMAC, VXI, SCXI, PXI, Sensors and transducers; Interfacing signal conditioning, Signal analysis techniques, Networking methods and their applications in instrumentation.

EE 676 **DIGITAL, MOBILE RADIO SYSTEMS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to Mobile Radio networks, channel description and analysis, Propagation Effects, Technologies, TDMA/CDMA Techniques, Architectures, Cellular Systems, GSM Systems, Mobile Satellite Communication, Wireless ATM, Third Generation Cellular, Universal Mobile Telecommunication Systems (UMTS).

EE 677 **KNOWLEDGE BASED MAN MACHINE SYSTEMS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Knowledge representation, state-space techniques, logic, semantic networks, frames, script. Production system, object oriented and ANN models. Applications in robotic vision and processing of documents, natural languages and speech. Course Project involving extensive programming is compulsory.

Combinational and sequential circuits, Logic families, Number systems, Arithmetic circuits using SSI/MSI chips. Basic microprocessor architecture, Essentials of a microcomputer system, Instruction sets, Machine cycles, Interrupt structures. Parallel /serial I/O, Analog I/O, DMA operation. Peripheral controllers.

EE 678 **NEURAL SYSTEMS AND NETWORKS, 2-0-3-4** **Prereq. #**

L-T-P-D-[C]
2-0-3-0-[4]

Memory: Eric Kandel's momery and its physiological basis, Explicit and Implicit memories, Short Term and Long Term potentiation (STP and LTP), Hopfield's Model of Associative Memories, its comparison with Kandel's model, Stability of Hopefield net, its use as CAM, Hamming's Model and comparision of number of weights, Learning: Supervised and Unsupervised nets, Learning Methods, Neural systems: Different types of neurons, dendrites, axons, role of Na^+ K^+ *AT* Pase and resting potentials, synaptic junctions and transmission of action potentials, Consciousness and its correlation with respiratory sinus arrythmia, a bioinstrumentation scheme for its measurement; Neural nets for technical applications: Bidirectional Associative Memories, (SAMs), Radial Basic, Function nets. Boltzmann machine, Wavelet nets, Cellular Neural Nets and Fuzzy nets.

EE 679 **QUEUEING SYSTEMS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Review of probability and stochastic processes, Markov chains, Little's theorem, modelling & analysis of M/M-/- queues, Burke's Theorem, Reversibility, Method of stages, Analysis of M/G/1 queues, Queues with vacations, Work conservation principle, Priority queues, Queues served in cyclic order, Fluid-flow and diffusion approximations.

EE 680 **INTELLIGENT INSTRUMENTATION**

L-T-P-D-[C]
2-0-3-0-[4]

Introduction, data flow and graphical programming techniques, Virtual instrumentation (VI), advantages, VIs and Sub-VIs, Data acquisition methods, DAQ hardware, PC hardware; Structure, Operating system, ISA, PCI, USB, PCMICA buses, Instrumentation buses. IEEE 488.1 and

EE 698 **Special Topics in Electrical Engineering,**

Courses contents will be decided by the instructor

EE 699 **M. Tech. Thesis**

EE 799 **Ph. D. Thesis**

ENVIRONMENTAL ENGINEERING AND MANAGEMENT

(Inter-Disciplinary M. Tech. Programme)

PROFESSORS

Onkar Dixit Head	onkar	7267	7582
Vinod Tare	vinod	7792	
Binayak Rath	brath	7155	
Mukesh Sharma	mukesh	7759	

ASSOCIATE PROFESSORS

Purnendu Bose	pbose	7403
Saumyen Guha	sguha	7917

ASSISTANT PROFESSORS

S Tripathi	snt	7845
T. Gupta	tarun	7128

Convenor, DUGC : Purnendu Bose pbose 7403

Convenor, DPGC : Mukesh Sharma mukesh 7759

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Recognising the emerging challenges for environmentally sustainable economic development, unique broad based programme in Environmental Engineering and Management has recently been started. This is primarily to meet the growing human resources requirements of high quality to provide leadership in various sectors such as environmental policy and planning, implementation and legal aspects, sustainable industrial development, environment-friendly infrastructure management, resource cleanup through remediation of land, water and air resources, over and above the traditional "end-of-the-pipe" pollution control measures. The need for an integrated approach to environmental issues that transcend the boundaries of traditional disciplines in social sciences, physical sciences, engineering sciences and management sciences has been recognised. This new programme builds on the past rich experience in environmental engineering, and the available experts and infrastructure across various branches of engineering, sciences and humanities in the institute.

This interdisciplinary programme offers M. Tech. (4 semesters) in Environmental Engineering and Management and is ad ministered by the Department of Civil Engineering. Doctoral programme in environmental engineering is offered by the Department of Civil Engineering. A Bachelor's degree in any branch of engineering, or a Master's degree in most branches of sciences is the minimum required for admission to the M. Tech. Programme.

Admission to the M.Tech. programme is generally offered in the semester beginning July/August.

COURSE DESCRIPTION

EEM 601 **EARTH AND ENVIRONMENT**
L-T-P-D-[C]
3-0-0-0-[4]

Understanding earth, atmosphere and processes governing environmental conditions; the biosphere, earth's energy budget, the atmosphere, climate and climate change, the geologic, tectonic, hydrological and biogeochemical cycles. Study and significance of natural resources; renewable biological resources, wildlife conservation/management, fisheries, forestry, energy resources, non-renewable energy resources, renewable energy resources, energy consumption, scarcity and conservation; mineral resources, mineral availability and recycling; air, water and soil resources. World food supply; traditional agriculture, green revolution, aquaculture, modern agriculture, ecological impacts of modern agriculture, organic farming. Major environmental concerns; natural hazards and processes, dams and environment, channelisation and environment, global climate and hazards, effect of population increase on environment, historical perspective of growing environmental concerns.

EEM 602 **PHYSICOCHEMICAL PRINCIPLES AND PROCESSES**
L-T-P-D-[C]
3-0-0-0-[4]

Structure and basic properties of water - their significance in environmental engineering, sources of water impurities, abiotic reactions, biological metabolism. Solid-liquid-gas interactions, mass transfer and transport of impurities in water and air, diffusion, dispersion. Physical and chemical interactions due to various forces, suspensions and dispersions. Chemical reactions, chemical equilibrium, and chemical thermodynamics, acid-base equilibria, solubility equilibria, oxidation-reduction equilibria. Process kinetics, reaction rates and catalysis, surface and colloidal chemistry, adsorption. Settling of particles in water, coagulation and flocculation, filtration - mechanisms and interpretations, ion exhange and adsorption, water stabilisation, acration and gas transfer. Membrane process; reverse osmosis, electrodialysis, desalination.

EEM 603 **ECOLOGICAL AND BIOLOGICAL PRINCIPLES AND PROCESSES**
L-T-P-D-[C]
3-0-0-0-[4]

Ecosystems; biotic and abiotic components, production and consumption, trophic levels, productivity and energy flow, food webs, cycling of elements. Ecology of population; ecological niche, mortality and survivorship, community interactions. Changes in ecosystems; succession. long range changes, long range stability. The organisation and dynamics of ecological communities. Description and study of typical natural and artificial ecosystems. Biochemistry; photosynthesis and respiration, important biological compounds, enzymes. Microbiological concepts; cells, classification and characteristics of living organisms, characterisation techniques, reproduction, metabolism, microbial growth kinetics.

Applications to environmental engineering; assimilation of wastes, engineered systems, concepts and principles of carbon oxidation, nitrification, denitrification, methanogenasis, etc., concepts of quantization of degradable pollutants.

EEM 604 **ENVIRONMENTAL QUALITY AND POLLUTION MONITORING TECHNIQUES**

L-T-P-D-[C]
2-4-0-0-[4]

Genral principles of sample collection and data analysis. Gravimetric methods for solids analysis in water and wastewater, determination of acidity, alkalinity and turbidity, analysis of common cations and anions in water/wastewater through various chemical techniques, determination of nitrogen, phosphorus and chemical oxygen demand (COD). Titrimetric methods; acid-base titrations, precipitation titrations, complexometric titrations, oxidation-reduction titrations. Electrochemical methods; working principles of electrodes, different types of electrodes. Spectrophotometric methods; Nephelometric methods; Atomic absorption spectroscopy; Biological methods and microbiology; biochemical oxygen demand (BOD), MPN test for microbial pollution, plate counts; confirmatory tests. Sampling techniques for air pollution measurements; analysis of particulates and common chemical air pollutants like oxides of nitrogen, oxides of sulphur, carbon monoxide, hydrocarbon.

EEM 606 **AIR POLLUTION AND ITS CONTROL, 3-0-0-4**

L-T-P-D-[C]
3-0-0-0-[4]

Air pollutants, their sources and harmful effects on the environment; Meteorology as applied to air pollution and dispersion of air pollutants; Air quality and emission standards; Air pollution legislation; Methods for monitoring and control, selection of control equipment. Engineering control concepts; process change, fuel change; Pollutant removal and disposal of pollutants; Control devices and systems, removal of dry particulate matter, liquid droplets and mist removal, gaseous pollutants and odour removal. Control of stationary and mobile sources. Economics and trends in air pollution control.

EEM 607 **ENVIRONMENTAL MANAGEMENT AND IMPACT ASSESSMENT**

L-T-P-D-[C]
3-0-0-0-[3]

Environmental management, problems and strategies; Review of political, ecological and remedial actions; Future strategies; multidisciplinary environmental strategies, the human, planning, descision-making and management dimensions. Environmental impact assessment (EIA), definitions and concepts, sustainable development (SD), initial environmental examination (IEE), environmental impact statement (EIS), environmental appraisal, environmental audit (EA); Environmental impact factors and areas of consideration, measurement of environmental impact, organisation, scope and methodologies of EIA, case studies stressing physical aspects of environment.

EEM 608 **INDUSTRIAL WASTE MANAGEMENT AND ENVIRONMENTAL AUDIT**

L-T-P-D-[C]

2-0-0-0-[3]

Sources and types of wastes; solid, liquid and gaseous wastes; water use in industry, industrial water quality requirements, deterioratation in water quality. Control and removal of specific pollutants in industrial wastewaters, e.g., oil and grease, cyanide, fluoride, toxic organics, heavy metals, radioactivity, etc. Solid and hazardous wastes; definitions, concepts and management aspects. Control of gaseous emissions; hood and ducts, tall stacks, particulate and gaseous pollutant control; recent trends in industrial waste management, cradle to grave concept, life cycle analysis, clean technologies. Case studies of various industries, e.g., dairy, fertiliser, distillary, sugar, pulp and paper, iron and steel, metal plating, thermal power plants, etc. Environmental audit; definitions and concepts; environmental audit versus accounts audit, compliance audit; relevant methodologies, regulations; Introduction to ISO and ISO 14000.

EEM 609 **FATE AND TRANSPORT OF CONTAMINANTS IN NATURAL SYSTEMS**

L-T-P-D-[C]

2-0-0-0-[3]

Introduction, modelling of volatilization, sorption / desorption, chemical transformations, photochemical transformations, biological transformations and bioturbation. Concepts of scale in natural systems, brief review of mass, momentum and energy balance, advection, molecular diffusion, dispersion. Modelling of rivers, lakes, large lakes, sediments, estuaries, wetlands, subsurface flow and transport. Finite difference and linear algebraic methods to solve the system equations. Some special models.

EEM 610 **PRINCIPLES AND DESIGN OF WATER SUPPLY AND TREATMENT SYSTEMS**

L-T-P-D-[C]

3-0-0-0-[4]

Definitions and Concepts: Water sources, Philosophy of water treatment, Review of water quality characteristics and potable and industrial water standards, Unit operations, Unit processes, Water supply; Theory and Design of Water Supply Systems; Estimation of water quantity, Review of flow in pipes and open channel flow, Review of pump characteristics, Design of water distribution networks, Theory and design of Conventional Unit Operations used in Water Treatment: Sedimentation, Floatation, coagulation, flocculation, filtration, and disinfection processes; Theory and Design of Advanced Unit Operations used in Water Treatment: Membrane Processes, Ion Exchange, Aeration/stripping, Percipitation, Adsorption, Oxidation-reduction and advanced oxidation processes; Water Treatment Plant Design; Selection of raw water source, Planning and siting of water treatment plant, Hydraulics of water treatment plant, Chemical requirement and residuals management.

EEM 611 **PRINCIPLES AND DESIGN OF WASTEWATER TREATMENT AND DISPOSAL**

L-T-P-D-[C]

2-0-0-0-[3]

Definition and Concepts; Philosophy of wastewater Treatment, Review of

Wastewater quality parametrs and discharge standards for aquatic and land disposal, Estimation of wastewater quantity; Wastewater Collection; Principles of open Channel flow, Design of sewers and sewerage systems; Wastewater treatment; Preliminary treatment, Bar-rack, Screens, Grit chamber, Equalization tank, Primary sedimentation, Secondary treatment, Aerobic processes, Anaerobic processes, Tertiary treatment, Nutrient removal, Residual management, Natural Design; Planning and siting of Wastewater treatment plant, Hydraulics of wastewater treatment plant, Chemical requirements and material balance; Wastewater Disposal; disposal to inland waters such as lakes reservoirs, rivers and streams, disposal to sea, disposal on Land.

EEM 612 **QUANTATIVE METHODS IN ENVIRONMENTAL SCIENCE AND ENGINEERING**

L-T-P-D-[C]
3-0-0-0-[4]

Review of Basic Mathematical Concepts; various theorems, series, matricies, ODs and PDs; Numerical Methods; Basic Concepts of numerical differentiation and integration, Finite difference techniques, solution of linear and nonlinear equations, problem formulation; Probability and Statistical Methods; Exploratory data analysis, Probability distribution, Linear and non-linear regression analysis, Analysis of varience, Design of experiments, Monto Carlo simulation; Optimization; Basic Concepts, Problem formulation and statement, Types of optimization problems; Environmental Decision making; Scaling and ranking techniques, Decision matrices, Decision making techniques. Emphasis on problem formulation and application of available software in the areas of environmental science, engineering and management.

ECO 747 **ENVIRONMENTAL ECONOMICS, LEGISLATION & SOCIAL IMPACT**

L-T-P-D-[C]
3-0-0-0-[4]

Broad aspects of environmental economics; society and environment, sustainable development, management of environment, regional and global environmental strategies, environmental movements. Environmental legislation; role of U.N. and its associate bodies, role of world bank, administering global environmental funds, environmental programmes and policies in developed and developing countries, environmental programmes and policies of the government of India, structural changes for environmental managements, sectoral policies regarding land, water, forestry, energy, industrial pollution, and human resources development. Environmental impact assessment (EIA); rationale and historical development of EIA, methodologies and socio-economic aspects of EIA, status of EIAs in india, case studies stressing socio-economic aspects of EIA.

EEM 613 **ATMOSPHERIC PHYSICS AND CHEMISTRY, 3-0-0-0-4**

L-T-P-D-[C]
3-0-0-0-[4]

Atmosphere as a Physical system, Introduction to Atmospheric Models: Simple Radiative model, Greenhouse Effect, Global Warming, Atmospheric Observations: The mean Temperature and Wind Fields, Gravity Waves, Rossby Waves, Ozone.

Atmospheric Thermodynamics: The Ideal Gas Law, Atmospheric Composition, Hydrostatic Balance, Entropy and Potential Temperature, Parcel Concepts, The Available Potential Energy, Moisture in the Atmosphere, The Saturated Adiabatic Lapse Rate, The Tephigram, Cloud Formation

Mass Conservation, The Material Derivative, Alternative form of the Continuity Equation, The Equation of State for the Atmosphere, The Navier- Stokes Equation, Rotating Frames of Reference, Equations of Motion in Coordinate Form, Geostropic and Hydrostatic Approxi-mations, Pressure Coordinates and Geopotential.
Further Atmospheric Fluid Dynamics: Vorticity and Potential Vorticity, The Boussinesque Approximation, Quasi Geostrophic Motion, Gravity Waves, Boundary Layers, General Considerations, The Laminar Ekman Layer, Baroclinic Instability, Barotropic Instability.

Thermodynamics of Chemical Reactions, Chemical Kinetics, Bimolecular Reactions, Photodissociation, Stratospheric Ozone, Chapman Chemistry, Catalytic Cycles, Transport of Chemicals, The Antarctic Ozone Hole.

Aerosol Dynamics: Discrete and continuous aerosol size distributions; Thermodynamics of atmospheric aerosols; Homogeneous and heterogeneous nucleation; Coagulation and coagulation kernels; Condensation/evaporation, saturation vapour pressure corrections; Fluxes to a particle population; Sedimentation and dry deposition; Chemical equilibria; Heterogeneous reactions in aerosol- aqueous-phase; Aerosol-cloud interactions.

Aerosol and Global Climate: Trends in anthropogenic emissions and troposphere composition; Solar and terrestrial radiation; Effect of pollutants on Earth's radiation budget; Radiation scattering by aerosols and clouds; Models for global warming and cooling.

EEM 699 M. TECH. THESIS

HUMANITIES AND SOCIAL SCIENCES

PROFESSORS

Boruah BH	boruah	7931
Dixit Shikha	shikha	7157
Krishnan L	lk	7287
Neelakantan G	gn	7872
(Head)		7510
Pattnaik BK	binay	7925
Raina AM	achla	7894
Rath Binayak	brath	7155
Saxena KK	kks	7129
Sharma AK	arunk	7946
Sinha AK	aks	7186
Sinha S	suraji	7268

ASSOCIATE PROFESSORS

Jha Munmun	mjha	7615
Mathur Suchitra	suchitra	7836
Ravichandran T	trc	7871
Tomy CA	cat	7633

ASSISTANT PROFESSORS

Bhushan Braj	brajb	7024
Chandran Mini	minic	7191
Kumar Ravi Priya	krp	7750
Madan A	amman	7073
Mathur S. K.	skmathur	6240
Prasad PM	pmprasad	7693
Roy Satyaki	satyaki	7616
Saha Bhattacharya	Sarani	7064
Singh SK	sanjay	7501

LECTURERS

Chakrabarti, A.	aninditac	6138
Patil K.P.	kpatil	7616
Sarma AVRS	avrs	6137

Convenor, DUGC :	Mathur, S.	suchitra	7836
Convenor, DPGC :	Raina, AM	achla	7894
Faculty Counsellor:			

E-mails : _____@iitk.ac.in Tel Nos : +91-512-259 7510 / 7632

The emphasis on teaching of humanities and social sciences for the overall intellectual and social development of the students of technology is an important feature of the undergraduate curriculum at IIT Kanpur. This education intends to expand the students' horizon of knowledge by exposing them to areas of study which make them sensitive to a wide range of human problems and social phenomena. Such a holistic education, it is hoped, would enable them to appreciate their role in national reconstruction by responding to the challenges of the time. The Department consists of six major disciplines: Economics, English (including Linguistics), Fine Arts, Philosophy, Psychology and Sociology. The department offers a five-year integrated M.Sc. programme in Economics and Ph.D. programmes in all disciplines except Fine Arts. **Admission to the M.Sc. programme is through the Joint Entrance Examination (JEE) and there is no need to have economics as a prerequisite for this at the 10+2 level.** The structure of the Ph.D. programme at IIT Kanpur is somewhat different from that in the universities. Admission to the programme is based on an all-India qualifying test like CSIR/UGC/GATE and a subsequent interview which may be supplemented by a written test. After admission, students are required to pass eight advanced level courses in their areas over a period of two semesters. Thereafter, they prepare themselves to take the comprehensive examination, which tests their overall preparedness for undertaking research. Only when these requirements are successfully met, is the candidate admitted to Ph.D. candidacy and allowed to work on his/her thesis. Students are normally required to complete their research work within four years from the date of their enrolment in the programme.

CURRENT COURSE STRUCTURE FOR M.Sc. (5-YEARS) STUDENT ECONOMICS

	SEMESTER				
	FIRST	SECOND	THIRD	FOURTH	FIFTH
COURSE	COM 101 PHY 101 MTH 101 ESC 101 PE 101 HSS-I-1 ENG 112	TA 101 PHY 103 MTH 102 ESC 102 ECO 100 PE 102	MTH 203 CHM 201 TA 201 ESO-1 ECO 201	HSS-I-2 ESO 209 ECO 202 ECO 231 OE-1	HSS-II-1 ECO 311 ECO 321 ECO 333 ECO 341
	SEMESTER				
	SIXTH	SEVENTH	EIGHTH	NINTH	TENTH
	ECO 303 ECO 312 ECO 332 DE - 1 OE-2	ECO 413 ECO 422 ECO 434 DE - 2 NDE - 2	ECO 423 ECO 424 NDE - 2 DE - 3 OE - 3	ECO 535 ECO 543 ECO 598 DE - 4 OE - 4	HSS-II-2 ECO 599 DE - 5 DE - 6 OE - 5

CHM 201	Chemistry
ESO	Engineering Science Option †
ESO 209	Probability & Statistics
HSS	Humanities & Social Sciences
MTH 203	Mathematics-III
TA 201	Manufacturing Processes
DE	Departmental Elective
NDE	Non Departmental Elective
OE	Open Elective (any course in any Department)
ECO ***	Professional Courses

ECO 201	Microeconomics I
ECO 202	Macroeconomics
ECO 231	Economic Problems and Policy
ECO 303	Microeconomics II
ECO 311	Econometric Methods
ECO 312	Econometric Practice
ECO 321	Industrial Economics
ECO 332	Development Economics
ECO 333	Money and Banking
ECO 341	Environmental Economics and Policy
ECO 413	Planning Techniques
ECO 422	Economics of Regulation and IPR
ECO 423	Financial Economics
ECO 424	Economic Analysis of Law
ECO 434	International Economics
ECO 535	Public Economics
ECO 543	Environmental Impact Analysis
ECO 598	Project-I
ECO 599	Project-II

* Students are not entitled for economics courses in HSS-II, HSS-III and HSS-IV

† Engineering Science Options must be chosen from the list of courses as advised by the Convenor, DUGC

DEPARTMENTAL ELECTIVES FOR ECONOMICS

ECO 404, ECO 405, ECO 406, ECO 407, ECO 408, ECO 425, ECO 442, ECO 514, ECO 526, ECO 527, ECO 528, ECO 536, ECO 537, ECO 544, ECO 545, ECO 546, ECO 547

ECO 404	History of Economic Thought
ECO 405	Contract Economics
ECO 406	Economics of Research & Development
ECO 407	Monetary Economics
ECO 408	Advanced Macroeconomics
ECO 425	Network Economics
ECO 442	Energy Economics
ECO 514	Input-Output Techniques
ECO 526	Economics of Biotechnology
ECO 527	Multinational Enterprises
ECO 528	Computational Finance
ECO 536	Regional Economics
ECO 537	Law, Technology and Public Policy
ECO 544	Human Development
ECO 545	Health Economics and Health Care Policy
ECO 546	Transport Economics
ECO 547	Water Resource Economics

COURSE DESCRIPTION

ART 101 **INDIAN ART AND CIVILIZATION**

L-T-P-D-[C]
3-0-1-0-[4]

Introduction to Early Civilization of Mesopotania Egypt, Indus Valley Civilization, Early Civilization in India, Maurya Period, Art of Gandhar, Gupta Period, Medieval Period, Art under Rajput Influence, Art under the Mughal Dynasty, colonial Period in India.

Studio: to familiarize with various 2-D & 3-D media works.

ART 102 **INTRODUCTION TO ART CRITICISM & APPRECIATION**

L-T-P-D-[C]
3-0-1-0-[4]

Introduce fundamental visual skills and analytical skills, Critical thinking about various forms of art, and close observation of art and performing art.

Principles of Analysis of Art, Art and perception, What is Style?, Style in Painting, Colour, Psychology of Colour Perception & Design, Space Illusion, Painting, Sculpture, Style in Sculpture Architecture, Style in Architecture, Space in Architecture, Print-making, Photography & Film, POP Art- Comics, Advertisements etc, Performing Art, Methodology of Criticism & Appreciation.

Studio: 2-D Exercise, Printmaking, 3-D Exercises, Sculpture, Field Trip.

ART 103 **INTRODUCTION TO WESTERN ART**

L-T-P-D-[C]
3-0-1-0-[4]

Outline history of Western Art with continuous weaving and changing of traditions from the prehistoric and primitive culture through the different periods and styles up to the early decades of 19th century art practices - the contents span from Art in the Ancient World (Prehistoric, Egyptian, Ancient Near Eastern, etc.,), the Middle ages (early Christian, Byzantine, Romanesque, etc.,), Renaissance to the Rocco and an introduction to modern World; Theoretical principles for painting; An introduction to the visual analysis and criticism of art-reading an art object, Fundamental concepts of two-dimensional and three-dimensional forms.

Studio : Lab sessions invoves practical exercises, demonstrations and related studio projects to explore technicalities and familiarize with various 2-D and 3-D media works in context of developments in western art.

ART 104 **ARCHITECTURE & ENVIRONMENTAL DESIGN**

L-T-P-D-[C]
3-0-1-0-[4]

Man-made Environment and Natural Environment Primary Function of Enclosed Space-shelter building, material consideration, Introduction to Architecture- what is architecture, difference between building and architecture.

Principle of Architecture, Traditional design in architecture-Vastu Shashtra ancient principles in architecture & town planning, Modern Architectural Principles-Industrial Revolution and modern building concept of houses and multi-story building.

Relationship between Environmental Design and Architecture, Principles of Environmental Design, Traditional Concept of Environmental Design, Environmental Design and Landscaping, Modern Environmental Design concept in urban planning

Studio: Scale model and field survey

ECO 100 **INTRODUCTION TO PROFESSION**

L-T-P-D-[C]
2-0-0-0-[0]

For whom the bell tolls; What is economics?; Basic concepts of supply and demand; Central Problems of very economic society; Development, freedom and opportunities; Dilemma of development; Linkages between technology, economics and environment; Business organizations and income; The role of economist in business and industry; The role of economist in societal development; The role of economist in governance

ECO 201 **MICROECONOMICS I**

L-T-P-D-[C]
3-1-0-0-[4]

Theory of consumer behavior; Theory of demand and supply; Production theory; Costs of production; Markets - Perfect competition, Monopoly oligopoly; Theory of distribution; Pricing.

ECO 202 **MACROECONOMICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction; Circular Flow of Income, Output and Expenditure; National Income Accounting Methods; Classical Models; Consumption Function, Keynesian Cross Model and Expenditure Multiplier; Investment Function; Govt. Expenditure and Fiscal Policy; Demand for Money; IS-LM Model; Aggregate Demand and Supply Functions; The Theory of Inflation; Macroeconomic Stabilization Policies; Theories of International Trade and Balance of Payment

ENG 112C **ENGLISH LANGUAGE AND COMMUNICATION SKILLS**

L-T-P-D-[C]
3-1-0-0-[4]

This course imparts training in the use of English language for communicative purposes, and aims to develop reading comprehension, writing, listening, and spoken language skills of the student. The Language Lab component seeks to provide training in pronunciation and listening skills. Instruction is carried out in small tutorial groups for effective individual attention.

ENG 122 **INTRODUCTION TO LINGUISTICS**

L-T-P-D-[C]
3-1-0-0-[4]

Introducing Language, Language as a cognitive faculty, Language as a socio-cultural artifact, Language and communication, Natural Language and Artificial Language, Natural Language and Animal Communication Systems, Evolution of Language, Linguistics as a Language Science, Ancient Indian Linguistics, Modern Linguistics, Understanding Language, Language and Society, Applying linguistics to computer processing of natural language.

ENG 123 **INTRODUCTION TO LITERATURE**

L-T-P-D-[C]
3-1-0-0-[4]

Nature and Functions of Literature, Literature and Society with special reference to Indian Literature and Society, Literary Forms, Poetry, Drama, Fiction, Essay, Autobiography, Approaches to the Study of Literature, Reader response to the study of Literature, Interpretation, Appreciation, Evaluation, Special problems in understanding Modern Literature.

ENG 124 **LANGUAGE AND SOCIETY**

L-T-P-D-[C]
3-1-0-0-[4]

The objective of this course is to sensitize students to the social dimension of language. Topics of study include problems of definition, multilingual communities, dominance and conflict, shift and attrition, language and the state, language and nation, Indian multilingualism, language variation, language and identity, linguistic prejudice and inequality, standardization, linguistic determinism, critical discourse analysis, and methodological issues.

PH1 140 **INTRODUCTION TO INDIAN PHILOSOPHY**

L-T-P-D-[C]
3-1-0-0-[4]

The method Purvapaksa-Siddantha method and Pramana method

The Most Common Presuppositions : The Theory of Karma and Dharma

The Astika-Nastika (orthodox-heterodox) division

The Debate about Knowledge : its Sources, Forms and Validity

Epistemic and Metaphysical Ignorance as well as knowledge

The Ultimate Reality and the Paths to it.

PHI 141 **INTRODUCTION TO PHILOSOPHY**

L-T-P-D-[C]
3-1-0-0-[4]

General Introduction to the Course; Nature of Knowledge; Sources of Knowledge; The Problem of Perception; Skepticism; Kinds of Metaphysics; Metaphysical Systems; Mind-Body Dualism; Proofs for the Existence of God; Positivistic Critique of Metaphysics; Normative Ethics; Meta-Ethics; Free will and Moral responsibility.

PHI 142 **INTRODUCTION TO LOGIC**
L-T-P-D-[C]
3-1-0-0-[4]

Introduction : Business of Logic; Sentential Connectives; Interdefinebility and Dependencies Between Propositions; Decision Procedures; Techniques of Proof construction; Introduction To Predicate Logic; Arguments involving General Propositions; Relational Propositions and Relational Arguments; Identity and Definite Description; Property variables and Properties of properties; Formal Deductive systems and their Properties.

PSY 151 **INTRODUCTION TO PSYCHOLOGY**
L-T-P-D-[C]
3-1-0-0-[4]

Psychological Perspectives and Approaches; Perception; Learning; Memory; Higher Cognitive Processes; Motivation and Emotion; Intelligence; Personality; Individual Differences.

PSY 152 **APPLICATION OF PSYCHOLOGY TO LIFE**
L-T-P-D-[C]
3-1-0-0-[4]

Nature and scope of applied psychology; historical perspective; areas of applied psychology, Roles and skills of applied psychologists; ethical issues in applied psychology, Clinical and counselling psychology, Educational psychology, Community psychology and mental health, Ecological Psychology, Industrial and organizational psychology, Legal Psychology.

SOC 171 **INTRODUCTORY SOCIOLOGY**
L-T-P-D-[C]
3-1-0-0-[4]

Sociology as a Science of Human Society: Introduction:- Basic concepts (Roles, Norms, Values, Groups and Institutions), Social Structure, Culture, Perspectives (Functionalist, Conflict & Interactionist),

Social Institutions:- Social Stratification, Family and marriage, Organizations: Formal & Informal, Religion,

Social Processes of Change:-Defining social change, various processes of change like Urbanization, Industrialization, Modernization (Social mobilization and differentiation, structural differentiation, consensual mass tendencies, etc.)

SOC 173 **INTRODUCTION TO INDIAN SOCIETY**

L-T-P-D-[C]
3-1-0-0-[4]

Indian Sociology: An Introduction, Social Roots of Indian Society:-Vedic heritage, Brahminic, Islamic, British, Indian Social Structure:-Rural Context, Urban Context, Indian Social Institutions and Organisations-Family, Marriage, Jajmani Relation, Caste and Tribe, Religion and education, Social Movements in India:-Reformist, Nationalist, Agrarian, Backward Caste, Processes of Social Change in India, Westernization, Sanskritisation, Contemporary Social Problems. Secularism, Common civil code, Reservation policy, Demographic transition, etc.

ART 402 **MODERN ART**

L-T-P-D-[C]
3-0-1-0-[4]

Neoclassicism, Romanticism, Realism, Impressionism & Post-Impressionism, Impressionism & Post-Impressionism, Fauvism, Expressionism, Cubism, Futurism, Constructivism, Suprematism, De Stijl- Pure Plastic Art' & 'Neo-Plastic Art' Bauhaus, Dada & 'Ready Made', Surrealism, POP and OP Art, Minimalism, Conceptual Art, Comic Art.

Studio: Familiarize with various 2-D & 3-D media works, Field Trip.

ART 404 **ENGINEERING DESIGN-AN ART**

L-T-P-D-[C]
3-0-1-0-[4]

Creativity in Design, Philosophy & Aesthetics Relationships between Science, Technology & aesthetics Engg. Design Problem & Aesthetics Craft and Industrial Design.

Design-structure, construction Architecture & Urban Planning Landscaping & Ecology Environment and Architecture.

Form and context of Product Design, Bauhaus, Product Design & Aesthetics, Design Paradigm, Design Process, Manufacturing Process, Costing, and Ergonomics.

Projects Execution: 'The projects are to be executed by groups of students consisting three members in each group. In middle of the semester each group would do the project presentation (conceptual). The project execution includes-innovative ideas, simple solution of the problem, detailed lists of plan of execution, detailed plan of action in steps, and fabricate a functional or scaled model. Project presentation at the end of the semester.

ART 405 **ARCHITECTURE & ENVIRONMENTAL DESIGN**

L-T-P-D-[C]
3-0-1-0-[4]

Primary function of enclosed space, Concept of space in design, Comparison between architecture & building, Principles of Architecture, Man made environment & natural environment.

Architecture & Environmental Design history, New material concepts in Modern Architecture Environment and architecture

History of ancient urban planning, Modern urban planning, Environmental Design problem in Developing Countries, Environmental Conflicts, Optimal structure configuration.

Studio : Scale model project execution.

ART 406 **ENVIRONMENTAL DESIGN & ETHICS**

L-T-P-D-[C]
3-0-1-0-[4]

Understanding of environmental issues viewed from interdisciplinary perspective; Introduction to Environmental Ethics; Man and Nature relationship through philosophy, religion and ethics.

Introduction to the history of architecture related to environment, New material concepts in Modern Architecture, Environment and architecture, Traditional Indian architecture, Town Planning & Vastu Shashtra

Modern architecture, environmental design and Landscaping; Modern Urban Planning; Ethical issues related to various modern environmental problems, Environmental Design problem in Developing Countries.

Studio: (i) Environmental Ethics related problem survey and presentation.
(ii) Scale Model - Landscaping & Environmental Design.

ART 407 **ENGINEERING DESIGN – CREATIVITY, CONCEPT & PRACTICE**

L-T-P-D-[C]
3-0-1-0-[4]

Creativity in Design; What Is Design ?, Design Process, Nature and Scope of Engineering in Human Society

A short history of Engineering Education at Bauhaus, Creativity of Design Concept, Design Philosophy, Design Principle, Art (Aesthetics) in Industrial Design, The principles of Modern Design from, shape, color, texture ets analysis.

What is Problem?, Problem definition or formulation, Creating Forms, Configuration Optimization, Decision Making, Uncoupled, Decoupled and Coupled Design, Products of Static and Dynamic Society

Colour Aesthetics, Difference between Products, Design & Industrial Design, Ergonomics, Brand Positioning, Legal Issues in Product Design.

Studio Work : Product design project (proto-type of functional model)

ART 408 / CSE 468 / ME 458 **VISUAL COMMUNICATION**

L-T-P-D-[C]
2-2-0-0-[4]

Principles of visual display, layout design and goal-oriented communication

Static, dynamic, interactive and multimedia visual communication, Layout and design of textual information

Design and development of animation/film, Presentation; Visual communication over Internet, Data representation, data compression and data Communication, Issues in visual communication, media study.

Studio: Related Project Execution.

ART 409 L-T-P-D-[C] 3-0-1-0-[4]

DESIGN PARADIGM

(i) Introduction to Design Paradigm : Recognizing Design Paradigm; Paradigm as Metaphor; Design and Nature; The Human Body; Where does Form come from ? Simple Shape Analysis - The Platonic Solids, Ball Sheet, Tube, etc. Concept of Enclosure; Bending and Flexing; Bigger and Smaller; Binary Relation; Multiple Object Relations; Objects with in Objects; Multi-function Objects.

(ii) Design Paradigm and Practice; In this module students will be encouraged to make conceptual project proposal and possible applications.

(iii) Related Studio Projects exploring the principles of paradigm.

ECO 231 L-T-P-D-[C] 3-1-0-0-[4]

ECONOMIC PROBLEMS AND POLICY

Global economic issues and challenges; From global to national issues; Economic institutions: markets, government, and social groups; Indian economic issues and policy; Indian agriculture and rural economy; Industrial economy; Policy towards social infrastructure; Trade and foreign exchange policy; Policy towards international capital flow

ECO 303 L-T-P-D-[C] 3-1-0-0-[4]

MICROECONOMICS II **Prereq. #**

Non-cooperative games; Simultaneous moves games; Dynamic games; Cases of Incomplete Information, Information asymmetry and adverse selection; Principle agent model; Theory of welfare; General equilibrium theory; Pine exchange economy; Fundamental theorey of welfare economics; 2 x 2 production model; Stoper - Samvebon theories; Rybctynsti theory; Social choice theory

ECO 311 L-T-P-D-[C] 3-1-0-0-[4]

ECONOMETRIC METHODS

Methodology of econometrics; The nature of regression analysis; Assumptions of the classical lineas ugeension Models; Two variable regression analyses; Multiple regression analyses; Hetesoscedasticity, Autocorelation and Malticollinearity; Dummy variable regression models; Model Selection; Qualitative response regression models; Lagged variables; Panel data regression models;

Dynamic econometric models; Simultaneous equation models; Time series econometrics; Non-linear regression models

ECO 312 **ECONOMETRIC PRACTICE** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Economic theory and econometrics; Types of models; Sources of data; Microeconometric models; Models of the firm and industry; Applications to development economics; Macroeconometric models; Models of international trade and finance; Deterministic and stochastic models

ECO 321 **INDUSTRIAL ECONOMICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction; Basic concepts in Game Theory; Technology, Production Cost and Demand; Perfect Competition, Monopoly and Monopolistic Competition; Foundations of Oligopoly Theory; Markets for Homogeneous Products; Markets for Differentiated Products; Concentration, Mergers and Entry Barriers; Strategic Behavior: Investment in Entry Deterrence; Pricing Tactics: Discriminatory Pricing; Marketing Tactics: Bundling, Upgrading and Dealership; Quality, Durability and Warranties; Advertising; Collusion and Cartels; Market Structure, Entry and Exit; Vertical Restraints; Research and Development; Empirical Studies on Structure-Conduct-Performance Relationship; Empirical Studies on Market Performance; Management, Compensation and Regulation

ECO 332 **DEVELOPMENT ECONOMICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Trends in international development; Perspective and methodological issues involved in growth and development; The development indices; Basic features of underdeveloped countries/ LDCs; Dualistic development; The stages of economic development; Theories of development; Strategies and policies towards development; Nurksian strategy; Strategy towards foreign capital / external finances; Strategy towards imports /export balance of payments; Balanced / unbalanced growth approach; Sectoral strategy; Some recent contributions to development theory; The global strategy: new international economic order (NIEO); The policy of structural adjustment; Project assignment

ECO 333 **MONEY AND BANKING** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Functions of Money and Interest Rates; Money Supply; Money Market; Regulatory and promotional institutions; Banking institutions; and Term structure of Interest Rates.

ECO 341 **ENVIRONMENTAL ECONOMICS AND POLICY** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction; Social Choice : How much environmental protection; Market failure: Public bad and externalities; Internalisation of externalities; Regulation : Emission Fees & Marketable permits; Environmental valuation; Hedonic price method, household production model & constructed markets method; Tronsboundary pollution Sustainable development; Economics of natural resources, Natural resource accounting; The environmental issues and policies in India.

ECO 404 **HISTORY OF ECONOMIC THOUGHT** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction; Social Choice : How much environmental protection; Market failure: Public bad and externatities; Internalisation of externalities; Regulations : Emission Fees & marketable permits; Environmental valuation; Hedonic price method, household production, model & consolouted markets method; Tronsboundary pollotion Sustainable development; Economics of natural resources, Natural resorces accounting;The environmental issues and policies in India.

ECO 405 **CONTRACT ECONOMICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction; Economics of contracts (adverse selection and moral hazard); Hidden action, monitoring, and control; Efficient contracts; Transfer prices; Contingent claims; Principal agent models; Incomplete and incentive contracts; Implicit contracts; Auctions and bidding; Regulation of contracts

ECO 406 **ECONOMICS OF RESEARCH AND DEVELOPMENT** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction; Technology and technological change; Innovation and growth; Market failures and technology; Schumpeterian perspective: evidence on big vs. small firms; Technology and market structure - the determinants of innovation; Models of innovation: product and process innovation; Product life cycles theories; R&D and licensing; Methods of appropriating rents - patents, secrecy, and IPR; Adoption, imitation, and diffusion of innovation; Firm-level strategic decisions; Technology financing and technology joint ventures; National technology policy - patents, R&D policy, public research etc.; International trade and technology; International technology transfer; Research policy

ECO 407 **MONETARY ECONOMICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Demand for money; Supply of money; Monetary aggregates; Neutrality of money; Money in a growth model; Money in an OLG model; Central bank goals, targets, and instruments; Time consistent versus discretionary policies; Credible monetary policy

ECO 408 **ADVANCED MACROECONOMICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction; The Solow growth model; Infinite-horizon and overlapping-generation models; New growth theory; Real-business-cycle theory; Traditional Keynesian theories of fluctuations; Incomplete nominal adjustment; Consumption and investment; Search frictions and unemployment; Inflation and monetary policy; Budget deficits and fiscal policy

ECO 413 **PLANNING TECHNIQUES** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Social accounting matrix; Leontief's open and closed I-O models; Multipliers and linkages in the I-O model; Organization of basic data for I-O models; Identification of the key sectors; Role of project in development planning; Project development cycles; Capital budgeting decisions; Commercial profit vs. social profitability analysis; Methods of measurement of benefits and costs of projects; Case studies

ECO 422 **ECONOMICS OF REGULATION AND IPR** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction; Rationale for regulation and antitrust; Regulatory practices, rules vs. implementation agencies; Regulatory capture; Discriminatory pricing; Controlling franchises; Public enterprise regulation; Restructuring and deregulation of key sectors such as energy, transport etc.; Externalities, environmental concerns, and controls; Product quality, safety, and health issues; Patents; Copyrights; Trademark and Service Mark; Industrial Designs Registration; Protection of Layout of Designs Integrated Circuit; Protection of New Plant Varieties; Antitrust Policy and IPR; Agreements and IPR Linkages; Litigation; Continuous Issues in IPR (Such as Biotechnology and IPR, TRIPS and Access to Medicines, etc.).

ECO 423 **FINANCIAL ECONOMICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Basic accounting principles; Basics of financial markets; Return, risk and risk aversion; How securities are traded?; Mutual funds and the institutional environment; Portfolio selection; The capital asset pricing model; Index models and the arbitrage pricing theory; Empirical evidence of market returns; Market efficiency; Bond prices and yields; The term structure of interest rates; Managing bond portfolio; Security analysis; Options and other derivatives; Option valuation; Futures and forward markets; Portfolio management techniques

ECO 424 **ECONOMIC ANALYSIS OF LAW** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction to economic analysis of law; Economic theory of property law; Contracts and warranties; and Economic theory of tort law in addition, The course focuses on any are of the following madule(s) : Economic crimes and penalties; Economic theory of administrative law; Corporations and corporate finance; Economic analysis of labor law; Economic analysis of competition law; Project assignment

ECO 425 **NETWORK ECONOMICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Overview of network industries; Information and scale economies; Switching cost, lock-ins and network structure; The network economy and regulatory/ antitrust policies; The Microsoft antitrust case; Versioning, intellectual property rights management and standards; Financial assessments of network firms and the future; The hardware industry; The software industry; Telecommunication; Broadcasting and markets for information; Network structures in the airline industry

ECO 434 **INTERNATIONAL ECONOMICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Global trade in goods and services; Why study international trade and finance; Growth and trade; Basic theory of international trade; Theory of comparative advantage; Implications of Heckser-Ohlin theory; Alternative theories of trade; Empiricial Tests of Trade Therics; International trade and technical change; Economics of import tariff; Non-tariff import barriers; Arguments for and against protection; Regional trading blocks; Trade policies for development; International factor movements; Exchange rate and open economy; Internal and External Balance with Fixed and Flexible Exchange rate; Foreign exchange markets and exchange rates; Balance of payments; International monetary system; Benefits and costs of the Globalication Process.

ECO 442 **ENERGY ECONOMICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction: energy and economics; Trends in energy production and consumption; Economic efficiency, growth, and modeling; Economic theory of natural resource extraction; The primary (extractive) energy industries (oil and natural gas); The electric utility industry; Electric utility and regulation; Renewable energy sources and energy conservation; Energy and air pollution; Global effects of energy use; Energy issues in India

ENG 423 **CURRENT ISSUES IN LINGUISTICS**

L-T-P-D-[C]
3-1-0-0-[4]

Conceptualising language: Internalised and externalised language, Study of I-language: Boundaries, methodology, theory and epistemology, Language Faculty: Modularity, architecture and optimality of design imperfections and their possible explanations, Universal Grammar: Constraints on possible grammars, Cross-linguistic Variation: Principles and parameters approach, morphology as the locus for language variation, Language Faculty and Interface Systems, Semantics reconsidered, Explaining Language Change, Contextualising Language: Language as a carrier of culture, language and social control, feminist critique of language, Discoursal Meaning.

ENG 425 **COMMUNICATION: PERSPECTIVES AND PRACTICE**
L-T-P-D-[C]
3-1-0-0-[4]

Introducing the field: A multidisciplinary orientation, Communication resources: Phatic and integrative potential of language underdetermination of meaning, linguistic knowledge and world knowledge, manipulative potential of language; Non-verbal codes, cognitive and social basis of non-verbal codes, Rhetorics: Aristotelian rhetorics; Stages in rhetorical composition, argumentation, syllogistic and rhetorical reasoning; types of rhetorical argument; the new rhetorics, Meaning theories: Epistemological basis of meaning theories, Traditional Indian Theories of Meaning, Semiotics: Signs and modality, syntagmatic and paradigmatic analysis Denotation, connotation and myth; Metaphor, metonymy and related modes of figurative discourse, Pragmatics: Speech acts; Maxims and implicatures; Communicative intent; Miscommunication, Contemporary discourse analytic approaches; Social construction of meaning; Knowledge and consensus; Ideologic approaches to meaning; Knowledge, power and ideology,

ENG 431 **THE INDO-ANGLIAN NOVEL**
L-T-P-D-[C]
3-1-0-0-[4]

Background, The Beginnings, From Independence through the 1970s, The Post-Rushdie Indo-Anglian Novel, Strategies for Reading Indo-Anglian Novels.

ENG 432 **LITERATURE AND IDEOLOGY**
L-T-P-D-[C]
3-1-0-0-[4]

Introduction to “Ideology:” Definitions, sub-categories, etc. The Relationship between Ideology and Literary Creativity; Literary engagement as elaboration: Manifesto Literature; Literary engagement as reaction: critique, refutations, etc. Ideology-based Schools of Criticism, Multiple Ideological Readings of Literary Texts; Literary Criticism: Aesthetics vs. Ideology.

ENG 433 **MODERN DRAMA**
L-T-P-D-[C]
3-1-0-0-[4]

Introduction to Drama, An Overview of the Theatre, European Drama & European Society, Ibsen’s *The Wild Duck,* Strindberg’s *The Father,* Russian Society in the 19th Century, Chekhov’s *The Cherry Orchard,* Pirandello’s *Six Characters,* Absurd Drama: An Overview, Ionesco’s *The Bald Soprano,* Beckett’s *Waiting for Godot,* An Overview of American Drama, Millier’s *Death of a Salesman,* Williams’ *A Streetcar Named Desire.*

ENG 434 **MODERN BRITISH AND AMERICAN NOVEL**
L-T-P-D-[C]
3-1-0-0-[4]

Introduction to the Novel, Novel in the Anglo-American Literary tradition, Major concerns in 19th & 20th century British, American Novel, Romance & the Novel in America, Hawthorne's *The Scarlet Letter,* Modernism & the English Novel, Art & the Artist in Modernist Novel, Joyce's *A Portrait of the Artist,* Feminism and Woolf, Woolf's *To the Lighthouse,* Forster's *A Passage to India,* American Modernism, Fitzgerald's *Tender is the Night,* Hemingway's *A Farewell to Arms,* Summing Up.

ENG 435 **TOPICS IN LITERARY MOVEMENTS**
L-T-P-D-[C]
3-1-0-0-[4]

Romanticism, Realism, Naturalism, Existentialism, Literature of Psychoanalysis, Literature of Ideas, Literature of Protest and Rebellion, Magical Realism.

ENG 436 **WRITER'S VISION OF THE FUTURE**
L-T-P-D-[C]
3-1-0-0-[4]

Definition and Origins of Visionary Writing, The Utopian Tradition and the Renaissance, Relationship between Visionary and Fantastic Literature, Futuristic Writing and Science Fiction, Visionary Writing and Social Change.

ENG 437 **INDIAN LITERATURE**
L-T-P-D-[C]
3-1-0-0-[4]

Issues in Indian Literature, Indian Aesthetic Theory and Critical Practice, Influence of Western Thought, Impact of freedom movement on Indian Literature, Dalit literature, Exemplification through selected texts.

ENG 438 **POSTCOLONIAL LITERATURE**
L-T-P-D-[C]
3-1-0-0-[4]

This course will outline the broad parameters of "postcolonialism" as a mode of literary criticism and debate its role in English literary studies through a study of British, African, Caribbean, and Indian literatures in English. In the process, questions such as the term's validity as an historical marker, its vexed relationship with neo- colonial global politics as well as the theoretical formulations of post-structuralism, and its privileged metropolitan academic location will be discussed in detail.

ENG 439 **LITERATURE AND CENSORSHIP**
L-T-P-D-[C]
3-1-0-0-[4]

The course proposes to explore the issue of censorship in literature, and how it affects creativity. The term 'censorship' implies external restrictions imposed on literary works by the government or other sources of power like organised religion. It can also encompass self-censorship imposed by the writer in response to extraneous factors. The attempt will be to understand why literature often comes under attack and also to analyse the impact of such restrictive practices on the writer as well as the reader.

ENG 440 **TOPICS IN LITERARY GENRES**

L-T-P-D-[C]
3-1-0-0-[4]

This course will explore the concept of literary genre and its implications for both the production and reception of literary works. Delving beyond the broad divisions of poetry, prose, and drama, this course will investigate the form and content of specific genres such as the pastoral, the epic, the dramatic monologue, the one-act play, detective fiction, gothic fiction, fantasy, etc. It will also situate these genres within a historical context and explore their regional variations by studying Western texts alongside non-Western ones from the same genre. In the process, the course will examine the ways in which various social categories overdetermine the contours of various literary genres and the extent to which genres are contained within cultural-temporal boundaries.

ENG 441 **INTERNATIONAL BUSINESS ENGLISH**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction, The social use of English, Case One, On the Phone, Case Two, Letter Writing, Memos, Telexes & Faxes, Meetings and Discussions, Writing Minutes, Case Three, Case Four, Employment Communications (Includes job ads, self-inventories; resumes, letter of application, interviews), *Bid for Power* (Video Serial for practice in the skills). Students are also required to do a project which entails preparation of a business case.

ENG 442 **PROFESSIONAL COMMUNICATION**

L-T-P-D-[C]
3-1-0-0-[4]

Importance of good communication skills, social, ethical and legal Implications of technical communication, Specific skills needed, Complexity of technical and professional communication, Strategies: Identifying audiences and purposes, Selecting visual elements, Resumes and job letters, Business letters, Report writing (including memos), Feasibility reports, Proposals, Quotations and tenders Instruction manuals, notices, agendas and minutes, Meetings and negotiations, Seminars and group discussions, Informal conversations, Public speaking, Interviews, Readability: General principles, Common usage problems

ENG 443 **NATURAL LANGUAGE SEMANTICS**

L-T-P-D-[C]
3-1-0-0-[4]

Familiarisation with issues in semantic knowledge representation from the point of view of human and machine processing of natural language.

Semantics and Semantic modelling: Philosophical and Linguistic Approaches to emantics, Semantic Structure and its Computational Modelling, Semantics

Pragmatics Distinction; Syntax-Semantics Interface: Syntactic and Semantic Parsing, HPSG, FrameNet Semantics, Universal Networking Language; Lexical Semantics; Lexical Underdetermination, Interlexical Relations, Ontological Semantics, Argument, Event and qualia Structure, WordNet and Generative Lexicons; Logical form for Natural Language: Quantification; Anaphoric Dependencies; Pragmatic Structure: Implicature and Non-literalness, Modelling Pragmatic Knowledge, Discourse Representation Theory, Situation Semantics.

ENG 444 **ANCIENT INDIAN AND MODERN GENERATIVE LINGUISTICS**

L-T-P-D-[C]
3-0-1-0-[4]

An Overview of Linguistics in Ancient India and in modern times from a Comparative Perspective, Paninian Grammar as a Generative Grammar, Some Fundamental Ideas in Paninian Linguistics, Modern Generative Grammar (First Phase), An Overview of Generative Grammatical Models in Ancient India and in modern times from a Comparativepoint of view, Outlines of the Principles and Parameters Grammar.

ENG 445 **LITERATURE AND THE INDIVIDUAL**

L-T-P-D-[C]
3-1-0-0-[4]

The precarious role of an individual in a dynamic society- totalitarian, democratic, technological, globalized, etc-has been and intense and perennial subject of concern in literature. Many literary works deal with such problems of humanity as the constraints of individual freedom, loss of identity search for self, struggele for individual survival, pangs of isolation and alienation, and attempts for salvaging sanity from a maddeningly disordered world. These works, through fables, fantasies, as will as futuristic representations, interrogate, probe into the prevalent values, and affect changes in the lives of individuals, and by extension, their societies. Apart from a utopian prophecy of deferred but ultimate triumph of humanity, these literary works for study in the course include the classics of world literature from George Orwell, Ernest Hemingway, Herman Hesse, R. K. Narayan , Saul Bellow, Somerset Maugham and Upamanyu Chatterjee to semi- philosophical and prpular texts of Ayn Rand, Khalil Gibran. Paulo Coelho, Richard Bach and Robert Pirsig.

ENG 446 **LITERATURE AND ADAPTATION**

L-T-P-D-[C]
3-1-0-0-[4]

This course will examine the processes and politics of adaptation as texts travel across genres, media, and cultures. Focusing primarily on literary texts, graphic narratives and films, it will investigate the different vocabularies of each media and see how meaning is transformed as it travels across different languages. In the process, it will delve into topics such as the semiotics of translation, the ‘fidelity’ debate, the relationship between adaptation and appropriation, ideology and intention in the creation of adaptations etc.

ENG 451 **GLOBAL COMMUNICATION**

L-T-P-D-[C]
3-0-1-0-[4]

Prerequisite : Any course in English is desirable

In a global context, communication skills of the present times demand expertise in both hard skills as listening, spoken, reading and writing abilities as well as soft skills as body language and etiquettes enhancesd with keen awareness of the local/ global, cultural and linguistic variations. The course aims at imparting students with professional skills of communication that are needed in regional, national and international situations. The methodology of the course is to use audio/ video gadgets in the language laboratory and provide appropriate training sessions. The focus of the course is on the use of English language in national/ multinational corporations and communication mediated through mobile, telephone, e-mail, internet and other advanced technologies. Significant topics for discussion include : 1. Communication, Culture, Power 2. Current World Trends in Media Communication 3. Ethnographic Perceptions 4. Global Imbalances in Informational and Cultural Exchange 5. Benefits of Intercultural Communication 6. Intercultural Competence 7. Interpersonal Communication 8. Environments and Information Load 9. Cross- Cultural Communication Styles 10. Etiquettes for the Net 11. Qualities of Effective Report Writing 12. Writing Effective E- mails 13. Communication Information Through Visuals 14. Channels of Nonverbal Communication 15. Competence in Interviewing Contexts 16. Confidence in Use of Body Language.

PHI 442 **MARXISM, GANDHI AND EXISTENTIALISM**

L-T-P-D-[C]
3-1-0-0-[4]

This course deals with the philosophical ideas of Karl Marx, Gandhi and some of the important existentialist thinkers, especially Jean-Paul Sartre and Matrin Heideggar. Major emphasis is laid on the moral issues raised by these thinkers.

PHI 444 **ISSUES IN THE PHILOSOPHY OF MIND**

L-T-P-D-[C]
3-1-0-0-[4]

Philosophy and Psychology of Mind; Philosophical Taxonomy of Mental Phenomena: Sensations and Propositional Attitudes; Philosophical Theories of Mind: Cartesian Dualism, Behaviourism, Materialism, Functionalism; Personal Identity & the Self..

PHI 446 **PHILOSOPHY OF SCIENCE**

L-T-P-D-[C]
3-1-0-0-[4]

On what Philosophy of Science is; Logic and Empiricism; Theory and Observation; Evidence, Confirmation and Falsificationism; Induction and Probability; Scientific Revolution versus Normal Science; Scientific Explanation I : Theoretical Entities; Scientific Explanation II : Naturalism, Realism and Anti-realism; Bayesian and Modern theories of Evidence; Science and Value.

PHI 447 **ETHICS AND SOCIETY**

L-T-P-D-[C]
3-1-0-0-[4]

Individual and Social Morality; The Classical Indian Perspective: Purusharthas, Varnashrama Dharma, Theory of Karma and the Idea of Nishkama Karma; The Greek Perspective: - Constitution of Human Soul & Society (Plato); Ethics and the Health of the soul (Aristotle); Moral Virtues; Immanuel Kant: The ethics of Duty; Respect for Persons(For and Against); J.S. Mill: Utilitarianism (For and Against); Annette Baier: The Feminist Ethic; Applied Ethics: Sexual Morality: The Libertarian View (For and Against); Abortion: (for and Against); Euthanasia: (For and Against); Capital Punishment: (For and Against); Social Justice: (For and Against); Job Discrimination (For and Against); Animal Rights: (For and Against); Environmental Ethics (For and Against).

PHI 448 **INDIVIDUAL VS. AUTHORITY**

L-T-P-D-[C]
3-1-0-0-[4]

The distinction between Authority, Power and Sovereignty; Political forms of Authority; The individual's Rights and his Legitimate Autonomy; Encroachment on the Individual's Legtimate Sphere: its Sources and their Disguised Forms; Misuse of Power and Safeguards against it.

PHI 449 **PHILOSOPHICAL PROBLEMS**

L-T-P-D-[C]
3-1-0-0-[4]

Major issues in Metaphysics, Epistemology and Ethics; Self and the world; Free Will; Mind-Body Problem; Theories of knowledge: Internalism & Externalism; The Meaning of Life.

PHI 450 **PHILOSOPHICAL AESTHETICS**

L-T-P-D-[C]
3-1-0-0-[4]

The Aesthetic attitude; Aesthetic Experience; Art and Aesthetic; Defining Art and its Problems; Art and Emotion; Literary Aesthetics; Art, Society and Morality; Philosophy of Literature. .

PHI 451 **TOPICS IN INDIAN PHILOSOPHY**

L-T-P-D-[C]
3-1-0-0-[4]

The subject considers topics in Indian philosophy from Ethics, Metaphysics and Epistemology and contrasts the Hindu and the Heterodox Buddhist and Carvaka approaches to these topics. In Ethics, the focus is on the Theory of Karma and its Relationship with Doctrines of Rebirth, Transmigration, Reincarnation and Moksa. In Metaphysics, we pay special attention on different theories regarding the Nature of the Self. In Epistemology the focus is on the search for a Definition of Knowledge.

PHI 452 **PHILOSOPHY OF COGNITIVE SCIENCE**

L-T-P-D-[C]
3-1-0-0-[4]

Functionalist Theories of the Mind; The Representational Theory of the Mind; Semantics of Mental Representations; Structure and Organization of Mind; Connectionism; The Problem of Intelligence.

PSY 451 **PSYCHOLOGY OF ADJUSTMENT**

L-T-P-D-[C]
3-1-0-0-[4]

Psychological adjustment in the mental health perspective, Dimensions of subjective adjustment. Methods of assessment, Conflict - the major views. Interpersonal maladjustment. Defence mechanisms in intra-personal conflict resolution, Psychological disorders, Anxiety, stress and burn-out, Emotions and adjustment, The self. The neo-Freudian and humanistic views of adjustment, Coping style, the sense of control, and learned helplessness. Depression and suicide, Psychotherapies.

PSY 452 **DEVELOPMENT OF PERSONALITY**

L-T-P-D-[C]
3-1-0-0-[4]

This course presents a psychological perspective on human development which spans the entire life cycle of the individual. The development of each stage is taken up for its characteristics and potential.

PSY 453 **MANAGEMENT DEVELOPMENT THROUGH ATTITUDE CHANGE**

L-T-P-D-[C]
3-1-0-0-[4]

Theoretical and methodological foundations, The concept of development at individual, group, and systems levels. The role of affective processes, in relation to cognitive and conative processes, for individual and systems development. Perception and individual decision-making, Values and attitudes, Skills of active listening, role taking, communicating, conflict handling, bargaining and negotiations, and effective behavior in group settings, Towards working in teams: Problem–solving teams, self-managed work teams, cross-functional teams, virtual teams. Teams and work-force diversity, reinvigorating mature teams, Creating a culture of learning and managing planned change.

PSY 454 **SOCIAL PSYCHOLOGY**

L-T-P-D-[C]
3-1-0-0-[4]

Social psychology as a branch of psychology - its historical background, Major features of contemporary social psychology. Methods adopted in social psychology. Aggression and violence. Attitudes. Social influence - Social facilitation. Social loafing, Social power, Conformity and Compliance, Obedience to authority. Distributive and procedural justice. Cooperation and competition in game-like settings, Coalition formation. Group dynamics. Specific issues in person perception. Social motivation.

PSY 455 **ENVIRONMENTAL AND ECOLOGICAL PSYCHOLOGY**

L-T-P-D-[C]

3-1-0-0-[4]

A framework for analysis, Person-Environment Relationship, Natural and man-made disasters. Reactions to environmental changes, Environmental perception and cognition, Environmental appraisal and aesthetics, Place attachment and rootedness : psychological consequences of displacement. Proxemics and personal space. Ecological concerns, Environmental design - vastu-shastra, architectural factors, and psychological reactions. Designing of specific places, Personality and the environment, Cultural factors in environmental and ecological psychology.

PSY 456 **INDUSTRIAL PSYCHOLOGY**

L-T-P-D-[C]

3-1-0-0-[4]

Taylorism and scientific management; employment psychology and training; test of special abilities and personality assessment, attitudes, morale and adjustment; principles of psycho-technology and consumer psychology; communication and leadership in organisation.

PSY 457 **INTERPERSONAL DYNAMICS**

L-T-P-D-[C]

3-1-0-0-[4]

The general scope of interpersonal dynamics. Methods used in the study of interpersonal dynamics. Major theoretical approaches to Interpersonal Dynamics. Communication and Miscommunication in interaction - verbal and non-verbal aspects. Communicator style. Interpersonal attraction - The major models / theories, Interpersonal judgment. Self-monitoring and impression management. Transactional analysis. Power and dependence in dyadic exchange. Shyness and loneliness. Interpersonal conflicts and their management. The social self. Cultural factors in interpersonal relationships. Promoting positive interpersonal relationships- the role of empathy as a personality component.

PSY 458 **ORGANIZATIONAL AND ADMINISTRATIVE PSYCHOLOGY**

L-T-P-D-[C]

3-1-0-0-[4]

Organizations and the systems concept, The chronological sequence of development of thought in Organizational Behavior area, A road map for understanding organizational behavior: The elementary aspects of function and structure, their contributions to organizational existence, Organizational models, Motivation and performance, Leadership, Power, Control, Organizational Citizenship, and Anti-organization behaviors, Organizational Change and Organizational Development: Individual and group approaches and Significance of individual and group effectiveness through awareness of self and others. This last portion requires experiential learning sessions and basic human process related laboratory work.

PSY 459 **SOCIAL PSYCHOLOGY OF INDUSTRIAL ORGANIZATIONS**

L-T-P-D-[C]

3-1-0-0-[4]

History, scope, and methodological foundations. Needs, values, attitudes, job-satisfaction, Basic motivation concepts and their applications, Understanding work teams, communication, conflict management and negotiations, Foundations of organizational structure, Work design and technology, Organizational culture, Organizational change, and factors contributing to the development, Case studies and problem solving sessions.

PSY 460 **INDIVIDUAL AND INDUSTRIAL ORGANIZATIONS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Theoretical and methodological foundations. Motivation theory. Human learning, Problems and new directions for Industrial psychology, Methods of research and analysis especially relevant to Industrial psychology, Assessment of individual differences: Intelligence, creativity, personality, attitudes, abilities, skills, vocational preferences. Man-machine systems, job and task analysis, recruitment, selection, training, and placement, The social environment of industry: consumer behavior. Management of ineffective performance.

PSY 461 **MANAGERIAL PSYCHOLOGY**

L-T-P-D-[C]
3-1-0-0-[4]

Psychology in management: Different roles of a manager in the organization. A historical account of management philosophy.The functions performed by effective managers, The manager as a decision-maker: Psychological models of managerial decision-making, The manager as a motivator: major models of work motivation. Managerial motivation. Goal-setting, intrinsic motivation, and self-efficacy in work settings. The manager as a communication link : superior-subordinate communication. Determinants of and barriers to effective communication at the managerial level, The manager as a conflict-resolver: major psychological approaches to conflict management, resolution and handling, The manager as a reward allocator . Basic principles of distributive and procedural fairness from a managerial perspective. Organizational justice theories: perceived fairness of wage structure. Reactions to perceived organizational injustice. The competent manager: Boyatzis' model. Thinking styles in strategic management. Cross-cultural perspectives in managerial behaviour, Case discussion on topics.

PSY 462 **ENGINEERING PSYCHOLOGY**

L-T-P-D-[C]
3-1-0-0-[4]

Engineering psychology and related areas: Professional and scientific aspects of engineering psychology; research tools and methods of engineering psychology, Human-machine systems: Concept and applications; analysis, design and evaluation of human machine systems, Human information input and processing: Sensory modalities; display of static and dynamic information; speech communications, Human activities: Energy expenditure, speed and accuracy of movement, Human control of systems: Anthropometric and biomechanical considerations; Design of controls, tools, equipment and related devices; design and arrangement of work place, physical space and environments, Cognitive ergonomics: Cognitive control of systems - task optimisation; human operator as a decision maker, improving human decision making and problem solving, Human-computer interaction: User interface and workstations; social computing; human factors in information access of distributed systems, Applications: Human factors in manufacturing, process control and transportation.

PSY 463 **DEVELOPMENT THROUGH ATTITUDE CHANGE**

L-T-P-D-[C]
3-1-0-0-[4]

The objectives of the course is to help the student to know the psychological variables related to the development, change and resistance to new knowledge and practice. It will cover some theoretical and empirical issues.

PSY 464 **HUMAN PERFORMANCE**

L-T-P-D-[C]
3-1-0-0-[4]

Concepts and approaches: Human performance and human competence; conceptual models of human in working environment; criteria and approaches to assessment of human performance, Human skills: Features and categories of skills; phases of skill acquisition and role of feedback, Quantification of human performance: Human capabilities; information theoretic measures for discrete and continuous signals; catastrophe theory and its application to human performance, Sensory processes: Detection, discrimination and absolute judgement; theory of signal detectability and performance in vigilance tasks, Perceptual processes, memory and attention: Verbal and nonverbal perception; pattern recognition; selective attention; search rate; navigational processes; memory processes and their application; time sharing and mental workload, Response processes: Measures - chronometric, psychophysical and physiological; selection of action; serial reaction times, transcriptions and error, Decision processes: Human limits; values and costs; decision making aids; optimality, Performance under degraded conditions: Uncertainty; degraded environmental conditions; hostile environments.

PSY 465 **COMMUNITY PSYCHOLOGY AND SOCIAL CHANGE**

L-T-P-D-[C]
3-1-0-0-[4]

The concept of a community - the need for community psychology. The inter-disciplinary nature of community psychology, Major principles from other disciplines, and other areas of psychology that are relevant to community psychology : social learning theory, neo-Freudian theories of personality (Horney, Adler, Fromm), and role theory, Community -based issues - social change and community development, literacy, poverty, mental health, and social justice, Social change in the context of globalization: the need for ‘globalization’ and how it can be brought about, Literacy as a community problem, The psychology of poverty, Mental health issues, The socially disadvantaged, Family violence: its causes, Social intervention.

PSY 466 L-T-P-D-[C] 3-1-0-0-[4]

CONSUMER PSYCHOLOGY

Consumer behaviour: Concepts and approaches; the consumer research process; market segmentation and segmentation strategies; consumer behaviour models, The consumer as an individual - I: Consumer needs and motivation; Motivational research; Personality and consumer diversity; consumer self-image; consumer characteristics and life-styles, The consumer as an individual - II: Consumer information processing; perception, imagery and perceived risk; learning and brand loyalty; consumer attitudes; attitude formation and change; marketing communications and persuasion, External influences on consumer behaviour: Group dynamics and consumer reference groups; cultural, social and situational influences; household influences; influence of marketer generated stimuli and information, Consumer decision making processes: Decision heuristics and principles; prepurchase, purchase and post purchase processes; personal influence and the opinion leadership process; diffusion of innovation, Consumer behaviour and society: Consumer behaviour application to profit and not-for-profit marketing; public policy and consumer protection.

PSY 468 L-T-P-D-[C] 3-1-0-0-[4]

SOCIAL COGNITION **Prereq. #**

Social nature of cognition : Historical perspective; approaches to studying social cognition. Principles of social cognition: Organization, explanation, knowledge activation, shared reality, role enactment, social positions and internal audiences. Attribution: Major theories; biases in attribution; applications of attribution theory. Social schemas: Nature and types of social schemas; active construction of reality; schema development, activation and change. Social representations: Theory and issues; relationship between social representations and social schemas, Social inference: Inferential strategies and errors. Person memory: Organization of social information in memory; expectancies and memory processes; contents and contexts of person memory. Affect and Social Cognition: Social cognitive foundations of affect; reciprocity of affect and cognition; mood and stereotyping. Everyday understanding and social cognition. Post-modernism and social cognition.

PSY 469 L-T-P-D-[C] 3-1-0-0-[4]

UNDERSTANDING PERSONALITY

Approaches to the study of personality : an introduction. Major techniques of personality assessment: inventories, the interview, projective techniques, the script, observational and behavioural assessment, and the case study. Personality theories : trait, type, psychoanalytic, humanistic, self, social learning, and cognitive theories. Emphasis on assessment methods in these theories, Writing a test report, Administration of major personality tests ; Cattell 16 PF ; the MBTI ; the TAT ; Holtzman's Ink Blot test ; Rotter's Incomplete Sentence Blank. Interpretation of test responses (with discussion). Psychometric properties of tests; response sets. The Rorschach Ink-blot test : theory and interpretation. The REP Test and other tests of cognitive complexity : theory and interpretation. Determinants of personality : biological factors and socialization (child rearing antecedents and sociocultural influences).

SOC 470 **SOCIOLOGY OF DEVELOPMENT**

L-T-P-D-[C]
3-1-0-0-[4]

Defining the concept of Development: Socio-cultural factors, the modernization perspective of development (the Functionalist view): The theory of Modernization, its assumptions, its methodology and its limitations, the Dependency perspective of development (the Neo-Marxist view):The theory of Dependency/ underdevelopment, its assumptions, its methodology and its limitations. The causes of underdevelopment and the social structure in the underdeveloped world, their impact on North South Relations, the World System Perspective: (Contributions of Immanuel Wallerstein), the theory, its assumptions, its methodology and its limitations. Global System Interdependence, New Structural analysis, agent centered analyses, a new-substantive focus-Dynamics of complex change. Development reconsidered-voices of Dissent, Defining the notion of quality of life, and search for alternatives.

SOC 473 **INDIAN SOCIETY AND CULTURE**

L-T-P-D-[C]
3-1-0-0-[4]

Appraches to study Indian Society, Features of Indian Society - Marriage and family among Hindus and Muglines, polyandry and polygyny, Regulations of marriage & seperation/divorce Social stratification : caste / jati and Varna, Jajmani system, caste system among non-hindus (and outside India), Kinship organization in India, Concepts and Approaches to Social change in India : Sanskritization and westerization parochialization and universatization, steyructural, Dialeefical and cagnitive historical / Indological approaches, TOward an integrated approach (Y. Singh), orthagenetic changes in the cultural traditions and Modernization. More recent processes of change through social movements : Peasant movements, Relegions and seefarian movement, Dalit/Backward caste movements, Tribal movements, labour movements and Ecological movements in India.

SOC 474 **INDUSTRIAL SOCIOLOGY**

L-T-P-D-[C]
3-1-0-0-[4]

Industrial Sociology, History of Industry, Industrial-Systems, Formal organization, Informal Organisations, and Group dynamics. Communication in management, Industrial Relations: Structure of labourorganizations, Trade Unionism in India, Collective Bargaining, Grievance Procedures, Participatory Management & Contemporary Management Issues.

SOC 477 **SOCIOLOGY OF URBAN LIFE**

L-T-P-D-[C]

3-1-0-0-[4]

The city: Origin, Concept, pre-industrial & industrial cities, The Economic institutions of City life-market, economy, machine production, migration, poverty, technological advancements, The political Institutions: Self-Governance, Special Interest Groupism, Urban Social and Cultural Systems-family, religion, education, Art, and Leisure, The rural-urban Dichotomy-Ruurbanism, slums, over-urbanization, Urban Ecology and its renewal –Spatial Theories, Ecological Processes Urban renewal, Ecological impairment, Urban Design and Planning: urban Land-use, Indian cities and their land-use patterns, Urban Crimes, Unrest and Social Control, Urban Policy and Urban problems: Water, power, housing, road, etc. (with special reference to India), Future urban life.

SOC 478 **SOCIOLOGY OF SCIENCE** **Prereq. #**

L-T-P-D-[C]

3-1-0-0-[4]

Socio-Economic Bases of Science: Puritanism, pietism and Science, Science and economy of 17th century England, Nature and Types of Scientific discoveries: Multiples and singletons, priority disputes in Science and Sociological Ambivalence of scientists, Theories of Scientific creativity (Discovery): Psychological Theories: by A Koestler, Albert Rothenberg, Howard Gruber, and the Mentalistic model, Philosophical Theories: by T.S. Kuhn, Imre Lakatos, Larry, Lauden, Paul Feyerabend, Gerald Holton, etc, Sociological Theories: by R.K. Merton, Michael Mulkay, Bruno Latour, etc, Social basis of Discoveries, Folk reasoning in theories about scientific discovery Scientific productivity and its patterns:- Institutional approach: Organizational Factors like Resources, Group climate, Leadership, etc, Individualistic approach : Personality Dispositions and person centered Variables in scientific productivity.

SOC 479 **POPULATION, ECONOMY AND SOCIETY**

L-T-P-D-[C]

3-1-0-0-[4]

Growth of world population: world population by regions, trends in birth and death rates in the developed and the developing countries, causes of change, gross domestic product and population growth, some recent population projections, Population of India: latest available estimates, demographic transition in India, regional variations in fertility, mortality and migration. Population theories: Malthusian and Marxian population theories, theory of optimum population, Gandhian theory, demographic transition theory, critique of demographic transition theory, threshold hypothesis, social justice and demographic change, contributions of Indian sociologists and economists to population theory. Sources of data: census, civil registration system, administrative records, sample registration scheme and surveys. Methodology for population studies: measures of fertility, mortality, migration and urbanization; life table analysis. Population and economic development: conceptual issues involved in defining development and linking population growth to socio-economic variables, Models in population studies:

some examples of deterministic and stochastic models in population studies, especially with respect to macro level linkages, Socio-cultural aspects of population growth in India, Population policy: population policy in the developed and the developing countries, with emphasis on population policy in India, Emerging issues in sociological studies of reproductive health, sexuality and AIDS.

SOC 481 **SOCIETY AND SOCIAL PROBLEMS OF INDIA**

L-T-P-D-[C]
3-1-0-0-[4]

Interaction between structural and cultural components in the process of Social Change : Identification of problematic issues linked with social change. Elements of institutional and structural change in India. Sociological dimensions of problems of Indian society in reference frame of social change. Problems of poverty, crimes, terrorism, justice, deviance, etc.

SOC 484 **CULTURE OF PRODUCTIVITY**

L-T-P-D-[C]
3-1-0-0-[4]

Socio-cultural sources of productivity in nations. Enterpreneurship and Risk taking, Role of social Institutions and values, Productivity, innovation, & management styles in Japan, USA & India. Requirements for a strong productivity culture in India; Organizing for productivity & technovation.

SOC 486 **HUMAN RIGHTS - THEORY AND PRACTICE**

L-T-P-D-[C]
3-1-0-0-[4]

To understand the signicance and limitation of the idea of human rights, particularly in the context of Indian society and policy; to understand the nature and causes of different forms of rights abuse in the country; to understand the role of various agencies and actors engaged in the promotion and protection of rights.

ECO 514 **INPUT-OUTPUT TECHNIQUES** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Basic input-output system; Projection of input-output coefficients; Non survey and partial survey methods; Input demand functions; Capital coefficients and dynamic considerations in input-output analysis; Application of input-output techniques in the economic planning; Input-output tables for the Indian economy; Application of I-O models in the field of energy and environment

ECO 526 **ECONOMICS OF BIOTECHNOLOGY, (3-1-0-4)** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Scope of biotechnology; Recominant DNA, Bioprocessing of agro products (plant breeding); R&D investment in biotechnology; Patents and regulation; Financing of biotechnology; private vs. public; Pricing policies; Trade in goods vs. technology transfer; Applications to agriculture; Applications to pharmaceutical products; Ethical and environmental issues involved in promotion of biotechnology

ECO 527 **MULTINATIONAL ENTERPRISES, (3-1-0-4)** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction; Foreign direct versus portfolio investment; Global and regional trends in direct investment; Horizontal and vertical integration; Ownership-location-internalization framework; Endogenous market structures in international trade; General equilibrium approaches to the multinational firm; Determinants of FDI; Overseas investment and firm exports; Vertical multinationals, fragmentation and outsourcing; Licensing versus direct investment: models of internalization of the multinational enterprise; Contracts, intellectual property rights, and multinational investment in developing countries; Multinational firms, technology diffusion and trade; International taxation and transfer prices; Do domestic firms benefit from direct foreign investment?; MNEs and host country relations

ECO 528 **COMPUTATIONAL FINANCE** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Basic numerical methods, including linear and nonlinear equation methods; Complementarity methods; Finite-dimensional optimization; Numerical integration and differentiation, and function approximation; Methods for solving dynamic stochastic models in economics and finance; Dynamic programming; Arbitrage pricing models in discrete and continuous time; Econometric Software for Computational Finance

ECO 535 **PUBLIC ECONOMICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Scope of public economics; Equity, social welfare and taxation; Taxation, income support and social insurance; Taxation and individuals; Market failure and government intervention; Optimal provision of public goods; Public expenditure and public debt; Modeling government behavior; Organization of public sector

ECO 536 **REGIONAL ECONOMICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Concepts – what is region ? Types of region; Regional growth; Techniques of regional analysis; Industrial location theory; Regional input-output economics; Identification of key sectors; Multi-stage planning

ECO 537 **LAW, TECHNOLOGY AND PUBLIC POLICY** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Economics, law and science: a necessary confrontation; Law and economics as competing paradigms for shaping public policy; Overview of legal system: a “science court”; Tort law and product liability; Environmental and health regulation; Regulation of genetic engineering; Public policies for fostering innovation and economic growth; Cyberspace: freedom of speech and privacy; International law: regimes to promote sustainable development

ECO 543 **ENVIRONMENTAL IMPACT ASSESSMENT** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Why environmental impact assessment (EIA)?; Historical development of EIA; Organization of EIA; Methodologies adopted, framework and guidelines in EIA studies; Socio-economic aspects of EIA- the approaches of engineers, economist and social scientists; EIA of sectoral development projects; Environmental policies and status of EIA in India; Case studies on EIA; Project assignment

ECO 544 **HUMAN DEVELOPMENT** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Development paradigm & introduction to human development; Understanding social realities in human development perspective; Human development & social inequality; Measurement of human development; Human development and freedom; Human rights and human development; Response to human development approach; Overview of human development approach; Education and human development; Health and human development; Human development and environment; Human development and gender; Human development in multi cultural societies; Human development and government; Financing of human development; International institution promoting human development; Economic reforms, rights and justice, and political decentralization; Human development in Indian states

ECO 545 **HEALTH ECONOMICS AND HEALTH CARE POLICY** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Health care as an economic commodity; Determinants of health; Efficiency and equity in health care; Demand and supply of health care; Optimal payments for health services; Health care and financing and insurance; Health policy (national and international); Liability and regulation

ECO 546 **TRANSPORT ECONOMICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Transport and Economics; Transport and Development; Movement, Transport and Location; The Demand for Transport; Firm production and Cost in Transportation; The External Costs of Transport; Pricing of Transport Services; Welfare effect of Public Sector Pricing and Investment; Congestion Pricing; Competition, Concentration and Market Power in Transportation; Transportation Investment; Transportation and Land Use in Urban Areas; Transport Planning and Forecasting; Public Health effect of Transportation; The Regulation of Transport

ECO 547 **WATER RESOURCE ECONOMICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Why plan for water resource in India?; Development of irrigation projects in India; Approaches and priorities in planning of irrigation of irrigation projects;

An approach towards evaluation/appraisal of multi-purpose river valley projects; Economic analysis of methods of cost allocation in planning of multi-purpose river valley projects; Priorities of irrigation under the special programmes of government of India; Role of World Bank and other international agencies; Environmental impact assessment of major irrigation projects in India; Irrigation development: a blessing or bane?; Linking of Indian rivers; Contamination of water bodies and its impact on economic development; Global efforts in water resource management: IWRM; Case studies

HSS 403
L-T-P-D-[C]
3-1-0-0-[4]

Meaning of health and illness behaviour ; social cognition models of health behaviour and illness cognition ; personality and health behaviour ; processes and outcomes in illness ; stress, coping, social support, pain and quality of life ; health care context; the healing process, hospitalization and health promotion ; sources of data on health ; relationship between culture and health ; basic analytical concepts in the study of social aspects of health such as life expectancy, infant mortality rate, maternal mortality rate, prevalence and incidence rates of diseases ; methodological issues in studying social aspects of health ;p epidemiological and statistical models ; social science in medicine and social science of medicine ; hospital as a social system ; social science knowledge for health planners and professionals ; counseling ; preventive and social medicine ; effect of psychological and sociological factors on access to and utilization of health facilities ; public health in India ; institutional support; role of state and NGOs.

ART 701 **METHODOLOGY : ART CRITICISM & APPRECIATION** **Prereq. History of Indian Art & Western Art (ancient and contemporary)**
L-T-P-D-[C]
3-1-0-0-[4]

To familiarize students with variety of methodological approach in art criticism and analysis The course proposes to develop visual skills and analytical skills in writing about various forms of art in using concepts and terminology. It also would enable research student to exercise skills in observation of various forms of visual media. The methodology of criticism is base on some of the following authors- John Dewey (Criticism and Perception), Barkan, Fidman's, Jack Hobbs, and Solomn's Phenomenological Model of Criticism, and Ducasse's Language of Feeling. The critical analysis would be based on Art and Perception, Principles of Style, Styles in 2-dimension and 3-dimension visual art.

ART 702 **DESIGN THEORY, 2-0-2-4**
L-T-P-D-[C]
2-0-2-0-[4]

Theory: The course intends to discuss on the following topics along with related studio activities- Design Philosophy, History of Design, Art, Design & Society, Form, Space & Texture, 2-D & 3-D Form Analysis in Product Design and its architecture, Theory of Color, Color Aesthetics, Introduction to Computer Art, Human Experience in Design, Indian Tradition & Products, Environmental Design.

Studio: The course intends to build an over all understanding in the following areas Form, Space & Texture, 2-D and 3-D Form Analysis, Color and Texture in 2-D & 3-D surface, Color Aesthetics, Computer and composition, Product Analysis and Ergonomics, Environmental Design Model

ART 703 **CREATIVE VISUALIZATION, 2-0-2-4**

L-T-P-D-[C]
2-0-2-0-[4]

Theory: Outline History of Art; Design & Performing Art; Art & Perception; Principles of Style; Style in Art; Design & Performing Art; Space in Art; Design & Performing Art, Style in 3-D work, Style in Architecture, Graphic Art; Photography; typography; Methodology of Criticism & Appreciation.
The course intends to build an over all understanding of the above areas with the help of short workshops, training, field trips, and projects on- photography, film making, stage-craft, script writing, editing, typography and visiting relevant sites.

Related Studio Projects

ART 704 **ART A MEDIUM OF COMMUNICATION** **Prereq. History of Indian Art & Western Art (ancient and contemporary)**

L-T-P-D-[C]
2-0-2-0-[4]

Theory: Pre-historic Art; Traditional Art as Medium of Communication- Religious Art, Buddhist Art, Christian Art, and Hindu Art; Critical analysis of the following theories/articles- Plato's 'Art as Imitation'; Aristotle's 'Theory on Art'; Leo Tolstoy's Theory of Art and 'Art as the Communication of Feeling'; David Hume's 'Of the Standard of Taste'; Susanne Langer's 'Art as Symbolic Expression: From Feeling and Form'; Arthur Danto's, 'The Art World'; POP Art and Comic Art; Art as Language of Expression in 2-D and 3-D media.

Studio: Relevant 2-D and 3-D design Projects

ECO 732 **ECONOMETRICS**

L-T-P-D-[C]
3-0-0-0-[4]

Problems of statistical inference in economics - constraints on the parameter space, random coefficient models, distributed lags, decision models, and systems of equations. New functional forms - kernel estimation, neural networks.

ECO 733 **THEORY OF ECONOMIC POLICY** **Prereq. #**

The objective of the course will be to discuss the structure, design and instruments of macro-economic policies with the help of the various policy models developed in the recent years. It will also include a critical examination of a few selected policy models which are being used in the deve-loped and/or in the underdeveloped countries.

ECO 734 **INDUSTRIAL ORGANIZATION AND POLICY** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Scope of Industrial organization; Industrial Efficiency; Basic Framework for the Study of Industrial Organization; Recent Approaches to Industrial Organization; Market Structure and Its Elements; Market Conduct, Internal Structure of the Firm. Critical Appraisal of Industrial Development policies in India; Case Studies from Heavy Industries, Consumer Goods Industries and Public Utilities.

ECO 735 **DEVELOPMENT ECONOMICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

The international trends in economic development, various development theories and operational strategies towards capital formation, international capital flows, foreign trade, agriculture, industry, HRD, technology transfer and environment will constitute the broad contents of this course. Further, focus will be on new economic policies and emerging new international structures. Besides, the shidents will undertake some empirical project as group assign many.

ECO 736 **APPLIED ECONOMETRICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

This course provides a methodology of emprical research in applying econometric tools for policy oriented research in social sciences. Emphasis will be given to various ways of handling problems faced in doing empirical research in India.

ECO 737 **ADVANCES IN MICRO ECO-NOMIC THEORY**
L-T-P-D-[C]
3-0-0-0-[4]

Developments in monopolistic competition (nonprice decisions in particular), the microeconomic theory of modern organiszations (discretionary managerial behaviour, the organizational dimension) as envisaged by Williamson and Coase, and their implications for industrial policy.

ECO 738 **INTER - INDUSTRY ECONOMICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

The course will highlight the basic input-output models and their extensions. Various examples would be drawn from the empirical analysis of the input-output framework in India and abroad.

ECO 739 L-T-P-D-[C] 3-0-0-0-[4]

PROJECT ECONOMICS **Prereq. #**

In view of the importance of development projects in the process of planning, this course will investigate the basic foundations of project economics, the rationale and methodologies of project evaluation. More particularly, the focus will be on the OECD and UNIDO Guidelines methods of project appraisal with case study exercises in the form of empirical projects.

ECO 740 L-T-P-D-[C] 3-0-0-0-[4]

SEMINAR ON SELECTED TOPICS IN ADVANCED ECONOMIC ANALYSIS **Prereq. #**

The course will cover some frontier topics in advanced economic analysis for a detailed discussion in seminars.

ECO 744 L-T-P-D-[C] 3-0-0-0-[4]

REGIONAL ECONOMICS **Prereq. #**

The major objective of the course is to analyse the different method of regional economic analysis. The focus will be on the economic theory of industrial location, the regional input-output economics, regional multipliers and identification of "Key" sectors. It will also include the introductory linear programming models as applied to regional problems and regional economic theory and multistage planning models.

ECO 745 L-T-P-D-[C] 3-0-0-0-[4]

ADVANCED MONETARY THEORY **Prereq. #**

The course begins with the role of money in static macroeconomic models, neoclassical growth models and consumption loan models, then focusses upon supply of money and monetary aggregate demand for money, and the role of the central bank.

ECO 746 L-T-P-D-[C] 3-0-0-0-[4]

INTERNATIONAL ECONOMIC RELATIONS **Prereq. #**

The course proposes to cover the main issues at the international level in terms of international trade, international monetary systems as well as financial systems and their impact on the international communty. The rise and fall of the Brettonwoods system would be discussed from the point of view of development of the Third world countries as well as from the viewpoint of establishing equity and social justice in the world.

ECO 747 L-T-P-D-[C] 3-0-0-0-[4]

ENVIRONMENTAL ECONOMICS, LEGISLATION & SOCIAL IMPACT

With a view to establish sustainable development and to overcome the dilemma of development, the course proposes to focus on the broad aspects of environmental economics, environmental legislations and the environmental impact assessment. The consequent changes in the approaches and policies of various Government under the leadership of U.N. and World Bank will be discussed along with a number of case studies. The legel aspects of various enviromental projects will be discussed. Besides the students will undertake an emperical excercise through project assignment.

ECO 750 **ADVANCED MACRO ECONO-MICS**
L-T-P-D-[C]
3-0-0-0-[4]

Discussions on macroeconomic theory within the IS-LM framework, add the supply considerations, and then review some of the new clasical and new keynesian contributions; budget financing, interactions with the rest of the world and common empirical issues in macroeconomics.

ECO 751 **LAW AND ECONOMICS** **Prereq. None**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction; Economic Analysis of Property Law: An Economic Theory of Property, and Intellectual Property Rights; Economic Analysis of Contrat Law: Economic Theory of Contract, and Economics of Remedies for Breach of Contract; Economic Analysis of Tort Law, and Economics of Tort Liability; Public Law and Economics: Legislative and Executive Participation and Discretion: Economic anaylsis of judicial review, and general Applications to Indian Institutes: Economic theory of Corporation Law: The Theory of the Firm, Corporation and their Interaction, the Economic Reconstruction of Corporation Law, analysis of Specific Problems of Corporation Law, Economic Analysis of Labour Law: Unions and Productivity, "Workers-Protective" Legislation, Issues in Employment discremination on grounds of Race Sex, and Age; and Economic Analysis of Competition Law: Economic Theory of Competition Law, and Competition Policy in India.

ENG 701 **FUNDAMENTALS OF MODERN LINGUISTICS**
L-T-P-D-[C]
3-0-0-0-[4]

Structure of language; statistical structure and information theory; phonetics, phonemics and the distinctive feature theory; grammatical structure; I-C analysis; phrase structure and transformational grammars; grammatical categories and functions; semantics.

ENG 703 **STRUCTURE OF MODERN ENGLISH**
L-T-P-D-[C]
3-0-0-0-[4]

Varieties of English; registers and dialects; phonetics of English; phonetic transcription; grammar of English; morphology and syntax; the transformational generative approach to the phonology and syntax of English.

ENG 708 **APPLIED LINGUISTICS**
L-T-P-D-[C]
3-0-0-0-[4]

Modern developments in applied linguistics particularly in the fields of language learning and teaching; psychological, sociological, linguistic, and pedagogical aspects of language learning, second language learning; teaching and learning of English as a second language in India; course-design, teaching of language skills; contrastive analysis, error-analysis, programmed instruction, audio-visual aids, language testing, etc.

ENG 709 **LINGUISTIC ANALYSIS**
L-T-P-D-[C]
3-0-0-0-[4]

This course attempts to apply the principles of linguistic analysis to real language data. It covers phonological, lexical, syntactic and semantic analysis and involves some amount of field-work.

ENG 710 **APPROACHES TO THE STUDY OF LITERATURE**
L-T-P-D-[C]
3-0-0-0-[4]

The course will examine the five major approaches-the sociological, the moral, the psychological, the textual, the archetypal - towards the study and interpretation of literary texts. A number of poems, plays, novels, and works of non- fictional prose will be analyzed as examples of these approaches.

ENG 711 **INDIAN WRITING IN ENGLISH**
L-T-P-D-[C]
3-0-0-0-[4]

Selected Indian writings in English or translated from Indian Languages will be used for an extensive examination of some significant themes, e.g., rejection of old taboos, industrialization and its attendant problems, growth of secularism, social changes, bureaucracy and its role, generation gap, etc.

ENG 712 **LITERATURE AND SOCIETY**
L-T-P-D-[C]
3-0-0-0-[4]

This course will study in depth and detail the various modes of interaction between literature and society. The primary emphasis will be on some of the major themes and social concerns (such as individual and society, alienation, technological progress and its human consequences, free will and determinism) which have preoccupied creative writers.

ENG 713 **THEMES AND VALUES IN MODERN LITERATURE**
L-T-P-D-[C]
3-0-0-0-[4]

A study of some of the major recurring themes of modern literature such as alienation, conflict between the generations, impact of science and technology on human life, problems of urbanization, individual versus social and political systems, through literary examples from modern Indian, British, American and European authors.

ENG 715 **METHODOLOGY OF TEACHING AND RESEARCH IN LITERATURE**
L-T-P-D-[C]
3-0-0-0-[4]

This course will study selected pedagogical material on the teaching of literature with a view to acquainting the student with the major theories and techniques of literary study as an academic discipline. It will also seek to familiarise the student with the basic tools and materials of literary research.

ENG 716 **INDIVIDUAL PROJECTS**
L-T-P-D-[C]
3-0-0-0-[4]

This course is intended to provide the students an opportunity to take up on their own a short-term field-work or library project, with constant guidance from the Instructor. Evaluation will depend on the final product and interim reports.

ENG 718 **MASTERS OF TWENTIETH CENTURY CRITICISM**
L-T-P-D-[C]
3-0-0-0-[4]

On the basis of selected works of I.A. Richards, William Empson, T. S. Eliot, F.R. Leavis, R. P. Blackmur, Cleanth Brooks, John Crowe Ransom, Allen Tate, Kenneth Burke, Yvor Winters, Northrop Frye, Harold Bloom and Jacques Derrida a study of their contribution will be made to literary theory and critical practice.

ENG 719 **AMERICAN RENAISSANCE**
L-T-P-D-[C]
3-0-0-0-[4]

The course will study the major themes and techniques in the literature of the American Renaissance, with special attention to the writings of Melville, Hawthorne, Emerson, Thoreau and Poe.

ENG 720 **STYLISTICS**
L-T-P-D-[C]
3-0-0-0-[4]

The course aims at a study of the application of theories and procedures of linguistics to literature to see how far they enrich the experience of literature and help in the evaluation of literary works.

ENG 723 **SEMANTIC THEORY**
L-T-P-D-[C]
3-0-0-0-[4]

Theories of meaning; referential, ideational, and behaviouristic; meaning and truth; meaning and use; lexical structure; semantic theories in generative grammar; generative semantics; the Extended Standard theory; Fillmore; Speech Act semantics; presupposition theory; semantic representations; semantics and pragmatics.

ENG 725 **HISTORY AND STRUCTURE OF THE ENGLISH LANGUAGE**
L-T-P-D-[C]
3-0-0-0-[4]

Varieties of English and the dimension of variation; the historical dimension; Old, Middle and Modern English. Structure: sound structure; syntactic structure; information structure and discourse structure; lexical structure and word-formation.

ENG 731 **SOCIOLINGUISTICS**

L-T-P-D-[C]

3-0-0-0-[4]

Relationship between language and culture; place of language in social life; socio-cultural knowledge in verbal communication; social meaning of dialectical, registral and stylistic variation; language contact; code mixing, language problems in multilingual societies and language planning.

ENG 733 **INDIAN LITERATURE**

L-T-P-D-[C]

3-0-0-0-[4]

The course deals with major trends and developments in Indian literature from ancient to modern times. The course will focus primarily on the following topics: the problem of definition;the growth of nationalism; elements of unity in a multilingual situation; ancient religious and secular liteature; impact of Western literatures; modern regional literatures.

ENG 734 **BLACK FICTION**

L-T-P-D-[C]

3-0-0-0-[4]

This course is a critical appraisal of the works of African American authors in the twentieth century. An attempt will be made to answer qustions such as "Is there a Black Experience that shapes the writings of African - American authors?", etc.

ENG 735 **COMMONWEALTH LITERATURE**

L-T-P-D-[C]

3-0-0-0-[4]

The course covers literature in English in the Commonwealth countries of Africa, Australia, Canada, India, New Zealand, and the West Indies. An attempt will be made to show that commonwealth writers, while contributing to the literature of their own country, find their particular artistic understanding inescapably informed by what William Walsh calls "other silent but active aims".

ENG 736 **THE GENERATIVE ENTERPRISE : GOALS AND METHODOLOGY**

L-T-P-D-[C]

3-0-0-0-[4]

Any post-graduate course in Modern Literature

Chomskyan revolution in grammar; Linguistics as an empirical science and as a branch of cognitive psychology, Linguistics and natural science methodology. Language universals and parameters; towards a restrictive theory of grammar; models of generative grammar in the mainstream (Prestandard, Standard, Extended Standard, Government and Binding, Minimalist Programme), Construction and refutation of syntactic arguments; rejection and falsification of syntactic theories, etc.

ENG 737 **LANGUAGE ACQUISITION**

L-T-P-D-[C]

3-0-0-0-[4]

Stages in the development of language in the child, approaches to the study of language acquisition; acquisition of phonology; acquisition of syntax; acquisition of semantics; lexical development; development of speech acts; the learnability theory.

ENG 739 **COMPUTATIONAL LINGUISTICS**
L-T-P-D-[C]
3-0-0-0-[4]

Description of English syntax in the Government and Binding framework; Augumented Transition Network; issues in Natural Language Understanding; frame-based knowledge representation; use of knowledge in disambiguation and understanding.

ENG 740 **THE PRINCIPLES AND PARAMETERS SYNTAX**
L-T-P-D-[C]
3-0-0-0-[4]

The government and Binding framework : Organisation of grammar, levels of representation, subsystems of principles; the knowledge of language; the minimalist programme : parameters, locality and bare phrase structure.

ENG 741 **PRINCIPLES AND PRACTICE OF LINGUISTIC COMMUNICATION**
L-T-P-D-[C]
3-0-0-0-[4]

Communication and language : selection of message, medium settings, negotiation of identities, spoken and visual discourse; language as a social artifact; structure of discourse; theories of discourse semantics; social control through language; applications.

ENG 742 **RESPONSIBLE DISSENT**
L-T-P-D-[C]
3-0-0-0-[4]

Concept and practice of responsible dissent in various socio-political contexts: Notions of dissent and responsible dissent, ethical roots of dissent, contexts and forms of dissent, profiles of dissenties (Chomsky, Russell, early Gandhi, Ram Mohan Roy, King, etc.), role and responsibility of the intellectual, role of media in supression of facts and dissemination of misinformation, strategies of manufacture of consent in totalitarian and democratic structures.

ENG 743 **FEMINIST THEORY AND LITERATURE**
L-T-P-D-[C]
3-0-0-0-[4]

Definitions: the Sex/Gender debate, Masculinity and femininity, patriarchy, the feminism/gender studies debate.

Gender and Identity: Processes of Identity formation, gender roles in different social contexts, gendered life-scripts and their historical transformations.

Gender and Representation: The politics of representation, external vs internal self-representations, the media and representation.

The Politics of Feminism: The reasons and implications of focusing on gender as a subject of inquiry, the relationship between theory and practice, the locational specificity of "feminism," the role of feminism in India.

ENG745 **LEXICAL SEMANTICS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Philosophical and linguistic approaches to lexical semantics; Semantic structure and its modelling; Semantics-syntax mapping; Semantics-pragmatics distinction; Lexical meaning, interlexical relations and semantic distance; Syntactic and semantic polymorphism; Semantic underspecification; Lexicon and modularity; Conceptual and linguistic structures; Conceptual spaces, Generative lexicon; Ontological semantics; Lexical semantic nets: frame semantics, wordnet and verbnet; Acquisition of lexical knowledge; Lexical semantics and discourse relations; Lexical semantics in figurative discourse

ENG748 **COGNITIVE LINGUISTICS**

L-T-P-D-[C]
3-0-0-0-[4]

The course explores language-cognition mappings in varied contexts such as unilingual, billingual and sign language use, Crosslinguistic variations in basic conceptual domains such as time and apace and lexicalization patterns will be examined. Other topics include nature of linguistic representations open- class semantics and semantics of grammar type hierarchies and continuums, compositional structures and co-compositionality, non-compositional structures, constrains on possible grammars, perceptual processes and grounding.

ENG 749 **POSTMODERN THEORY AND LITERATURE**

L-T-P-D-[C]
3-0-0-0-[4]

Any post-graduate course in Modern Literature

Acquainting the students with the major critical concepts, self-reflexive texts and amorphous themes of Postmodernism, the course aims to explore the usefulness of the term “postmodernism” as a means of approaching contemporary literature. The course will offer an advanced introduction to the central concepts of postmodernism by providing an approach to contemporary American, Latin American, European and Indian (Writing in English) literature. Major topics for discussion are: The relevance of Postmodernism, differences between Modernism and Postmodernism, Deconstuction, the Death of the Author, Rhizome, Knowledge and Power, Entropy, the Literature of Exhaustion, the Hyperreal and the Simulacrum, Cyberspace and Cyberpunk, Postmodern Ethics, Postmodernism and Popular Culture, Postmodernism in an Indian context, Postmodern Films, Postmodernism and its Limitations.

ENG 750 **POSTWAR AMERICAN FICTION**

L-T-P-D-[C]

3-0-0-0-[4]

Postwar American fiction is characterized by a complex sensibility that is often pervasive in the novels of the period from 1945 through the Cold War of the seventies and eighties to the present. With America coming into unexampled prosperity following WWII, this sensibility manifests itself as a sense of triumphalism only to give way to introspection and self-debate concerning the problematic of defining American identity and nationhood against a distinct multicultural presence, and the unviability of "American Dream" in a transnational and globalized world in the creation of which, curiously, America itself has enormous investments. Interestingly, fiction of this period frames war both as a trope and a realistic concern. The protracted cultural wars which began with the Civil Rights era of the 1960s infused new life into the literature of the United States in that the traditionally oppressed voices of minorities, be they African Americans, women or the immigrants, began to be heard. And the variegated literary movements (postmodernism, humanism, and feminism to name a few) and fictional strategies (such as protest, fantasy, black humor) employed in the genre bring in to one's reading a nuanced and engaging perspective of how these writers have negotiated reality into their imaginative artistic vision. The fiction of this period is marked by thematic concerns such as politics, paranoia, race, money, technology, sex, suburbia, urban decay, immigration, and spirituality, among others. The course strives to close-read select texts, in the light of rigorous theoretical interventions.

ENG 751 **CONTEMPORARY CRITICAL THEORIES AND LITERARY PRAXES**

L-T-P-D-[C]

3-0-0-0-[4]

Any postgraduate course in English Literature is desirable

Contemporary critical theories particularly those of the post-1960s, have problematised the writing, reading and receiving of literature. This course examines complex aspects of recent critrical theories associated with gender, race, subjectivity, sexuality, textuality, narratology, ecology, and notions of culture and history. It aims to expose students to contemporary theories that would enhance their research into chosen areas of literature. Delving on relevant issues and debates, the course acquaints students with various strategies of reading, interpretation and analysis of literary/non-literary texts and the acquistion of current critical vocabulary. Important topics of discussion include semiotics, deconstruction, interextuality, reader response theory, autobiographical theory, post-Lacanian psychoanalytic criticism, postcolonialism, postmodernism, third wave feminism, cultural materialism, new historicism, posthumanism, ecocriticism, hypertext theory, and cyber criticism. Siginficant contributions by the following and other such representative figures will be incorporated in the discussions: Edward Said, Frantz Fanon Fredric Jameson, Gilles Deleuze and Felix Guattari, Jacques Derrida, Mikhail Bakhtin, Michel Foucault, Roland Barthes, Stephen Greenblatt and Umberto Eco.

ENG 752 **COMPARATIVE AESTHETICS**

L-T-P-D-[C]
3-0-0-0-[4]

The course explores the convergence and divergence of eastern and western aesthetic practices, in an attempt to two. Its scope includes classical Greek and Sanskrit texts like Bharata' s Natyasastra and Aristotle's Poetics which are extensive treatises on dramaturgy, Longinus' s concept of the sublime, Anandavardhana's concept of dhvani and postulates of New Criticism.

HSS 701 **THEORIES OF RIGHTS**

L-T-P-D-[C]
3-0-0-0-[4]

The aim of the course is to understand the origins of the notions in the classical period, its rejuvenation in the medieval and early modern periods, and contemporary debates surrounding different theories of rights with special emphasis on examining debates on human rights. Some specific domains of rights will be taken up for intensive study in the light of various theoritical positions. Themes include: Stoicism, Republicanism, Natural Law Discourse, Liberalism, Utilitiarianism, Legal Positivism, Marxism, and Communitarianism.

PHI 701 **PHILOSOPHY OF MIND**

L-T-P-D-[C]
3-0-0-0-[4]

Conceptual Taxonomy of Mental Phenomena; Mind-Body Relation in Dualism, Behaviourism, Physicalism, Functionalism; Consciousness and First-person Subjectivity; Meaning and Mental Representation; Self and Self-identity; Thought and Language; Folk Psychology versus Cognitive Science.

PHI 751 **TWENTIETH CENTURY PHILOSOPHY-I**

L-T-P-D-[C]
3-0-0-0-[4]

An analytical study of Russell's The Philosophy of Logical Atomism and Wittgenstein's Tractatus Logico-Philosophicus: Facts and Propositions; Names and Objects; Definite Description; Picture Theory of Meaning; Limits of Language, Thought and The World; Silence and the Transcendental.

PHI 752 **PROBLEMS IN PHILOSOPHICAL AESTHETICS**

L-T-P-D-[C]
3-0-0-0-[4]

Theories of Art as Mimesis, Expression and Form; Aesthetic Experience; Art as a Cultural System; Art and Morality; the Philosophy of Literature: Truth, Meaning, Interpretation and Evaluation; Literature and Cultural Studies.

PHI 753 **MODERN LOGIC**

L-T-P-D-[C]
3-0-0-0-[4]

Propositional Logic; Decision Procedures; Quantification Theory; Axiomatic Method; Philosophical Problems.

PHI 757 **MORAL JUDGEMENT**

L-T-P-D-[C]

3-0-0-0-[4]

The details of the studies in this course will be designed for advanced students depending on their fields of research.

PHI 765 **TWENTIETH CENTURY PHILOSOPHY-II**

L-T-P-D-[C]

3-0-0-0-[4]

An Analytical Study of the Logic of Ordinary Language; Problems of Meaning, Reference and Truth; the Analytic-Synthetic Distinction; the Scheme-Content Distinction; Antifoundationalism and Neo-pragmatism. Special reference to the views of Wittgenstein, Austin, Strawson, Quine, Davidson, Kripke, Putnam and Thomas Nagel.

PHI 766 **PHILOSOPHY OF ACTION**

L-T-P-D-[C]

3-0-0-0-[4]

A conceptual study of the Nature of Human Agency and Human Action; Action and Purpose; Rational and Causal explanation of Action; Action and Obligation; Logic of Action-statements; Logic of Reasoning about Actions and their Defence.

PHI 767 **LOGIC OF MORAL DISCOURSE**

L-T-P-D-[C]

3-0-0-0-[4]

Valuation: Moral and Non-moral; Standards and Principles; Value- judgements; Ought-judgements; Imperatives and Moral Principles; Generalizability; Rules, Instances and Exceptions; Reasons, Choices and Actions and validity.

PHI 768 **MODAL LOGIC**

L-T-P-D-[C]

3-0-0-0-[4]

The History of Modal notions; The Lewis systems; Strict Implication and Entaliment; The System E and Relevance Logic; Philosophical Problems.

PHI 769 **INDIAN PHILOSOPHY-I**

L-T-P-D-[C]

3-0-0-0-[4]

A discussion of Epistemological, Meta-physical and Value problems raised in the Classical Systems of Indian Philosophy. Depending on the students' interest, aptitude and progress, either some texts will be studied in details or one set of problems will be studied through relevant texts.

PHI 770 **PHILOSOPHY OF SOCIAL SCIENCE I**

L-T-P-D-[C]

3-0-0-0-[4]

Philosophical presuppositions of Social-scientific method; Explanation and Understanding: The Hypothetico-Deductive model; the Verstehen Model and others; The problem of Rationality: of Rational Explanation and Rational Action; Value and Objectivity.

PHI 772 ETHICAL THEORIES

L-T-P-D-[C]
3-0-0-0-[4]

A critical and analytical study of ethical theories of some classical and contemporary moral philosophers.

PHI 773 WITTGENSTEIN

L-T-P-D-[C]
3-0-0-0-[4]

A study of Wittgenstein's later philosophy: critique of Wittgenstein's earlier philosophy; Private Language Argument; Meaning, Use and Rule-following; Aspect-seeing; Pre-epistemic certainity.

PHI 774 SOCIAL AND POLITICAL PHILOSOPHY

L-T-P-D-[C]
3-0-0-0-[4]

Nature and Method of Social Philosophy; Nature of Society; Theories of Origins of Society; Place and Role of Social Institutions; Social Values and Ends of Political Authority; Sources of Justification and Legitimacy of Political Authority; Individual and Society; Individual and State.

PHI 776 PHILOSOPHY OF THE SOCIAL SCIENCES II **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Philosophical approaches to the problem of the relationship between Knowledge and Social Structure. Studies will be undertaken from selections from Marx, Weber, Durkheim, Mannheim, Critical Theory, Hermeneutics and Post Modernism.

PH1 777 INDIAN PHILOSOPHM IN CONTEMPORARY PERSPECTIVE

L-T-P-D-[C]
3-0-0-0-[4]

Conscious and the Self ; The Problem of Intentionality ; Nyaya Realism & Buddhist Idealism ; Svatah- pramanyavada; Theries of Meaning ; Dharma, Morality and Freedom.

PHI 779 ADVANCED ETHICAL THEORY

L-T-P-D-[C]
3-0-0-0-[4]

Main topics to be covered: Rules; Moral Rules; Utility; Moral Virtues; Obligations; Morals and Rationality.

PHI 782 EXISTENTIALISM

L-T-P-D-[C]
3-0-0-0-[4]

The course seeks to go into the sources of modern existentialist movement in the thoughts of Hegel, Husserl and Kierkegaard. A detailed study of Sartre's philosophy will be undertaken in the light of his early and later writings.

PHI 798 PHILOSOPHY OF HISTORY

L-T-P-D-[C]
3-0-0-0-[4]

The course is in two parts. Part one is Analytical Philosophy of History: Explanation and Understanding of Historical Events; Objectivity and Evaluation in Historical

Writing etc. Part two is Speculative Philosophy of History: those of Augustine, Vico, Herder, Kant, Hegel, Marx and Toynbee.

PSY 774 **QUALITATIVE RESEARCH : THEORY AND PRACTICE**

L-T-P-D-[C]
3-0-0-0-[4]

In the last few years, research in psychology has witnessed a remarkable shift to a post- positivist paradigm. A large number of qualitative methods have emerged in consonance with this shift. For a researcher in psychology. the knowledge of reseach methods and methodological issues is now incomplete without an in- depth understanding of the qualitative methods. This course is aimed at providing an extensive overview of qualitative research methods, methodological roots, major theoretical principles and issues in qualitative research. Various methods would be discussed along with examples of representations cultural psychology developmental psychology discursive psychology, counseling and psychotherapy.

PSY 775 **FUNDAMENTALS OF NEUROPSYCHOLOGY**

L-T-P-D-[C]
3-1-0-0-[4]

Development and evolution of brain : Brain organization and function; Cerebral asymmetry; Neuropsychology of higher order functions - memory language, emotional processes, spatial behaviour ; Applied human neuropsychology.

Selected Readings:

1. Barrett, L., Dunbar, R., & Lycett, J. (2002). Human evolutionary psychology, Palgrave Publishers Ltd.

2. Kolb, B. & Whishaw, I.Q. (1990) Fundamentals of human neuropsychology, W.H. Freeman & Company.

3. Mandal, M.K., Bulman-Fleming , M.B., & Tiwari, G.(2000). Side Bias: A Neuropsychological Perspective, Kluwer Academic Publishers.

PSY 777 **ELEMENTS OF STATISTICAL ANALYSIS**

L-T-P-D-[C]
3-0-0-0-[4]

The essentials of statistics in a relatively non-mathematical form, statistical techniques most frequently employed in psychology for the analysis and synthesis of data.

PSY 778 **EXPERIMENTAL DESIGN**

L-T-P-D-[C]
3-0-0-0-[4]

The course intends to familiarize the students with the statistical principles involved in experimental designs. The course focuses on the use of factorial designs in psychological research. Single and multi-factor experiments are covered.

PSY 780 **PSYCHOLOGY OF PERSONALITY**

L-T-P-D-[C]

3-0-0-0-[4]

Introduction to the field of personality. Trait and situational approaches to personality are covered, along with a critical assessment of the major theories of personality.

PSY 781 **DEVELOPMENT OF PERSONALITY**

L-T-P-D-[C]

3-0-0-0-[4]

Growth and development of personality, the critical stages of growth, contributions of the psychoanalytically-oriented psychologists, ego psychologists, and social learning theorists; and role of external interventions on the ongoing process of personality growth.

PSY 783 **ADVANCED EXPERIMENTAL SOCIAL PSYCHOLOGY**

L-T-P-D-[C]

3-0-0-0-[4]

The course includes experimental paradigms in contemporary social psychology covering areas such as attitude and attitude change, group processes, social power, reward allocation, prosocial behavior, social cognition, social influence processes, aggression and violence; and the important theories in social psychology.

PSY 784 **APPLIED SOCIAL PSYCHO-LOGY**

L-T-P-D-[C]

3-0-0-0-[4]

This course will explain how social psycological theories can be applied to real life. The prime objective is to disseminate findings from behavioural science research which have relevance for problems of society.

PSY 785 **PERSONALITY ASSESSMENT, THEORY AND TECHNIQUE**

L-T-P-D-[C]

3-0-0-0-[4]

The techniques of assessing personality. A discussion of current approaches to personality theory as related to assessment. Rating scales, inventories, projective techniques, the experimental methods, and the principles and theoretical bases underlying these assessment techniques will be discussed.

PSY 786 **UNDERSTANDING ORGANIZATIONAL BEHAVIOUR**

L-T-P-D-[C]

3-0-0-0-[4]

A coherent introduction to organizational psychology, historically taking off from industrial psychology and human relations movement. The course takes a look at man-in- organizations in a social environment and concentrates on the theoretically significant empirical research.

PSY 787 **MANAGEMENT OF ORGANIZATIONAL BEHAVIOUR**

L-T-P-D-[C]

3-0-0-0-[4]

The course focuses on a practical training to understand the human behaviour at work in order to predict the effectiveness and well-being in various types of organizations, and to enhance the understanding of change processes in these organizations.

PSY 788 L-T-P-D-[C] 3-0-0-0-[4]

ADVANCED COURSE ON DEVELOPMENT OF PERSONALITY: PSYCHOLOGY OF WOMEN

The overall objective of the course is to gain insight into the development of persoanlity through the specific study of the woman, develoment of the woman through the entire life the interplay between cultural context, biological factors and psychological influences.

PSY 789 L-T-P-D-[C] 3-0-0-0-[4]

LEARNING, MEMORY AND COGNITION

A wide coverage of behavioural functions characterized as "Learning and Cognition". It presents a broad spectrum of current developments in these areas. The main objective of the course is to expose the students to some of the recent advancement in the areas of learning, memory, and cognition.

PSY 790 L-T-P-D-[C] 3-1-0-0-[4]

HUMAN COGNITIVE PROCESSES

The course deals with scientific study of human mind and explores cognitive processes involved in perception, memory, pattern recognition, psycholinguistics, and bilingualism. Recent research techniques, issues and stands in these areas are critically examined.

PSY 791 L-T-P-D-[C] 3-1-0-0-[4]

ADVANCED COURSE IN PSYCHOLOGICAL ASSESSMENT

The course is designed for students who already have a general overview of testing. Practical applications and use of psychological tests such as WAIS, TAT, 16 PF, Kelly's Rep Grid and others are considered for administration, scoring and interpretation.

PSY 793 L-T-P-D-[C] 3-0-0-0-[4]

COMMUNITY PSYCHOLOGY

The course is concerned with generating theory and research that will clarify the complex interaction between individuals and social institutions, developing methods and procedures that will help individuals to cope with their environments, tailoring environments to meet human needs better and developing intervention strategies.

PSY 795 L-T-P-D-[C] 3-0-0-0-[4]

LEADERSHIP AND STRATEGIC MANAGEMENT IN ORGANIZATIONS

Whether an organization will succeed or fail ultimately depends upon the appropriate administration of the subject of this course: leadership and strategic management. It includes the advanced understanding of modern theory and practice in leadership and strategic management.

PSY 796 **CROSS-CULTURAL PERSPECTIVES IN PSYCHOLOGY**

L-T-P-D-[C]
3-0-0-0-[4]

The course highlights the role of cultural factors in psychological processes, including the anthropological and psychological views of culture, cross-cultural variations in social and organizational behaviour, cognition and personality, the major models, and methodological issues.

PSY 797 **COGNITION IN ORGANIZATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

The course contents include foundations of cognitive research in organizations; role of knowledge in managerial performance; cognitive cause mapping; cognition of groups; organizational culture and individual sense-making; organizational decision-making; negotiator cognition and collective scripts and other related topics.

PSY 798 **ADVANCED COURSE IN SOCIAL COGNITION**

L-T-P-D-[C]
3-0-0-0-[4]

The course aims at providing an understanding of the concepts and issues in social cognition research. The course contents include historical roots of social congnition; social congnitive principles - a cost-benefit analysis; representation of social knowledge; social schemas; heuristics and biases; contribution of social representations; rituals and rhetoric; knowledge and social process; social cognition and the study of stereotyping, prejudice and discrimination, social cognition and discourse; social sensibility and neural function.

SOC 720 **RESEARCH METHODS**

L-T-P-D-[C]
3-0-0-0-[4]

Nature and types of scientific explanation, Values and objectivity in social science research, Various research designs: (i) Descriptive, (ii) Exploratory, (ii) Experimental (two and multigroup designs). Tools and techniques of data collection, both direct and indirect methods of data collection (projective techniques), Various scaling techniques (Differential scales, Summated scales and Cumulative scales, etc), problems of measurement, Various types of reliability and validity of measures, Qualitative research.

SOC 721 **SOCIOLOGICAL THEORY**

L-T-P-D-[C]
3-0-0-0-[4]

Relation between theory and research. The nature and use of theory, basic concepts, fundamental perspectives of society, conceptualization of social system social structure and culture, Various perspectives; Structural Functional, conflict Theory - Frankfurt school critical theory, Exchange theory, Symbolic - Interactionism, Phenomenology, Ethnomethodology & Structuration theory.

SOC 723 **INTRODUCTION TO STATISTICAL INFERENCE**
L-T-P-D-[C]
3-0-0-0-[4]

Basic statistics; correlation and regression analysis; probability and probability distributions; sampling designs; tests of significance; analysis of variance; non-parametric methods; recent developments in applied statistics in social sciences.

SOC 724 **URBAN SOCIOLOGY**
L-T-P-D-[C]
3-0-0-0-[4]

Process of urbanization and urban social structure in contemporary societies. Role of capital and state in the urban social formations, Urban development-theory and practice. Class, ethnic relations in Urban societies etc., Urban renewal, Urban Problems in India.

SOC 725 **SOCIAL CHANGE IN DEVELOPING SOCIETIES**
L-T-P-D-[C]
3-0-0-0-[4]

Process of change, models of change, Factors of change characteristics and problem of developing societies with special reference to India, problems of countinuity, identity and conflict, traditionalism and modernity, methodology (comprative) for the study of change.

SOC 729 **AGRARIAN SOCIAL STRUCTURE AND CHANGE IN INDIA**
L-T-P-D-[C]
3-0-0-0-[4]

Evolution of the agrarian system from the Mughal period onwards, changes introduced by the British in land administration, emergence of new agrarian classes and class relations in the countryside, the Marxian model of agrarian classes, the traditional model namely the Jajmani system, the changing problems of tribal lands, rural credit, development of capitalist farming and other changes since the land reforms in India, and a review of major sociological studies on the agrarian class relations in India.

SOC 731 **INDUSTRIAL SOCIOLOGY**
L-T-P-D-[C]
3-0-0-0-[4]

The industrial revolution and the process of industrialization. The formal organization, nature and characteristics, Structure of Industrial bureaucracy and its functions, informal organization of Industry, nature and role of trade unions, etc., labour movements in India, Indian labour problems and policies. Triangular relationship : government, management and union.

SOC 732 **SOCIOLOGY OF DEVELOPMENT**
L-T-P-D-[C]
3-0-0-0-[4]

Sociological perspective on development problems with special reference to India, theories/models of development, Modernization Theory (New modernization studies) Dependence Theory (New dependence studies), World System Theory, Global system Interdependence, Globalization, UNDP definition of Development-indicators. The sustainable nature of Development, Development reconsidered-voices of Dissent.

SOC 733 **POPULATION PROCESSES**
L-T-P-D-[C]
3-0-0-0-[4]

Basic concepts in demography; sociology of population; recent developments in population theory; population policies; population research methods; population studies in India.

SOC 734 **SOCIAL INEQUALITY AND STRATIFICATION**
L-T-P-D-[C]
3-0-0-0-[4]

Critical evaluation of concepts and theories of social inequality and stratification; aspects of inequality in contemporary societies; methodology of stratification; stratification in India.

SOC 737 **DEVELOPMENT AND SOCIAL STRATIFICATION**
L-T-P-D-[C]
3-0-0-0-[4]

Sociology of Social Stratification (in classical writings), Theories of stratification and issues ; social stratification and development; three worlds of development and international stratification; development and distri-bution; economic growth and poverty, Theories of poverty & Relative Deprivation).

SOC 742 **SOCIOLOGY OF ENVIRONMENT**
L-T-P-D-[C]
3-0-0-0-[4]

The new environmental paradigm in sociology. The relationship between environment and 'social complex'. Environmentalism and Development (issue of socio-economic equities), The concept of sustainable development in environmental studies. Social response to environmental-imperatives (Role of value structure, normative and attitudinal patterns in communities). Social Institutions in the context of environmentalism, e.g. Roligion, caste, tribe, local communities and voluntary associations. Evinmental movements and their impacts.

SOC 745 **SOCIAL THEORY IN LATE TWENTIETH CENTURY**
L-T-P-D-[C]
3-0-0-0-[4]

Canons in sociological theory, breaking with modernity, post positivist and post structural social thought, post modernism in social theory: present images and future possibilities, Writings of J Baudrillard, Michel Foucault, J F Lyotard, J Derrida, and F Jameson.

SOC 746 **SOCIAL MOVEMENTS: OLD AND NEW**
L-T-P-D-[C]
3-0-0-0-[4]

The aim of the course is to define the various types of social movements, and understand their role in striving for social change or transformation. It will examine theories of social movements in the context of recent debates surrounding issues of nationalism, ethnicity, and identity. Specific movements, including the role of various actors, will be studied with special reference to India.

SOC 747 **PARTICIPATORY RURAL APPRAISAL (PRA): Philosophy, practical approaches and methods**
L-T-P-D-[C]
3-0-0-0-[4]

Critique of positivist approach in sociology, and limitations of conventional methods such as survey and non-participatory fieldwork. Sociology as the study of social actors, Touraine's concepts of intervention method, and sociology without society. Paradigmatic shift from sociological discourse to advocacy. Origin and development of Rapid Rural Appraisal, Relaxed Rural Appraisal and Participatory Rural Appraisal methods. PRA as a process of empowering people. Principles of PRA. Common methods such as observation, semi-structure interviewing, transect walks, time lines, and trend and change analysis, participatory mapping and modeling, Venn diagramming, linkage diagrams, well-being grouping, matrix scoring and ranking, local indicators, alternatives to questionnaires, listing and card sorting.

SOC 748 **EDUCATION AND SOCIAL CHANGE**
L-T-P-D-[C]
3-0-0-0-[4]

General introduction to the place of learning in society. Learning, education and training. Changing meanings of education across time and society. A brief historical perspective on education in India. Social-political arithmetic as a spurious way of understanding education and social change. Structural functionalist perspectives and structural-conflict perspect-ives on education. Class, conflict, legitimation processes, reproduction of society. Anarchist perspectives. “New” Sociology of Education. Symbolic interactionist perspectives on education. Resistances to schooling. Critical theory and education. Neo-Weberian perspect-ives on education. Status politics and education. Caste, class, gender and education in India. Indian thinkers on education. Current debates on the place of education in India.

ECO 799 **Ph. D. Thesis**

ENG 799 **Ph. D. Thesis**

PHI 799 **Ph. D. Thesis**

PSY 799 **Ph. D. Thesis**

SOC 799 **Ph. D. Thesis**

INDUSTRIAL AND MANAGEMENT ENGINEERING

PROFESSORS

Chatterjee Jayanta	jayanta	7858
Mittal A K	mittal	7345
Kripa Shanker	ks	7683
Sharma N K	nksharma	7622
Sharma R R K (Head)	rrks	7172
Sinha Arun P	asinha	7782
Varman, Rahul	rahulv	7970

ASSOCIATE PROFESSOR

Bansal, Veena	veena	7743
Swami Sanjeev	sswami	7460

ASSISTANT PROFESSORS

Peeyush Mehta	pmehta	6647
Sarkar Runa	runa	6608
Sengupta R N	raghus	6607
Phani B V	bvphani	6606
Singh Anoop	anoops	7679

VISITING FACULTY

Chandra B	chandrab	7781

Convenor, DUGC	:	A P Sinha	asinha	7782
Convenor, DPGC	:	Anoop Singh	anoops	7679

Faculty Counsellor:

Set up in 1974, the Department of Industrial and Management Engineering (IME) at IIT Kanpur was one of the first in the country to recognise the strength of combining the training of engineers with management education. Today, the Department is engaged in a diverse set of activities that include teaching, academic research, industry consulting, regularly held management development programmes, and public sector projects.

The curriculum comprises state-of-the-art techniques to plan, design, implement and manage integrated systems of men, materials, capital, information and technology. The subjects taught provide a well-rounded coverage of the methods to manage and improve productivity, customer satisfaction and profitability of industrial, information and infrastructural (service) systems. In today's competitive era, these methods have rapidly become relevant to engineers in all disciplines, Consequently, fresh engineering graduates as well as practicing professionals in fields ranging from computer science to aerospace engineering and architecture to electronics engineering regularly enrol in IME's postgraduate programmes.

Current areas of research include Operations Research, Operations Management, FMS/CIMS, TQM, Manufacturing Policy, Information Management, and Information Technology, Knowledge Management, Service Management, Strategic Management, Infrastructure Regulation and policy, Infrantucture project financing Energy Modelling and Management, Financial Management, Risk Modelling and Management, Revenue and Yield Management, Technology Management, IPR, Marketing of Services, Marketing Science, International Marketing, Consumer behaviour, Personnel Management and Industrial Relations, Management of Change and Organisation Restructuring.

The Department offers M. Tech., MBA and Ph. D. degrees in Industrial and Management Engineering. A bachelor's degree in any branch of engineering is the minimum requirement for admission to M. Tech./MBA. A Master's degree in Management/Industrial Engineering/Operations Research is required for admission to Ph. D. The process of admission to M. Tech. and Ph. D. programmes includes a written test and a personal interview.

The Department has started a 2 year MBA programme beginning July 2001. Open to engineering graduates of any branch, the programme consists of four semesters of course work with the intervening summer to be spent on a summer internship project in a host industry. Admission is through a combined all-IIT MBA entrance test and Personal Interview/Group discussion.

Specialisation offered in MBA includes sectorial areas of Service infrastructure and Manufacturing and Functional areas of Operations and Systems.

COURSE DESCRIPTION

UNDERGRADUATE OPEN ELECTIVES

IME 301 **COST AND FINANCIAL ACCOUNTING**
L-T-P-D-[C]
3-0-0-0-[4]

Uses of Accounting, Principles and conventions of Financial Accounting, Balance Sheet concepts, Profit and Loss Accounts, Accounting Records, Preparation of Financial Statements, Cost Classification, Allocation and Absorption of Cost, Historical and Standard Costing Systems, Use of Relevant Costs in Decision Making.

IME 401 **DESIGN OF PRODUCTION SYSTEMS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Product Design and Development, Capacity Planning and Forecasting, Plant/ Facility Location, Plant Layout and Materials Handling, Job Decision and Work Measurement, Project Management.

IME 402 **OPERATION AND CONTROL OF PRODUCTION SYSTEMS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[3]

Production Planning and Scheduling, Materials Requirement Planning, Inventory Control Models, Quality Management.

IME 403 **QUANTITATIVE DECISION MODELS**
L-T-P-D-[C]
3-0-0-0-[4]

Decision making, goals and objectives, Decisions under certainty, risk and uncertainty, Linear programmes, Sensitivity analysis, Duality, Transportation assignment, Dynamic programming, Shortest path, Max-flow and minimum cost models, Unconstrained optimization, Constrained optimization.

IME 404 **COMPUTER METHODS FOR ENGINEERING MANAGEMENT, 3-0-0-4**
Prereq. Esc 01 or equv.
L-T-P-D-[C]
3-0-0-0-[4]

Information Systems; MIS, DSS, Office Automation; Information Technology: Computer Networking, Expert Systems; Information Management; DBMS, Files & Systems, 4GLs; Computer Simulation: Modelling, Simulation languages, Statistical Methodologies in Simulation Experiments.

IME 412 **MANAGEMENT OF QUALITY AND RELIABILITY**
Prereq. Elementary Probability Theory
L-T-P-D-[C]
3-0-0-0-[4]

Quality Control Systems, Basic concepts in Quality and Reliability, Economics of Quality, Control Charts, Process Capability, Acceptance Sampling Plans, Recent Trends in Quality Control, Maintenance and Reliability Models in Industry, Quality Circles, Troubleshooting Quality Problems, Computer Applications.

IME 431 **MANAGING ENTREPRENEURIAL ORGANIZATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Role of Entrepreneur and Entrepreneurship in Evolution of Industrial Society, Global Experience, Case Studies of Enrepreneurs Indian and International, Unique nature of Small Enrepreneural Organizations: Environment-Organizational Relationship, Policy Issues: Indian Experience and International Comparisons, Flexibility and Innovations, Growth and Survival Strategies for Entrepreneurial Organizations, Managing Clusters and Networks of Small Organizations.

IME 511 **MARKETING MANAGEMENT**

L-T-P-D-[C]
3-0-0-0-[4]

Marketing-mix, Buyer Behaviour, Household, Industrial and Institutional Market Segmentation, Targeting and Positioning, Demand and Forecasting, Product policy, Distribution, Advertising and Promotion, Marketing Research, Consumerism and other social issues in Marketing.

IME 514 **FINANCIAL MANAGEMENT AND BUSINESS ECONOMICS**

Prereq. IME 301 or equivalent

L-T-P-D-[C]
3-0-0-0-[4]

Basic concepts in Business Economics, Economics of the market, Demand Theory, Demand Assessment, Cost Functions, Economics of Scale and their estimation, Production Functions and their uses, Market Structure and Price. The flow of Funds in a business, Cash Flow estimation, Capital Structure, Investment Analysis, Sources and Costs of funds, Feasibility Study, Cost Benefit Analysis.

IME 515 **INFORMATION AND EFFECTIVE COMMUNICATION**

Prereq. IME 404 or equv.

L-T-P-D-[C]
3-0-0-0-[4]

Communication in Organizations Informal and Formal Communication, Effectiveness of Communication with respect to Accuracy, Quality and Speed of Information Collection and Dis-semination.

IME 521 **PERSONNEL MANAGEMENT & INDUSTRIAL RELATIONS (HUMAN RESOURCE MANAGEMENT)**

L-T-P-D-[C]
3-0-0-0-[4]

Human Resource Planning, Selection & Recruitment, Motivation and Wage Structure, Performance Appraisal, Promotion Policy, Training and HRD, Trade Unions and Industrial Relations, Strikes and Lockouts, Due Processes, Public Policy and Collective Bargaining.

IME 522 **BUSINESS POLICY** **Prereq. IME 301, IME 511, IME 514 or equv.**

L-T-P-D-[C]
3-0-0-0-[4]

Management Performance, the General Management Function, Corporate Strategy, Analysis of Strengths and Weaknesses, Opportunities and Threats, Strategic choices, Organizational Processes in Strategy Implementation, Individual group and structural issues, the Control Systems, Culture, Management Style.

POST GRADUATE (M.Tech./Ph.D.) COURSES

IME 602 **PROBABILITY AND STATISTICS**

L-T-P-D-[C]
3-0-0-0-[4]

Axioms of probability, Conditional probability, Discrete and Continuous random variables, Functions of random variables, Expectations of random variables. Jointly distributed random variable. Descriptive and inferential Statistics, Estimation of Parameters, Test of Hypothesis, Analysis of Variance, Regression Analysis, Introduction to statistical Packages.

IME 603 **INTRODUCTION TO COMPUTING**

L-T-P-D-[C]
2-0-3-0-[4]

Computing Computer Organization, Data Representation, Data Structures such as Arrays, Stacks, Queues and Trees, Algorithms for Searching and Sorting, Complexity, File Processing, Structured Programming, Lab exercises on Data Structure, Algorithms and File Management using any appropriate programming language.

IME 604 **MANAGERIAL ACCOUNTING, FINANCE AND ECONOMICS**

L-T-P-D-[C]
3-0-0-0-[4]

Financial Accounting, Conventions, Balance Sheet concepts, Profit and Loss account, Accounting mechanics, Basic records, Preparing financial statements, Adjustment entries, Inventory valuation financial rations, Sources of funds, Cost of capital, Cash Flow statements, Simulation of cash flow Cost accounting, Cost classification, Allocation and Absorption of cost, Relevant costs, Allocation joint costs, Design of historical and standard costing systems, Overhead cost control, Managerial Economics concept, Demand Theory and Demand Assessment, Cost functions, Effect of plant size on cost, Production Functions and their estimation, Market Structure and Price, Capital Budgeting.

IME 605 **OPERATIONS RESEARCH FOR MANAGEMENT**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction, Mathematical Modeling, Linear programming Formulation, solution procedures, Duality, Sensitivity, Applications, Network methods Max Flow, Min cost, Shortest path, Dynamic programming Sequential decisions, Principle of optimality, Applications Integer Programming Formulation, Nonlinear Programming Applications and solution methods.

IME 611 **Financial Engineering**

L-T-P-D-[C]
3-0-0-0-[4]

Module 1 : Basic Elements of Financial Systems and Financial Management

- Fundamentals of Financial Systems and Domain Knowledge of Finacial Management

Module 2 : Mathematical Background

- **Introduction to Stochastic Calculus :** Wiener processes and Ito's lemma, Stochastic Differential Equations, Martingales and Measures
- Numerical procedures : Binomial & trinomial trees, Monte Carlo simulation; finite difference methods

Module 3 : Options and Futures Markets

- **Forward and futures contracts :** Basic definition, Differences between Forwards & Futures, Futures & Forwards on Commodities & Currencies, Valuation of Futures, Interest Rate Futures.
- **Swaps :** Currency Swaps, Interest Rate Swaps
- **Options :** Definitions, Payoff Diagrams, General Arbitrage Relationships, The Binomial Method, Applications to Hedging & Speculating, Delta Hedging, Arbitraging mispriced Options, Pricing of Stock Options on Stock Indices, Currencies, and Futures.

Module 4 : Financial Risk Management

- **Introduction :** Different types of risk ; approaches to risk management; history of bank regulation.
- **Greek letters :** Definitions and how they are used.

IME 624 **COMPUTER AIDED DECISION SYSTEMS** **Prereq. IME 605 or equv.**

L-T-P-D-[C]
2-0-0-0-[4]

System Analysis: Information System Analysis and Design, Decision Support System, Database Management Systems, Query Languages, Emerging Areas like communication network distributed systems and knowledge based systems, Simulation; Methodology Approaches Programming Considerations, Languages and Data Structures, Statistical Considerations, Validation, Simulation Languages, Applications.

IME625 **Introduction to Stochastic Processes and its Applications**

L-T-P-D-[C]
3-0-0-0-[4]

Course contents

a) Introduction to stochastic process, Random walks, Markov chains, Markov processes, poisson process
b) Application of Stochastic processes in (i) Queueing Theory, (ii) Scheduling, (iii) Manufacturing (iii) Finace, (vi) Marketing, etc.

IME 632 L-T-P-D-[C] 3-0-0-0-[4]

NETWORK FLOWS ALGORITHMS **Prereq. IME 605 or equv.**

Graph nations and computer representations; Applications to various disciplines; Worst-case complexity; Shortest paths; label setting and label correcting algorithms; Maximum Flows; augmenting path and preflow-push algorithms; Minimum cost flows; pseudopolynomial and polynomial-time algorithms; Assignments and matching; Minimum spanning trees; Convex cost flows; and Generalized flows. Emphasis on real-life applications of network flows and state of the art algorithms.

IME 633 L-T-P-D-[C] 3-0-0-0-[4]

COMBINATORIAL OPTIMIZATION **Prereq. IME 605 or equivalent**

Complexity of algorithms, Polynomial problems-shortest path, Spanning tress, Sequencing, Max flow, Matching, Linear Programming, (Khaciyan's algorithms), NP-hard problems-Knapsack, Travelling Salesman, Vertex Packing, Sequencing problems, Set-covering and other Integer programming problems, Matroid Intersec tion problem. Analysis of Heuristics. Data structure for combinatorial optimization problems.

IME 634 L-T-P-D-[C] 3-0-0-0-[4]

MANAGEMENT DECISION ANALYSIS

Multi-objective decisions, Decisions under uncertainty, Statistical Decision Trees, Applications from Quality Control and Production Control.

IME 635 L-T-P-D-[C] 3-0-0-0-[4]

METHODS IN MANAGEMENT SCIENCE **Prereq. IME 602 or eqv. and IME 605 or eqv.**

Stochastic processes, Markov Chains, Applications in queues and inventories. Scheduling methods including Complexity Theory ,Meta heuristic optimization methods – Simulated Annealing, Genetic Algorithms, Tabu Search Single and multi-criteria Decision Analysis, Analytic Hierarchy Process, Game Theory, Project Risk Analysis.

IME 641 L-T-P-D-[C] 3-0-0-0-[4]

DESIGN OF PRODUCTION SYSTEMS

Production systems : concepts and integrated view, Policy Decisions, Capacity planning, Product development, Plant location, Plant layout, Materials handling, Assembly line balancing, Work design, Methods engineering, Human Factors engineering, Project Management and Network models, Recent trends

IME 642 L-T-P-D-[C] 3-0-0-0-[4]

OPERATIONS MANAGEMENT

Overview of Manufacturing Planning and Control; Forecasting; Smoothing Methods, Time Series Analysis, Decomposition Methods. Autoregressive and Box Jenkins Models. Qualitative Models; Aggregate ProductionPlanning, Master

Production Scheduling. Capacity Planning. Demand Management. Scheduling; Performance Measures, Single Machine Models, Flow Shop and Job Shops, Dynamic Scheduling, Evaluation of Heuristics and Dispatching Rules.

IME 646 **ANALYSIS AND CONTROL OF QUALITY** **Prereq. IME 602 or equv.**

L-T-P-D-[C]
3-0-0-0-[4]

Quality Control and Production Systems, Systems Approach, Basic Concepts in Quality and Reliability, Economics of Quality, Basic Statistical Concepts, Process Capability Studies, Control Charts, Acceptance Sampling Plans, Economics of Charts and Plans, Regression Analysis, Design of Experiments, Technical Specifications and Standardization, Process and Product Reliability, Human Factors in Quality and Reliability, Related Organizational theory and recent trends in Quality Control and Reliability, Computer Applications, Vendor Development and Rating.

IME 647 **QUALITY ASSURANCE AND TAGUCHI METHODS** **Prereq. IME 602 or BSO 209 or equv.**

L-T-P-D-[C]
3-0-0-0-[4]

Quality Assurance and TQC, Basic statistical concepts, Control of Accuracy and Precision, Shewhart Control Charts for Process Control; Xbar, Range, p, np, c, and u charts, CUSUM chart, Subgroup selection, Process Capability, Process diagnosis using runs, Cause-Effect and Pareto diagrams; Acceptance Sampling plans, IS 2500, MIL-STD-105E, Continuous sampling Plans, Sequential Sampling; Effect of Inspection Errors on QA : ISO 9000/QS9000, FEMA Reliability, Review of Design of Experiments; Quality Engineering: System, Parameter and Tolerance Design, Process Optimization and Robust Product Design using Orthogonal Arrays, Taguchi Loss Functions, Manufacturing Tolerance Design. Course will include software applications and industry case studies.

IME 654 **MANAGEMENT OF RESEARCH AND DEVELOPMENT**

L-T-P-D-[C]
3-0-0-0-[4]

Types of technological change, their inter-relationships, R&D environment in India, Process of innovation, R&D as an element of corporate strategy, Technological Forecasting, Technology Assessment, Project selection and evaluation, Structure of organization for R&D in Indian firms and in Govt. research laboratories, Perception and Motivation of R&D employees, Leadership styles in R&D, Effect of Organizational climate on R&D, Creativity, Blocks to creativity, Improving creativity.

IME 656 **MANUFACTURING POLICY**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to Management and Corporate Strategy, Manufacturing policy, Capacity Planning and Facility Choice, Formulating and Implementing Manufacturing

Policies, Technology-Strategy Linkage, Evaluation of Manufacturing Strategies, Case Studies.

IME 657 **INDUSTRIAL POLICY & TECHNOLOGY MANAGEMENT**

L-T-P-D-[C]
3-0-0-0-[4]

Policy-Technology Choice : Linkage; National Technology Policies; Technology, Competition and Industrial Structure; Formulating a Technology Strategy; Technology Development and Acquisition process; Managing Technologies, Technology in Indian Industries, Technology Development Process; Strategic R&D Management and Technological Consortia; Technology Acquisition Process; Licenting and Joint Ventures, Managing Technology Spillovers; Justification of new Technology; Management Accounting and Technology; Integration of New with Old Technology; Assimilation of Technology; Intellectual property Rights and Implications for Industry Policy and Technology Management

IME 661 **DESIGN OF ORGANIZATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to organizations and evolution of organization theory, Organization structure, Organization environment and culture, values and organizations as institutions Power and politics in organizations, organization conflict and change, organizational restrictions, Learning organizations and organization effectiveness

IME 671 **MANAGING SOFTWARE PROJECTS**

L-T-P-D-[C]
3-0-0-0-[4]

This course will cover the techniques for managing software projects. It is intended to give the students both knowledge about, and practical experience in, the design and development of production quality software. The techniques taught in the class will be applied to a substantial teamproject.

Course topics will be as follows: Software Process; Software Configurat-ion Management, CMM Levels, Software Project Planning and Costing; Requirements Engineering; Software Project Design; Testing; Software Metrics; Quality, Software Project Management; Human Factor.

IME 681 **COMPUTER INTEGRATED MANUFACTURING SYSTEMS**

L-T-P-D-[C]
0-0-0-0-[0]

Fundamental of Automation in Manufacturing, Functions and Components of CIMS; Quantitative Methods; Software Technology DBMS, Expert Systems, Simulation; Classification and Coding; Group Technology; NC Machines and Part Programming; Computer-Aided Process Planning; Process Control; Automated Materials Handling: Robots, Conveyors, AGVs; Automated Quality and Inspection; Flexible Manufacturing Systems-Planning and Scheduling; Factory Areas Networking, Factory of the Future.

IME 682 **FLEXIBLE MANUFACTURING SYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Flexible Automation An Overview. Integrated Manufacturing Modelling and FMS, Flexibility Measures, Hardware Components, Control Components, System Planning and Design Problems, Aggregate Production Planning for FMS, Process Planning, Scheduling, Loading and Routing, Simulation of FMS, Communication and Networking, Economic and Technological Aspects, Management Issues.

IME 683 **INTELLIGENT MANUFACTURING SYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to and overview of Expert Systems, Introduction to Artificial Intelligence; Development of Expert Systems; Problem Presentation, Expert System Structure, Knowledge Bases and Representation, Inference Mechanism, Probability and Fuzzy Logic, User Interface, Development Cycle, Expert System Development tools, Introduction to PROLOG; Syntax and operations, Data Structures, Backtracking and Cut, Input-Output, Predicates, Logic; Classes and Expert System Approaches; Analysis, Design Planning and Object-Oriented Systems in Manufacturing; Systems in System Design; Equipment Selection, Layout Design, Materials Handling, Capacity Planning; Systems in Product Design and Development; Product Design, Feature Extraction and Recognition, Bar Codes and Coding of Components; System in Manufacturing Planning, Scheduling and Control; Group Technology, NC Part Programming, Process Planning Generative and Variant, Production Planning, Resource Scheduling, Automatic Storage and Retrieval, Robot Trajectory Planning, Inspection; Applications Exercises; Exposure to Expert System Shells and Packages, Manufacturability Evaluation, Mini Projects.

IME 697 **INDUSTRIAL PROJECT**

L-T-P-D-[C]
0-0-0-0-[4]

A 6-8 week industrial project for M Tech students during the period intervening the II and III semesters on a problem of practical relevance completed in an industrial or service organization. The student will study, analyze and then solve the problem and prepare its implementation details, under the supervision and guidance of an officer/executive of the host organization. On completion of the summer project the student will submit a written report and give a seminar to the IME Department.

IME 698 **SEMINAR, 0-0-0-0**

L-T-P-D-[C]
3-0-0-0-[4]

IME 699 **M. Tech. THESIS**

IME 799 **Ph. D. THESIS**

MASTER OF BUSINESS ADMINISTRATION PROGRAMME

MBA 601 **ACCOUNTING FOR MANAGEMENT**
L-T-P-D-[C]
3-0-0-0-[4]

Balance sheet, profit and loss concepts, accounting principles and mechanics, Inventory Valuation and Depreciation accounting, Ratio and Fund flow analysis. Introduction to cost Accounting. Various methods of cost determination and cost accounting systems such as activity based costing systems and responsibility accounting. Use of costing systems in decision making. Extensive case studies will employed in this course.

MBA 606 **ECONOMIC ANALYSIS FOR MANAGEMENT**
L-T-P-D-[C]
3-0-0-0-[4]

Basic concepts in business economics, Economics of Market, Utility theory, Determination of Price, Production Function, Theories of Competition, Theory of Supply and Demand, Micro Level Firm Behaviour, Market Structure and Price, Concept of GDP, Theories of Money Supply, theory of Macro Economics. National Income and domestic product. Keynesian theory of income determination, Monetary approach, Inflation, balance of Payments, Structure of Indian economy, Indian economic growth and development.

MBA 607 **FINANCIAL MANAGEMENT**
L-T-P-D-[C]
3-0-0-0-[4]

Fund and Cost Flow Analysis, Working capital management, Determination of capital structure of the firm, Cost of Capital, Capital asset pricing models, Leverages, Investment Analysis, Portfolio Management, Debt Management, Dividend Policy, Concept of Financial Strategy, Course will be based on case study and journal articles.

MBA 608 **MEASURING AND DRIVING CORPORATE PERFORMANCE**
L-T-P-D-[C]
3-0-0-0-[4]

This course is relevant to all managers and consultants. It focuses on developing expertise in designing the means of measuring corporate performance, identifying the scope for improvement, and in evolving managerial action to achieve improvement. A number of accounting concepts and techniques, covered in the foundation course, are basic skills required for this course. Another premise of this course is that organizations have different strategies, and different control systems are required to implement their strategies and achieve superior performance.

The course is organized in three modules. The first module deals with techniques to measure and enhance profitability and quality of products and services. Tools such as Activity Based Management, Target and Kaizen costing, Flexible Budgeting, and Activity-based Budgeting are key topics in this module. The

2nd module deals with the setting of performance goals and incentives, and the use of diagnostic tools and control systems to achieve the goals. Strategic Profitability Analysis, Economic Value Added (EVA), and Balanced Scorecard are some of the tools used in this module. A third module introduces the student to the Information Systems aspects of management control. It deals with the control-needs of Information flow, and its consolidation in multi-locational setting.

MBA 609 **FINANCIAL INTERMEDIARIES, FINANCIAL INSTITUTIONS AND REGULATORS**

L-T-P-D-[C]
3-0-0-0-[4]

This course is about financial systems, players, and their methods. It is meant for all those who have anything to do with finance or corporate strategy. It is descriptive at core, peppered with analytical parts. The analytical parts will help students to participate with numbers and decisions in the context of the financial system. This will be done through small problem-exercise/case-discussion/term paper.

The course first explores the Intermediaries in the share market – brokers, depositories, underwriters, registrars, and the market itself. For each, we analyse their Role, functions and dysfunctions, the economics of their operation, structure of their markets, and their regulation. Another part of this module deals with intermediaries that help in buying goods and services viz., Leasing, Hire purchase, and Consumer finance enterprises. Economics of their operations in India, and their long-term strategy are key analytical aspects in this module.

In its 2nd module, the course will look at Financial Institutions – all India Development Finance institutions (FI's), state level institutions, and Foreign Financial institutions (FFI's). Analytical focus will be on Project Appraisal, broad portfolios, and new financial products. In the Banking part of this module, the course will deal with – retail banking, merchant banking, and investment banking. Banking instruments, cash management in banks, investment planning and strategy will be the analytical focus. Finally, the course will deal with the regulation of the financial sector, viz., the operation of RBI and SEBI.

MBA 610 **INVESTMENT VALUATION AND REAL OPTIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Investment Valuation Estimating Cost of Equity and Cost of Capital, Option Pricing Theory, Option Pricing Applications in Valuation Real Options in Managerial Decision Making Binomial Tree Method for Valuing Real Options, Option to Delay, Option to Expand Option to Abandon, Valuing Natural Resoures Using Real Options, Appraising Projects with Real Options.

MBA 611 **ORGANIZATION STRUCTURE AND DESIGN**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to Organizations, Organization Goals, Organizations and Markets, Organization Structures and Systems, Strategy, Structure & Technology, Organization Environment and Culture, Various Design Options, Power and Politics, Organization Conflict, Change and Restructuring, Growth and Evolution, Learning Organizations and organization Effectiveness, Service Organizations, Organizations as Networks.

State of-art research papers and case studies will be used for the selected topics.

MBA 612 **MANAGING CHANGE IN ORGANIZATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Problematising organizations: Stakeholders; environment, structures, cultures and organizations; recalcitrant instruments – linear and nonlinear changes, Systems Perspective of change, Frameworks for conceptualizing change and organizational change – people, process, technology issues, Restructuring of PSUs, Creative destruction, Information technology and organization change.

Total quality management and organization change, Reengineering and restructuring, Self-regulating, organization – Integrating evolutionary and revolutionary changes, Challenges of continuous change.

MBA 613 **ORGANIZING FOR SERVICES**

L-T-P-D-[C]
3-0-0-0-[4]

The context of service organizations- organizing for customer participation. Organization structure and the open system design. Structuring high performance service businesses. Impact of technology on service business functions. New interfaces and boundary spanning roles. Organizing and leading shared services and BPO projects. Organizing for strategic flexibility in service organizations. Management of conflict and crativity. Behavior models in services. Developing deductive, combinative and rapid replication capabilities in the service business. cultural dimensions in service business.

MBA 616 **HUMAN RESOURCES MANAGEMENT**

L-T-P-D-[C]
3-0-0-0-[4]

Meaning of Work and Humans as Resource, Human Resource Planning and Selection, Motivation and Compensation Management, Performance Appraisal, Career Management, Training and HRD, Group Dynamics and Leadership, Trade Unions and Industrial Disputes, Public Policy and Collective Bargaining, Due Process, Empowerment and Participation, Technology & HRM, Japanese HRM.

MBA 617 **SOCIAL POLITICAL AND LEGAL ENVIRONMENT OF BUSINESS**

L-T-P-D-[C]
3-0-0-0-[4]

Industrial revolution and industrialization, Political economy of underdevelopment, Sociology of development, Indian rural and urban society, Influence of religion and karma, Multiplicity of languages, cultures, castes, Feudalism, Work ethic, Constitution of India, Party system, Fundamental rights, Local self government, Directive principles of state policy, Welfare state and Civil society, Social stratification, Environmental issues and legislation, and social movements, Corporate social responsibility and business ethics, Judicial system, Business law, Contract act, Arbitration, Companies Act, Sale of goods act, partnership act, negotiable instruments act, Income tax Act, Environmental legislation.

MBA 618 **GLOBALISATION STATE & CORPORATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

'Globalisation' perhaps is one of the most debated and contested concept of the contemporary times. As we are living in an era of unprecedented economic political and social interconnections there is a need to re-examine our assumptions about social and econmic organization. The purpose of the course is to study the concept of globalisation and develop a multi-faceted understanding of it. The course will focus on the role of corporations as drives of the contemporary wave of globalisation. It would also examine the changing role of State, especially in the framework of state - corporation relations, both in the context of the developed economies as well as the third world. Further it would attempt to situate the significance of global institutions like the IMF and the WTO in the Corporation vs. State debate on the one hand and the tension between the interests of the developed countries and the third world on the other. The course proposes to develop a historical understanding of the present wave of globalisation by delving in to the evolution of capitalism from its early mercantilist phase, to the industrial phase and finallly to its present finance capitalism phase. It will also discuss the contradictions of globalisation - prosperity vs. poverty growth vs. underdevelopment and the underlying reasons for the same. Finally the course will endeavour to evaluate some alternate forms of globalisation which have the possibility of going beyond the problems of the current form of globalisation. The course proposes to adopt a multi disciplinary approach in developing an understadnding of the dominant theories and concepts. The classroom discussions will be based primarily on appropriate case studies of various countries and corporations.

MBA 621 **MANAGERIAL COMMUNICATION**

L-T-P-D-[C]
3-0-0-0-[4]

the Manager, Interpersonal Communication, Ongoing Communication Process and flow, Organizational Managerial Communication, Personal Language, use and Communication System, The Media and Tools of Communication Climate, Low Structure: One to One Communication, High Structure: One to One Communication, Meetings and Conferences, Interactional Presentation, Keys to Functional Writings, Formats for Business letters and Memos, Exposure to e-Communication, Planning and Producing Effective Business Reports, Business and Managerial Communication Research. There will be atleast one case/exercise in each class.

MBA 622 **MANUFACTURING STRATEGY**

L-T-P-D-[C]
3-0-0-0-[4]

Product and factory life cycle, strategic dimensions of technology, characteristics of job shops and flow shops, learning curve effects, economies of scale, resolution of conflicts between manufacturing and marketing, concept of PWP, design of organization structure of manufacturing divisions, interactions of design department with manufacturing, marketing, service and purchasing. Concept of aligning of manufacturing and the corporate strategy.

MBA 623 **STRATEGIC MANAGEMENT**

L-T-P-D-[C]
3-0-0-0-[4]

General Management Function, Introduction to the corporate strategy, concept of organizational purpose, environmental scanning and formulation of objectives, strategy for growth such as concentric growth and diversification, role of values in strategy formulation and evaluation, managing diversity and growth, choice of organizational structure and designing control systems to support the implementation of the strategy. Role of implementation issues in strategy formulation. Impact of organizational culture, structure, systems in strategy implementation and Merger and Acquisitions.

MBA 624 **Corporate Innovation & Entrepreneurship:**

L-T-P-D-[C]
3-0-0-0-[4]

In the first module this course will take an applied approach to learn the imperatives of lateral thinking and accelerated innovation in large organizations under relentless pressure of discontinuity. It will explore integrative framework for individuals, virtual teams, using CPC and other rapid development/deployment IT tools for accelerating targeted innovation and new product concept to market processes.

In the second module this course will develop from theories of entrepreneurship an applied approach for managing disruptive innovation to create new high growth businesses. The crafting approach to finance, operations and other entrepreneurial strategies, real time monitoring and adaptive control systems for small businesses and the role of clusters, community of practitioners for strategic flexibility will be some of the emerging paradigms covered in this course.

MBA 626 **MANAGEMENT OF TECHNOLOGY**

L-T-P-D-[C]
3-0-0-0-[4]

Policy – Technology Choice: Linkage; National Technology Policies; Technology, Competition and Industrial Structure; formulating the technology strategy, Technology Development and Acquisition process; Managing Technologies, Technology in Indian Industries, Strategic R&D management and Technological Consortia; Licensing and joint Ventures, Managing Technology Spillovers;

Justification of new technology; management accounting and technology; Integration of New with Old technology, Assimilation of Technology; Intellectual Property Rights and their Implications for Industry Policy and Technology Management.

MBA 627 **MANAGING HIGH TECHNOLOGY, 3-0-0-4.**

L-T-P-D-[C]
3-0-0-0-[4]

Many competitive strategy models, no longer works in high technology firms. Continuous innovation is the only way to survive in global, convergent, highly volatile industries in Telecom, Pharma, Life science, Biotechnology, Semiconductor and Consumer electronics domains.

This course will take a close look at strategy, practices in high technology firm who depend on the mastery of the dynamic tension between stability and change, efficient use of core technologies and effective exploration of "pacing" to "break through" changes simultaneously. This elective course will also explore new software tools for managing policy dynamics and multi option strategies.

— The high technology – strategy interface, IP audit and the strategy of renewable, incremental and radical innovation.

— Strategic technology maps, technology platforms and option architecture.

— The challenge of high technology convergence and diffusion, network economics and connected corporations.

— The paradox of formal systems and flexible strategies.

— Global high technology products and services – proactive IP management strategies in global organizations.

— Forecasting and real time integration of Enterprise Systems.

— Organizing for perennial renaissance–Hard, soft and creative paradigms in High technology management.

MBA 628 **INTERNATIONAL BUSINESS MANAGEMENT**

L-T-P-D-[C]
3-0-0-0-[4]

This course is relevant to all executives who plan or operationalise business strategies across multiple countries -–for international marketing, international sourcing, or international ownership. It focuses on learning about the global business environment, strategic opportunities and competeness for internationalising, design and marketing of appropriate products and services, and key aspects in operationalising the strategy – through organization structure, human resource, international coordination and leadership.

While working towards these learning objectives, the course will maintain a close proximity to some themes of particular interest. We shall invite frequent attention to businesses that originate or operate in India/Asia. We will also be conscious of Governance relationships of investors from developed countries that affect their businesses in less developed ones. Cultural patterns as well as the Regulatory environment in different countries will be a recurrent theme in our discussions. And, we shall be conscious of how organizations may, through business "without borders", stretch their capacities, and develop new competences and relationships.

Much of the course will be through Case-discussions. Country and product based presentations will also be utilised for building specific understanding.

MBA 629 **MANAGEMENT IN A GLOBAL ECONOMY : AN INDIAN PERPECTIVE :**

L-T-P-D-[C]
3-0-0-0-[4]

The purpose of this course is to acquaint students with the current global market trends, issues of global governance and emarging debates about new technologies and corporate ethics. The expectation is to add value in the making of students worldviews on economy and society and provide a conceptual framework for the managerial tasks of diagnosing predicting and responding to changes in the world economy.

MBA 630 **ECONOMICS OF BUSINESS POLICY :**

L-T-P-D-[C]
3-0-0-0-[4]

Intermationally, a lot of intergration is taking place between economic theory, particularly industrial organization theory and management sterategy theory. On the one hand, industrial organization theorists are trying to draw on real life management practices to develop never and more relavent theories. On the other hand, management strategy theorists are coming to depend on industrial organization theory to provide a general framework for organizing the otherwise incoherent mass of facts available to them.

In this context, Economics of Business Policy seeks to provide management students an introduction to the interface between industrial organization theory and strategic management theory. It uses the business- related tenents of economics (old and new) to develop a coherent analytical basis for the formulation and evaluation of the external and internal strategies of the firm. This is true with respect to both a firm's external market environment and its internal organization. The course emphasizes practical managerial applications of topics from industrial economics and strategy: economics of scale and scope, industry analysis market structure commitment dynamic competition entry/exit the econmics of competitive advantage incentives in firms internal labour markets and executive remuneration.

MBA 631 **MARKETING MANAGEMENT**

L-T-P-D-[C]
3-0-0-0-[4]

Marketing Environment, Company analysis (strength, weaknesses, opportunities and threats), the concept of marketing mix., four P's of marketing, and the concept of marketing strategy. The concept of market segmentation and differentiation, product positioning and its applications in demand forecasting. Consumer Behaviour and Marketing Research. International marketing. Marketing economy and public policy issues. E-marketing. In this course concepts will elaborated by the use of cases and research papers.

MBA 632 **E-MARKETING**
L-T-P-D-[C]
3-0-0-0-[4]

Marketing Fundamentals (environment, competition, consumer behaviour segmentation, Targeting, and positioning, 4P's – product, price, promotion, place), Marketing strategy, Digital marketing Opportunities, E-Paradigm, Internet Networking, Enterprise Middleware, Right Enterprise Applications, operational challenges – web sales and marketing, web services, ASP and other financial choices, Real-time Analytic, Frontline Access, Miscellaneous Emerging opportunities.

MBA 633 **MARKETING RESEARCH, 3-0-0-4**
L-T-P-D-[C]
3-0-0-0-[4]

Nature and scope of Marketing research: (a) the Marketing Research Process, (B) Research design and Implementation, Data collection : (a) Secondary Sources of Marketing Data, (b) Standardized Sources, (c) Information Collection: Qualitative and Observational Methods, (d) Information from Respondents, (e) Attitude Measurement, (f) Experimentation, (g) Sampling fundamentals, Data Analysis: (a) Hypothesis Testing: Basic concepts and tests of Associations, (b) Correlation Regression Analysis, (c) Discriminant and Canonical Analysis, (d) Factor and Cluster Analysis, (e) Multidimensional Scaling and Conjoint Analysis, (f) Presenting the results.

MBA 634 **CONSUMER BEHAVIOUR, 3-0-0-4**
L-T-P-D-[C]
3-0-0-0-[4]

Consumers in the Market place: (a) An introduction to Consumer Behaviour, Consumers as individuals: (a) Perception, (b) Learning and Memory, (c) Motivation, Values and Involvement, (d) Attitudes, (e) Attitude change and Persuasive Communication, (f) Self, Consumers as decision Markers: (a) Individual decision Making, (b) The Purchase Situation, Postpurchase Evaluation and Product Disposal, (c) Group Influence, Opinion Leadership, (d) Organizational and Household Decision Making, Consumers and Sub Cultures: (a) Income and Social Class, (b) Ethic, Ratial and Religious Subcultures,

Consumers and Cultures: (a) Cultural Influences on Consumer Behaviour, (b) Lifestyles and Global Culture, (c) Sacred and Profane Consumption.

MBA 635 **MARKETING OF SERVICE, 3-0-0-4.**
L-T-P-D-[C]
3-0-0-0-[4]

Service businesses today are global from inception yet needs intricate localization. Managing 'on line' 'on demand' multiplicity makes marketing of services challenging. Service marketing is a thriving area of academic pursuit and excellent textual as well as research findings will support this course.

Strategic Marketing of Services

— Segmentation and Targeting of Service

— Positioning

Service Marketing as "Process"

— Service Product

— Service Delivery

— Servicescapes

Some Cases:

Four customers in search of solution (Segmentation)

— Vertical Net (e-Business Strategy

MBA 636 **ADVERTISING AND MARKETING STRATEGY**

L-T-P-D-[C]

3-0-0-0-[4]

This course is an advanced marketing elective that focuses on the job of the product/brand manager. There are two modules in the course. The first module is on advertising and the second on strategic issues of market planning. The first module is designed to examine agency as business, the fundamentals of advertising theory and the evaluation of different kinds of advertising. The second module will stress on (1) the development and implementation of marketing strategies with focus on issues like organizational capabilities, resource base, market structure, and competitive behaviour (2) branding strategy with emphasis on product positioning.

MBA 637 **BUSINESS TO BUSINESS MARKETING**

L-T-P-D-[C]

3-0-0-0-[4]

Business to Business Marketing encompasses those management activities that enable a supplier firm to understand, create, and deliver value to other businesses, governments, and/or institutional customers. Business to business marketing is also referred to as business market management an industrial marketing. In year past, the topical area applied largely to industrial manufacturing firms. Today, business to business marketing provides practical frameworks, concepts, and tools for organizations as diverse as management consulting firms, investment banks, software solutions providers, and integrated supply management operations, among many other leading-edge technology and service companies.

As business to business marketing expands its scope and stature, this course aims at reinvigorating training in marketing beyond the tired old, “4P’s plus industrial examples” format. This course will emphasize the interrelatedness of concepts such as multifunctional teams, strategic alliance environmental sensitivity, inter-organizational trust, organizational learning and adherence to ethical principles. Furthermore, with the advent of relationship and network theories, this course emphasises that business marketer must learn not only to create value, but also to equitably share value with customer firms. Understanding of business buying and marketing behaviour within the context of relationship/network theories is the central learning from this proposed elective.

Given this background, the overall objectives of this course are to create an understanding of the current state-of-art of organizational buying behaviour and business-to-business marketing.

MBA 638 **DECISION MODELS FOR MARKETING :**

L-T-P-D-[C]
3-0-0-0-[4]

This is course where engineering techniques such as modeling and optimization are applied to the area of marketing. Various scenarious in marketing such as shelf space allocation problem viewer ship maximizing problem contract design (between producers and customers) for perishable products (such as movies) and many others.

MBA 641 **COMPUTING FOR MANAGEMENT**

L-T-P-D-[C]
3-0-0-0-[4]

Computers and Management Function, Introduction to an appropriate high level language, Introduction to Data Structures, Computer Organization, System Configuration, Introduction to data base management, management information systems, decision support systems and simulation.

MBA 642 **DATABASE MANAGEMENT**

L-T-P-D-[C]
3-0-0-0-[4]

Decision Process and Database Management, Evolution of Databases, Schemas and subschemas, global view of data, datastructures, file organization, criteria for database design, canonical databases, normal forms, relational data model, relational algebra and calculus, query languages, query optimization, SQL, security, integrity and protection, recovery methods, Role of database administrator, concurrent operations, distributed databases, industrial applications.

MBA 643 **SIMULATION OF BUSINESS SYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Simulation Philosophy and Methodologies, Review of Basic Probability and Statistics, Random number Generation, Programming Considerations, Languages and Data Structures, Verification and Validation, Simulation Languages, Animation, Design and Execution of Simulation Experiments, Applications: Case Flow and Risk Analysis by Simulation Using Spreadsheets, Simulation of Production System – Inventories, Queues and Production Scheduling.

MBA 644 **KNOWLEDGE STRATEGIES & KNOWLEDGE SYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Successful knowledge management requires strategic management of information system and organizational culture. Hence this course will focus on process as well as technology systems for anticipation, creation and use of knowledge as a strategic resource for competitive advantage. Harnessing tacit knowledge using the SECI and other models deal with people issues of learning, sharing and integrating knowledge. Strategies for managing explicit knowledge deal with technologies and systems for storage, retrieval, recombination and analytics of modules in a global organization. Students will design Knowledge Management Systems for functional applications in different industry domains using various tools like document management, content management, search and pattern analysis, groupware, BI & EIP.

MBA 645 **MANAGEMENT INFORMATION SYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Foundation Concepts: Basic information systems concepts about the components and the operations, managerial, and strategic roles of information systems; Technology: Major concepts, developments, and managerial implications involved in computer hardware, software, telecommunications and database management: technologies; Applications How the Internet, intranets, extranets and other information technologies are used in modern information systems to support electronic commerce, enterprise collaboration, business operations, managerial decision making, and strategic advantage; Development Developing information system solutions to business problems using a systems approach to problem solving and variety of business application development methodologies; Management The challenges of managing information systems technologies, resources, and strategies, including global IT management, strategic IS planning and implementation, and security and ethical challenges.

MBA 646 **ENTERPRISE INTEGRATION WITH INFORMATION TECHNOLOGY**

Prereq. MBA 645 or #

L-T-P-D-[C]
3-0-0-0-[4]

Need for integration, Evolution of ERP, Components of ERP, Enterprise evaluation, Business process mapping, Business Process Re-engineering ,Understanding and evaluating ERP packages, Technology evaluation, Networking issues, ERP implementation, Human resource issues and change management, SAP system, Project on SAP system, Case studies

MBA 651 **QUANTITATIVE METHODS FOR DECISION MAKING**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction to decision analysis and process. Elementary probability theory, conditional probability, Bayesian decision analysis, EVPI, moment generating functions, the central limit theorem, Descriptive and deductive statistics, Hypothesis testing and Regression

MBA 661 **PRODUCTION AND OPERATIONS MANAGEMENT**
L-T-P-D-[C]
3-0-0-0-[4]

Concepts, Context and Decision Process in Production System; Manufacturing and Service Systems; Policy Decisions; Product Decisions; Process Decisions; Forecasting Methods, Product Design and Process Selection in Manufacturing and Service; Value Analysis; Facilities Location and Layout, Capacity Planning; Job Design and Work Measurement, Learning Curves, Production Planning Models– Lot Sizing and Aggregate Planning; Line Balancing; Inventory Systems – Costs, EOQ, Continuous and Periodic Review Models, Stochastic Models and Safety Stock; Inventory Systems for Dependent Demands – Material Requirements Planning; Operations Scheduling; Quality Control; Integration – JIT and Kanban Systems.

MBA 663 **TOTAL QUALITY MANAGEMENT**
L-T-P-D-[C]
3-0-0-0-[0]

Total Quality Management, quality management Philosophies, Leadership, Employee involvement and customer Value Evaluation, Kaizin, Problem Solving and Quality Management, problem solving Fundamentals, Problem Identification, Definition, Diagnosis, Alternative Generation and Evaluation, Elementry concepts related to 7 Old and 7 New Tools for quality Assurance, Basic Statistical Concepts, Control of Accuracy and Precision, Process Capability, SPC, Acceptance Sampling, MIL-STD-105D. Quality Management Systems, ISO 9000, Quality Engineering, Quality Function Development, Introduction to Design of Experiments, Process Optimization and Robust Product Design, Steps to Six Sigma, Management of Service Quality, Management of Software Quality, Course will include projects and industry case studies.

MBA 664 **SUPPLY CHAIN MANAGEMENT**
L-T-P-D-[C]
3-0-0-0-[0]

Strategic Framework for Supply Chain, Materials Management Functions, Forecasting and market Analysis, Purchasing and Procurement, Physical Supply, Managing Inventories, MRP and Capacity Planning, Inventory Valuation, Logistical Management – Materials Handling, Warehousing/Storage and Retrieval, Transportation and Distribution, IT and Role of E-Business, Financial Evaluation.

MBA 665 L-T-P-D-[C] 3-0-0-0-[4]

MANUFACTURING PLANNING AND CONTROL

Framework of Manufacturing Planning, Forecasting Models, Hierarchical Planning System, Facility Location and Layout, Resource Scheduling, Flexible Manufacturing-analysis, design and Planning, Just-in-Time Manufacturing, Simulation and Performance Evaluation, Lean and Agile Manufacturing.

MBA 666 L-T-P-D-[C] 3-0-0-0-[4]

PROJECT MANAGEMENT

Characteristics of Projects, Project Economics, Screening and Selection, Evaluation, Structuring – Organizational and Work Breakdown, Scheduling, Budgeting, Resource Management, Life-Cycle Costing, Project Control, R&D Projects, Computer Supports, Project Termination.

MBA 671 L-T-P-D-[C] 3-0-0-0-[4]

MANAGING SERVICE OPERATIONS

Service as Product, Design of Service Systems, Location and Layout of Service Facilities, Service Engineering including Work Design, Human Factors, Automation and Communication, Productivity and Service Effectiveness, Network Planning including Queuing Networks, Manpower and Resource Scheduling and Distribution Planning. Professional Service: Achieving differentiation through knowledge and relationship, Service and Competitive Strategy; Service delivery systems and IT applications; IT enabled services and Technology Convergence; Managing for World Class; Service Quality and Service Level best practices for call centers and related services, Cross Cultural issues; Pricing and Transfer Pricing of Connected Services, Project Implementation, Learning, Innovation and Knowledge Management in the Service based business.

MBA 672 L-T-P-D-[C] 3-0-0-0-[4]

ADVANCED MANUFACTURING SYSTEMS

Manufacturing System – Decisions and Functions, Product Development – Conceptual Design, Automation and Integration, CIMS Technology, Concurrent Engineering, Process Engineering and CAPP, Numerical and Computer Control, Robotic Systems and AGV, Group Technology and Cellular Manufacturing, Information Systems and Factory Area Networks, World Class Manufacturing.

In the second module this course will develop from theories of entrepreneurship an applied approach for managing disruptive innovation to create new high growth businesses. The crafting approach to finance, operations and other entrepreneurial strategies, real time monitoring and adaptive control systems for small businesses and the role of clusters, community of practitioners for strategic flexibility will be some of the emerging paradigms covered in this course.

MBA 675 **INFRASTRUCTURE REGULATION, POLICY AND FINANCE**

L-T-P-D-[C]
3-0-0-0-[0]

Role of Infrastructure in Economic Development, Natural Monopoly and Economics of Infrastructure Regulation, Rate of Return Regulation, Performance Based Regulation, Pricing for Infrastructure Sector, Role of Subsidies, Reforms in the Infrastructure Sector (Power, Telecom, Roads, Ports, Urban Services) Restructuring and Privatisation in Infrastructure Sector, Reform Acts, Competition in Infrastructure Sector (Bulk Power, Telecom, Transportation), Issues in Infrastructure Finance, Modes of Project Financing, Risks in Infrastructure Sector, Development of Infrastructure Projects --BOO, BOOT, BOLT etc.

MBA 676 **SECURITY ANALYSIS, DERIVATIVES AND PORTFOLIO MANAGEMENT**

L-T-P-D-[C]
3-0-0-0-[0]

Financial Markets, Investment Alternatives, Risk and Return, Portfolio Theory and Capital Asset Pricing, Capital Asset Pricing Theory and Arbitrate Pricing Theory, Efficient Market Hypothesis, Security Analysis and Valuation, Valuation of equity and Fixed-income securities, Fundamental Analysis, Technical Analysis, Investment Strategies, Derivatives, Options, Futures, Swaps, Black-Scholes model, Value at risk, Estimating volatility and correlations, Hedging and Portfolio Management.

MBA 677 **PROJECT FINANCING AND MANAGEMENT**

L-T-P-D-[C]
3-0-0-0-[0]

Generation and Screening of Project Ideas, Project Appraisal and Evaluation, Financial Projections, Investment Criteria, Cost Benefit Analysis, Project Finance, Financing Infrastructure Projects, Sources of Finance, Multilateral Project Financing, Consortium Financing, Venture Capital, Risk Analysis, Project Life Cycle, Techniques for Project Management.

MBA 678 **MANAGEMENT OF RISK IN FINANCIAL SYSTEM**

L-T-P-D-[C]
3-0-0-0-[0]

Concept of Risk and Risk Management., Different types of Risks like Systematic Risk, Interest Rate Risk, Liquidity Risk, Operational Risk, Regulatory Risk, Market Risk, Foreign Exchange Risk, Commodity Price Risk, Industry Concentration Risk, Environmental Risk, Counter party Risk, Credit Risk, Legal Risk, Regulatory Risk etc. Methods of identifying and measuring different types of risks. Use of Risk Models. Methods of Risk control and Management, i.e., requirement of active Risk Management techniques through use of VaR model; monitoring of ALM (Asset Liability Management); use of derivatives like currency swaps, interest rate futures, forward rate agreements etc.

MBA 697 **SUMMER PROJECT**

L-T-P-D-[C]
3-0-0-0-[0]

During the summer after first two semesters, each student will take up a summer project in an industrial or service organization for 8-10 weeks. During this period, the student will work under the guidance of an executive of the host organization, complete the assignment, prepare a written report, and make a presentation during the third semester.

MBA 698 **SEMINAR**

L-T-P-D-[C]
3-0-0-0-[0]

MBA 699 **SPECIAL STUDIES / PROJECT**

L-T-P-D-[C]
3-0-0-0-[0]

In this course, each student will take up a management project or management topic under the guidance of a specific faculty. Towards the end of the semester, the student will present a final report of the project.

LASER TECHNOLOGY PROGRAMME

PROFESSORS

Budhani R C	rcb	7185	
Das U (Head)	utpal	7150	
Ghosh AK	anjn	7105	
John J	jjohn	7088	
Kamle S	kamle	7689	
Muralidhar K	kmurli	7182	7928
Panigrahi P K	panig	7686	
Thareja RK	thareja	7143	7989

ASSOCIATE PROFESSORS

Goswami D	dgoswami	7101	
Mishra D P	mishra	7125	
Pradhan A	asima	7691	7971
Singh YN	ynsingh	7944	

ASSISTANT PROFESSORS

Wanare H	hwanare	7885

CHIEF SCIENTIFIC OFFICERS

Bansi Lal	bansi	7930

Convenor, DUGC : Mishra D P mishra 7125

Convenor, DPGC : Goswami D goswami 7101

Faculty Counsellor:

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The Laser Technology Programme (LTP) at IIT Kanpur started in July 1988 with the aim and objective of training young Engineering and Science graduates for providing skilled manpower in a very specialised field - lasers and cognated areas. An M Tech (LT) degree is awarded by the Institute to successful candidates. It is a unique interdisciplinary programme which draws faculty from the departments of Aerospace Engineering, Chemistry, Electrical Engineering, Mechanical Engineering, Metallurgical Engineering and Physics, to teach various core courses and guide/supervise M Tech theses. In addition to the usual classroom teaching, emphasis is on hands-on experience on lasers. The compulsory courses on Laser Technology laboratory techniques facilitate the process. Depending on the problem chosen, students carry out their M Tech projects in the laboratories of the Centre for Laser Technology (CELT) or in those of the departments stated above. Students of suitable background generally coming from Physics, Chemistry, Electrical Engg., Electronics Engg., Mechanical Engg, are accepted into the program.

STRUCTURE OF THE (M.TECH.) PROGRAMME

Semester I	Semester II	Semester III	Semester IV
LT 601	**LT 611**	**LT 699**	**LT 699**
LT 631	**LT 680**		
OE*	**OE***		
OE**	**LT 699**		

LT 601 Introduction to Lasers
LT 631 Introduction to Coherent and Laser Optics
LT 680 Laser Technology Lab Techniques
LT 699 M. Tech. Thesis

** One Electronics Course
* One Elective Course
LT 611 Laser Systems and Applications

COURSE DESCRIPTION

LT 601 **INTRODUCTION TO LASERS, 3-0-0-4**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction to general lasers and their types, Brief intro. quantum physics, Schrodinger wave eqn., Atomic systems, emission and absorption processes, Population inversion, gain, optical cavities, three- and four- level lasers, CW and pulsed lasers, Q-switching and mode-locking, Physics of gas discharge, Atomic, Ionic, molecular, liquid, and excimer lasers, Optical pumping.

LT 608 **ELECTRONICS, 3-0-1-5**
L-T-P-D-[C]
3-0-1-0-[5]

Rectification, Amplification, Oscillation, Pulse generation, Elements of Analog and Digital circuitry, Power and Control electronics.

LT 611 **LASER SYSTEMS AND APPLICATIONS, 3-0-0-4**
L-T-P-D-[C]
3-0-0-0-[4]

Atomic, ionic, molecular, excimer and liquid laser systems and applications, Solid state lasers. Short Pulse generation and measurement. Laser applications in medicine and surgery, Materials processing, Optical Communication Lasers, Metrology and LIDAR.

LT 631 **INTRODUCTION TO COHERENT AND LASER OPTICS**
L-T-P-D-[C]
3-0-0-0-[4]

Maxwell eqns. and electro magnetic waves, Wave properties of light and propagation. Waveguides, Optical resonators. Ray Optics, Matrix methods, Optical Anisotropic materials. Interference and interferometers, Diffraction and Fourier Optics, Optical components (Laser mirrors, windows, Polarizors, Holography, Meteorology.

LT 635 **FOURIER OPTICS AND OPTICAL INFORMATION PROCESSING**
L-T-P-D-[C]
3-0-0-0-[4]

Practical examples of Diffraction theory, Coherence theory, Geometrical optics, Fourier transforming properties of lenses, Fast Fourier transforms, Holography (optical, acoustic, microwave), Elements of digital signal processing and pattern recognition.

LT 651 **LASER-INDUCED PROCESSES IN SPECTROSCOPY**
L-T-P-D-[C]
3-0-0-0-[4]

Laser-induced fluorescence, Laser photochemistry, Nano-, pico-, femto second spectroscopy, Photoacoustic & photogalvonic spectroscopy, Resonance Raman and stimulated scattering; Scattering from dense fluids, Amorphous materials, Semiconductor and single crystal spectroscopy, Applications in biology, Medical science, Atmospherics.

LT 661 — **LASERS IN INDUSTRY**

L-T-P-D-[C]
3-0-0-0-[4]

Primary production role of lasers. Laser - materials interaction. Safety, Machining & Welding mechanisms, Heat flow theory. Num. and robot control cutting. Machining with CO_2 & YAG lasers, Laser Materials processing. Surface treatment, finish, etc. Arc-augmented laser, Processes Characterization of single and multiphase metals

LT 671 — **SEMICONDUCTOR LASERS**

L-T-P-D-[C]
3-0-0-0-[4]

Review of Semiconductor properties; Review of Electromagnetic properties; Basic principle of laser action, Fabrication of lasers; Modulation of lasers; Quantum Well and Quantum Dot Lasers. Passive mode Locking of Semiconductor Lasers.

LT 680 — **LASER TECHNOLOGY LABORATORY TECHNIQUES** **Prereq. LT 601, LT 631**

L-T-P-D-[C]
3-0-0-0-[4]

Accuracy and precision in measurements, Virtual Instrumentation, Optical aperture and filter measurements, Beam profile and parametric study of different lasers and LEDs, Temporal fluorescence measurement, Spectral measurements of bio-molecules and tissues, Optical fiber transmitter and receiver measurements, Interference measurements of coherence length and convective flow patterns, Laser material processing.

MATERIALS & METALLURGICAL ENGINEERING

PROFESSORS

Balasubramaniam R	bala	7089	
Bhargava S (On leave)	bhargv	7427	
Brahma Deo	bdeo	7256	
Dube RK	rkd	7769	
Gupta SP	shantpg	7648	
Koria SC	satishch	7940	
Mazumdar D	dipak	7328	
Mehrotra SP (On leave)	spm	7161	
Mishra BK (On leave)	bk	7263	
Rajiv Shekhar (Head)	vidtan	7016	
Sangal S	sangals	7167	
Sharma RC	rc	7710	
Gupta D	saboo	7353	7935
Katiyar Monica	mk	7941	

ASSOCIATE PROFESSORS

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Development of innovative engineering systems and processes greatly depends on the availability of high performance materials. The field of engineering materials has expanded enormously in the recent past and now encompasses a large variety of materials such as ceramics, glasses, polymers, intermetallics, semiconductors together with traditionally important metals and their alloys. Composites having metal, ceramic, intermetallic or polymer base materials as the matrix have further created a range of commercially important engineering materials so that a great flexibility exists today to create *tailor-made* engineered materials with specific properties and characteristics for specific applications. Functionally gradient materials fall in this category of materials. Both traditional as well as *engineered* materials are competing with each other in today's world. Thus, there exists a strong need for a broad-based unified approach in imparting education and carrying out research in the area of Materials and Metallurgical Engineering that has been pioneered in the country by this Department.

A relatively novel undergraduate programme in Materials and Metallurgical Engineering at IIT Kanpur aims at providing the basic understanding of principles underlying metals extraction and refining, structural characterisation of materials at different levels, phase equilibria and phase transformations in material systems and processing-structure-property-performance relationships that exist in materials at large. Several courses on these topics have laboratory experiments built into them. All undergraduate students are thus required to do about 75 experiments related to various aspects of processing, characterisation and performance of materials as part of their compulsory departmental courses. An in-depth study in the area of interest/specialisation is undertaken through departmental electives and the project work. Departmental electives have been designed so as to incorporate new and upcoming knowledge in different areas and also the state of art technologies. The course work is further supplemented with industrial tours that are separately arranged during vacations in the third year and which have a bearing on some of the compulsory courses. The project work in the fourth year of the programme, which may be experimental or computational, enables students to carry out the required work independently, broadening their knowledge in the area of interest/ specialisation.

Developing fundamental understanding regarding materials, and their processing and structure-property- performance correlations that exist in them is the basic goal of the postgraduate programme leading to M Tech and Ph D degrees. This is achieved by offering a good number of courses in different areas of Materials and Metallurgical Engineering. Students are generally encouraged to learn inter-disciplinary aspects of engineering through course work. After a student completes his/ her course requirement for the given programme, he/she carries out research work towards the thesis in the area of his/her specialisation. Theses making original research contributions form an integral part of the programme.

Currently, the Department's areas of research interest include (a) Mineral Engineering and Extractive Metallurgy, (b) Design, Processing and Characterisation of Metallic Materials, (c) Computational Materials Science and Engineering, (d) Intermetallics, Ceramics and Composites, (e) Electron and Spin Device Materials and (f) Nano-Materials Technologies. To this end, the Department is equipped with high intensity magnetic separator, crushers and ball mills, semi-automatic floatation cells, hydro-cyclone test rig, jigging facilities, a wet chemical analysis laboratory, gas chromatograph; oil-fired, electric and induction melting furnaces, sand testing and sand casting facilities, pneumatic hammers and hydraulic presses, a swaging mill, a 2-High rolling mill, melt-atomization facility, a hot press for consolidating powder materials, heat treatment and sintering furnaces for different applications, metallography facilities and an Image Analysis System, Scanning and Transmission Electron Microscopes, Electron Probe Microanalyzer, X-Ray and DTA facilities, Instron and MTS testing facilities for mechanical testing of materials at low-ambient - and high temperatures, powder characterisation and pressing facilities for metal, ceramic and intermetallic powders. Besides having a reputation for carrying out experimental research work, the Department has also a strong tradition for working in the area of mathematical and physical modeling for materials processing using conventional numerical methods as well as methods based on artificial intelligence and neural networks.

STRUCTURE OF THE B.TECH. PROGRAMME

SEM. II	SEM. III	SEM. IV	SEM. V	SEM. VI	SEM. VII	SEM. VIII
MME 100	MME 200	MME 210	MME 310	MME 331	MME 410	MME 480
		MME 250	MME 320	MME 340	MME 415	MME 499
		HSS II	MME 330	MME 350	MME 470	E III
			E1	MME 370	DE I	DE II
				MME 390		DE III
				E II		

HSS II
Elective-I
Science-I/HSS-III
Elective II
HSS-III/Science-I
DE- I
HSS-IV/Science-II
Scence-II/HSS-IV
Elective -III
DE- II
DE- III

MME 100	Introduction to Profession
MME 200	Thermodynamics of Materials
MME 210	Metallurgical Kinetics
MME 250	Materials Characterization
MME 310	Mechanical Behaviour of Materials
MME 320	Principles of Metal extraction and refining
MME 330	Phase equilibria in Materials
MME 331	Process Metallurgy Lab.
MME 340	Phase Transformation in Materials
MME 350	Iron and Steel Making
MME 370	Fundamentals of Materials Processes
MME 390	Industrial Tour
MME 410	Electronic and Magnetic Proerties of Materials
MME 415	Physical Metallugy Lab.
MME 470	Manufacturing Processes:Selection and their Design
MME 480	Materials Degradation and prevention
MME 499	Project II

COMPULSORY PROFESSIONAL COURSES FOR UNDER GRADUATE STUDENTS

MME 100 **INTRODUCTION TO THE PROFESSION**
L-T-P-D-[C]
2-0-0-0-[0]

Historical aspects of various materials, including some landmarks; Natural resources of materials; Cost, economics, energy, environmental and political issues relating to materials industry and applications; Importance of materials and their properties, performance and manufacturing processes in the development and growth of automotive, aerospace and railway sectors, electrical, electronic and telecommunication equipment/systems, energy sector, military hardware, structural and general engineering applications, biomedical/implant materials etc.; Demonstrations/film- shows related to selected materials and their characterization, properties and processing.

MME 200 **THERMODYNAMICS OF MATERIALS**
L-T-P-D-[C]
3-1-0-0-[4]

Heterogeneous and homogeneous systems, extensive and intensive properties, simple equilibrium; First Law of thermodynamics, constant volume and constant pressure processes; Spontaneous processes, entropy and quantification of irrversibility, properties of heat engines, thermodynamic temperature scale, Second Law of thermodynamics, criterion for equilibrium, Entropy and disorder, most probable microstate, configurational entropy and thermal entropy; auxiliary functions, Maxwell's relations, Gibbs-Helmholtz equation; Third Law of thermodynamics; variation of Gibbs energy with temperature and pressure, Clausius-Clapeyron equation; thermodynamic properties of mixtures of ideal and imperfect gases; reactions in gas mixtures; reactions of pure condensed phases with gas mixtures -standard Gibbs energy of reactions, Ellingham diagrams; Raoulfs and Henry's Law, activity of a component, Gibbs-Duhem equation, non-ideal solutions, regular solutions, quasi-chemical model of solution, activity and alternative standard states; reaction equilibrium in condensed system, Gibbs phase rule, binary systems involving compound formation, solubility of gases in metals, formation of oxide phases of variable composition; relation between chemical and electrical driving forces, Nernst equation, concentration and formation cells, Pourbaix diagrams; thermodynamics of Point Defects.

MME 210 **METALLURGICAL KINETICS** **Prereq. ESO 212**
L-T-P-D-[C]
3-1-0-0-[4]

Thermodynamics vs. kinetics, homogeneous and heterogeneous reactions; Chemical Reaction Control-rate equation, reaction rate constant, reaction order, non-elementary reactions; Solid State Diffusion -Fick's Law, mechanism of diffusion, uphill diffusion, Kirkendall effect, steady and transient diffusion; External Mass Transfer -fluid flow and its relevance to mass transfer, general mass transport equation, concept of mass transfer coefficient, models of mass transfer -film theory and Higbie's penetration theory; Internal Mass Transfer-Ordinary and Knudsen diffusion, Mass transfer with reaction; Adsorption -physical adsorption vs. chemisorption, adsorption isotherms; Langmuir, BET, adsorption as the rate limiting step; gasification of C by CO_2, dissolution of N_2 in molten steel, porous solids, specific surface area and pore size distribution; Reactor Design -batch vs. continuous reactors, ideal stirred tank and plug flow reactors, mass balance in ideal reactors, residence time distribution; models of industrial reactors; Electrochemical Kinetics-concept of polarization, activation over potential, Butler-Volmer and Tafel's equation, applications in electro-deposition and corrosion, concentration over-potential, limiting current; electro-winning and corrosion.

MME 250 **MATERIALS CHARACTERIZATION**
L-T-P-D-[C]
3-1-0-0-[4]

Chemical bonding, fundamentals of crystallography, reciprocal lattice, structures in metals, inorganic compounds, polymers, silicates and glasses, stereographic projections; Production, characterization, and interaction of X-rays with matter, Bragg's Law and Laue's equations, Ewald's construction, diffraction techniques and applications; Optical principles of microscopy -resolution, magnification, depth of focus; electron diffraction, imaging (various contrasts), determination of crystal structure, burgers vector, electron beam-specimen interactions and other applications of Transmission Electron Microscopy; Applications of Scanning Electron Microscopy and, Electron Probe Micro- Analyser; Principles of Quantitative Microscopy: volume density, surface density, length density, numerical density, particle and grain size; Overview of other characterization techniques such as Auger electron spectroscopy, Scanning Tunneling Microscopy, Atomic Force Microscopy.

MME 310 **MECHANICAL BEHAVIOUR OF MATERIALS** **Prereq. ESO 204**
L-T-P-D-[C]
3-0-3-0-[5]

Stress tensor and stress transformation equations, Principal stresses; Strain tensor and strain transformation equations; Isotropic and anisotropic elasticity, elastic strain energy; Yield criteria and constitutive relationships; Work hardening, plastic instability and its significance; Crystallographic aspects of plastic deformation; Dislocation theory - edge, screw and mixed dislocations, resistance to dislocation motion and elastic properties of dislocations, dislocation interactions, multiplication and dissociation; Strengthening mechanisms; Creep -characteristics of creep curve and steady-state creep, mechanisms and creep mechanism maps, creep under complex stress-states, prediction of long- time properties; Fracture toughness and fatigue -Griffith's crack theory, energy release rate analysis, modes of loading, stress analysis of cracks, fracture toughness, Low- and High-cycle fatigue, Fatigue crack initiation and propagation, structural aspects of fatigue, fatigue under complex stress-states, environmental assisted cracking and fatigue; Some case studies related to design.

MME 320 **PRINCIPLES OF METAL EXTRACTION AND REFINING** **Prereq. MME 200**

L-T-P-D-[C]
3-1-0-0-[4]

History and importance of metal extraction; Introduction of mineral dressing: Communition, Tabling, Jigging and flotation; Metallurgical fuels and the energy scenario; Pyrometallurgical operations -roasting, agglomeration, smelting, refining and secondary refining; Principles of Hydro Metallurgy; Principles of Electro Metallurgy -Aqueous solution and fused salts; Flow sheet design of important non ferrous metals based on materials and heat balance.

MME 330 **PHASE EQUILIBRIA IN MATERIALS** **Prereq. MME 200**

L-T-P-D-[C]
3-0-3-0-[5]

Phase rule, lever rule and Free energy of phase mixtures; Binary isomorphous systems -Equilibrium solidification, non-equilibrium solidification, dendritic growth, coring, Cu-Ni alloys and Zone refining; Binary Eutectic and Peritectic Systems -solidification of eutectic, hypo-eutectic, and hyper-eutectic alloys; solidification of peritectic, hypo-peritectic, and hyper-peritectic alloys; morphologies of eutectic systems, Binary Monotectic and Syntectic Systems; Stability of regular solution and miscibility gas, intrinsic stability of solution and spinodal; Hume-Rothery rules and intermediate phases e.g., laves, sigma, electron compounds; Binary eutectoid, peritectoid, metatectic and monotectic systems; Iron-carbon phase diagram and microstructures of plain carbon steel and cast iron: non-equilibrium structures; Binary ceramics systems: SiO2AbOa, NiO-MnO, etc.; Ternary phase diagrams -Gibbs triangle, isothermal and vertical sections, polythermal projections, two-phase equilibrium, concept of tie lines, rules for construction of tie lines, three phase equilibrium, concept of tie-triangle, four phase equilibria; Multi-component alloy systems: Stainless steels, high-speed steels, Hadfield steels, superalloys, light metal alloys, refractory systems, (AbOa-SiO2-MgO) , sialanes.

MME 331 **PROCESS METALLURGY LABORATORY** **Prereq. MME 200 & MME 320**

L-T-P-D-[C]
0-0-3-0-[2]

Laboratory techniques of temperature and flow rate measurement and calibration: Experiments on Mineral Engineering, Metallurgical Thermodynamics and Kinetics, Fuels and Furnaces, Iron making, steelmaking, pyro-, hydro-, electro-metallurgy in extraction of non-ferrous metals and metallurgical analysis.

MME 340 **PHASE TRANSFORMATIONS IN MATERIALS** **prereq. MME 330**

L-T-P-D-[C]
3-0-0-0-[4]

Thermodynamic order of transformations; Theory of nucleation -Kinetics of homogeneous, transient and heterogeneous nucleation; Theory of Thermally Activated Growth: Interface controlled growth, Diffusion controlled growth, Interface instability and Widmanstatten growth, Eutectoid growth, Discontinuous precipitation, Massive transformation; Transformation Kinetics -Johnson-Mehl equation, Avrami model, Transformation kinetics in diffusion-controlled transformations, Isothermal and continuous cooling transformation diagrams;

Precipitation and Particle Coarsening; Kinetics of recrystallization, Theory of grain growth, Effect of second phase particles; Martensitic transformation - Nature of martensitic transformations, Bain distortion, Nucleation, and growth of martensite, Athermal, isothermal and burst transformations, Thermoeleastic martensitie; Spinodal Decomposition -Diffusion equation in spinodal region, Effect of gradient energy and elastic strain energy; Solidification -Nature and growth of solid-liquid interfaces, Rapid solidification, Glass transition, metallic glasses; Heat Treatment -IT and CCT Diagrams in steels, quench hardening and tempering of martensite, hardenability of steels, surface hardening processes, tool steels and their heat treatments, heat treatment of cast irons, heat treatment of Ni-base superalloys and Ti alloys, Thermo-mechanical treatments.

MME 350 **IRON AND STEELMAKING, 3-1-0-0-4** **Prereq. MME 200 & MME 210**
L-T-P-D-[C]
3-1-0-0-[4]

Refractories for iron and steel; Design and profile of an iron blast furnace and its auxiliaries; Performance evaluation of bast furnace -Iron ore reduction, fuel rate calculations, BF aerodynamics and hot metal quality control; Energy and materials balance calculations in steelmaking processes; Physical chemistry of steelmaking and secondary steelmaking deoxidation, ladle and tundish metallurgy, ingot and continuous casting of steel; Emerging trends in iron and steelmaking.

MME 370 **FUNDAMENTALS OF MATERIALS PROCESSING** **Prereq. TA 201**
L-T-P-D-[C]
3-0-0-0-[4]

Overview of various processing methods for materials; microstructural evolution during solidification and effect of cooling rate on cast microstructures, micro- and macro-segregation in alloys, directional solidification, rapid solidification; Elements of casting mold design -solidification shrinkage and its role in riser design, fluid flow fundamentals and metal fluidity, elements of mold design; Fundamentals of deformation processing -State of stress during various metal working operations, friction and its role in bulk metal forming operations, microstructural evolution during deformation processing, workability of metals, superplastic forming; Metal flow and aspects of design during bulk forming operations, elementary load calculations during various bulk-metal working operations; Sheet metal forming -State of stress during sheet metal forming processes, forming limit diagram, ehancement of sheet metal formability; Fundamentals of powder processing -Basics of metal and ceramic powder productions and characterization, design aspects during powder consolidation; solid and liquid state sintering, driving force and mechanism of si ntering , selection of sintering atmosphere for different systems, characterization of sintered products, full density processing.

MME 390 **INDUSTRIAL TOUR, 0 UNIT**
L-T-P-D-[C]
3-0-0-0-[4]

Visit to industries in and around Kanpur or elsewhere primarily of interest to Materials and Metallurgical Engineering.

MME 410 L-T-P-D-[C] 3-0-0-0-[4]

ELECTRONIC AND MAGNETIC PROPERTIES OF MATERIALS

DC conductivity of metals, Hall effect and magnetoresistance, AC conductivity of metals, thermal conductivity and specific heat of metals, Thermopower of metals; Review of quantum mechanics and free electron theory, failures of free electron theory and introduction to the role of lattice; Review of reciprocal lattice, Brilouin zone, Free electron band diagrams, potential in a crystal, electron dynamics and concept of holes, conductivity in relation to band structure, band structures of metals and semiconductors; empirical estimates of conductivity in metals and alloys; Semiconductors -band diagrams, direct and indirect band gap, applications of semiconductors; Degenerate and non- degenerate semiconductors, intrinsic and extrinsic semiconductors, determination of dopant levels and mobility measurements; Ionic conduction -review of defect equilibrium and diffusion mechanisms, theory of ionic conduction, conduction in glasses, effect of stoichiometric and extrinsic defects on conduction, applications in sensors and batteries; Dielectric Materials -Dielectric constant and polarization, linear dielectric materials, capacitors and insulators, polarization mechanisms, non-linear dielectrics pyro-, piezo- and ferro-electric properties, hysterisis and ferroelectric domains and applications; Optical Materials -electron-hole recombination, solid-state LED's, lasers and IR detectors, band gap engineering; Light interaction with materials -transparency, translucency and opacity, refraction and refractive index, reflection, absorption and transmission; Magnetic field, flux density, susceptibility and permeability; Orbital and spin, permanent magnetic moment of atoms, diamagnetism, paramagnetism and Pauli-paramagnetism, ferro, anti-ferro and ferri magnetism, Fe, Co and Ni and alloy additions, ferrites, magnetic hysterisis, soft and hard magnet materials.

MME 415 L-T-P-D-[C] 0-0-3-0-[2]

PHYSICAL METALLURGY LABORATORY **Prereq. MME 250**

Laboratory techniques for studying phase transformations in materials, recrystallization and grain growth, eutectoid transformations in steels, hardenability, tempering of martensite; resistivity of metals, conductivity of semiconductors, conduction in ionic solids, dielectric measurements in BaTiO3, reflection, absorption and transmission measurement on various metals.

MME 420 L-T-P-D-[C] 3-0-0-4-[5]

HISTORY OF SCIENCE AND TECHNOLOGY OF METALLURGY

Mining, Smelting, Alloying (mainly copper tin), Metal forming : forging, casting Origins of metallurgy in Balkans, Near and Middle East ; Metallurgy in Prehistoric World, Iron and Steel, Silver, Lead, Brass, Zinc, Gold and Platinum, Decoration, Plating, Metal Fakes and Forgeries, Surface Treatment, Metallurgy of India, Metallurgy in Asia, Metallurgy of Greece and Rome, Metallurgy in Europe and the Middle East, Metallurgy of the Americas and Africa.

MME 470 **MANUFACTURING PROCESSES: SELECTION & DESIGN** **Prereq. MME 370**

L-T-P-D-[C]
3-0-3-0-[2]

Overview of manufacturing systems; role of traditional and near-net shape processes in manufacturing industry; Basic attributes of manufactured products -size and shape complexity, machining requirement and machining losses, dimensional tolerances, surface condition, mechanical properties and manufacturing costs, expendable mold and permanent mold shape casting processes; Open die and closed die forging processes and design considerations; Manufacturing processes for making products such as sheets, round/sectioned bars, seamless tubes/rings and wires; Criteria for selection of metal and ceramic powder production processes for a given application; Powder processing equipments and their selection; Joining processes, selection and design; Case studies with CAD/ CAM aspects.

MME 480 **MATERIALS DEGRADATION AND PREVENTION**

L-T-P-D-[C]
2-0-0-0-[2]

Types of processes leading to degradation of materials, viz Oxidation Corrosion, Wear, Creep and fatigue review of basics of thermodynamics and kinetics related to oxidation and corrosion studies, Pourbaix diagram, Polarization, Mixed potential theory, Passivity Characteristics of passivation ; Various types of degradation : atmospheric galvanic, intergranular, dealloying, crevice and pitting corrosion, microbiological, stress corrosion cracking, hydrogen damage, radiation damagte; Oxidation and hot corrosion of materals at high temperatures ; Wear of materials, analytical models of wear; Prevention of meaterials degradation - alloying, environment conditioning design modification cathodic and anodic protection, metallic coating inorganic coating organic coating, inhibitors and passivators wear resistant materials- structural modifications, wear resistant coatings.

MME 421 **MINERAL ENGINEERING**

L-T-P-D-[C]
3-0-0-0-[4]

Status of mineral engineering with regard to sister disciplines: Some concept in geology and mineralogy: Mineral resources in India: Liberation: Com munition and sizing: Hydrodynamics of movement of solids in fluid and gravity separation of different kinds: Coal washing: Magnetic and electrostatic separation: Surface chemistry and other principles of froth floatation: Mill calculation and selectivity index: Typical mineral Engineering flow sheets and case studies.

MME 422 **SCIENCE AND TECHNOLOGY OF NON-FERROUS METAL EXTRACTION**

L-T-P-D-[C]
3-0-0-0-[4]

State of non-ferrous industry in India, Present industrial practice: Recent advances and future trends in extraction and refining of non-ferrous metals: Reclamation of metals from scrap and industrial wastes: Flow sheet analysis of commercial extraction units: Environmental considerations.

MME 423 **SECONDARY STEELMAKING**

L-T-P-D-[C]
3-0-0-0-[4]

Secondary steel making principles and practices: Ladle metallurgy: Outline of inert gas stirring: CAS/CAS(OB), Ladle furnace vacuum degassing of steel and related processes: Transport phenomena in ladles: Tundish metallurgy: Evaluation of tundish hydrodynamic performances: Solidification phenomena: Conventional, continuous and near net shape casting phenomena.

MME 424 **MODELLING OF STEELMAKING PROCESSES**

L-T-P-D-[C]
3-0-0-0-[4]

Brief review of fundamentals of steel making processes: Brief review of fundamentals of transport processes: Mathematical modeling fundamentals: Successful modeling examples.

MME 425 **PROCESS PLANT DESIGN FOR METALLURGICAL ENGINEERING OPERATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Identification of process flow sheet: Preliminary estimate of resources and facilities: Materials and energy balance, detailed plant flow sheet: Equipment selection and specification, economic selection and specification: environmental impact analysis: Report presentation, case studies of typical metallurgical plant operation.

MME 426 **FUELS, REFRACTORIES AND FURNACES**

L-T-P-D-[C]
3-0-0-0-[4]

Conventional and newer sources of energy, energy management problems in metallurgical industries, role of high temperature systems and materials; Deposits, manufacturing, properties and testing of solid, liquid and gaseous fuels; Principles of fuel combustion and burner design; Classification of refractories, manufacturing and properties of common refractories such as silica, fire clay, high alumina, dolomite, magnesite and chrome refractories; Design of high temperature furnaces, waste heat utilization, heat recuperators and regenerators, stack design, gas cleaning, heat balance diagrams; furnace dynamics and fluid and heat flow calculations; Fuel fired furnaces, electric arc furnaces, vacuum, electron beam, plasma, laser furnaces.

MME 428 **ADVANCES IN IRONMAKING**

L-T-P-D-[C]
3-0-0-0-[4]

Recent advances in science and technology of iron making: Developments in blast furnace iron making: Sponge iron making: New emerging coal-based iron making for liquid iron: Gas-solid and slag-metal reactions: Analysis of iron making processes and reactors: Emphasis on application of fundamentals: Term paper on short analysis/design projects.

MME 430 **FURANCE TECHNOLOGY**

L-T-P-D-[C]
3-0-0-0-[4]

Definition and classification of furnaces; Principles of heat generation in fuel fired furnaces and combustion, Flame temperature, Burners for liquid and gaseous fuels, Movement of gases in furnaces, ducts and chimneys, Heat generation in electric furnaces, resistance, induction, are, plasma etc. Metallic and non-metallic heating elements. Furnaces, resistence, induction, are, plasma etc. Metallic and non-metallic heating elements. Furnace construction materials: Manufacture and uses of different types of refractories and insulators, critical insulation thickness, criteria of section of refractory material. Heat balance of a furnace and thermal efficiency, Waste heat recovery systems and their designs, Atmosphere in furnaces. Fuel economy measures in furnaces. Constructional, operational and design features of different types of furnaces like soaking pits, pusher type, walking beams, forging furnaces etc.

MME 441 **STRUCTURAL CHARACTERIZATION TECHNIQUES AND THEIR APPLICATIONS, Prereq. MME 250**

L-T-P-D-[C]
3-0-0-0-[4]

Hierarchy in structure -nano-to macro-scale, structural defects and structural property correlations, overview of characterization need and challenges.
Physical phenomena and basic concepts: Waves particle beams, radiation-matter interactions, concepts likes resolution, lens defects, depth of focus, depth of field, detection limits etc. Neutron diffraction. XRD, electron diffraction. ESBD and their applications. Principles of microscopic techniques like TEM, HRTEM, SEM, OIM, SPM etc., and their applications. Nanometer scale design and fabrication using STM and AFM. Fundamentals of EPMA, ESCA, AES, SIMS, EELS etc., and applications.

Case studies: Super alloys, HSLA, FGM, device structure, structural ceramics, high T_c superconductor, CNT, polymeric L-B films.

MME 452 **SURFACE COATING TECHNOLOGY** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Purpose and scope of surface coatings: Surface coating processes and characterization of coatings: Flame spraying: Detonation spraying: Spray and fuse welding: Clading: Electroplating: Electrophoretic deposition: Chemical vapour deposition: Metallizing etc.; Factors affecting the choice of coating material and process: Testing of surface coatings.

MME 455 **ADVANCES IN POWDER METALLURGY**

L-T-P-D-[C]
3-0-0-0-[4]

Advances in metal powder production methods, Characterization of metal powders: Chemical composition and structure: Particle size and their shape and their determination: Powder flow, compressibility and porosity measurements: Treatment of metal powders: Behaviour of powder during compaction: Die compaction: Types of presses: Tooling and design: Modern methods of powder consolidation, Isotactic pressing: Roll compaction, Powder extrusion and forging, Slip casting, evaluation of sintered products.

MME 456 **MECHANICAL PROCESSING OF MATERIALS**

L-T-P-D-[C]
3-0-0-0-[4]

Fundamentals of metal working: Metal working processes such as forging, rolling, extrusion, drawing, sheet metal forming: Automation and recent advances in Metal working technology: Polymer working processes such as extrusion, moulding, thermoforming and callendering: Advances in polymer working technoloy.

MME 461 **INTRODUCTION TO TECHNICAL CERAMICS**

L-T-P-D-[C]
3-0-0-0-[4]

Powder preparation, forming and consolidation, non-powder processing routes: Structural ceramics: Elastic behaviour, toughness, strength, creep and plastic deformation: Electronic magnetic and optical properties: Conductivity, dielectric, piezo-and pyro-electric materials, magnetic ferrites, transparent and non-linear optical ceramics.

MME 464 **REFRACTORIES**

L-T-P-D-[C]
3-0-0-0-[4]

Raw materials, manufacture testing and properties of heavy and special refractories, silica, silicous alumino-silicate, high alumina, magnetisite, chrome, chrome-magnesite, dolomite, forsterite, chemically bonded basic, carbon and insulating refractories and special purpose oxides, carbide nitride refractories: application and causes of destruction of ferrous, non-ferrous, ceramic and glass furnaces.

MME 467 **Materials for Semiconductors Industry**

L-T-P-D-[C]
3-0-0-0-[4]

Semiconductor fundamentals, band structure, indirect and direct band gap, optical properties, carrier statistics, semiconductor material purification and crystal growth, epitaxy, CVD and MBE, P-N Junction, Schottky and MaS device structures, specific material requirements, Doping by implantation and diffusion, dielectric and insulators, ohmic and barrier contacts, band edge behaviour, empirical rule, alloy design.

MME 471 **METAL JOINING, 3-0-0-0-4**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction, classification of joining processes, soldering and brazing, arc welding processes such as SMAW, GMAW, GTAW, FCAW, EGW, ESW and PAW, Electron beam and Laser beam welding, solid state welding processes, Adhesive and diffusion bonding of materials, heat flow, residual stresses, welding defects and testing, welding metallurgy of carbon steels, alloy steels, stainless steels, aluminium alloys and copper.

MME 472 **ADVANCES IN FOUNDRY TECHNOLOGY**

L-T-P-D-[C]
3-0-0-0-[4]

Casting design: casting with ferrous, non-ferrous and superalloys: net-shape casting: advances in molding materials, melt treatment and casting techniques: modeling of casting, solidification: automation and quality control, foundry pollution and control.

MME 478 **FAILURE ANALYSIS**

L-T-P-D-[C]
3-0-0-0-[4]

Type of failures, buckling, fracture in brittle and ductile materials, fractography, mixed mode, and fatigue failures environmental effects, wear, creep, and yielding phenomena, high strain rate failures, case histories of component failures.

MME 481 **ENGINEERING APPLICATIONS OF METALLIC MATERIALS**

L-T-P-D-[C]
3-0-0-0-[4]

Effect of modification in composition, structure and processing on properties; underlying metallurgical principles, microstructure-property correlation; Criterion in materials selection, Material property charts, Processing maps; Concept of strain ratio, forming limit diagram, transformation induced plasticity and superplasticity, strengthening mechanisms, thermo-mechanical processing, controlled cooling; Inclusin type/shape control, Grain boundary engineering, single grain processing, directionally solidified materials, textural effects;

Important groups of metallic meterials - Carbon, alloy and Stainless steels: Electrical and Magentic steels and alloys, coated sheets; Cast Iron; Light metal and alloys, Copper and its alloys, Nickel, Iron, Cobalt base superalloys Titanium, Zirconium alloys.

Applications to focus on Transport, Energy and Chemical Plant Sectors highlighting criteria for material selection.

MME 482 **ADVANCES IN HEAT TREATMENT TECHNOLOGY**

L-T-P-D-[C]
3-0-0-0-[4]

Hardenability, Selection and specification of steels: New technology such as thermo-chemical and thermo- mechanical and thermocycling treatments: Quantitative approach to heat-treatment: Failure analysis of heat treated products: Applications tailoring and computer harmonizing techniques.

MME 484 **COMPOSITE MATERIALS**

L-T-P-D-[C]
3-0-0-0-[4]

Classification of composite materials, Dispersion strengthened, particle-reinforced and fiber-reinforced composites, laminates, properties of matrix and reinforcement materials: Micromechanics and principle of strengthening, elastic properties, stress-strain relations, fracture be-haviour, Fabrication methods and structural applications of different types of composite materials.

MME 485 **STRUCTURAL MATERIALS FOR AEROSPACE APPLICATIONS**
L-T-P-D-[C]
3-0-0-0-[4]

Design of gas turbine aero-engines: Creep, fatigue and corrosion as limiting factors for high-temperature application of materials: Development of Ni and Co based super alloys, special steels, Ti alloys, intermetallics, ceramics and their composites, New high strength-high modulus materials, ablative materials.

MME 486 **PARTICULATE MATERIALS**
L-T-P-D-[C]
3-0-0-0-[4]

The particular state: attributes and morphology of particles: Distribution of particles in a single attribute: expectation as a measure of global properties of particular ensembles, Analysis of static and dynamic particulate systems by transformation in attributes and measures, Production of particles by mechanical and thermo-chemical means, Particulates in suspension, stability, rheology and settling, Size analysis, Particles in natural phenomena and man- made processes.

MME 498 **PROJECT I, 0-0-4-0-2**

MME 499 **PROJECT II, 0-0-10-0-5** **Prereq. MME 498**

MME 600 **ADVANCED THERMODYNAMICS**
L-T-P-D-[C]
3-0-0-0-[4]

Advanced treatment of the thermodynamic properties of metallurgical systems, properties of solutions: Thermodynamics of interfaces: Irreversible Thermodynamics: Defect structures in solids: Non-equillibrium solid state phase transformations: Gas-metals & slag-metal reactions.

MME 602 **ELECTROCHEMISTRY AND CORROSION**
L-T-P-D-[C]
3-1-0-0-[5]

Advanced theory of electro-chemical kinetics and corrosion, theory of electro-deposition and allied processes, stress corrosion behaviour of materials (important metals, alloys etc.) in various environments, corrosion testing: Metal-gas reaction at high temperatures, corrosion by liquid metals.

MME 603 **NON-EQUILIBRIUM PROCESSING OF MATERIALS**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction to non-equilibrium proccsing Thermodynamics and kinetics of metastable phase formation ; Rapid solidification : Undercooling. Phase diagram metastable states, Methods of rapid solidification, Mienrostruclure formation by rapid solidification, Application for rapid solidification ; Mechanical alloying: Process of mechanical alloying, Mechanism of alloying Energy criteria for mechanical alloying, Synthesis of non-equilibrium phases, Application of mechanical alloying, Metallic glass : Understanding of glass formation, thermal stability and glass forming ability, structure of metallic glass, crystallization behavior, properties of metallic glass, application, Special non-equilibrium processing and phase transformations

MME 604 **SURFACE PHENOMENA IN CHEMISTRY AND METALLURGY**

L-T-P-D-[C]
3-0-0-0-[4]

Physical aspects of interfaces, thermodynamics of surfaces, anisotropy effects, adsorption mechanism, electrical phenomena at interfaces, theory and properties of electric double layer, application to problems in chemistry and metallurgy.

MME 607 **COMPUTING APPLICATIONS IN METALLURGY**

L-T-P-D-[C]
3-0-0-0-[4]

Fortran fundamentals: Applications of regression analysis and curve fitting techniques, computer calculations of phase diagrams: Numerical of partial differential equations pertinent to heat, mass and momentum transfer: Computer applications in solidification, potential energy diagrams and experiment in metallurgy.

MME 608 **COMPUTER APPLICATION IN MINERAL ENGINEERING**

L-T-P-D-[C]
3-0-0-0-[4]

Mass balancing, data reconciliation, problem solving with a material balance software package: Quantitative description of mineral processing units and its computer implementations: Introduction to a general purpose modular simulator for process analysis.

MME 609 **SOFT COMPUTING METHODS IN ENGINEERING PROBLEM SOLVING**

L-T-P-D-[C]
3-0-0-0-[4]

Working principles of genetic algorithms, artificial neural nets, fuzzy logic technique, soft computing techniques like fuzzy regression, fuzzy coded GA, fuzzy neural nets, ANN-fuzzy information system, Fuzzy-ANN-GA; case studies in process control and optimization.

MME 610 **HYDROMETALLURGY**

L-T-P-D-[C]
3-0-0-0-[4]

Thermodynamic and kinetic principles involving solid solution equilibria: Various unit operations in Hydrometallurgy, such as, pretreatment of raw materials, leaching, solvent extraction, ion exchange, gaseous reduction, cementation, precipitation, electro-winning, etc.: Technological aspect of typical hydrometallurgical plants.

MME 613 **ELECTROCHEMICAL TECHNOLOGY IN MATERIALS PROCESSING**

L-T-P-D-[C]
3-0-0-0-[4]

Thermodynamic of electrolyte, electrochemical potential, conduction of ions in solution, overpotential, absorption, phase formation: Economics of an electrolytic process, principles of cell design, Electrochemical technology: Elactowinning, electro refining and metal electroforming, electrochemical machining, electroplating, anodizing, pickling, electrophoretic painting, electrochemical treatment of minerals, batteries and fuel cells, water treatment and environmental protection.

MME 619 **PHYSICO-CHEMICAL BE-HAVIOUR OF MATERIALS AT HIGH TEMPERATURE**

L-T-P-D-[C]
3-1-0-0-[5]

Salient features of physico-chemical behaviour of inorganic materials at high temperatures including interaction with environment, gas composition and pressure dependent phase stability diagrams for non-metallic and metal-nonmetal systems. Nonstoichiometry and defect equlibrium in oxides: Structure and physico-chemical measurements at high temperatures: Vapour and plasma states: Reaction kinetics at high temperatures with specific emphasis on reactivity of solids.

MME 620 **ADVANCED MINERAL ENGINEERING**

L-T-P-D-[C]
3-0-0-0-[4]

Mathematical model of comminution and classification systems: Kinetics of floatation and leaching: Design of comminution circuits: floatation cells and thickners: Filteration, drying and control systems: Coal washing in India: Computer simulation of mineral engineering operations: Flowsheet and economic analysis of mineral processing plants.

MME 622 **MATERIAL SEPARATION AND PURIFICATION**

L-T-P-D-[C]
3-0-0-0-[4]

Differential physico-chemical properties of materials as the basis of separation and purification leaching, solvent extraction, foam fractionation, ion exchange, zone refining, etc: Computation of length transfer unit, making of ultrapure metals: Advanced techniques of analysis, growth of single crystals.

MME 624 **ADVANCED CHEMICAL METALLURGY**

L-T-P-D-[C]
3-0-0-0-[4]

Structure, physical properties and thermodynamics of solutions: Ternary and multicomponent systems: High temperature physico-chemical measurements: Heterogneous reaction equilibria at high temperatures: Stabilities of high temperature materials: Special topics: Theory of reaction rates and applications.

MME 626 **HEAT AND MASS TRANSFER**

L-T-P-D-[C]
3-1-0-0-[5]

Review of the basic concepts in heat,mass and momentum transfer: Advanced topics in convective heat and heat transfer: Radiative heat transmission:

Simultaneous heat and mass transfer: Selected topics in metallurgical engineering, Reaction kinetics.

MME 627 **INJECTION METALLURGY**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to processes and treatment based on injection: Fundamentals of injection metallurgy: Gas and powder injection: Design of lances, nozzles and dispensers: Heat and mass transfer, Technological applications in refining and recycling processes and product developments and quality control and assurance.

MME 628 **APPLICATION OF TRANSPORT PHENOMENA IN METAL PROCESSING**

L-T-P-D-[C]
3-0-0-0-[4]

Review of heat mass and momentum transfer fundamentals: Turbulence phenomenon and heat and mass transfer in turbulent flows: Dimensional analysis and reactor design: Free convection phenomena and bubble/gas driven systems: Applications of transport phenomena to (1) gas stirred ladle systems (2) desulphurization of pig iron using Mg vapour (3) alloy addition kinetics (4) soaking and reheat furnaces.

MME 629 **PHYSICAL AND MATHEMATICAL MODELLING OF STEELMAKING PROCESSES**

L-T-P-D-[C]
3-0-0-0-[4]

Brief review of scientific fundamentals such as thermodynamics, kinetics and transport phenomena of relevance to steel making: Mathematical modeling techniques: Principles of physical modeling: Successful modeling examples including converter steel making, gas stirred ladles: Alloy addition kinetics, tundish operations and continuous casting.

MME 630 **ADVANCES IN IRON AND STEEL MAKING**

L-T-P-D-[C]
3-0-0-0-[4]

Recent trends in iron and steel making: Gas-solid and slag-metal reaction: Sponge iron making: Continuous steel making: Continuous casting: Vacuum degassing and electroslag remelting: Advances in agglomeration, blast furnace and steel making, analysis of iron and steel making processes and reactors: Deoxidation and impurity control: Emphasis on application of physical chemistry and transport phenomena.

MME 631 **ADVANCES IN ALLOY STEEL MAKING**

L-T-P-D-[C]
3-0-0-0-[4]

Classification and properties of alloy steels, raw materials for alloy steel making: Manufacture of ferro-alloys, electrical and mechanical design of electric arc furnaces and induction furnaces and induction furnaces for steel making, manufacture and testing of graphite electrodes: Physical chemistry of alloy steel making, developments in stainless steel making, secondary steel making: Refractories foe alloy steel making: Continuous casting of alloy steels: Mini steel plants in India.

MME 632 **ANALYSIS OF PARTI-CUALTE SYSTEMS**

L-T-P-D-[C]

3-0-0-0-[4]

Characterization and statistics of small particles: Distribution in single and multiple particle attributes: Transformation of attributes: Statistical, empirical, and series distribution and their statistical properties: Evolution of particulate spectra in size reduction, agglomeration, coagulation, crystal and grain growth, floatation, etc.: Moments, similarity and approximate methods for the solution to the particle population equation.

MME 633 **MINERAL AND METALLURGICAL WASTES RECYCLE AND RESOURCE RECOVERY**

L-T-P-D-[C]

3-0-0-0-[4]

Properties and characterization of major waste products in mining, mineral benefications, pyro-and hydrometallurgy and ceramic processes: Recycle of waste in the parent process: Problems of particulate solids, briquetting and agglomeration of fines: Utilization of wastes for cements, building materials, light weight aggregates, ceramics, filters, fertilizers etc.: Miscellaneous applications.

MME 635 **MATHEMATICAL MODELLING OF METALLURGICAL AND MINERAL PROCESSES**

L-T-P-D-[C]

3-1-0-0-[5]

Introduction to mathematical modeling and simulation: Basic concepts in mathematics and numerical analysis, optimium experimental design, smoothing and generation of data: Time series analysis: Development and analysis for empirical model -estimation of parameters, error analysis: Mathematical modeling and simulation of some of the metallurgical and mineral engineering processes.

MME 636 **PROCESS CONTROL IN METALLURGY AND MINERAL PROCESSING**

L-T-P-D-[C]

3-0-0-0-[4]

Introduction to and incentives for process control: Design aspects of a process control system, role of mathematical modeling and development of mathematical models for control purposes: Linearization of non-linear systems, transfer function and the input-output models: Dynamics behaviour of first and second order systems: Introduction to feedback control: Feed forward and ratio control: Adapture and inferential control: Control hard wares and instrumentation: Case studies of process control in metallurgy and mineral engineering.

MME638 **PROCESS METALLURGY**

L-T-P-D-[C]

3-0-1-0-[5]

Introduction to metallurgical processes: Physical separation methods for ore penetration:Principles of pyro-, hydro-and electrometallurgy:Basic furnace technology:Extraction and refining of common non-ferrous metals such as aluminium,copper,lead,zinc etc.:Iron and steelmaking laboratory exercises.

MME 639 **PHYSICAL METALLURGY**
L-T-P-D-[C]
3-0-1-0-[5]

Crystallography, X-ray diffraction, defects, diffusion, phase diagrams, metallography, phase transformation,heat treatment,plastic deformation, creep, fatigue and fracture, minerals processing.

MME 640 **SOLID STATE TRANSFORMATIONS**
L-T-P-D-[C]
3-0-0-0-[4]

Classification of transformation based on thermodynamics, mechanism and kinetics: Homogeneous transformation: Nucleation and growth phenomenoa: Spinodal decomposition: Crystallographic features of transformation.

MME 641 **ORDER-DISORDER TRANSFORMATIONS**
L-T-P-D-[C]
3-0-0-0-[4]

Occurrence of different types of ordering in metals and alloys, property changes due to ordering, statistical theory of ordering: Bragg-Williams and Bathe theories of LRO and SRO, thermodynamics of order-disorder transformation, detection of order by X-ray, electron and neutron diffraction, antiphase domains, long periods superlattices, kinetics of order-disorder transformation.

MME 642 **QUANTITATIVE MICRO-SCOPY**
L-T-P-D-[C]
3-0-0-0-[4]

Mathematical treatment of prediction of microstructure: Estimation of size distribution of inclusions from measurements on a two dimensional section: Image analysis through computers.

MME 643 **THEORY OF ALLOYS**
L-T-P-D-[C]
3-0-0-0-[4]

Structure and physical properties of elements: Alloys formation: primary solid solution, intermetallic compounds, concept of atomic size factor, normal valance compounds, electron compounds in noble metals and transition metal systems, size compounds, borides, carbides and silicides of metals: Experimental methods for the study of alloying behaviour of metals.

MME 644 **PHYSICAL METALLURGY OF STEELS**
L-T-P-D-[C]
3-0-0-0-[4]

Mechanical Behaviour of steels: Iron-carbon phase equilibria: Structure and property relationship in steels: High strength low alloy structural steels: Medium-high carbon ferrite-pearlite steels: Tool steels, stainless steels, surface hardening of steels, welding of steels.

MME 645 **INTERFACIAL PHENOMENA IN METALS AND ALLOYS**

L-T-P-D-[C]
3-0-0-0-[4]

Phenomenology of solid surface free energy, Equillibrium shape: Wulff theorm: Gibb's adsorption isotherm, interphase-interfaces in heterogeneous systems: Grain and twin boundary equilibria and multiphase equilibria: Determination of surface free energy: Temperature coefficients, interfaces fracture, interface embrittlement, grain boundary migration and sliding, sintering mechanism, solid-liquid transition, nucleation and growth.

MME 646 **X-RAY CRYSTALLOGRAPHY-I & II**

L-T-P-D-[C]
3-0-0-0-[4]

Elemental compound and alloy crystals, modes of bonding, crystal types, density of packing, atomic stacking, inter- atomic voids, coordination polyhedra, Pauling's rules, symmetry elements, space and point groups, group theoretical formulation, diffraction or radiation.

MME 647 **ELECTRON MISCROSCOPY AND ELECTRON DIFFRACTION**

L-T-P-D-[C]
3-1-1-0-[4]

Interaction of electrons with matter: Electron optical systems: Kinematical theory of electron optical systems and electron diffraction: Contrast effect due to lattice particles: Electron diffraction, double diffraction: Fine structure of diffraction patterns: preparation of replicas and thin foils: Analysis of electron micrographs and diffraction patterns.

MME 648 **DIFFUSION IN SOLIDS**

L-T-P-D-[C]
3-0-0-0-[4]

Diffusion equations and mathematical solutions: Phenomenological diffusion theories: Atomic theory of diffusion, theoretical and experimental investigation of diffusion phenomena: Diffusion in ionic solids and semiconductors: Grain boundary and surface diffusion, thermal and electro-diffusion.

MME 649 **DEFORMATION PHENO-MENA**

L-T-P-D-[C]
3-0-0-0-[4]

Stress and strain tensors: Anisotropic and isotropic elastic stress-strain relations: Dynamic elasticity: Anelasticity, visco-elasticity: Phenomenological aspects of plastic deformation in crystalline materials: Creep and Fatigue: Types of Fracture: Griffith theory of brittle fracture and its modification: Ductile fracture: Notch effect in fracture: Fracture mechanics.

MME 650 **FUNDAMENTALS OF STEREOLOGY AND APPLICATIONS TO MICROSTRUCTURAL ANALYSIS**

L-T-P-D-[C]
3-0-0-0-[4]

Concepts and language of stereology; geometrical probability; fundamental operations in stereology; averaging with respect to orientation; basic stereological parameters on true 2-D sections and thick sections; topological parameters of microstructure; error analysis; applications of analysis of optical, scanning and transmission electron micrographs; numerical density and size distribution of particles and grains of various shapes and sizes; stereological analysis of anisotropic microstructures; fractal description of various microstructures; fractal dimensions and its significance; applications to characterization of martensitic, polycrystalline and other structures and fracture surfaces.

MME 651 **X-RAY CRYSTALLOGRAPHY II** **Prereq. MME 342 or equivalent**
L-T-P-D-[C]
3-0-0-0-[4]

X-ray diffraction: Diffraction theory, atomic scattering factor, integrated intensity of diffracted beams, temperature factor, line broadening: Techniques: Laue, powder and rotating crystal techniques, techniques for studying bent crystal, texture, order-disorder changes etc.

MME 655 **MODERN TRENDS IN METAL FORMING PROCESSES**
L-T-P-D-[C]
3-0-0-0-[4]

Limitation of conventional metal forming methods: Powder rolling and its various variants, spray rolling, direct strip process: Powder, spray, rotary and isothermal forging: Hydrostatic and powder extrusion: Conform process: Applications of these processes for making conventional and speciality products.

MME 656 **TEXTURE IN METALS AND ALLOYS**
L-T-P-D-[C]
3-0-0-0-[4]

Concepts of texture: Pole figure, inverse pole figure, inverse pole figure and O.D.F. methods: Experimental techniques in texture analysis-Schultz reflection, transmission, offset quadrant, spherical specimen and neutron diffraction methods: Specimen preparation for texture measurements: Random samples and normalizing procedures: Origin and development of textures on mechanical, physical and magnetic properties: Industrial texture control.

MME 657 **MATHEMATICAL THEORY OF DISLOCATIONS**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction to Volterra dislocation and disclinations -dispirations in crystal - isotropic and anisotropic stress fields: Fast moving dislocations and instability-dislocation intersection and relation of properties in microstructure.

MME 659 **ENGINEERING APPLICATION OF DISLOCATION IN MATERIALS**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction to dislocation, disclinations, dispirations: Isotropic and anisotropic stress fields and energies of dislocations: Stability of dislocation in crystal structure: Interaction between dislocations, impurities, microparticles and related topics in deformation and relation of properties to microstructure.

MME 660 L-T-P-D-[C] 3-0-0-0-[4]

PROCESS CERAMICS-I: CRYSTAL STRUCTURE, PHASE EQUILIBRIA AND MICROSTRUCTURE DEVELOPMENT

Introduction to ceramics, common ceramic crystal structure, silicates, clay minerals, graphite, carbides etc.: Pauling rules, crystal binding and cohesive energy co-ordination, structural imperfections, diffusion, ceramic phase equilibrium diagram, nucleation, grain growth, sintering and vitrification, microstructure development of ceramics whitewares, refractories, technical ceramics and abrasives.

MME 661 L-T-P-D-[C] 3-0-0-0-[4]

PROCESS CERAMICS II: FABRICATION TECHNOLOGY

Classification and application of ceramic materials: Raw materials preparation and characterization of ceramic powders: Mixing, packing, compaction enlargement of powders: Uniaxial and isotatic pressing: Plastic jiggering, forming and extrusion: Injection molding: Slip casting, hot pressing methods: Drying, calcination and firing, solid state reaction and kinetic models, machining: Grinding and finishing of green and fired bodies: Glazing and enamelling: Quality control and testing.

MME 662 L-T-P-D-[C] 3-0-0-0-[4]

TRIBOLOGY OF MATERIALS

Background and importance of Tribology; A system approach to Tribology; Characterization of tribosurfaces; mechanics of solid contacts; theory of friction and frictional heat generation; role of contact temperature; Different modes of wear;Tribological testing techniques and analysis of the worn surfaces; Lubrication; Importance and properties of lubricants; Different wear resistant materials; Recent research results illustrating the performance of surface coatings, bulk materials and composite materials in tribological contacts.

MME 663 L-T-P-D-[C] 3-0-0-0-[4]

ELECTRICAL AND MAGNETIC PROPERTIES OF CERAMIC MATERIALS

Structure of oxides: Ionic diffusion in oxides: Defect structure of non-stoichiometric compounds: Conductivity dependence on partial pressure of oxygen: Macroscopic characterization of dielectric materials: Electronic, atomic dipole, space charge polarization: Relaxation phenomenoa-Debye equations: Ferroelectrics: Diamagnetism, paramagnetism and ferromagnetism, exchange ferromagnetic domain: Structure and properties of ferrites.

MME 666 L-T-P-D-[C] 3-0-0-0-[4]

SCIENCE AND TECHNOLOGY OF MAGNETIC MATERIALS

Magnetic units: Magnetic moments: Dia, para and pauli-para magnetism: Molecular field: Ferro, antiferro and ferrimagnetism: Alloying effect on transition metals and intermetallics: Stability of domain structure: Origin of magnetic anisotropy and its application: Effect of inclusions, internal stress, magnetostriction and preferred orientation on magnetization: Susceptibility and coercivity calculations: Magnetic thin films-amorphous and crystalline, soft and permanent magnets: Technological aspects of magnetic materials.

MME 667 **SELECTION AND DESIGNING WITH ENGINEERING MATERIALS**

L-T-P-D-[C]
3-0-0-0-[4]

Overview of the design process: concepts and stages of engineering design and design alternatives to develop materials with tailored properties; Performance indices of materials; function, objective and constraints in design, "specific stiffness-limited" and "strength-limited" design for maximum performance, Performance indices for thermal, mechanical, thermo-mechanical applications, damage tolerant designs for structural applications; Basic concepts of materials science: processing-structure-property-performance correlation; overview of conventional and advanced materials; Brief overview of the elements of chemical bonding, crystal structure, defect structure of different material classes, Brief introduction to the manufacturing processes for metals, polymers, ceramics, glasses and composite materials; design for manufacturability, Ashby's material property charts; Decision matrices and decision matrix techniques in materials selection, relationship between materials selection and processing; Case studies: designing of Metals and alloys, ceramics and glasses, composite materials (MMC, CMC and PMC/ FRC) for specific applications.

MME 668 **MATERIAL FOR BIOMEDICAL APPLICATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to basic concepts of Materials Science; Salient properties of important material classes; Property requirement of biomaterials; Concept of biocompatibility; cell-material interactions and foreign body response; assessment of biocompatibility of biomaterials, important biometallic alloys; Ti-based, stainless steels, Co-Cr-Mo alloys; Bioinert, Bioactive and bioresorbable ceramics; Processing and properties of different bioceramic materials with emphasize on hydroxyapatite; synthesis of biocompatible coatings on structural impant materials; Microstructure and properties of glass-ceramics; biodegradable polymers; Design concept of developing new materials for bio-implant applications.

MME670 **SOLIDIFICATION PROCESSING**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction ; Thermodynamics of solidification ; Nucleation and growth ; Pure metal solidification : Gibbs- Thomson effect ; Alloy Solidification : Mathematical Analysis of redistribution of solute during solidification. Constitutional undercooling, Mullins-Sekerka instability ; Single phase solidification ;Cellular and Dendritic growth ; Multiphase solidification : eutectic, peritectic and monotectic ; Modelling of solidification ; Case studies.

MME 671 **ANALYSIS AND APPLICATIONS OF SOLIDIFICATION**

L-T-P-D-[C]

3-0-0-0-[4]

Nucleation, nature of solid/liquid interface: Growth morphologies: heat flow considerations: Solute redistribution in alloy solidification: Zone melting: Effect of growth parameters on microstructure: Segregation and homogenisation: Manipulation of structure and properties: Metal matrix composites.

MME 672 **ADVANCED STRUCTURAL CERAMICS**

L-T-P-D-[C]

3-0-0-0-[4]

Fundamentals of Material Properties and the importance of Ceramic materials; Glass and glass-ceramic; Processing and properties of different ceramic monoliths-Fundamental Sintering mechanisms, various advanced sintering techniques (e.g. Hot Isostatic Pressing, Spark Plasma Sintering, Microwave sintering); Mechnacial behaviour of Structural ceramics-Brittleness of ceramics, Concept of fracture toughness and different toughness measurement techniques, Elastic modulus, Strength measurement and Weibull theory of strength variability, Concept of various toughening mechanisms; Processing and Properties of ceramic composites-Examples of toughened particle reinforced composites, Whisker reinforced composites, Fibre reinforced composites; Recent advances in Structural Ceramics-Functionally graded ceramic composites, Bioceramics and composites.

MME 673 **SINTERING AND SINTERED PRODUCTS**

L-T-P-D-[C]

3-0-0-0-[4]

Stages of sintering, driving forces for sintering, mechanism of sintering, liquid phase sintering, hot processing: Sintering furnaces and atmosphere: Iron, copper and aluminium base P/M alloys: Porous materials: Friction and Antifriction materials: Brushes, Heavy alloys, Cemented carbides: Cermets, Electrical contact materials.

MME 674 **DESIGN OF SINTERED PRO-DUCTS**

L-T-P-D-[C]

3-0-0-0-[4]

Factors affecting design-materials and geometry: Specific design of products like permeable materials, structural parts, bearings and cutting tool materials: conditioning of metal powders to influence processing parameters: Product properties evaluation and their standardization.

MME 675 **SINTERED TOOL MATERIALS**

L-T-P-D-[C]

3-0-0-0-[4]

Classification of cutting materials-tools steels, cemented carbides, ceramic tools and diamond tools: Production method of raw materials powder steel, tungsten carbide, cobalt, A12O3, Si3N4 etc.: Consolidation of shaped products, sintering mechanism liquid phase sintering, cold and hot isostatic pressing: Reclamation of tool materials, Evaluation of sintered tool material.

MME 678 **HIGH TEMPERATURE OXIDATION AND CORROSION**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction experimental techniques: Oxide and defect structure: Thermodynamics, Ellingham diagrams, vapor species diagrams, isothermal stability diagrams: kinetics, rate laws, Wagner's theory of parabolic rate laws, mechanism of oxidation: Oxidation of pure metals, multiple scale formation, scale cracking, oxygen dissolution: Oxidation of alloys, internal oxidation, catastrophic oxidation, stresses in oxides: Hot corrosion, acid fluxing, basic fluxing, High temperature materials, superalloys, intermetallics: Protection against oxidation, coatings, atmospheric control: Conclusions.

MME680 **GRAIN BOUNDARY ENGINEERING**

L-T-P-D-[C]
3-0-0-0-[4]

Grain boundary structure : Geometrical aspects, Degress of freedom, Principles governing grain shape and size their orientation. Theoretical formulations : Structurals units model, Plane matching model, O Lattice model, Special boundaries, CSL and DSC Lattice. Boundary energy and equilibria, Grain Boundary types, GB mobility and boundary- solute interactions. GB structure and Properties: mechanical strength wear, creep magnetic, electrical etc. Simulation and modeling . Grain boundary engineering strategy : Deformation, thermomechanical treatment trace additions, Magnetic Field etc. GB descriptors : Connectivity, density junction distribution, Character distribution. Boundary Characterization Tools : X-ray, EBSD-OIM, CTEM, AEM, HRTEM, etc. Macrotexture analysis : Pole figure measurement, X-ray diffraction, neutron diffraction methods. Microtexture analysis : Automated EBSD Kikuchi pattern, Hough's transform, SEM-OIM based TEM based, Schemes for representation of Data Prospective applications: Superplasticity. Creep resistance, Corrosion Resistance, Superconductivity, Electronic ceramics etc.

MME 684 **NUCLEAR MATERIALS**

L-T-P-D-[C]
3-0-0-0-[4]

Nuclear radiation, microscopic flux and microscopic cross-section, attenuation of radiation fission, elastic collision slowing down infinite multiplication constant: Fuel and breeder materials manufacture and properties: Structural materials: Radiation damage in fuel elements: Structural coolant and control rod materials: Nuclear power; present and future states.

MME 685 **THIN FILM: PHYSICS AND APPLICATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Surface science; experimental techniques to study surfaces; kinetics of surface processes -impingement of atoms, scattering, adsorption, sticking coefficient; Film nucleation and growth mechanisms, critical radius of nuclei, computer simulation of film growth, microstructure evolution; Film growth by evaporation, sputtering, chemical vapour deposition, atomic layer epitaxy, liquid phase epitaxy, sol-gel technique etc, Electrical, optical, magnetic and mechanical properties of thin films and their applications.

MME 687 **PHYSICAL METALLURGY, PROCESSING AND APPLICATIONS OF REFRACTORY METALS AND ALLOYS**

L-T-P-D-[C]
3-0-0-0-[4]

Characteristics of Pure Refractory Metals- crystal structure, recrystallization behavior, compatibility of refractory metals and alloys with various materials; Physical, chemical, mechanical and thermal properties of refractory metals; Alloys of Refractory Metals- phase equilibria in major refractory alloy systems, alloy design principles, physicochemical interaction of refractory metals with elements of periodic system, interaction of refractory metals with interstitial impurities; Mechanism of Deformation and Strengthening in Refractory Metals- solid-solution strengthening, dynamic strain aging, effect of dispersed second phases, thermo-mechanical treatment, grain size and grain-shape strengthening; Solidification processing, mechanical treatment, powder processing of refractory metals and alloys; Structure and Properties of Refractory Alloys- substitutional alloy, doped Wand Mo, dispersion-strengthening alloys, tungsten heavy alloys, composites reinforced with refractory metal-fibers, refractory-metal cermets, amorphous refractory alloys; Application of Refractory Metals & Alloys: general applications, requirements for special applications, porous metals, refractory alloy for electrical contacts, refractory metals for superconductors, requirements of use in themo-nuclear reactors, refractory alloys for thermal-management applications, refractory alloys for wear-resistant applications; case studies; Novel Processing Techniques

MME 688 **NANOMATERIALS : PROCESSING AND PROPERTIES (3-0-0-4)**

L-T-P-D-[C]
3-0-0-0-[4]

Definition and Classification of Nanomaterials, Fundamental Properties of various primary material classes (Metals, ceramics and Polymers), Size dependent properties and various characterization techniques of Nanomaterials, Synthesis / Consolidation routes to produce Nanomaterials, Mechanochemical synthesis to produce nanosized precursor powders, Various routes to produce Nanometallic alloys (Rapid solidification), Challenges in processing bulk ceramic nanomaterials, Various densification routes for nanoceramics and nanoceramic composites, Processing- structure-properties of important bulk nanomaterials, Mechanical Properties, Thermal properties, Tribological Properties, Biological Properties (Biomedical applications), Applications of bulk nanomaterials, Critical issues related to understanding properties of nanomaterials.

MME 689 **MULTIFUNCTIONAL OXIDES: THIN FILMS AND DEVICES**

L-T-P-D-[C]
3-0-0-0-[4]

Fundamentals of oxides : crystal structure, defect chemistry, and properties; focus on various material systems methods of fabrication e.g. solid state chemistry. Oxide thin films. polycrystalline versus epitaxial, main film deposition techniques: physical vapor and chemical deposition methods, PVD techniques: sputtering (fundamentals of glow discharge processes and film deposition RF and DC magnetron sputtering new approaches), laser ablation (basic science, applications, various approaches), science and technology of evaporation and molecular beam epitaxy (MBE) Chemical processes basic and technological issues of sol-gel chemical vapor deposition atomic layer deposition; PVD visa- vis chemical processes; issues related to epitaxy and case studies. Characterization methods : Structural techniques- uses of X- ray diffraction, atomic force microscopy scanning and transmission electron microscopy, spetroscopic methods; Electrical Measurements. Devices types of devices, fabrication: fundamentals and issues; Lithographic methods: conventional and next generation, FIB (field ion) techniques, Nanofabrication: principles, processes and issues, Use of Scanning force microscopy in nanofabrication case studies..

MME 690 SEMINAR PARTICIPATION

MME 691 SEMINAR PRESENTATION

MME 699 M. TECH. THESIS,

MME 799 Ph. D. Thesis

MATERIALS SCIENCE
(Inter-disciplinary Programme)

PROFESSORS

Kumar Jitendra (Head)	jk	7107
Shahi K (Jointly with Physics)	kshahi	7042
Mohapatra YN (Jointly with Physics)	ynm	7802

ASSISTANT PROFESSOR

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Gupta Rajeev (Jointly with Physics)	guptaraj	6095

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Understanding, developing and characterisation of materials are at the root of man's progress in the modern world. Recent advances in electronics, energy conversion, space flight, to name only a few, have become possible due to the extension of materials behaviour. For further progress and to meet the future requirements, a thorough study of existing materials and tailor-making of newer functional materials are to be continued with increasing vigour. Such a task, however, requires an interdisciplinary approach to the subject. Keeping this objective in view and to provide focus and co-ordination for teaching, research and development, an interdiciplinary programme in materials science leading to Master of Technology (M. Tech.) degree was initiated at the Indian Institute of Technology, Kanpur in July 1971. The doctoral programme leading to Ph. D. degree was started two years later in 1973.

The above M. Tech. and Ph.D. postgraduate programmes provide opportunities to young engineers and scientists to undergo training in different aspects of materials science and engineering. The courses are designed to illustrate the applications of fundamental principles of solid state physics, chemistry and engineering and also to understand and utilize the properties of a broad range of materials including metals and alloys, semiconductors, ceramics, glasses, composites, polymers, etc. Emphasis is given to various aspects of preparation, structural properties and application of materials.

The M. Tech. programme requires crediting a set number of courses covering the basic concepts of the materials science and engineering and modern experimental techniques and a few electives chosen from among the existing courses (listed below) and others offered by various engineering and science departments. Students besides undertaking course work participate in research activities and submit their individual contributions in the form of a thesis to fulfill the requirements of the M.Tech.

degree. For Ph. D. degree, one has to credit at least four courses, pass the comprehensive examination and complete a research project leading to an acceptable thesis.

Research and development in modern materials require an integrated approach based on different established disciplines of science and engineering. Excellent infrastructure exists for materials research at the Advanced Centre for Materials Science and at various other laboratories in the Institute. Students are encouraged to select an interdisciplinary problem for their thesis work. The broad areas of research under progress include electronic materials, ceramics, composites, solid state ionics, the energy storage materials, thin films, high T_c superconductors, magnetic materials, polymers, nano-structured materials and specialised techniques. Summer work in industries or R and D organisations can also be arranged on a personalised basis to complement the student's training in Institute.

COURSE DESCRIPTION

MS 601 **STRUCTURAL AND MAGNETIC PROPERTIES OF MATERIALS**
L-T-P-D-[C]
3-0-0-0-[4]

Crystal structure, Bonding of atoms, Crystal chemistry, Equilibrium thermodynamics, Phase equilibria, Phase transformations, Dia, Para-, Ferro-, Ferri- and Antiferro-magnetism, Magnetic domains, Anisotropy effects, Magnetostriction, Measurement of magnetic properties, Soft and hard magnetic materials and their technology.

MS 602 **ELECTRICAL AND DIELETRIC MATERIALS**
L-T-P-D-[C]
3-0-0-0-[4]

Metallic conduction, Energy bands, Brillouin zones, Temperature dependence of metallic conductivity, Impurity contributions, Semiconductor materials, Doping effects, Law of mass action, Electrical resistivity and Hall effect measurements, Recombination Processes, p-n junctions, MOS field effect transistors, Semiconductor technology, Point defects, Diffusion phenomenon, Ionic conduction, Temperature and (aliovalent) impurity effects, Superionic conductors and devices, Di-, piezo- and ferro-electric materials, Mechanisms of polarization, Dielectric parameters and their measurements.

MS 603 **MECHANICAL PROPERTIES OF MATERIALS**
L-T-P-D-[C]
3-0-0-0-[4]

Stress and strain tensors, Elastic constants, Effect of structure on elastic behaviour, Elastic stress distributions, Viscosity and viscoelasticity in polymers, Yielding criteria, Dislocations and plastic deformation of metals and ceramics, Strengthening mechanisms, Creep, Brittle fracture in ceramics and glasses, Toughening of ceramics and composites, Fatigue, Mechanical testing, Strength and engineering design with brittle solids, Heat treatment, Powder processing.

MS 604 **CHARACTERIZATION OF MATERIALS**
L-T-P-D-[C]
3-0-1-0-[5]

Crystallography, Reciprocal lattice, Diffraction methods, Electron microscopy, Metallography, Thermal analysis, Chemical analysis, Spectroscopic techniques, Laboratory sessions.

MS 605 **MATERIALS ENGINEERING**
L-T-P-D-[C]
3-0-0-0-[4]

Solidification, Powder processing, Crystal growth, Heat treatment and microstructures, Non destructive evaluation, Processing of glasses and polymers, Novel processing methods, Thin films, Surface phenomena and corrosion.

MS 606 **ELECTRONIC MATERIALS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Classification, Crystal growth techniques, Wafer processing, Doping methods, Formation of oxide layer, CVD, MOCVD and MBE, Metallic contacts and interconnects, Lithography, Processing integration.

Photonic materials-solar cells, photodetectors, light emitting diodes, Superlattice structures, Materials for high frequency and high temperature devices, Application of linear and non-linear dielectric materials, Electro-optic ceramics, Materials for signal processing, transducers and digital data storage, Superconducting materials and applications.

MS 607 **ELECTRO CERAMICS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to electronic ceramics, Defects and diffusion in ionic solids, Ionic conductivity, Applications, Liner dielectrics, Frequency dependence of polarization, impedance spectroscopy, Dielectric material design for microwave, thin film capacitor, microelectronics and VLSI applications; Nonlinear dielectrics, Structural origin, Thermodynamic formulation, Ferroelectrics and piezoelectrics, Applications; Electro-optic ceramics, Birefringence, Linear and quadratic optoelectric effects, Electro-optic coefficients, KDP, $LiNbO_3$, $LiTaO_3$, PLZT; Processing, Applications, Magnetic ceramics, Ferro-, Ferri-, ferrites and other magnetic materials, Applications, New high permeability magnets, Giant and colossal magnetoresistance, Magneto-electronics; High temperature superconductors : Structure, synthesis and characterization, Applications.

MS 611 **MATERIALS FOR ENERGY CONVERSION AND STORAGE** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Characteristics of solar radiation, Basic features of solar cells, Various junction configurations, p -n homojunction, Schottky barrier, Heterojunction, Photo-electrochemical cells, Desired material properties, Promising semiconductor materials, Various fabrication techniques, Solid state diffusion, Vacuum evaporation, Sputtering, Thermal oxidation, Chemical displacement, Plasma deposition, Energy storage devices.

MS 612 **ELECTRON MICROSCOPY AND MICROANALSIS, 3-1-0-0-5** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[5]

TEM-Introduction, Instrument details, Resolution, Modes of operation, Specimen preparation, Principles of electron diffraction, Formation of ring, spot and textured patterns, Indexing procedures, identification of phase, Amplitude and phase contrast, BF and DF images, Kinematical and dynamical theories, Contrast from defects, Weak beam technique, Lattice resolution, etc.

SEM- Electron-specimen interactions, Signal characteristics, Image formation, SE, BSE and CL detecting systems, Contrast mechanisms, Resolution, EBIC microscopy, Electron channelling Patterns and Kossel technique.

MICROANALYSIS- X-ray emission, Wavelength and Energy dispersive analyzers, Point analysis, Line scans, Distributiion mapping, Quantitative analysis.

MS 614 L-T-P-D-[C] 3-0-0-0-[4]

ENGINEERING POLYMERS

Classification and structure of polymers, Glass transition, Linear viscoelasticity, Stress relaxation and dynamic experiments, Mechanical models, Superposition principles, Effect of structure on mechanical properties, Rubber elasticity, Yield and fracture.

MS 615 L-T-P-D-[C] 3-0-0-0-[4]

PRINCIPLES OF CERAMIC PROCESSING

Particle size, Particle packing, Size reduction, Particles in liquid suspension, Rheology, Polymers in ceramic processing, Colloidal processing, Sintering, Sintering defects, Surfaces and interfaces in processing, Sol-gel and other chemical processing methods.

MS 616 L-T-P-D-[C] 3-0-0-0-[4]

HIGH PERFORMANCE POLYMERS AND COMPOSITES **Prereq. #**

Introduction to high performance polymers and composites, Classifications and examples, Characterization methods, Processing of high performance polymers and composites; Open two roll mill, Internal mixer, Extruder, Calendering, Various moulding units, Fibre spinning, Lamination, etc, Structure, chemistry, grade, processing parameters, properties and application of various high performance polymers and composites, Application of polymers in space, ocean, electronics, medical, agriculture, automobile, sports, building construction, etc.

MS 617 L-T-P-D-[C] 3-0-0-0-[4]

INTRODUCTION TO NANO MATERIALS AND NANOTECHNOLOGY **Prereq. #**

Effects of confinement and finite size-zero, one and two dimensional nano-structures (concepts of surface and interfacial energies), Intermolecular and interfacial forces in organic, polymeric, biological and aqueous systems-Van der Waals, electrostatic, double layer, acid base, depletion interactions, hydrophobic force, layering, mesoscale thermodynamics, Gibbs treatment of interfaces, mesoscale fluid dynamics, thin soft films, mesoscale phenomena in soft matter and applications: adhesion, wetting, nucleation, Nanofabrication: patterning of soft materials by self organisation and other techniques, chemical self assembly, artificial multilayers, cluster fabrication, Langmuir-Blodget growth, Nanolithography, Scanning probe lithography, Micro contact printing, Synthesis of nanoparticles and films: sol-gel, hydrothermal, freeze drying, intercalation, attrition, ion implantation, Gas phase condensation, Chemical vapour deposition, Nanosuspensions-ferrofluids, Compaction of nanocrystlline materials, Carbon nanotubes, short and long term applications and perspectives, Demonstration of some techniques in preparation and characterization of nanomaterials.

MS 691 **SPECIAL TOPICS**
L-T-P-D-[C]
3-0-0-0-[4]

MS 698 **GRADUATE SEMINAR**
L-T-P-D-[C]
1-0-0-0-[0]

MS 699 **M. TECH. THESIS UNITS - MULTIPLE OF 4**

MS 799 **PH. D. RESEARCH UNITS - MULTIPLE OF 4**

MATHEMATICS AND STATISTICS

PROFESSORS

Bahuguna D	dhiren	7053
Chandra Peeyush (Head)	peeyush	7285
Dutt Pravir K	pravir	7074
Dhariyal ID	idd	7692
Gupta Manjul	manjul	7963
Kadalbajoo MK	kadal	7732
Kapoor GP	gp	7609
Kundu D	kundu	7141
Lal AK	arlal	7662
Madan Shobha	madan	7402
Misra Neeraj	neeraj	7087
Raghavendra V	vrag	7084
Rathore RKS	rksr	7228
Rathish Kumar BV	bvrk	7660
Shunmugaraj P	spraj	7297
Sinha Prawal	prawal	7213
Tewari UB	ubtewari	7015

ASSOCIATE PROFESSORS

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Ghorai S	sghoria	7461
Maloo AK	akmaloo	7813
Mitra A.	amitra	6064
Rawat Rama	rrawat	7466
Santhanam G	santhana	7433

ASSISTANT PROFESSORS

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Mitra S.	smitra	6044
Nilakantan N.	nandini	7066
Ray SK	skray	7972
Shalabh	shalab	7905

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The Department of Mathematics and Statistics (earlier known as the Department of Mathematics) came into existence together with IIT Kanpur in 1960. Right from its inception the Department shares the vision of the Institute in striving for excellence in research and teaching activities. The department has succeeded in this endeavor by producing highly qualified and motivated mathematicians who are providing leadership in different educational institutions and R&D organizations in India and abroad. The vibrant academic environment of the department is nurtured by strongly motivated faculty and students.

The broad areas of research specialization in the department are: Algebra, Analysis, Biomathematics, Complex Dynamics, Topology, Combinatorics, Mathematical Logic, Geometry, Differential Equations, Optimization, Fluid Mechanics, Mathematical Modeling, Computational Fluid Dynamics, Parallel Computing, Image Processing and Probability and Statistics.

The current pace of advancement of technology needs a coherent back up of basic science education and research. The vibrant academic ambience and research infrastructure of IIT Kanpur provides an opportunity to pursue research career in frontier areas of basic sciences as well as in interdiciplinary areas of science and technology. The department encourages interdisciplinary trends with the help of the expertise available at this Institute. In the coming decade, apart from the existing areas, the department intends to develop areas related to mathematical aspects of computing science in all its manifestations.

ACADEMIC PROGRAMMES

At the Master's level, the department has a 5 year M.Sc. (Integrated) Programme in Mathematics and Scientific Computing. The admission to this programme is through the Joint Entrance Examination (JEE). The philosophy behind this programme is to provide young students with an exposure to Engineering Sciences during the first two years as a core programme common to all undergraduate students of the Institute. Thereafter, the students of this programme are trained with the professional courses in the department up to the Master's level.

The department also has M.Sc. (2 year) programmes in (i) Mathematics and (ii) Statistics, where the students are selected with a Bachelor's degree though a Joint Admission Test (JAM) common to all IIT's. This curriculum eventually merges with that of M.Sc. (integrated) programme.

The department offers Ph.D. programmes in (i) Mathematics and (ii) Statistics. The admissions to these programmes are through GATE/CSIR/NET examination followed by a departmental interview/ test.

These programmes are dynamic in nature and are flexible enough to allow students to pursue their own interests even outside the department. The scope of these programmes is to provide comprehensive knowledge and training in the fundamental principles. It also trains them in the mathematical aspects of computing science. The department has a well equipped PC lab, providing computing and remote access facilities exclusively to the department students. It also has a Parallel Computing Lab and its own computer server. The department has well stocked departmental library. The P. K. Kelkar Library of the Institute has been identified as Regional Library for Mathematics by the National Board for Higher Mathematics (NBHM).

CURRENT COURSE STRUCTURE FOR M.Sc. [5-YEAR] STUDENTS
MATHEMATICS & SCIENTIFIC COMPUTING

	SEMESTER				
	First	Second	Third	Fourth	Fifth
COURSE	CHM 101 PHY 101 PHY 102 MTH 101 ESC 101 PE 101 HSS-I-1/ ENG 112	TA 101 PHY 103 MTH 102 ESC 102 MTH 100 PE 102	MTH 203 CHM 201 TA 201 ESO-211 MTH 201	HSS-I-2 ESO 209 MTH 202 MTH 204 MTH 302	HSS-II-1 MTH 301 MTH 311 OE-2 MTH 401
	SEMESTER				
	Sixth	Seventh	Eighth	Ninth	Tenth
COURSE	OE/DF MTH 304 MTH 306 MTH 308 GE - 1*	OE/DF MTH 403 MTH 421 MTH 423 GE-2	GE - 3 GE - 4 GE - 5 DEL - 1 NDE - 1	HSS-II-2 MTH 598 GE - 6 OE - 3 OE - 4	MTH 599 GE - 7 DEL - 2 NDE-2 OE - 5

COM 200	Communication Skills
CHM 201	Chemistry
ESO 209	Probability & Statistics
HSS	Humanities & Social Sciences
MTH 203	Mathematics-III
TA 201	Manufacturing Processes
DE	Departmental Elective
NDE	Non-departmental Elective
OE	Open Elective (any course in any Department)
MTH ***	Professional Courses
GE	Group Electives*

MTH 201	Linear Algebra
MTH 202	Discrete Mathematics
MTH 204	Algebra-I
MTH 301	Analysis-I
MTH 302	Mathematical Logic
MTH 304	Topology
MTH 306	Linear programming & Extensions
MTH 308	Principles of Numerical Computations
MTH 311	Probability Theory-I
MTH 401	Theory of Computation
MTH 403	Complex Analysis
MTH 421	Ordinary Differential Equations
MTH 423	Introduction to Continuum Mechanics
MTH 598/599	Project-I & II

* The student has to take a course from one of the two prescribed lists A and B. During the entire programme, every student has to take a minimum of two courses from each group (A and B). The list is given on the next page.

Group Electives

Group A : **MTH 404, MTH 405, MTH 411, MTH 424, MTH 611, MTH 620, MTH 648, MTH 649**

Group B : **MTH 412, MTH 416, MTH 418, MTH 428, MTH 506, MTH 511, MTH 515, MTH 522, MTH 523, MTH 524, MTH 603, MTH 657, MTH 692, MTH 693**

MTH 404	Analysis-II
MTH 405	Functional Analysis
MTH 411	Probability Theory-II
MTH 424	Partial Differential Equations
MTH 611	Algebra-II
MTH 620	Measure Theory
MTH 648	Differential Geometry
MTH 649	Algebraic Topology

MTH 412	Stochastic Processes
MTH 416	Regression Analysis
MTH 418	Inference-I
MTH 428	Mathematical Methods
MTH 506	Optimization
MTH 511	Statistical Simulation & Data Analysis
MTH 515	Inference-II
MTH 522	Finite Element Method
MTH 523	Fluid Mechanics
MTH 524	Algorithms
MTH 603	Mathematical Modelling
MTH 657	Graph Theory
MTH 692	Numerical Solutions to Ordinary Diffl. Equations
MTH 693	Numerical Solutions to Partial Diffl. Equations

STRUCTURE OF THE M.Sc. (TWO YEAR) PROGRAM IN MATHEMATICS

YEAR I		YEAR II	
Semester I	Semester II	Semester III	Semester IV
MTH 201	MTH 204	MTH 403	OE - II
MTH 301	MTH 304	MTH 405	MTH 306
MTH 409	MTH 308	MTH 421	MTH 424
MTH 423	MTH 404	DE - I	DE - II
MTH 428	ESO 209	OE - I	MTH 598/ DE - III

STRUCTURE OF THE M.Sc. (TWO YEAR) PROGRAM IN STATISTICS

YEAR I		YEAR II	
Semester I	Semester II	Semester III	Semester IV
MTH 311	MTH 306	MTH 513	MTH 514
MTH 409	MTH 412	MTH 515	MTH 516
MTH 413	MTH 411	MTH 517	MTH 511
MTH 415	MTH 416	DE - I	OE - II
MTH 417	MTH 418	OE - I	MTH 598/ DE-II

ESO 209	Probability & Statistics
MTH 201	Linear Algebra
MTH 204	Algebra-I
MTH 301	Analysis-I
MTH 304	Topology
MTH 306	Linear programming & Extensions
MTH 308	Principles of Numerical Computations
MTH 403	Complex Analysis
MTH 404	Analysis-II
MTH 405	Functional Analysis
MTH 409	Computer Prog. & Data Sructures
MTH 421	Ordinary Differantial Equations
MTH 423	Introduction to Continuum Mechanics
MTH 424	Partial Differential Equations
MTH 428	Mathematical Methods
MTH 598	Project
MTH 311	Probability Theory-I
MTH 411	Probability Theory-II
MTH 412	Stochastic Processes
MTH 413	Real Complex Analysis
MTH 415	Matrix Theory & Linear Estimation
MTH 416	Regression Analysis
MTH 417	Sampling Theory
MTH 418	Inference-I
MTH 511	Statistical Simulations & Data Analysis
MTH 513	Analysis of Variance
MTH 514	Multivariate Analysis
MTH 515	Inference-II
MTH 516	Non-parameteric Inference
MTH 517	Time series Analysis

DE	Departmental Elective
OE	Open Elective (any course in any Department)
GE	Group Electives*

COURSE DESCRIPTION

ESO 209 **PROBABILITY AND STATISTICS** **Prereq. MTH-101**

L-T-P-D-[C]
3-1-0-1-[4]

Probability:- Axiomatic definition, Properties. Conditional probability, Bayes rule and independence of events. Random variables, Distribution function, Probability mass and density functions, Expectation, Moments, Moment generating function, Chebyshev's inequality. Special distributions: Bernoulli, Binomial, Geometric, Negative Binomial, Hypergeometric, Poisson, Uniform, Exponential, Gamma, Normal, Joint distributions, Marginal and conditional distributions, Moments, Independence of random variables, Covariance, Correlation, Functions of random variables, Weak law of large numbers, P. Levy's central limit theorem (i.i.d. finite variance case), Normal and Poisson approximations to binomial, Statistics:- Introduction: Population, Sample, Parameters. Point Estimation: Method of moments, MLE, Unbiasedness, Consistency, Comparing two estimators (Relative MSE). Confidence interval estimation for mean, difference of means, variance, proportions, Sample size problem, Test of Hypotheses:-N-P Lemma, Examples of MP and UMP tests, p-value, Likelihood ratio test, Tests for means, variance, Two sample problems, Test for proportions, Relation between confidence intervals and tests of hypotheses, Chi-square goodness of fit tests, Contingency tables, SPRT, Regression Problem:- Scatter diagram, Simple linear regression, Least squares estimation, Tests for slope and correlation, Prediction problem, Graphical residual analysis, Q-Q plot to test for normality of residuals, Multiple regression, Analysis of Variance: Completely randomized design and randomized block design, Quality Control: Shewhart control charts and Cusum charts.

MTH 100 **INTRODUCTION TO PROFESSION** **Prereq. None**

L-T-P-D-[C]
2-0-0-0-[0]

Mathematical thought process: Proofs by construction, existence, specialization, induction, contradiction, Abstraction, Sets: Russel's paradox, Axiom of Choice, Counting, Infinity, Continuum Hypothesis, Numbers:Real numbers, Cantor's diagonalization arguments, e, p, Complex numbers, Fundamental theorem of algebra, Fermat's last theorem, Goldbach's conjecture, Analysis: Existence of nowhere differentiable functions, Zeno's paradox-infinite series, Geometry: Euler's theorem, Mobius strip, Trisection of an angle, Squaring a circle, Euclid's parallel postulate, Non-Euclidean geometries, Mathematical structures: Euclidean structure, Metric spaces, Hilbert spaces, Topology, Groups, Rings, Modules, Vector spaces, Algebraic geometry, Networks, Map coloring, Graphs, Computation:Iteration Approximations, Computability, Church-Turing thesis

MTH 101 **MATHEMATICS-I** **Prereq. None**

L-T-P-D-[C]
3-1-0-1-[4]

Real numbers, Sequences; Series; Power series, Limit, Continuity; Differentiability, Mean value theorems and applications; Linear Approximation, Newton and Picard method, Taylor's theorem (one variable), Approximation by polynomials, Critical points, convexity, Curve tracing, Riemann Integral, fundamental theorems of integral calculus, Improper integrals, Trapezoidal and Simpson's rule; error bounds, Space coordinates, lines and planes, Polar coordinates, Graphs of polar equations; Cylinders, Quadric surfaces, Volume, Area, length; Continuity, Differentiability of vector functions, arc length; Curvature, torsion, Serret-Frenet formulas, Functions of two or more variables, partial derivatives Statement only, of Taylor's theorem and criteria for maxima/Minima/saddle points, Double, triple integrals, Jacobians; Surfaces, integrals, Vector Calculus, Green, Gauss, Stokes Theorems.

MTH 102 **MATHEMATICS-II** **Prereq. MTH 101**

L-T-P-D-[C]

3-1-0-1-[4]

Matrices: matrix operations (Addition, Scalar Multiplication, Multiplication, Transpose, Adjoint and their properties; Special types of matrices (Null, Identity, Diagonal, Triangular, Symmetric, Skew-Symmetric, Hermitian, Skew-Hermitian, Orthogonal, Unitary, Normal), Solution of the matrix Equation Ax = b; Row-reduced Echelon form, Determinants and their properties, Vector Space $R^n(R)$; Subspaces; Linear Dependence/Independence; Basis; Standard Basis of R^n; Dimension; Coordinates with respect to a basis; Complementary Subspaces; Standard Inner product; Norm; Gram-Schmidt Orthogonalization Process; Generalization to the vector space $C^n(C)$, Linear Transformation from R^n to R^m (motivation, X* AX); Image of a basis identifies the linear transformation; Range Space and Rank; Null Space and Nullity; Matrix Representation of a linear transformation; Structure of the solutions of the matrix equation Ax = b; Linear Operators on R^n and their representation as square matrices; Similar Matrices and linear operators; Invertible linear operators; Inverse of a non-singular matrix; Cramer's method to solve the matrix equation Ax = b; Eigenvalues and eigenvectors of a linear operator; Characteristic Equation; Bounds on eigenvalues; Diagonalizability of a linear operator; Properties of eigenvalues and eigenvectors of Hermitian, skew-Hermitian, Unitary, and Normal matrices (including symmetric, skew-symmetric, and orthogonal matrices), Implication of diagonalaizability of the matrix $A + A^T$ in the real quadratic form X^TAX; Positive Definite and Semi-Positive Definite matrices, Complex Numbers, geometric representation, powers and roots of complex numbers, Functions of a complex variable, Analytic functions, Cauchy-Riemann equations; elementary functions, Conformal mapping (for linear transformation); Contours and contour integration, Cauchy's theorem, Cauchy integral formula; Power Series, term by term differentiation, Taylor series, Laurrent series, Zeros, singularities, poles, essential singularities, Residue theorem, Evaluation of real integrals and improper integrals.

MTH 201 **LINEAR ALGEBRA** **Prereq. MTH 102**

L-T-P-D-[C]

3-1-0-0-[4]

Fields and linear equations. Vector spaces. Linear transformations and projections, Determinants. Elementary canonical forms: diagonalization, triangulation, primary decomposition etc. Secondary decomposition theorem, Rational canonical forms, Jordan canonical forms and some applications. Inner product spaces, Selfadjoint, Unitary and normal operators, Orthogonal projections. Bilinear forms, Symmetric, Skew-symmetric, Positive and semi-positive forms etc.

MTH 202 **DISCRETE MATHEMATICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Permutations and combinations and basic definitions. Generating functions. Polya's enumeration theory. Recurrence relations. Principle of inclusion and exclusion. Balanced incomplete block design. Difference sets. System of distinct representatives. Orthogonal Latin squares. Hadamard matrices.

MTH 203 **MATHEMATICS-III** **Prereq. MTH 102**

L-T-P-D-[C]
3-1-0-1-[4]

Introduction and Motivation to Differential Equations, First Order ODE y'=f(x,y)- geometrical Interpretation of solution, Equations reducible to separable form, Exact Equations, Integrating factor, Linear Equations, Orthogonal trajectories, Picard's Theorem for IVP (without proof) and Picard's iteration method, Euler' Method, Improved Euler's Method, Elementary types of equations. F(x,y,y') = 0; not solved for derivative, Second Order Linear differential equations: fundamental system of solutions and general solution of homogeneous equation. Use of Known solution to find another, Existence and uniqueness of solution of IVP, Wronskian and general solution of non-homogeneous equations. Euler-Cauchy Equation, extensions of the results to higher order linear equations, Power Series Method - application to Legendre Eqn., Legendre Polynomials, Frobenious Method, Bessel equation, Properties of Bessel functions, Sturm-Liouville BVPs, Orthogonal functions, Sturm comparision Theorem, Laplace transform, Fourier Series and Integrals, Introduction to PDE, basic concepts, Linear and quasilinear first order PDE, second order PDE and classification of second order semilinear PDE (Canonical form), D' Alemberts formula and Duhamel's principle for one dimensional wave equation, Laplace's and Poisson's equations, Maximum principle with application, Fourier Method for IBV problem for wave and heat equation, rectangular region, Fourier method for Laplace's equation in three dimensions, Numerical methods for Laplace's and Poisson's equations.

MTH 204 **ALGEBRA** **Prereq. MTH 203 / #**

L-T-P-D-[C]
3-1-0-0-[4]

Binary operation, and its properties, Definition of a group, Examples and basic properties. Subgroups, Coset of a subgroup, Lagrange's theorem. Cyclic groups, Order of a group. Normal subgroups, Quotient group. Homomorphisms, Kernel Image of a homomorphism, Isomorphism theorems. Permutation groups, Cayley's theorems. Direct product of groups. Group action on a set, Semi-direct product. Sylow' theorems. Structure of finite abelian groups. Applications, Some nontrivial examples. Rings: definition, Examples and basic properties. Zero divisors, Integral domains, Fields, Characteristic of a ring, Quotient field of an integral domain. Subrings, Ideals, Quotient rings, Isomorphism theorems. Ring of polynomlals. Prime, Irreducible elements and their properties, UFD, PID and Euclidean domains. Prime ideal, Maximal ideals, Prime avoidance theorem, Chinese remainder theorem.

MTH 215 **NUMBER THEORY** **Prereq. #**
L-T-P-D-[C]
3-1-0-0-[4]

Divisibility, Primes, Congruences, Residue systems, Primitive roots; Quadratic reciprocity, Some arithmetic functions, Farey fractions, Continued fractions, Some Diophantine equations, Bertrands postulate and the partition function.

MTH 247 **ELEMENTARY DECISION THEORY** **Prereq. MTH 203 / #**
L-T-P-D-[C]
3-1-0-0-[4]

Utility and loss functions; The prior information; Basic principles of making decisions under uncertainity; Bayes and Minimax decision rules; Prior and posterior analysis; Applications to classical statistical inference procedures; Sequential procedures.

MTH 300 **BASIC STRUCTURE OF MATHEMATICS** **Prereq. #**
L-T-P-D-[C]
3-1-0-0-[4]

Finite and Infinite Sets: Finite sets, Countable sets, Uncountable sets. Groups and Symmetry: Groups, Sub-groups, Lagrange theorem, Normal subgroups, Quotient groups, Group actions, Homomorphisms, Group of symmetry - rigid motion group, finite subgroups of the rotation group, symmetric group. Metric Spaces: Open sets, Closed sets, Sequences, Continuity, Complete metric spaces, Contraction principle and applications, Connectedness and compactness. Fractals: Metric space of fractals and its completeness, Iterated function systems, Attractor, Algorithms to generate fractals. Topology of Surfaces: Euler's theorem, Construction of surfaces by identification: Torus, mobius strip, Klein bottle.

MTH 301 **ANALYSIS-I** **Prereq. MTH 101 / #**
L-T-P-D-[C]
3-1-0-0-[4]

Real number system and set theory : Completeness property, Archimedian property, Denseness of rationals and irrationals, Countable and uncountable, Cardinality, Zorn's lemma, Axiom of choice. Metric spaces: Open sets, Closed sets, Continuous functions, Completeness, Cantor intersection theorem, Baire category theorem, Compactness, Totally boundedness, Finite intersection property. Functions of several variables: Differentiation, inverse and implicit function theorems. Rlemann-Stieitjes integral: Definition and existence of the integral, Properties of the integral, Differentiation and integration. Sequence and Series of functions: Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation. Equicontinuity, Ascoli's Theorem.

MTH 302 **MATHEMATICAL LOGIC** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Formal theories, consequence and deduction. Classical Propositional Calculus: Syntax, truth, validity, Adequacy of connectives, normal forms, applications to circuit design, Axiomatic treatment, deduction theorem, derived rules of inference, Soundness, Independence of axioms, Consistency, completeness, Completeness w.r.t. Boolean algebras, Computer-assisted formal proofs: tableaux, resolution. Classical first order theories: Syntax, satisfaction, truth validity, Axiomatic treatment, Equality, Examples of first-order theories : Peano arithmetic, Groups, Orderings, Basis of axiomatic set theory, Deduction theorem, derived rules of inference, soundness, Consistency, completeness, Lowenheim-Skolem theorems, compactness, First-order theories with equality, Decidability, Computer-assisted formal proofs: tableaux, resolution. Godel's incompleteness theorems. Examples of other/non-classical logics. Other proof techniques-natural deduction, sequent calculus.

MTH 304 **TOPOLOGY** **Prereq. MTH 301**

L-T-P-D-[C]
3-1-0-0-[4]

Topological spaces, Basis for a topology, The order topology, Subspace topology, Closed sets. Countability axioms, Limit points, Convergence of nets in topological spaces, Continuous functions, The product topology, Metric topology, Quotient topology. Connected spaces, Connected sets in R, Components and path components, Compact spaces, Compactness in metric spaces, Local compactness, One point compactification. Separation axioms, Uryshon's lemma, Uryshon's metrization theorem, Tietz extension theorem. The Tychonoff theorem, Completely regular spaces, Stone -Czech compactification.

MTH 306 **LINEAR PROGRAMMING AND EXTENSIONS** **Prereq. MTH 201**

L-T-P-D-[C]
3-1-0-0-[4]

Linear Models: Formulation and Examples, Basic Polyhedral Theory- Convexity, Extreme points, Supporting hyperplanes etc, Simplex Algorithm- Algebraic and Geometrical approaches, Artificial variable technique, Duality Theory: Fundamental theorem, Dual simplex method, Primal-dual method, Sensitivity Analysis, Bounded Variable L.P.P. Transportation Problems: Models and Algorithms, Network Flows: Shortest path Problem, Max-Flow problem and Min-cost Flow problem, Dynamic Programming: Principle of optimality, Discrete and continuous models.

MTH 308 **PRINCIPLES OF NUMERICAL COMPUTATION** **Prereq. MTH 203**

L-T-P-D-[C]
3-1-0-0-[4]

Root find problem for transcendental and polynomial equations - methods and analysis. Interpolation: Lagrange, divided difference, finite difference, Hermite and Spline interpolation, Inverse interpolation. Approximation - Least squares and minimax approximation. Numerical differentiation. Numerical integration-Newton-Cotes and Gauss quadratures. Numerical methods (direct and iterative) for solving linear systems with error analysis. Eigen values and eigen vectors for linear algebraic systems. Numerical methods for initial value problems.

MTH-311 **PROBABILITY THEORY-I** **Prereq. ESO 209**

L-T-P-D-[C]
3-1-0-0-[4]

Sets and set operations, Sample space, Sigma fields, Measurable spaces, Events. Measure spaces, Caratheodory's extension theorem, Construction of measures, Product spaces, Product measures. Probability measurer and its properties. Independence of events. Measurable functions, Approximations through simple functions, Random variables. Induced measures and probability distribution functions: discrete, continuous and absolutely continuous, one to one correspondence with induced probability measure, decomposition. Independence of random variables, Borel-Cantelli lemmas. Integration in measure spaces, Expectation, Fatou's lemma, Monotone convergence and dominated convergence theorems, Uniform integrability, Markov, Chebyshev, Cauchy-Schwarz, Minkowski, Holder, Jensen and Lyapunov inequalities. Absolute continuity of measures, Randon-Nikodym theorem, Conditional expectation, Conditional probability measures. Fubini's theorem, Convolution. Functions of random variables, Jacobian theorem.

MTH 401 **THEORY OF COMPUTATION** **Prereq. ESO211 / MTH303 / #**

L-T-P-D-[C]
3-1-0-0-[4]

Some fundamental proof techniques. Finite Automata: Finite automata and regular languages, Languages that are and are not regular, Algorithm aspects of finite automata. Context-free grammars: Push-down automata, Languages that are and are not context-free, Algorithms for context-free grammars. Basic Turing machine model and Turing computability: Variants of Turing machines. Grammars and Turing machines: Primitive recursive functions, μ-recursive functions and Turing computability. Church-Turing thesis and Universal Turing machines: Halting problem, Some undecidable problems. Time-bounded Turing machines: Classes P and NP, NP-completeness, Examples of NP-complete problems, The time hierarchy.

MTH 403 **COMPLEX ANALYSIS** **Prereq. MTH 301 / #**

L-T-P-D-[C]
3-1-0-0-[4]

Spherical representation of extended complex plane, Analytic Functions, Harmonic Conjugates, Elementary Functions, Cauchy Theorem and Integral Formula, Homotopic version, Power Series, Analytic Continuation and Taylor's theorem, Zeros of Analytic functions, Hurwitz Theorem, Maximum Modulus Theorem and Open Mapping Theorem, Laurent's Theorem , Classification of singularities, Residue theorem and applications, Argument Principle, Theorems of Rouche and Gauss-Lucas, Mobius Transformations, Schwarz-Christoffel Transformation, Iterated Functions System, Fractals, Algorithms to generate Sierpinski Gasket.

MTH 404 **ANALYSIS-II** **Prereq. MTH 301 / #**

L-T-P-D-[C]

3-1-0-0-[4]

Lebesgue measure on R^n : Introduction, outer measure, measurable sets, Lebesgue measure, regularity properties, a non-measurable set, measurable functions, Egoroff's theorem, Lusin's theorem. Lebesgue integration: Simple functions, Lebesgue integral of a bounded function over a set of finite measure, bounded convergence theorem, integral of nonnegative functions, Fatou's Lemma, monotone convergence theorem, the general Lebesgue integral, Lebesgue convergence theorem, change of variable formula. Differentiation and integration: Functions of bounded variation, differentiation of an integral, absolutely continuity, L^p-spaces: The Minkowski's inequality and Hölder's inequality, completeness of L^p, denseness results in L^p. Fourier series: Definition of Fourier series, formulation of convergence problems, The L^2 theory of Fourier series, convergence of Fourier series.

MTH 405 **FUNCTIONAL ANALYSIS** **Prereq. MTH 301 / #**

L-T-P-D-[C]

3-1-0-0-[4]

Fundamentals of normed linear spaces: Normed linear spaces, Riesz lemma, characterization of finite dimensional spaces, Banach spaces. Bounded linear maps on a normed linear spaces: Examples, linear map on finite dimensional spaces, finite dimensional spaces are isomorphic, operator norm. Hahn-Banach theorems: Geometric and extension forms and their applications. Three main theorems on Banach spaces: Uniform boundedness principle, divergence of Fourier series, closed graph theorem, projection, open mapping theorem, comparable norms. Dual spaces and adjoint of an operator: Duals of classical spaces, weak and weak* convergence, Banach Alaoglu theorem, adjoint of an operator. Hilbert spaces : Inner product spaces, orthonormal set, Gram-Schmidt ortho-normalization, Bessel's inequality, Orthonormal basis, Separable Hilbert spaces. Projection and Riesz representation theorem: Orthonormal complements, orthogonal projections, projection theorem, Riesz representation theorem. Bounded operators on Hilbert spaces: Adjoint, normal, unitary, self adjoint operators, compact operators, eigen values, eigen vectors, Banach algebras. Spectral theorem: Spectral theorem for compact self adjoint operators, statement of spectral theorem for bounded self adjoint operators.

MTH 406 **DISTRIBUTION THEORY AND FOURIER TRANSFORMS**

L-T-P-D-[C] **Prereq. MTH 304, MTH 405 #**

3-1-0-0-[4]

Introduction, Test function spaces, Calculus with distributions, supports of distributions, Structure theorems, convolutions, Fourier transforms, L^1 L^2 theory of Fourier Transform, Tempered distributions, Paley-Wiener theorem, weiner-Tauberian theorem, Applications of distributions theory and Fourier transform to differential equations.

MTH 407 L-T-P-D-[C] 3-1-0-0-[4]

CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS **Prereq. MTH 203 #**

Euler's equation and its generalization; Variational problems with moving boundaries; Rayleigh-Ritz method. Classification of integral equations, Neumann's iterative method for Fredholm's equation of 2nd kind; Volterra type integral equations; Integral equations of first kind.

MTH 409 L-T-P-D-[C] 3-1-0-0-[4]

COMPUTER PROGRAMMING AND DATA STRUCTURES **Prereq. #**

Fortran 77: Integer and real operations, logic and complex operations, Control statements, Do statement, arrays subroutines and functions. Introduction to data structures in C Programming Language; Arrays: linear, Multi-dimensional, Records, Pointers, Stacks, queues, Linked Lists; Singly linked lists, doubleed linked lists, circular linked lists, Application of Linked Lists; Polynomial addition, sparse matrices, Trees: binary trees, red-black trees, Hash tables. some discussion about data structures in F90-F95 with examples.

MTH 411 L-T-P-D-[C] 3-1-0-0-[4]

PROBABILITY THEORY-II **Prereq. MTH 311 / #**

Tight families of probability distributions, Convergence of probability distribution functions, Helly's theorem, Helly-Bray theorem, Skorohod's fundamental theorem, Scheffe's theorem; Weak convergence, Uniform integrability and convergence of expectations. Characteristic functions, Inversion formula, Levy continuity theorem, Expansion of characteristic functions, Polya's theorem, Bochner's theorem. Moments and uniqueness of the probability distribution, Frechet-Shohat theorem. Central limit theorems: Lindeberg-Levy, Lyapunov and Lindeberg-Feller. Various modes of convergence and the interrelations. Strong and weak laws of large numbers.

MTH 412 L-T-P-D-[C] 2-0-3-0-[4]

STOCHASTIC PROCESSES **Prereq. MTH-311 / #**

Definition and classification of general stochastic processes. Markov Chains: definition, transition probability matrices, classification of states, limiting properties. Markov Chains with Discrete State Space: Poisson process, birth and death processes. Renewal Process: renewal equation, mean renewal time, stopping time. Markov Process with Continuous State Space: Introduction to Brownian motion.

MTH 413 L-T-P-D-[C] 3-1-0-0-[4]

REAL AND COMPLEX ANALYSIS **Prereq. #**

Real and complex numbers; Open, closed and compact sets in R^n ; Limits and continuity; Differentiation and Integration; Sequences and series; Sequences and series of functions; Complex integration.

MTH 415 **MATRIX THEORY AND LINEAR ESTIMATION** **Prereq. ESO 209, #**

L-T-P-D-[C]
3-1-0-0-[4]

Review of finite dimensional vector spaces (Null space and nullity), Linear dependence and independence, Matrix algebra, Rank of a Matrix, Inverse of a non-singular matrix. Hermite canonical forms, Generalised inverses, Moore-Penrose inverse, solution of linear equations, Projection and orthogonal projection matrices, Idempotent matrices. Real quadratic forms, reduction of pair of real symmetric matrices, Singular value decomposition. extrema of a quadratic forms, Vector and matrix differentiation. Least squares theory and Gauss-Markoff theorem, Cochran's theorem and distribution of quadratic forms, test of single linear hypothesis and more than one hypothesis, ANOVA table, Confidence interval and regions, Power of F-test. Multiple comparisons and simultaneous confidence intervals.

MTH 416 **REGRESSION ANALYSIS** **Prereq. MTH 415, ESO 209, #**

L-T-P-D-[C]
3-1-0-0-[4]

Simple and multiple linear regression, Polynomial regression and orthogonal polynomials, Test of significance and confidence intervals for parameters. Residuals and their analysis for test of departure from the assumptions such as fitness of model, normality, homogeneity of variances, detection of outliers, Influential observations, Power transformation of dependent and independent variables. Problem of multicollinearity, ridge regression and principal component regression, subset selection of explanatory variables, Mallow's Cp statistic. Nonlinear regression, different methods for estimation (Least squares and Maximum likelihood), Asymptotic properties of estimators. Generalised Linear Models (GLIM), Analysis of binary and grouped data using logistic and log-linear models.

MTH 417 **SAMPLING THEORY** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Principles of sample surveys; Simple, Stratified and unequal probability sampling with and without replacement; ratio, product and regression method of estimation; systematic sampling; cluster and subsampling with equal unequal sizes; double sampling; sources of errors in surveys.

MTH 418 **INFERENCE I** **Prereq. ESO 209, #**

L-T-P-D-[C]
3-1-0-0-[4]

Parametric models, parametrs, random sample and its likelihood, statistic and its sampling distributions, problems of inference. Examples from standard discrete and continuous models such as Bernoulli, Binomial, Poisson, Negative Binomial, Normal, Exponential, Gamma, Weibull, Pareto etc. Concept of sufficiency, minimal sufficiency, Neyman factorization criterion, Fisher information, exponential families. Maximum likelihood estimators, method of moment estimators, percentile estimators, least squares estimators, minimum mean squares estimators, uniformly minimum variance unbiased estimators, Rao-

Blackwell theorem, Cramer-Rao lower bond, different examples. Statistical Hyptheses-simple and composite, statistical tests, critical regions, Type-I and Type-II errors, size and power of a test, Neyman Pearson lemma and its different applications. Most powerful test, uniformly most powerful test, unbiased test and uniformly most unbiased test. Likelihood ratio test. Interval estimation, confidence intervals, construction of confidence intervals, shortest expected length confidence interval, most accurate one sided confidence interval and its relation to UMP test.

MTH 421 **ORDINARY DIFFERENTIAL EQUATIONS** **Prereq. MTH-203 / #**

L-T-P-D-[C]
3-1-0-0-[4]

Vector Fields, Graphical representation of solutions, Lipschitz functions, Integral inequalities, Uniqueness of solutions, Boundary value problems, Green's functions, Distribution of zeros of solutions, Functional analytical preliminaries, Existence of solutions by Picard's method, Existence by Perron's method, Uniqueness and continuous dependence, Continuity and differentiability w.r.t., initial Conditions and parameters, Continuation of solutions, Linear equations, general theory, Solutions of linear equations with constant coefficients, Equations with periodic coefficients, Floquet's theory, Classification of stationary points and phase portraits, Oscillation and boundedness of solutions, Lyapunov theory of stability, Poincare Bendixon theorem and applications.

MTH 423 **INTRODUCTION TO CONTINUUM MECHANICS** **Prereq. MTH-203 / #**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction to tensors. Stress tensor. Equilibrium equations. Mohr's circle for plane stress. Deformation, Strain tensor, Rate of deformation tensor. Equations of motion. Dynamic similarity. Exact solutions. Laminar boundary layer over a float plat. Vorticity circulation & irrational flow. Torsion of cylindrical bars, Plane elastic waves.

MTH 424 **PARTIAL DIFFERENTIAL EQUATIONS** **Prereq. MTH-421 / #**

L-T-P-D-[C]
3-1-0-0-[4]

Mathematical models leading equations. First order quasi-linear equations. Nonlinear equations. Cauchy-Kowalewski's theorem. Higher order equations and characteristics. Classification of second order equations. Riemann's method and applications. One dimensional wave equation and De'Alembert's method. Solution of three dimensional wave equation. Method of decent and Duhamel's principle. Solutions of equations in bounded domains and uniqueness of solutions. BVPs for Laplace's and Poisson's equations. Maximum principle and applications. Green's functions and properties. Existence theorem by Perron's method. Heat equation, Maximum principle. Uniqueness of solutions via energy method. Uniqueness of solutions of IVPs for heat conduction equation. Green's function for heat equation. Finite difference method for the existence and computation of solution of heat conduction equation.

MTH 428 **MATHEMATICAL METHODS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Multiple Integral Theorems and their Applications: Green's theorem, Stoke's theorem and Gauss divergence theorem. Integral Transforms: Fourier, Fourier sine/cosine and Hankel Transforms with their inverse transforms (properties, convolution theorem and application to solve differential equation). Perturbation Methods: Perturbation theory, Regular perturbation theory, Singular perturbation theory, Asymptotic matching. Calculus of Variation: Introduction, Variational problem with functionals containing first order derivatives and Euler equations. Functionals containing higher order derivatives and several independent variables. Variational problem with moving boundaries. Boundaries with constraints. Higher order necessary conditions, Weiretrass function, Legendre's and Jacobi's condition. Existence of solutions of variational problems. Rayleigh-Ritz method, statement of Ekeland's variational principle; Self adjoint, normal and unitary operators; Banach algebras.

MTH 488 **TOPICS IN PROBABILITY AND STOCHASTIC PROCESSES** **Prereq. MTH 411, #**

L-T-P-D-[C]
3-1-0-0-[4]

Conditional probabilities and conditional expectations with respect to a algebra, Construction of a process with a given finite dimensional distribution, The Hilbert space L^2, Gaussian systems, Markov processes with continuous state space, Renewal theory, Stationary processes and Ergodic theory, Martingales, Branching processes.

MTH 506 **OPTIMIZATION** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Optimization Problem: various examples, Characterization of optimality and constrained optimal problems, Convex sets and convex functions and their properties, Non-linear programming theory - Kuhn-Tucker conditions, Lagrange's theory, Duality theory, Search techniques - one variable and several variables, Pontryagin's maximum principle and its applications, Dynamic programming and its applications.

MTH 511 **STATISTICAL SIMULATION AND DATA ANALYSIS** **Prereq. ESO-209 / #**

L-T-P-D-[C]
3-1-0-0-[4]

Simulation of random variables from discrete, continuous, multivariate distributions and stochastic processes, Monte-Carlo methods. Regression analysis, scatter plot, residual analysis. Computer Intensive Infer-ence Methods - Jack-Knife, Bootstrap, cross validation, Monte Carlo methods and permutation tests. Graphical representation of multivariate data, Cluster analysis, Principal component analysis for dimension reduction.

MTH 512 **FOUNDATIONS OF MATHMATICAL FINANCE** **Prereq. ESO-209 / #**

L-T-P-D-[C]

3-1-0-0-[4]

Fundamentals of the financial markets, meaning of notions like asset portfolio derivatives (example : Futures, options forwwards etc.)

Binomial asset pricing model under no arbitrage condition single-period model, multi-period model. risk-neutral probabilities, martingales in the discreate framework, risk-neutral valuation of European and American ooptions under no arbitrage condition in the binomial framework.

Introduction to continuous time models. Basic notions of probability theory on an infinite sample space. Change of measure and the Radon-Nikodym derivative. Random walk and Brownian motion, Ito intergral and Ito formula Black-Scholes formula for pricing an European call option.

Markowitz mean-variance portfolio optimization problem. Single-period and multi- period model, Capital asset pricing model, outlines of the measures of risk, Value- at - Risk (VaR) and Conditional - Value- at - Risk (CVaR)

MTH 513 **ANALYSIS OF VARIANCE** **Prereq. MTH 416**

L-T-P-D-[C]

3-1-0-0-[4]

Analysis of completely randomized design, randomized block design, Latin squares design; Splitplot, 2" and 3" factorials with total and partial confounding, two-way non-orthogonal experiment, BIBD, PBIBD; Analysis of covariance, missing plot techniques; First and second order response surface designs.

MTH 514 **MULTIVARIATE ANALYSIS** **Prereq. MTH 418**

L-T-P-D-[C]

3-1-0-0-[4]

Multivariate normal distribution, assessing normality, Wishart and Hotelling's T^2; Comparisons of several multivariate means, MANOVA; multivariate linear regression models; principal components, factor analysis; canonical correlations; discrimination & classification.

MTH 515 **INFERENCE II** **Prereq. MTH 418**

L-T-P-D-[C]

3-1-0-0-[4]

Group families, the principle of equivariance, location family, scale family, location scale family. Minimum risk equivariance estimators, risk functions, admissibility, prior distribution, posterior distribution, geometric interpretation for finite parameter space, Bayes estimators, limit of Bayes estimators, minimax estimators and their relations. Review of convergence in probability and convergence in distributions. Consistency results of the mle's, and the mme's. Asymptotic relative efficiency. Consistent and Asymptotic Normal (CAN) estimators, Invariance of CAN estimators under different transformations. CAN estimators obtained by moments and MLE methods in one parameter xponential family and multiparameter exponential family. Sequential Probability Ratio Tests and its applications in different practical problems. Invariant test and unbiased tests, Likelihood ratio test and its asymptotic distributions, Wald test, Rao's score test, Pearson c^2 test for goodness of fit. Large sample tests and confidence intervals based on CAN estimators. Consistency of large sample tests and asymptotic powers of large sample tests.

MTH-516 **NON-PARAMETRIC INFERENCE** **Prereq. ESO 209, #**

L-T-P-D-[C]
3-1-0-0-[4]

Order statistics, Run tests, Goodness of fit tests, rank order statistics, sign test and signed rank test. general two-sample problems, Mann-Whitney test, Linear rank tests for location and scale problem, k-sample problem, Measures of association, Power and asymptotic relative efficiency, Concepts of jackknifing, Bootstrap methods.

MTH-517 **TIME SERIES ANALYSIS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Linear stationary processes, AR, MA, ARMA and ARIMA; identification, estimation of the models; forecasting time series regression; Fourier analysis, spectral representation of a stochastic process, properties of ARMA processes in the frequency domain; estimation of the spectrum, Kalman filter.

MTH 520 **NUMERICAL LINEAR ALGEBRA** **Prereq. MTH102/ #**

L-T-P-D-[C]
3-1-0-0-[4]

Computer arithmetic. Vector and matrix norms. Condition number of a matrix and its applications. Singular value decomposition of a matrix and its applications. Linear least-squares problem. Householder matrices and their applications. Numerical methods for matrix eigenvalue problem. Numerical methods for systems and control.

MTH 522 **FINITE ELEMENT METHOD** **Prereq.:#**

L-T-P-D-[C]
3-1-0-0-[4]

Introduction and motivation, Weak formulation of BVP and Galerkin approximation, Piecewise polynomial spaces and finite element method, Computer implementation of FEM, Results from Sobolev spaces, Variational formulation of elliptic BVP, Lax-Milgram theorem, Estimation for general FE approximation, Construction of FE spaces, Polynomial approximation theory in Sobolev spaces, Variational problem for second order elliptic operators and approximations, Mixed methods, Iterative techniques.

MTH 523 **FLUID MECHANICS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Review and General Properties of Navier Stokes Equations; Some Exact solutions of NS equations; Introduction to boundary layer theory; Introduction to turbulent flow; Introduction to compressible flow; Applications.

MTH 524 **ALGORITHMS** **Prereq. #**

L-T-P-D-[C]
3-1-0-0-[4]

Preliminaries: Introduction to algorithms; Analyzing algorithms: space and time complexity; growth of functions; summations; recurrences; sets, etc. Greedy Algorithms: General characteris-tics; Graphs: minimum spanning tree; The knapsack problem; scheduling. Divide and Conquer: Binary search; Sorting: sorting by merging, qucksort. Dynamic Programming: Elements of dynamic programming; The principle of optimality; The knapsack problem; Shortest paths; Chained matrix multiplication. Graph Algorithms: Depth-first search; Breadth-first search; Backtracking; Branch-and-bound. Polynomials and FFT: Representa-tion of polynomials; The DFT and FFT; Efficient FFT implementation. Number Theoretic Algorithms: Greatest common divisor; Modular arithmetic; Solving modular linear equations. Introduction to cryptography. Computational Geometry: Line segment properties; Intersection of any pair of segments; Finding the convex hull; Finding the closest pair of points. Heuristic and Approximate Algorithms: Heuristic algorithms; Approximate algorithms; NP-hard approximation problems.

MTH 531 **ALGEBRAIC TOPOLOGY** **Prereq. MTH 330 #**

L-T-P-D-[C]
3-1-0-0-[4]

Homotopy of paths; The fundamental group, Covering spaces. Simplicial complexes and simplicial maps; Homology groups; Barycentric subdivision; The simplicial approximation theorem. Singular homology groups; The exact homology sequence; The Eilenberg-Steenrod axioms, Mayer-Vietoris sequence.

MTH 598 / MTH 599 **Project I** **Project I** L-T-P-D-[C] 0-0-0-7-[4] For both course **Prereq. #**

MTH 600 **SET THEORY AND LOGIC** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Propositional calculus, Set theoretic concepts; Truth on algebraic systems; The calculus of predicates; Model theory; Proof Theory; Algorithms and recursive functions.

MTH 601 **MATHEMATICS OF COMPUTERIZED TOMOGRAPHY** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Elements of digital image processing. Fourier, Random & related trans-forms.Projection theorem. Helgason-Ludwig consistency theorem. Sampling, resolution, ill-posedness, regularization and accuracy. Limited data problems. SVD, Tikhonov Phillips,CBP, FT, ART, EM, MENT, CSI etc. methods.

MTH 603 **MATHEMATICAL MODELLING** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Elementary mathematical models; Role of mathematics in problem solving;

Concepts of mathematical modelling; System approach; formulation, Analyses of models; Sensitivity analysis, Simulation approach; Pitfalls in modelling, Illustrations.

MTH 606 **BIOMATHEMATICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Biofluid dynamics; Blood flow & arterial diseases; Transport in intestines & lungs; Diffusion processes in human systems; Mathematical study of nonlinear Volterra equations, Stochastic & deterministic models in population dynamics and epidemics.

MTH 608 **MODEL THEORY** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Some first order logic-completeness, compactness and Skolem-Lowenheim theorems, Theories, Models of theories, Elementary extensions and chains, Skolem functions and indiscernibles, Elementary embeddings and equivalence, Algebraic charecterization of elementary equivalence, Ehrenfeucht games, Finite axiomatizability, Lindstrom's characterization theorems, Ultraproducts, Lindenbaum algebras, Ultrafilters, Rasiowa-Sikorski construction. Free models, Basics of logic programming.

MTH 609 **PROOF THEORY AND AUTOMATED DEDUCTION** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Classical Propositional Logic - Deduction Systems, Automatic Methods; Non - classi cal Propositional Logic - Intutionistic Logic, Normalization, Cut Elimination; Curry-Howard Correspondence; First Order Logic-Deduction Systems; Resolution; Tableaux Methods; Equality and Equational Logics; Type theory; Formalized Number Theory; Godel's Incompleteness Theorems.

MTH 610 **APPLIED MATRIX THEORY** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Review of basic lin.alg. canonical factorization. Q-Forms. Courant- Fischer minmax & related theorems. Perron-Frobenius theory. Matrix-stability. Inequalities, g-inverse (A^-, A_m, A^+). Direct, iterative, projection and rotations methods for solving linear systems & eigenvalues problems. Applications.

MTH 611 **ALGEBRA-II** **Prereq. MTH-204 / #**
L-T-P-D-[C]
3-0-0-0-[4]

Fields: definition and examples. Ring of polynomials over a field. Field extensions. Algebraic and transcendental elements, Algebraic extensions. Splitting field of a polynomial. Algebraic closure of a field, Uniqueness. Normal, separable, purely inseparable extensions. Primitive elements of a field extension - simple extensions. Fundamental theorem of Galois. Solvability by radicals - Solutions of cubic and quartic polynomials, Insolvabity of quintic and higher degree polynomials. Geometric construct-ions. Cyclotomic extensions. Finite fields.

Cyclotomic polynomials and its properties. Traces and norms. Modules - definition, examples and basic properties. Free modules, submodules and quotient modules, isomorphism theorems. Localization. Direct sum and direct products. Noetherian and Artinian rings and modules, structure of Artinian rings, Hilbert basis theorem. Jordan - Holder theorem. Radicals of modules, Nakayama lemma.

MTH 612 **AN INTRODUCTION TO COMMUTATIVE ALGEBRA** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Commutative rings, ideals, prime and maximal ideals, Noetherian Artinian rings, Primary decomposition and Noetherian rings, Modules over commutative rings, Exact sequences, the Hom and tensorufunctors, rings and modules of fractions, integral dependence, valuations and dedekind domains.

MTH 613 **RINGS AND MODULES** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Modules, Free modules, Cartesian products and direct sums of modules. Split exact sequences, Projective modules, Injective modules. Structure modules and rings, Artinian and Noetherian modules, Simple and semi simple modules, Radicals of rings and modules, Special rings and modules.

MTH 614 **MATHEMATICAL CODING THEORY-I** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Polynomial rings over fields, Extension of fields, computation in GF(q), Root fields of polynomials, Vector spaceover finite fields, Binary group codes, Hamming codes, Polynomial codes, Linear block codes, The structure of cyclic codes. Quadratic residue codes, Reed Mueller codes, Simplex codes.

MTH 616 **ANALYTIC NUMBER THEORY** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Averages of mathematical functions. Distri-bution of primes, Weyl's, Kronecker's and Minkowski's theorems. Characters. Dirichlet's theorem on primes in arithmetic progression. Gauss sums. Dirichlet series and Euler products. Analytic proof of the prime number theorem.

MTH 617 **ALGEBRAIC NUMBER THEORY** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Congruences with prime modulus, P-adic equations & padic fields, Hasses Minkowski theorem, Hilbert-symbol, Algebraic number fields, Unique factorization, Cyclotomic integers, Characters of finite abelian groups, Dirichlet series, Dirichlet's theorem on prime numbers in A.P. & class number.

MTH 618 — **FINITE FIELD AND ITS APPLICATIONS** — **Prereq. MTH 204 #**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction, Structure of finite fields, Polynomials over finite fields, Factorization of polynomials, Construction of irreducible polynomials, Applications in cryptography and coding theory.

MTH 619 — **COMMUTATIVE ALGEBRA II** — **Prereq. MTH 612**

L-T-P-D-[C]
3-0-0-0-[4]

Completions, Diemension theory, Cohen-Macaulay rings, Regular local rings, Projective and injective modules and resolutions, Homological methods.

MTH 620 — **MEASURE THEORY** — **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Algebras and s-algebras, Measures, Outer measures, Lebesgue measure in R^n, Completeness and regularity. Measurable functions and their properties, Convergence in measure, Integral, Convergence theorems. Signed and complex measures, Radon Nikodym theorem, Lebesgue decompostion theorem, L^p-spaces and their dual. Product measures, Construction, Fubini theorem and its applications, Differentiation of measures.

MTH 621 — **FOURIER ANALYSIS** — **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Fourier series; Norm and pointwise convergence, Approximate identities, Plancherel theorem, Conjugation, Maximal functions, Classical Hardy spaces, F. and M. Riesz theorem, Interpolation of linear operators. Fourier & Fourier Stieltjes transforms, Tempered distributions, Paley-Wiener theorems. Wiener-Tauberian theorems & applications.

MTH 623 — **TOPOLOGY OF RIEMANNIAN MANIFOLDS** — **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

First & second variation of arc length, Conjugate points, Myers & Bonnet theorem, Rauch comparison theorems, Cartan-Hadamard theorem, Cartan-Abrose-Hicks theorem, Spaces of constant curvature; Morse theory; Application to the path space of a manifold.

MTH 624 — **DIFFERENTIABLE MANIFOLDS AND LIE GROUPS** — **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Differentiable manifolds; Tangent space. Vector fields; Frobenius theorem; Relation between Lie sub-algebras & Lie subgroups; Cartan's theorem on closed subgroups; One parameter subgroups; Exponential maps; Adjoint representation; Homogeneous spaces; Compact Lie groups; Symmetric spaces.

MTH 625 — **NON-LINEAR ANALYSIS** — **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Calculus in Banach spaces, Inverse & implicit function theorem, Fixed point theorems of Brouwer, Schauder & Tychonoff; Fixed point theorems for nonexpansive & set-valued maps; Predegree results, Compact vector fields, Homotopy, Homotopy extension & invariance theorems & applications.

MTH 626 **TOPICS IN ANALYSIS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Review of basic theorems on Banach spaces, Locally convex spaces, Convexity, Hahn Banach separation theorems, Extreme points, Krein-Milman theorem, Theory of distributions, Tempered distributions, Interpolation of operators, Weak type inequalities, Applications, Compact operators, Integral operators, Fredholm alternative.

MTH 627 **APPLIED HARMONIC ANALYSIS**
L-T-P-D-[C]
3-0-0-0-[4]

Basic Fourier Analysis-a review Convolutions, Multipliers and Filters, Poisson Summation Formula, Shannon Sampling Discrete Fourier Transform, Fast Fourier Transform, Discrete Wavelets, Continuous Wavelets, Uncertainty Principles, Radar Ambiguity, Phase Retrieval, Random Transform, Basic Properties, Convolution and Inversion, Computerized Tomography

MTH 628 **TOPICS IN TOPOLOGY** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Classification of 2-dimensional surfaces; Fundamental group; Knots and covering spaces; Braids and links; Simplicial homology groups and applications; Degree and Lefschetz Number; Borsuk-Ulam Theorem; Lefschetz Fixed-Point Theorem.

MTH 629 **BANACH SPACES OF VECTOR VALUED FUNCTIONS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Banach spaces containing copies of c_α l_1 or l_∞ The spaces L_∞ (μ, X), C(K, X) and their duals. Copies of c_α, l_1 or l_∞ in L_π (μ, X), and C(K, X), Complemented copies of c_α, l_1 or l_∞ in $L_\pi(\mu$, X), C(K, X) complemented copies of c_α and l_1 or l_∞ in L_∞ (μ, X).

MTH 630 **FUNCTIONAL ANALYSIS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Completion of metric spaces, Banach fixed point theorem, Baire category theorem, Banach spaces, Conjugate spaces, Reflexivity, Open mapping & closed graph theorems, The principle of uniform boundedness, Hilbert spaces, Riesz representation theorem, Banach algebras, Gelfand Naimark theorem; Spectral decomposition for compact normal operators.

MTH 631 **APPROXIMATION THEORY** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Best approximation in normed spaces. Tchebycheff systems. Tchebycheff-Weierstrass - Jackson - Bernstein - Zygmund-Nikolaev etc. theorems. Fourier series, Splines, Convolutions, Linear positive, Variation diminishing, Simultaneous etc. approximations. Direct-inverse-saturation theorems. Applications.

MTH 632 **VECTOR MEASURES** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

General vector measure theory, Integration, Analytic Radon Nikodym theorems and operators on L (μ), Martingales, Geometric aspects of the Radon-Nikodym property.

MTH 633 **APPLIED FUNCTIONAL ANALYSIS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Hahn Banach theorem, Open mapping theorem, Uniform boundedness principle; Applications. Weak and weak-star topologies, Mazur's, Alaoglu's, and Goldstine theorems, Reflexive spaces, James characterization of reflexivity. Fixed point theorems of Brouwer, Schauder and Tychonoff; Applications.

MTH 634 **BASES IN LOCALLY CONVEX SPACES AND KOETHE SEQUENCE SPACES,** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Preliminaries, Elements of basis theory, Types of bases, Summability (summation of infinite series), Koethe sequence spaces, Bases in OTVS, Isomorphism theorems.

MTH 635 **WAVELETS AND APPLICATIONS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Fourier transforms, Wavelets transforms and time-frequency analysis, Cardinal spline analysis, Scaling functions and wavelets, Cardinal spline wavelets, Orthogonal bases of compactly supported wavelets, Applications to signal analysis.

MTH 636 **GEOMETRY OF NORMED LINEAR SPACES** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Geometric form of Hahn-Banach theorem, w-w* topologies, James characterization of reflexivity, Strict convexity, Uniform convexity, Duality between strict convexity and smoothness, Differentiability of the norm, Drop theorem, Bishop-Phelp theorems, Krein-Milman theorem and Radon-Nikodym property.

MTH 637 **TOPICS IN OPERATOR THEORY AND HARMONIC ANALYSIS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Operators on Hilbert spaces: Compact operators, Schatten class and Hilbert Schmidt operators, Spectral theorem. Fourier series, Smooth functions and distributions. Hardy spaces, Carleson measures, H^1-BMO duality. Hankel and Toeplitz operators on H^2. Representation theory of compact groups, Representation of SU(2) and SO(3).

MTH 638 L-T-P-D-[C] 3-0-0-0-[4]

ABSTRACT HARMONIC ANALYSIS **Prereq. #**

Integration on locally compact spaces, Topological groups, Haar measure, Fourier transforms, Bochner theorem, Pontryagin's duality theorem, Plancherel theorem, Bohr compactification.

MTH 639 L-T-P-D-[C] 3-0-0-0-[4]

LOCALLY CONVEX SPACE **Prereq. #**

Topological linear spaces, Equicontinuity, Function spaces, Convexity & convex topological spaces, Hahn-Banach theorem, Barrelled spaces, Principle of uniform boundedness, Bornological spaces, Duality theory (Aren's Th., Mackey topology, S-topology, Polarity).

MTH 640 L-T-P-D-[C] 3-0-0-0-[4]

SEVERAL COMPLEX VARIABLES **Prereq. #**

Cauchy integral formula, Taylor series, Associated radii of convergence, Analytic functions, Reinhardt domain, Logarithmic convexity, Laurent's expansion, Envelope of holomorphy, Goldberg's growth parameter, Factorization, Weirestrass preparation theorem, Types of singularity, Domain of holomorphy, Complex analytic structure.

MTH 641 L-T-P-D-[C] 3-0-0-0-[4]

COMPUTATIONAL COMPLEX ANALYSIS **Prereq. #**

Formal power series, Quotient-difference algorithm, Algorithms for determination of zeros of entire functions and residues of rational functions, Horner's algorithm. Continued fractions, Pade' approximation and applications, Complex variable boundary element method & engineering applications.

MTH 642 L-T-P-D-[C] 3-0-0-0-[4]

GEOMETRIC FUNCTION THEORY **Prereq. #**

Normal families & applications, Riemann mapping theorem, Conformal mapping of a sequence of domains; Modular function, Hyperbolic metric, Elementary theory of univalent functions, Löwner's theory, Dirichlet problem,Green's function & conformal mapping; Transfinite diameter & capacity; Symmetrization, Extremal length and prime ends.

MTH 643 L-T-P-D-[C] 3-0-0-0-[4]

COMPLEX APPROXIMATION **Prereq. #**

Faber series. Polynomial approximation in L^p-norm and supnorm. Theorems of Weierstrass, Bernstein & Walsh. Approximation on general compact sets. Theorems of Runge, Mergelyan etc, Approximation by interpolation, Complex planar splines. Complex spline approximation.

MTH 644 L-T-P-D-[C] 3-0-0-0-[4]

COMPLEX FUNCTION THEORY **Prereq. #**

Fundamental theorems, Winding number & applications,Normal families, Riemann mapping theorem, Fundamentals of univalent functions & entire functions, Phragmen-Lindelöf theorems, Gamma-, Riemann-zeta functions; Harmonic functions,Dirichlet problem for disc, Analytical continuation, Runge's theorem.

MTH 645 L-T-P-D-[C] 3-0-0-0-[4]

ENTIRE AND MEROMORPHIC FUNCTIONS **Prereq. #**

Maximum modulus, Maximum term and rank, Order and lower order, Type and lower type, Rate of growth & distribution of zeros, Hadamard's factorization theorem & its implications, Minimum modulus, Proximate order and proximate type, Entire functions of exponential type, Nevanlinna theory.

MTH 646 L-T-P-D-[C] 3-0-0-0-[4]

UNIVALENT AND MULTIVALENT FUNCTIONS **Prereq. #**

Area principle, Distortion theorems, Coefficient estimates, Bieberbach-Branges theorem, Variational methods, Extremal problems, Rotation theorems, Radii of starlikeness and convexity, Principle of subordination, p-valent, Mean p-valent and circumferencially mean p-valent functions.

MTH 647 L-T-P-D-[C] 3-0-0-0-[4]

COMPLEX ANALYTIC DYNAMICS AND FRACTALS **Prereq. #**

Chordal & spherical metrics, Normal families. Iteration of polynomials and rational functions, Periodic points & orbits, Julia & Fatou's sets and their characterizations, Dynamics of Julia and Fatou's sets for quadratic, Rational & entire functions; The Mandelbrot set. Julia sets & fractals, Self-similarity and fractal dimension.

MTH 648 L-T-P-D-[C] 3-0-0-0-[4]

DIFFERENTIAL GEOMETRY **Prereq. MTH-301 / #**

Theory of Space Curves-The Serret-Frenet formulas. Gauss Theory of Surfaces-First and second fundamental form, Examples, Weingarten map, Principal curvatures, Gaussian curvature, Examples. Computation of the curvature in standard spaces: Sphere, Torus, Surfaces of revolution etc. Levi-Civita connection-Uniqueness, Gauss theorem Egregium, Hilbert's theorem on the positivity of curvature at a point on a compact surface in R^3. Geodesics, Equations of geodesics, Examples. Jacobi fields, Conjugate points etc. Riemannian area element on a surface, Gauss Bonnet theorem. Differentiable manifold, Differentiable structure. Sub-manifolds, Immersions, Embeddings. Metric tensor, Riemannian connection and curvature.

MTH 649 L-T-P-D-[C] 3-0-0-0-[4]

ALGEBRAIC TOPOLOGY **Prereq. #**

Homotopy, Path homotopy. The fundamental group. Covering spaces. The fundamental group of the circle, S1, sphere, S2, Surfaces 2-dimensional, Punctured plane etc. Techniques of calculation. The special Van Kampen theorem. Essential and Inessential maps - Applications. The fundamental theorem of algebra, Brower's fixed point theorem for the disc etc. Triangulations. Simplical complexes. Barycentric subdivision. Simplical mappings, The simplical approximation theorem. Simplical homology groups; Calculations for cone complex, S^n etc. The Euler-Poincare formula. The Lefschetz fixed point theorem. Singular homology groups, Topological invariance. The exact homology sequence. The Eilenberg Steenrod axioms.

MTH 650 **PARTIAL DIFFERENTIAL EQUATIONS & THEIR APPLICATIONS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

First order equations, Cauchy Kowalewski theorem. Characteristics. Classification of second order equations. Uniqueness theorems for hyperbolic equations with initial & boundary conditions, Elliptic equations, Dirichlet & Neumann problems. Maximum and minimum theorem, Poisson's integral, Green's & Neumann's functions. Heat equations.

MTH 651 **PARTIAL DIFFERENTIAL EQUATIONS OF PARABOLIC TYPE** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Maximum principle, Function spaces and imbedding theorems, Some inequalities, Weak solution, Energy inequality, Uniqueness theorem, Solvability of boundary value problems, Estimates in different functional norms, Regularity of the solutions.

MTH 652 **BOUNDARY VALUE PROBLEMS IN PARTIAL DIFFERENTIAL EQUATIONS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Distributions & fundamental solutions; Fredholm alternative; Interior problem for elliptic equations; Surface layers & Green's function; Eigenvalue problems, Variational principle; Parabolic equations, Uniqueness & continuous dependence; Causal Green's functions; Wave equation & energy principle.

MTH 653 **INTEGRAL EQUATIONS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Volterra and Fredholm integral equations, Resolvent Kernels. Operator equations, Fredholm theory, Hilbert-Schmidt theory. Nonlinear integral equations, Singular integral equations.

MTH 654 **ELLIPTIC EQUATIONS** **Prereq. #**
L-T-P-D-[C]
3-1-0-0-[4]

$W^{m,p}$ space, Imbedding & Trace theorems, Compactness of imbeddings, Green's formula, Weak formulation, Continuous dependence of solutions, Elliptic systems, Regularity in the interior, in a neighbourhood of a boundary. Existence of solution of BVP. Applications of Rellich's inequality.

MTH 655 **INITIAL BOUNDARY VALUE PROBLEMS - THEORY & APPLICATIONS TO HYPERBOLIC PROBLEMS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Energy estimates for symmetric hyperbolic systems, Maximal dissipative boundary conditions, Kreiss theory for well posedness of hyperbolic initial boundary value problems, A prior energy estimates and differentiability results, Application of theory to radiative boundary conditions.

MTH 656 **SOBOLEV SPACES AND APPLICATIONS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Elements of operator theory and Hilbert spaces; Introduction to the theory of distributions. Sobolev Spaces : Imbedding and compactness theorems, Fractional spaces and elements of trace theory. Applications to elliptic equations or parabolic equations.

MTH 657 **GRAPH THEORY** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Basic definitions. Blocks. Ramsey Numbers. Degree sequences. Connectivity. Eulerian and Hamiltonian Graphs. Planar graphs and 5-colour theorem. Chromatic numbers. Enumeration. Max-Flow Min-Cut Theorem. Groups and graphs. Matrices and graphs. Matchings and Hall's Marriage Theorem. Eigen values of graphs.

MTH 658 **NONLINEAR DYNAMICAL SYSTEMS** **Prereq. 421, #**
L-T-P-D-[C]
3-0-0-0-[4]

Picard's theorem, Boundedness of solutions, Omega limit points of bounded trajectories.LaSalle's invariance principle; Stability via Lyapanov's indirect method, Converse Lyapanov functions, Sublevel sets of Lyapanov functions, Stability via Lyapanov's direct method, Converse Lyapanov's theorems, Brokett's theorem, Applications to control system; Stable and unstable manifolds of equilibria, Stable manifold theorem, Hartman-Grobman theorem, Examples and applications, Center manifold theorem, Center manifold theorem, Normal form theory, Examples and applications to nonlinear systems and control; Poincare map, and stability theorems for periodic orbits; Elementary Bifurcation theory.

MTH 659 **ADVANCED QUANTITATIVE FINANCE** **Prereq. MTH 512**
L-T-P-D-[C]
3-0-0-0-[4]

Stochastic Voltality Models, Local Volatility, Short- Term Interest Rate Models, Health-Jarrow-Morton Framework, Options on Bonds, Options on Coupon- Bearing Bonds, LIBOR models, forward and Future LIBOR Rates, Valuation of Cap and floor, Interest Rate Swaps, Valuation of Swapation. Option pricing under jumps, overview of princing in incomplete matkets, basic notions of credit-risk modelling.

MTH660 **NOLOCAL INITIAL AND BOUNDARY VALUE PROBLEMS**
L-T-P-D-[C] **Prereq. MTH 421, 424**
3-0-0-0-[4]

Introducing of nonlocal initial and boundary value problems, types of nonlocal initial conditions, types of nonlocal boundary conditions, multi-point conditions, for heat and wave equations and their interpretations, functional analytic approach to solving such problems, formulation of the problems in a Hilbert/ Banach space, well-posendess of the models in the sense of Hadamard, semigroup of operators and their application to solving nonlocal problems, method of time iscretization and its applications to noncal problems, Galerkin approximation of solutions. Fourier Series method to nonlocal problems, Laplace transform method to nonlocal problems, certain problems in control theory modeled as nonlocal problems and their wellposedness.

MTH 661 **BIO-MECHANICS** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction to bio-mechanics, Circulatory system, Pressure & flow in arterial system, Elastic & non-Newtonian effects on blood flow. Arterial diseases, Dialysis, Artificial kidneys. Human joints & their mechanism, Human joint lubrication; Mucus transport in lung.

MTH 662 **NAVIER-STOKES EQUATION** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Navier-Stokes equations, derivation, properties & historical perspective, Potential flows; Eulers, Stokes & Oseens equations; Free surface phenomena; Strong & weak solutions of basic equations; Existence, Uniqueness and properties of solutions.

MTH 664 **TRIBOLOGY** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

The fundamentals of lubrication, friction & wear. Boundary lubrication, Hydrodynamic lubrication, Elastohydrodynamic lubrication. Compressibility & thermal effects, Non- Newtonian lubrication, Roughness effects, Magneto-hydro-dynamic effects, Application to engineering & human systems.

MTH 665 **ENVIRONMENTAL DYNAMICS AND POLLUTION** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Our environment and its characteristics, Atmospheric motion, Basic equations, Atmospheric waves; Atmospheric turbulence, Logarithmic velocity profile, Diffusion equation; Environmental pollution and dispersion of pollutants. Effects of greenbelt and rain washout on dispersion.

MTH 666 L-T-P-D-[C] 3-0-0-0-[4]

MATHEMATICAL THEORY OF ENVIRONEMNTAL BIOLOGY **Prereq. #**

Introduction to environmental biology, environmental pollution & population dynamics. Diffusion of pollutants and toxicants, Their effects on biological species, Models of population interaction with environmental effects and their analyses.

MTH 669 L-T-P-D-[C] 3-0-0-0-[4]

THEORY OF STABILITY **Prereq. #**

Stabililty of fluid flows; Benard convection, Poisseuille flow, Rotatory Couette flow. Rayleigh-Taylor and Kelvin-Helmholtz problems. Nonlinear stability limits, Supercritical and subcritical regimes.

MTH 672 L-T-P-D-[C] 3-0-0-0-[4]

COMBINATORIAL OPTIMIZATION **Prereq. #**

Optimization problems; Convex sets & functions, Algorithms & complexity; Analysis of algorithms. Polynomial time algorithms; Strongly poly. algorithms for special LPs; NP- complete problems, Integer linear programming, Pseudo-poly. algorithm & strong NP-completeness. Approximation algorithms. Heuristics.

MTH 673 L-T-P-D-[C] 3-0-0-0-[4]

CONVEX ANALYSIS AND OPTIMIZATION **Prereq. #**

Convex functions, Separation theorems, Krein-Milman theorem, Reflexivity, Directional derivatives, Sub-gradients, Convex programs, Kuhn-Tucker theory, Lagrange multipliers, Conjugate functions, The Fenchel-duality theorem, Ekelands variational principle, Phelps extremization principle.

MTH 675 L-T-P-D-[C] 3-0-0-0-[4]

ADVANCED GRAPH THEORY **Prereq. #**

Graphs, Groups, Schur functions, Polya's theorem, de Burijn's theorem, Redfield's theorem, Matroids, Transversal theory, Hypergraphs, Planarity, Colourability, Four colour problem.

MTH 680 L-T-P-D-[C] 3-0-0-0-[4]

ELEMENTARY STOCHASTIC PROCESSES **Prereq. #**

Markov chain, Chapman- Kolmogorov equation, Classification of states, Stationary distributions, Birth & death processes, Kolmogorov forward & backward equations. Poisson process; Strictly stationary and covariance stationary processes, Processes with independent increments; Continuity.

MTH 681

STATISTICAL DECISION THEORY **Prereq. #**

Decision function, Risk function, Optimal decision rules, Admissibility & completeness, The minimax theorem, The complete class theorem, Sufficient statistics. Invariant decision problems, Admissible & minimax invariant rules, The Pitman estimates, Estimation of a distribution function.

MTH 682 L-T-P-D-[C] 3-0-0-0-[4]

ORDER STATISTICS **Prereq. #**

Basic distribution theory, Moments of order statistics including recurrence relations, Bounds and approximations, Estimation of parameters, Life testing, Short cut procedures, Treatment of outliers, Asymptotic theory of extremes.

MTH 683 L-T-P-D-[C] 3-0-0-0-[4]

NON-PARAMETRIC INFERENCE **Prereq. #**

Order statistics, Tests of goodness of fit, Sign & signed rank tests, Wald-Wolfowitz, Kolmogorov-Smirnov, Median & Mann-Whitney tests, Linear rank tests for the location problem & scale problem, Measures of association, Asymptotic relative efficiency.

MTH 684 L-T-P-D-[C] 3-0-0-0-[4]

STATISTICAL SIMULATION, DATA ANALYSIS AND MODEL BUILDING **Prereq. #**

Introduction to simulation & Monte-Carlo studies; Generation of random variables. Interactive computational & graphical techniques in model building; Data based inference methods such as Jack-Knife, Bootstrap and cross-validation techniques; Use of statistical packages in data analysis.

MTH 685 L-T-P-D-[C] 3-0-0-0-[4]

TIME SERIES ANALYSIS: FORECASTING AND CONTROL **Prereq. #**

Linear stationary processes, Autocovariance & spectral density functions & moving average processes, Linear non-stationary processes, Model estimation & identification, Forecasting, Transfer function models, Design for discrete control.

MTH 686 L-T-P-D-[C] 3-0-0-0-[4]

NON-LINEAR REGRESSION **Prereq. #**

Estimation methods, Commonly encountered problems in estimation, Statistical inference, Multiresponse non-linear model, Asymptotic theory, Computational methods.

MTH 687 L-T-P-D-[C] 3-1-0-0-[4]

RANKING, SELECTION & MULTIPLE DECISIONS **Prereq. #**

The philosophy of ranking & selection, Indifference zone approach & subset selection (Elimination) approach, Procedures for complete ranking & selecting the best out of populations, Nonparametric formulations, Estimation of ordered parameters and other related topics.

MTH 688 L-T-P-D-[C] 3-0-0-0-[4]

TESTING OF HYPOTHESES II **Prereq. #**

Neyman-Pearson lemma & its generalization. UMP & UMPU tests. SPRT & its properties. Distribution-free statistics, Linear rank test statistics, U-statistics, Asymptotic distributions of test statistics, ARE of tests. Bayes, Invariant and minimax, Randomization & permutation tests.

MTH 689 L-T-P-D-[C] 3-0-0-0-[4]

LINEAR AND NON-LINEAR MODELS **Prereq.#**

Generalized inverse, Eigen values & canonical reduction of matrices, Least square theory, Regression analysis. Unified theory of least squares, Variance component estimation, Minimum mean square error estimation & ridge regression, Generalised linear and non-linear models.

MTH 690 L-T-P-D-[C] 3-0-0-0-[4]

APPLIED NUMERICAL METHODS **Prereq. #**

Fortran IV, Interpolation and approximation, Numerical integration, Numerical solution of a system of linear algebraic equations, Inverse of a matrix. Eigen-values and eigen-vectors of matrices. Numerical solution of ordinary & partial differential equations.

MTH 691 L-T-P-D-[C] 3-0-0-0-[4]

NUMERICAL LINEAR ALGEBRA **Prereq. #**

Triangular form, Matrix norms, Conditioning of linear systems, Direct methods (Gauss, Cholesky, Householder), Iterative methods (Jacobi, Gauss-Seidel, Relaxation) for solving linear systems, Computing of eigenvalues & eigen-vectors (Jacobi, Givens-Householder, Q-R, Inverse methods), Conjugate gradient method & its preconditioning.

MTH 692 L-T-P-D-[C] 3-0-0-0-[4]

NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS **Prereq. #**

Introduction. Runge-Kutta methods -derivation, error bounds and error estimates. Weak stability theory for Runge-Kutta methods. Order and convergence of the general explicit one-step methods. Linear multi-step methods -derivation, order consistency, zero-stability and convergence. Weak stability theory for general linear multi-step methods. Predictor-Corrector methods. Stiff systems.

MTH-693 L-T-P-D-[C] 3-0-0-0-[4]

NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS **Prereq. #**

Basic linear algebra - vector and matrix norms and related theorems. Parabolic equations in one and two space dimensions - explicit and implicit formulae. Consistency, stability and convergence. Iterative methods for linear systems.

Split operator methods. Multilevel difference schemes. Nonlinear equations. Elliptic Equations - Dirichlet, Neumann and mixed problems. Direct factorization methods and successive over-relaxation (S.O.R.). ADI and conjugate gradient methods. Hyperbolic equations. First order hyperbolic systems in one and two space dimensions-stability and convergence. Second order equations in one and two space dimensions. The Galerkin method and applications.

MTH 694 **COMPUTATIONAL FLUID DYNAMICS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Conservation laws, Weak solutions & shocks, Monotone difference schemes, Total variation diminishing schemes, Godunov-type schemes, Essentially nonoscillatory methods, Flux limiters.

MTH 695 **INTRODUCTION TO MATHEMATICS OF CAGD (COMPUTER AIDED GEOMETRIC DESIGN)** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

B-splines, Be'zier curves, Splines in Bezier form, Geometric continuity, Tensor product, Bezier surfaces, Composite surfaces and spline interpolation, Geometric continuity for surfaces.

MTH 696 **SPECTRAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Galerkin, Collocation & Tau methods, Spectral approximation, The Fourier system, Continuous & discrete Fourier expansion, Orthogonal polynomials in (-1,1), Fundamentals of spectral methods for PDEs, Temporal discretization, The Galerkin- Collocation method, Implicit spectral equations, Case of nonsmooth solutions.

MTH 697 **FINITE ELEMENT METHOD: BASIC & APPLICATIONS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction: Weighted Residual and Variational Approaches; Element Shape Functions; Curved and Isoparametric Elements' FEM for Elliptic; Parabolic and Hyperbolic Equations; Error Estimates; FEM Computations - Some Preprocessing and Processing Methods; Flow Analysis - Psi-Omega and UVP Approaches; Upwind Strategies; Recent Trends in FEM; Parallel FEM.

MTH 698 **PARALLEL NUMERICAL ALGORITHMS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Fundamentals of parallel computing; Parallel techniques and algorithms; Parallel algorithms for linear algebriac equations; Design of parallel algorithms for eigen value problem; Parallel issues of factorization : singular- value decomposition and related problems; Parallel implementation of classical iterative methods; Conjugate gradient method; Parallel methods for ordinary and partial differential equations.

MTH 699 **PARTIAL DIFFERENTIAL EQUATIONS ON PARALLEL COMPUTERS Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to parallel computers; Parallel fdm-ADI algorithm, Multigrid method; Conjugate gradient method, Pre-conditioned conjugate gradient method; Parallel fem - domain decomposition method; Parallel time stepping algorithm, Applications from CFD + Project.

MTH 700 **NUMERICAL METHODS FOR SINGULAR PERTURBATON PROBLEMS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Examples of singular perturbation problems, Analytical behaviour of solutions, Asymptotic expansions (brief description), Turning point problem, Numerical methods based on FInite Differance, Finite Element and Finite Volume for singular perturbation problems in ODE;s and PDE;s, convergence analysis Adaptive methods.

MTH 701 **MODAL LOGIC** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Modal Propositional Logic-Systems K, T, D, S4, S5, B; Automated Proof Methods, Decidability; Consistency, Frames, Canonical Models, Completeness; Finite Models, Incompleteness.

Algebraic semantics-Lindenbaum-Tarski Algebras, Jonsson-Tarski Theorem, Goldblatt-Thomason Theorem.

Modal Predicate Logic-Completedness; Automated Proof Methods; Identity. some Modal Systems and applications-Temporal, dynamic and epistemic Logics, Topology via Modal Logic

MTH 730 **DIMETRAL DIMENSIONS & NUCLEARITY** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Operators in Hilbert spaces, Trace of operators; Nuclearity; Nuclearity of operators and their characterisations; Diametral dimensions & their relationships with nuclearity; Bases in nuclear spaces.

MTH 731 **REPRESENTATIONS OF COMPACT & NILPOTENT LIE GROUPS** **Prereq. #**

L-T-P-D-[C]
3-0-0-0-[4]

Unitary representations, Irreducibility, Characters, Peter- Weyl theorem, Fourier series of square integrable functions. The classical groups. Irreducible representations of SU(2). Lie algebras and their representations, Representations of SO(3), Spherical harmonics. Basic theory of nilpotent Lie groups. Elements of Kirillov theory.

MTH 732 L-T-P-D-[C] 3-0-0-0-[4]

REPRESENTATION THEORY OF FINITE GROUPS **Prereq. #**

Basic representation theory, Irreducible representation, Equivalence and unitary equivalence, Construction of new representation, Character of a representation, Schur's lemma and its applications, Schur's orthogonality relations, Schur's theory of characters, induced representations, Frobenius reciprocity, group algebra C[G], Plancherel, Forier Inversion theorems, Some applications, Representations of S_n and A_n for small values of n.

MTH 733 L-T-P-D-[C] 3-0-0-0-[4]

REPRESENTATION THEORY OF LINEAR LIE GROUPS

Prereq. M.Sc. Level Analysis, #

Representation theory of Compact groups; Peter Weyl Theorem. Linear Lie Groups; The Exponential map, Lie Algebra, Invarient Differential Operaters. Representations of the group and its Lie Algebra. Fourier Analysis on SU(2) and SU(3). Representation theory of the heisenberg Group and some Harmonic Analysis. Representation of the Euclidean Motion Group.

MTH 734 L-T-P-D-[C] 3-0-0-0-[4]

BANACH ALGEBRAS, C* ALGEBRAS AND SPECTRAL THEORY

Prereq. #

Elementary properties of Banach Algebras and examples; Ideals and quotients, the Spectrum, the Riesz Functional Calculas.Abelian Banach Algebras, C* Algebras; Representations of C* Algebras and the Gelfand- Naimark -Segal Construction. Normal Operators on Hilbert Space, Spectral measure and representation of abelian C* algebras; The Spectral theorem; Some applications.

MTH 735 L-T-P-D-[C] 3-0-0-0-[4]

TOPICS IN FOURIER ANALYSIS ON EUCLEDIAN SPACES **Prereq. #**

L1 and L2 Theory of Fourier transform, schwartz space and tempered distribution, pointwise pincare inequality, Housdroff-Young inequality, Khinchin's inequality, Uncertaininty principles, Bernstein's inequality for ellepsoid and disc, stationry phase and nonstationary phase, restriction problem, stein-tomas restriction theorem, Housdorff measures, sets with maximal fourier dimension, Kakeya problem, Fefferman - Bourgain theorem.

MTH 736 L-T-P-D-[C] 3-0-0-0-[4]

FOURIER ANALYSIS AND DISTRIBUTION THEORY

Prereq. #

Introduction, Test function spaces, Calculus with distributions, supports of distributions, Structure theorems, convolutions, Fourier transforms, L^1, L^2 theory of Fourier Transform, Tempered distributions, Paley-Wiener theorem, wiener-Tauberian theorem, Applications of distributions theory and Fourier transform to differential equations.

MTH 737 L-T-P-D-[C] 3-0-0-0-[4]

THE THEORY OF OPERATOR SPACE **Prereq. None**

Completely Bounded Maps, Minimal Tensor Product, Ruan's Theorem, Basic Operations, Minimal and Maximal Operator Space Structures, Projective Tensor Profuct, The Haagerup Tensor Product, Characterization of Operator Algebras, The Operator Hilbert Space.

MTH 738 L-T-P-D-[C] 3-0-0-0-[4]

THEORY OF INTERPOLATION

Distribution Functions and Decreasing Rearrangements, Rearrangement Invariant Spaces, The Spaces L1+L and L Interpolation Spaces, Hilbert Transform and Operations of joint Weak Type, The Riesz Thorin Convexity Theorem Complex Interpolation, Stein's Interpolation Theorem for Analytic Familites. The Marcinkiewicz Interpolation Theorem Restricted Weak Type, Orlicz Spaces, The K- Method Besov Spaces Sobolev Type Embedding Therem.

MTH 751 L-T-P-D-[C] 3-0-0-0-[4]

ALGEBRA **Prereq. None**

Groups, Basic properties, Isomorphism theorems, Permutation groups, Sylow Theorems, Structure theorem for finite abelian groups, Rings, Integral domains, Fields, division rings, Ideals, Maximal ideals, Euclidean rings, Polynomial ring over a ring, Maximal & Prime ideals over a commutative ring with unity, Prime avoidance theorem and Chinese Remainder theorem, Field Extension, Cramer's rule, Algebraic elements and extensions, Finite fields.

Determinants and their properties, Systems of linear equations, Eigenvalues and Eigenvectors, Caley-Hamilton theorem, Characteristic and minimal polynomial, diagonalization, Vector spaces, Linear transformations, Inner product spaces.

MTH-752 L-T-P-D-[C] 3-0-0-0-[4]

MATHEMATICAL METHODS **Prereq. : None**

Calculus of Variations; Sturm Liouville Problem and Green's Function; Perturbation Methods and Similarity Analysis; Stability Theory.

MTH 753 L-T-P-D-[C] 3-0-0-0-[4]

ANALYSIS **Prereq. None**

Metric spaces, Open and closed sets, Compactness and connectedness, Completeness, Continuous functions (several variables and on metric spaces), uniform continuity C(X), X, compact metric space, Uniform convergence, compactness criterion, Differentiation, Inverse and Implicit fuction theorems. Riemann Integration, Lebesgue Integration, L^p-spaces.

Complex Analysis: Analytic functions, Harmonic conjugates, Cauchy theorems and consequences, Power series, Zeros of analytic functions, Maximum modulus theorem, Singularities, Laurent series, Residues. Mobius transformations.

Hilbert spaces: Inner product, Orthogonality, Orthonormal bases, Riesz Lemma, The space L^2 as a Hilbert space.

MTH 754 **PROBABILITY THEORY** **Prereq. None**

L-T-P-D-[C]
3-0-0-0-[4]

Algebras and sigma algebras; Measurable spaces; Methods of introducing probability measures on measurable space; Random variables; Lebesgue integral; Expectation; Conditional probabilities and conditional expectations with respect to sigma-algebras; Radon Nikodym theorem; Inequalities of random variables; Fubini's theorem; Various kinds of convergence of sequence of random variables; Convergence of probability measures; Central limit theorem; delta method; Infinitely divisible and stable distributions; Zero-or-One laws; Convergence of series; Strong law of large numbers; Law of iteratedlogarithm; Matringales and their basic properties.

MTH-755 **STATISTICAL INFERENCE** **Prereq. None**

L-T-P-D-[C]
3-0-0-0-[4]

Population and samples; Parametric and nonparametricmodels; Exponential and location-scale families; Sufficiency and minimal sufficiancy; Complete statistics; Unbiased and UMVU estimation; Asymptotically unbiased estimators; Method of moments; Bayes estimators; Invariance; Minimaxity and admissibility; The method of maximum likelihood; Asymptotically efficient estimation; Variance estimation; The jacknife; The bootstrap; The NP lemma; MLR; UMP tests for one and two sided hypotheses; Unbiased and similarity; UMPU tests in exponential families; Invariance and UMPI tests; LR tests; Asymptotic tests based on likelihoods; Chi-square tests; Bayes tests; Pivotal quantities; Inverting acceptance regions of tests; The Bayesian confidence interval; Prediction sets; Length of confidence intervals; UMA and UMAU confidence sets; Invariant confidence sets.

MTH 761 **HYDRODYNAMIC STABILITY**

Prereq. MTH 461 #

L-T-P-D-[C]
3-0-0-0-[4]

Basic concepts of linear theory, stability, instability, neutral curves, Marginal stability; thermal instability and Rayleigh-Benard problem: governing equations, deriviation of stability equations and general characteristics, free-free, rigid-free and rigid-rigid boundary conditions, cell patterns, experimental observations; parallel shear flow instability: derivation of the Orr-sommerfeld equations, basic properties, Squires' transformations, inviscid theory, Rayleigh's criterion and Fjortoft's theorem, matching conditions for broken line profiles; Bioconvection problem: governing equations and derivations of stability conditions: gravitactic, gyrotactic and chemotactic micro-organisms; Weakly nonlinear theory: basic concepts, derivation of the amplitude equation through compatibility conditions, application of the Weakly nonlinear theory to Benard convection, bioconvection.

MTH 762 **CARDIO VASCULAR MODELLING**

L-T-P-D-[C]
3-0-0-0-[4]

The physical problem, principles of circulation heart, modelling of vessel walls, blood flow in Artries, blood flow in veins. Micro-circulation, coronary blood flow. ALE formulation of fluid motion in moving domains, analysis of incompressible NS equations, some numerical results.

MTH 781 **STATISTICAL PATTERN RECONGNITION** **Prereq.: ESO 209#**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to pattern recongnition supervised and unsupervised classification. Dimension redution techniiques: principal component analysis, multidimensional scaling features for maximum linear separation projection pursuit Parametric methods for discriminant analysis: Fisher's linear discriminant function. linear and quadratic discriminant analysis regularized discriminant analysis. Linear and nonlinear support vector machines. Cluster analysis: hierarchical and non-hierarchical techniques classification using Gaussian mixtures. Data depth: different notions of depth, concept of multivariate median, application of depth in supervised and unsupervised classification.

MTH 782 **TOPICS IN PROBABILITY AND STOCHASTIC PROCESSES**
Prereq. MTH 385 or #

L-T-P-D-[C]
3-0-0-0-[4]

Conditional probabilities and conditional expectations with respect to a s-algebra, Construction of a process with a given finite dimensional distribution, The Hilbert space L^2, Gaussian systems, Markov processes with continuous state space, Renewal theory, Stationary processes and Ergodic theory, Martingales, Branching processes.

MTH 783 **ADVANCED STOCHASTIC PROCESSES** **Prereq. MTH 488/MTH 782 or #**

L-T-P-D-[C]
3-0-0-0-[4]

Weak convergence of stochastic processes, Stochastic calculus, Theory of continuous time Markov processes.

MTH 784 **STATISTICAL RELIABILITY THEORY** **Prereq. ESO 209, #**

L-T-P-D-[C]
3-0-0-0-[4]

Reliability concepts and measures, Components and systems, Coherent systems, Cuts and Paths, Modular decomposition, Bounds on system reliability; Life distributions, Survival functions, Hazard rate, Residual life time, Mean residual life function, Common life distributions, Proportional Hazard models; Notions of aging, Aging properties of common life distributions, closure under formation of coherent structures, Convolutions and mixture of these cases; Univariate and bivariate shock models, Notions of bivariate and multivariate and depedence; Maintainance and replacement policies, Availabilityof repairable systems, Optimization of system reliability with redundancy.

MTH 785 **ECNOMETRIC THEORY** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4]

Multiple linear model , estimation of parameters under spherical and non-spherical disturbances by least squares and maximum likelihood methods, tests of hypothesis, R^2 and adjusted R^2. Prediction, within and outside sample predictions. Problem of structural change, tests for structural change. Use of dummy variable. Specification error analysis related to explanatory variables, inlusion and deletion of explanatory variables. Idea of Stein-rule estimation.Exact and stochastic linear restrictions, restricted and mixed regression analysis. Multicollinearity, problem, implications and tools for handling the problem, ridge regression. Heteroskedasticity, problem and test, estimation under Hetero-skedasticity. Autocorrelation, Durbin-Watson test. Errors-in-variables, inconsistency of least squares method, methods of consistent estimation, instrumental variable estimation. Seemingly unrelated regression equation model, least squares, generalized least squares and feasible generalized least squares estimators. Simultaneous equations model, structural and reduced forms, rank and order conditions for identifiability, indirect least squares, two stage least squares and limited information maximum likelihood methods of estimation. Additional topics like as Panel data models and unit roots & co-integration.

MTH 786 **MULTIOBJECTIVE OPTIMIZATION, THOEY, METHODS, AND APPLICATIONS**
L-T-P-D-[C] **Prereq. #**
3-0-0-0-[4]

Theory: Fundamentals of Optimisation with single objective. Karush-Kuhn-Tucker Conditions. Langrangian Multipliers. Introduction to multiobjective optimization problem. Solution Concepts (Efficency, Weak Efficiency and Proper Efficiency). Scalarization Techniques. Structure of the efficient set. Karush-Kuhn-Tucker Conditions for multiobjective problem. Lexicographic ordering.

Methods : Classical methods- weighted-sum approaches, e-constraint method. Tchebycheff methods. Utility function methods. interactive methods.

Evolutionary methods - Fundamental principles, differences with classical methods, non-elitist methods (NSGA, MOGA, NPGA etc.). elitist method (NSGA-II, SPEA, PESA etc.), constrained methods, salient advaned techniques (scale-up to large number of objectives, parallel computing, convergence issues, hybrid classical-evolutionary methods etc.,).

Applications: Case studies from science and engineering domains, relevance to innovative design.

MTH 791 **FINITE ELEMENT COMPUTATIONS** **Prereq. MTH 697 or #**

L-T-P-D-[C]
3-0-0-0-[4]

Basic of finite element approximation; Mesh generation; Global problem issues systems of linear equations; Sparse systems; Eigen value problems; Issues in time dependent problem calculations; Parallel computing aspects; Other current trends in fem computations + Project.

MTH 799 **RESEARCH**

STA 799 **RESEARCH**

MECHANICAL ENGINEERING

PROFESSORS

Banerjee BN	bnb	7081
Biswas Gautam	gtm	7656
Choudhury SK	choudhry	7270
Deb K	deb	7205
Dhande SG (Joint appointment with CSE)	sgd	7170
Dixit PM	pmd	7094
Eswaran V	eswar	7429
Ghoshdastidar PS	psg	7019
Hatwal H	hhatwal	7098
Jain V K	vkjain	7916
Kalra MS	msk	7527
Kishore NN	nnk	7049
Kumar P	prkumar	7048
Mallik AK	akmallik	7098
Munshi P	pmunshi	7243
Muralidhar K	kmurli	7182
Pundir BP	pundir	7684
Vyas NS (Head)	vyas	7040

ASSOCIATE PROFESSOR

Sarkar S	subra	7942
Panigrahi PK	panig	7686
Reddy NV	nvr	7362
Dasgupta B	dasgupta	7095

ASSISTANT PROFESSORS

Agarwal AK	akag	7982
Basu S	basu	7506
Bhattacharya S	bhattacs	6056
Bhattacharya B	bishakh	7824
Das Malay	mldas	7359
Dutta A	adutta	7995
Khandekar S	samkhan	7038
Kar KK (Joint appointment with MSP)	kamalkk	7687
Mahesh S (Joint appointment with AE)	smahesh	7060
Ramkumar J		
Saxena A	anupams	7988
Saha AK	aksaha	7869
Venkitanarayanan P	venkit	7528
Sharma I	ishans	6152
Sharma B L	bls	6173
Wahi P	wahi	6092

EMERITUS PROFESSOR

Ghosh A	amitabha	7010

EMERITUS FELLOW

Sengupta A (Joint appointment with NET)	osegu	7035

Convenor, DUGC :	P. S. Ghoshdastidar	psg	7019
Convenor, DPGC :	Eswaran V	eswar	7429
Faculty Counsellor :	P. Venkitanarayanan	venkit	7528

The Department of Mechanical Engineering trains students in the methods of engineering science and in the application of these methods to conceive, analyse and design engineering systems.

The professional programme of the department includes a deeper study of a number of engineering sciences (to which the students are introduced at the core curriculum level), theoretical and experimental solution of physical problems, and design of systems relevant to the contemporary industrial world. The areas introduced by the department include Energy Conversion and Power Systems, Heat Transfer and Fluid Mechanics, Mechanics of Solids and Stress Analysis, Manufacturing Science, Industrial Engineering, Automatic Controls and Engineering Design and Optimisation. Laboratory experience is considered an important part of the mechanical engineering programme. There are course-oriented laboratories where a student does experimental work leading to a better understanding of physical phenomena.

The department of mechanical engineering has a postgraduate programme leading to M. Tech. and Ph. D. degrees in four broad streams: Solid Mechanics and Design, Fluid Mechanics and Thermal Sciences, Manufacturing Sciences and Mechatronics. Within these streams, new areas which receive vigorous attention include Fracture mechanics, Experimental mechanics, Flow control, Optical measurements, Alternative fuels, Computer Aided Manufacturing, Computational Fluid Dynamics and Heat Transfer, Genetic Algorithms, Smart Materials, Rapid prototyping, Microscale transport, Micro measurements and sensors, Nanomechanics, and Mechatronics. In the postgraduate programme, the emphasis is on the development of a broad background in a particular stream followed by a deeper study of a research topic.

CURRENT COURSE STRUCTURE FOR B.TECH. STUDENTS

MECHANICAL ENGINEERING

	S E M E S T E R							
	FIRST	**SECOND**	**THIRD**	**FOURTH**	**FIFTH**	**SIXTH**	**SEVENTH**	**EIGHTH**
C O U R S	PHY102 MTH101 TA101 ESC102 PE101 HSS-I-1/ ENG112N	PHY101 CHM101 MTH102 ESC101 PHY103 ME100 PE102	MTH203 CHM201 TA201 ESO202 ESO210	HSS-I-2 ESO204 ESO214 ME231 ME251	HSS-II-1 ME321 ME341 ME352 ME361 OE-1	SE-1 ME301 ME351 ME353 ME371 DEL-1	SE-2 ME300 ME401 ME451 ME453 ME471 OE-2	HSS-II-2 ME452 ME461 DEL-2 DEL-3 OE-3

ME 100 Introduction to Profession
ME 251N Graphics In Mechanical Design
ME 231N Fluid Mechanics
ME 251N Engineering Design and Graphics
ME 321N Advanced Mechanics of Solids
ME 341N Heat & Mass Transfer
ME 352N Theory of Mechanisms & Machines
ME 361N Manufacturing Technology
Open Elective-I
ME 301N Energy Systems-I
ME 351N Design of Machine Elements
ME 353N Dynamics &Vibration of Machinery
ME 371N M.E. Laboratory I
Departmental Elective-I
Science Elective-I
ME 300 Summer Industrial Training
ME 401N Energy Systems II
ME 451N Project-I
ME 453N Automation & Contol
ME 471 M.E. Laboratory II
Open Elective-II
Science Elective-II
ME 452N Manufacturing Systems
ME 461N Project-II
Open Elective-3
Departmental Elective-2
Departmental Elective-3
HSS-4

COURSE DESCRIPTION

ME 100 **INTRODUCTION TO MECHNICAL ENGINEERING**
L-T-P-D-[C]
1-0-2-0-[0]

Historical perspective; description of devices used in power production; energy storage and transmission; manufacturing and automation; new materials; future trends including interfacing with microprocessors, sensors, actuators, and virtual systems; demonstration and hands-on laboratory.

ME 231N **FLUID MECHANICS**
L-T-P-D-[C]
3-0-0-1-[4]

Reynolds Transport Theorem; Integral form of continuty, momentum and energy; Eulerian and lagrangian view-points; Constitutive relations; Navier Stokes equations: Exact solutions; Potential flow; Boundary layer theory; Separation and drag; Turbulent flow: Reynolds averaged equations; Turbulent flows in pipes and channels; compressible flows.

ME 251N **ENGINEERING DESIGN AND GRAPHICS** **Prereq. TA 101N**
L-T-P-D-[C]
2-0-3-0-[4]

Theory of general engineering design; conceptual design; embodiment design involving layout and form; designing to standard; basic sketching; machine drawing including fits and tolerances, machine elements, assembly drawing and list of parts; geometric modeling; project based lab session including sketching and geometric modelling using a software package; drawing project on reverse engineering.

ME 300 **SUMMER INDUSTRIAL TRAINING**

Six weeks training after the sixth semester in the Industry.

ME 301N **ENERGY SYSTEMS-I**
L-T-P-D-[C]
3-0-0-0-[4]

Energy resources: Fossil fuels, Hydrogen energy, Solar thermal, Nuclear fuels, and renewable energy sources. Direct energy conversion: Solar Photo voltaic, MHD power, Fuels cells. Energy Release: Combustion of fossil fuels, Adiabatic flame temperature, Modern boilers, mountings and accessories. IC engine fundametals: SI and CI Engines, real cycles. Combustion in SI and CI Engines: performance and trail of Engine. Refrigiration and Airconditioning: Reciprocating single and multi-stage compressors, Refrigeration cycles, Psychrometric processes, Airconditioning systems.

ME 311 **REFRIGERATION& AIR CONDITIONING** **Prereq. ME 301, #**

L-T-P-D-[C]
3-0-0-0-[4]

Refrigeration Cycles: vapour absorption and thermo-electric refrigeration systems. Refrigerants: multistage refrigeration. Load calculations. Design of various elements of a refrigeration unit, psychrometry. Applications : ice plant, water-coolers, cold storage, comfort airconditioning etc.

ME 321N **ADVANCED MECHANICS OF SOLIDS** **Prereq. ESO 204**

L-T-P-D-[C]
3-0-0-0-[4]

Continuum concepts; Stress field (Cauchy's principle, equilibrium equation); Deformation (strain tensor, compatibility); Principle of virtual work; Constitutive equations; Uniqueness and superposition; Boundary value problems in plane stress and plain strain, torsion of non circular cross section, Kelvin problem and 3-D problems; Failure theories, plasticity, fracture mecahnics; Stress waves in 1-D; Large deformations; Numerical and Experimental methods.

ME 341N **HEAT AND MASS TRANSFER** **Prereq. ME 231N**

L-T-P-D-[C]
3-0-0-1-[4]

Conduction: 1-D & 2-D Steady State conduction with and without heat sources-Analytical and Numerical Solutions; 1-D & 2-D Transient Conduction- Analytical and Numerical Solutions; Convection; Velocity, Thermal and Concentration Boundary Layers; Heat Transfer in External Flows; Heat Transfer in Internal Flows; Turbulent Heat Transfer; Free Convection; Boiling & Condensation; Heat Exchangers; Radiation: Black Body Radiation, The Gray Surface; Radiation shields.

ME 351N **DESIGN OF MACHINE ELEMENTS** **Prereq. ME 251**

L-T-P-D-[C]
3-0-2-0-[4]

Material and manufacturing in design; materials selection; reliabilty based design; modes of failure, failure theories; fracture and fatique; analysis synthesis and selection of machine component including spring, joining and fastening methods; shaft, keys, coulings, bearing and lubrication, brakes, and gears; project based lab session involving analysis and design of machine using software packages.

ME 352N **THEORY OF MECHANISMS AND MACHINES**

L-T-P-D-[C]
3-0-0-0-[4]

Kinematic pair, diagrams and inversion. Mobility and range of movement. Displacement velocity and acceleration analysis of planar linkages. Dimensional synthesis for motion, path and function generation. Cam profile synthesis. Gears, Dynamic force analysis, flywheel, inertia forces and balancing for rotating and reciprocating machines.

ME 353N **DYNAMICS AND VIBRATIONS OF MACHINERY**

L-T-P-D-[C]
3-0-0-0-[4]

Three dimensional motion of rigid bodies kinematics and kinetics. Gyrodynamics. Vibrations of single, two and multiple degrees of freedom systems, free and forced vibrations; Time and frequency domain analysis, Free vibration of one dimensional continuous systems, approxi-mate methods.

ME 355 **INTRODUCTION TO TRIBOLOGY** **Prereq. ESO 212**

L-T-P-D-[C]
3-0-0-0-[4]

The tribological system: Common modes of failure and common solutions. Theories of friction and wear; Lubrication, Properties of lubricants. Boundary, hydrodynamic, hydrostatic, elasto-hydrodynamic lubrication and bearings based on these principles. Thermo-elastic deformation and fluid sealing. Lubrication methods.

ME 356 **ANALYSIS AND SYNTHESIS OF LINKAGES** **Prereq. ME 252**

L-T-P-D-[C]
3-0-0-0-[4]

Advanced techniques of kinematic analysis and synthesis of mechanisms. Spatial kinematics and space mechanisms. Error analysis. Optimization techniques and computer applications in synthesis of mechanisms. Dynamic, elastodynamic and kineto-elastodynamic analysis.

ME 358 **AUTOMOTIVE MECHANICS**

L-T-P-D-[C]
3-0-0-0-[4]

Reciprocating automotive engines including their lubricating and cooling systems, ignition and electrical systems, carburation and fuel injection systems, fuel supply system, transmission system, breaking system, steering, chassis and suspension.

ME 359 **INTERNAL COMBUSTION ENGINES**

L-T-P-D-[C]
3-0-0-0-[4]

Classification, Construction, Valve arrangements. Fuels, Fuel air cycle. Combustion, Effect of engine variables, Combustion chambers, Carburation and fuel injection, Knocking. Engine cooling, Friction and lubrication Supercharging. Wankel engine. Testing and performance. Pollution.

ME 360 **COMPUTER AIDED MANUFACTURING**

L-T-P-D-[C]
3-0-0-0-[4]

Direct numerical control (DNC) and computer numerical control (CNC), adapative control of manufacturing processes. Manufacturing system concepts. Computer processes monitoring and control, off-line use of computers. Computer aided design. Computer-process interface, programming, introduction to FMS.

ME 361 **MANUFACTURING TECHNOLOGY** **Prereq. TA 202**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to manufacturing processes, Metal casting; Foundry automation. Plastic deformation; load estimation: High velocity forming; defects. Metal cutting: tool specification system. Merchants' theory; Tool life; Economics of machining. Mechanics of grinding. Common shaping processes for plastics; defects and product design. Joining processes, solidification of welds, TIG, MIG, resistance welding; design considerations and weld quality. Unconventional machining processes, RP processes. Rapid tooling techniques. Metrology: limits, fits and tolerance. Automated inspection and CMM; Selection of manufaturing processes for a given product.

ME 363 **DESIGN OF MACHINE TOOLS**

L-T-P-D-[C]
3-0-0-0-[4]

Analysis of machine tool systems from the point of view of kinematics, strength and rigidity. Design of drive systems. Design of machine tool structures, static and dynamic points of view. Design of spindles, bearings, slides and guides. Control systems for machine tools. Design aspects of conventional machine tools and case studies.

ME 365 **NUMERICAL CONTROL OF MACHINE TOOLS**

L-T-P-D-[C]
3-0-0-0-[4]

Data processing machines. Continuous sampled data on digital control systems. Positioning, straight cut and contouring control systems. Numerical control application. Machine tools and their relation to numerical control. Manual and computer aided programming, specialized manufacturing applications.

ME 371 **MECHANICAL ENGINEERING LAB I** **Prereq.: ESO 214, ME 361, ME 231**

L-T-P-D-[C]
0-0-6-0-[0]

Experimentation in machine dynamics, Materials, Manufacturing Sciences and Fluid mechanics.

ME 373 **MEASUREMENT AND CONTROL OF FLOW SYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Similarity, errors, dynamic response, Pitot tube, hot-wire anemometer, laser Doppler velocimeter, optical techniques for field measurement, image procesing, volume-averaged measurement, uncertainty analysis. Signal processing and compensation for probe characteristics, data acquisition, feedback control, adaptive control, practical configurations, lab work.

ME 374 **MECHANICAL ENGINEERING RESEARCH**

L-T-P-D-[C]
0-0-0-0-[4]

To learn about a topic in depth through independent study under the guidance of a faculty member from the department. Based on a Original Research Project/ design project/experimental project.

ME 401N **ENERGY SYSTEMS-II**

L-T-P-D-[C]
3-0-0-0-[4]

Thermal power plants: Gas and steam power cycles, Regenerative and reheat cycles, Lorenz and Kalina cycles. Turbo Machinery: Classification Similitude and specific speeds, Euler turbine equation, Velocity triangles. Turbine and compressor cascades. Axial-flow turbines and compressors: Stage efficiency and characteristics, Radial equilibrium, Governing. Fans, blowers and compressors: Slip factor, performance characteristics. Hydraulic Machines; Pelton wheel, Francis and Kaplan turbines, Draft tubes, Pumps, Cavitation, Fluid coupling and torque converter.

ME 402 **POWER SYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Power plant layout, Plant performance and operation characteristics. Coal handling units and furnaces, ash handling systems and dust collectors. Water and fire-tube boilers, modern boilers, boiler mountings and accessories, safety devices. Natural, forced, induced and balanced drafts. Steam gas and hydraulic turbines. Diesel power plants, Cogeneration with steam power plant. Nuclear power plants.

ME 404 **DIRECT ENERGY CONVERSION** **Prereq. ME 304 #**

L-T-P-D-[C]
3-0-0-0-[4]

Electrochemical effects and fuel cells. Thermionic systems: Thermionic emission and conversion. Thermoelectric systems: Kelvin relations, power generation, properties of thermoelectric materials, fusion plasma generators. Recent experiments.

ME 423 **FINITE ELEMENT METHODS IN ENGINEERING**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to I-D FEM Problems in structural mechanics using two dimensional elements. Plane stress, plane strain, axisymmetric analysis. Three dimensional stress analysis; Shell analysis. Solution of heat conduction, fluid flow, vibration, stability, and non-linear, large scale systems.

ME 427 **COMPOSITE MATERIALS**

L-T-P-D-[C]
3-0-0-0-[4]

Structures and method of preparation of fibres and fibre reinforced composites. Micromechanics and prediction of elastic constants. Strength of composites. Properties of laminated composites and their constitutive equations. Laminates. Interfacial mechanics and properties. Applications.

ME 430 **NUMERICAL FLUID FLOW AND HEAT TRANSFER**

L-T-P-D-[C]
3-0-0-0-[4]

ODE, matrix methods, root finding. Classification of PDE, finite differences, Steady and unsteady conduction, explicit and implicit method, advection-diffusion problems, upwinding, boundary-layers. Navier-Stokes equations, MAC and SIMPLE, finite element method for heat conduction.

ME 442 **OPTIMIZATION METHODS IN ENGINEERING DESIGN**

L-T-P-D-[C]
3-0-0-0-[4]

Classical optimization methods, unconstrained minimization. Univariate, conjugate direction, gradient and variable metric methods, constrained minimization, Feasible direction and projections. Integer and Geometric programming, genetic algorithms, simulated annealing techniques, design applications.

ME 443 **SOLAR ENERGY THERMAL PROCESSES**

L-T-P-D-[C]
3-0-0-0-[4]

Fundamentals of solar radiation Review of fluid mechanics and heat transfer. Flat plate collectors, Focussing collectors, Solar water and air heating systems, solar cooling and dehumidification, solar energy storage, solar electric power, solar distillation of saline water and solar stills, solar cookers, solar pond and its thermal performance.

ME 449 **INTERACTIVE COMPUTER GRAPHICS AND DESIGN**

L-T-P-D-[C]
3-0-2-0-[5]

Interaction devices and techniques, geometrical transformations, viewing in three dimensions, modelling and object hierarchy, raster algorithms, display, representation of 3-D shapes, rendering of surfaces and solids, hidden lines, edge and surface removal, shading models, shadows.

ME 450 **COMPUTER AIDED ENGINEERING DESIGN**

L-T-P-D-[C]
3-0-0-0-[4]

Methodology of interactive, graphical, engineering design: Discretization, optimization, simulation in CAED. Design of curves and surfaces. Applications in conveyor systems, sheet metal working, tool design, pumps etc. Design of volumes. Intersection of surface and interference of volumes.

ME 451N **PROJECT-I**

L-T-P-D-[C]
0-0-6-0-[4]

Project work involving the analysis, synthesis, material/component selection and detailed design of a mechanical system including the preparation of working drawings. The system may be integrated with electronics, electrical, hydraulic and other systems. Projects may be selected by students from any of the four streams, Fluid mechanics and Thermal sciences, Solid Mecahincs and Design, Manufacturing Science and Robotics.

ME 452N **PROJECT-II**

L-T-P-D-[C]
0-0-4-0-[2]

Fabrication of a prototype based on the work done in project-I. Qualitative performance evaluation and appropriate modification of a prototype.

ME 453N **AUTOMATION AND CONTROL**

L-T-P-D-[C]
3-0-0-0-[4]

Modeling, Analysis, and Simulation of Dynamic System; Mechanical, electronic, electrohydraulic and electomechanical systems; Stepper and Servo-motors; use of MATLAB; State-Space, laplace and frequency domain system behaviour; Bode, Nyquist, and root-locus plots; open and closed loop control systems; stability and sensitivity; PID, Phase lag and Phase lead compensation; Sampled data systems and Digtal controllers; DA/AD converters; Microprocessors; Sensors and actuators; interfacing with computers.

ME 454 **INDUSTRIAL DESIGN**

L-T-P-D-[C]
3-0-0-0-[4]

Ergonomics-Estimation of performance and power requirements of Vehicles, Power Hydraulics, the form and function of Industrial Structures, product costing and pricing, the choice of suitable technologies, new engineering materials and their usage and costs. Case studies in engineering design, Industrial model making. Industrially sponsored project studies.

ME 457 **ENGINEERING DESIGN CREATIVITY**

L-T-P-D-[C]
3-0-2-0-[4]

Concepts and Practice: 2-D and 3-D form analysis in product design and in architecture; Aesthetics and Design; Evolution of design from craft to modern products; Technology and Society; Problem definition; Functional requirements, independence and hierarchy, constraints, non-uniqueness etc; Generation of ideas, courage, communication, decision making, synthesis and analysis. Robust design; Forms of traditional and modern societies - misfits between form and context, elimination of misfits, feedback. Studio Work : Design and fabrication of a product

ME 461 **MANUFACTURING SYSTEM** **Prereq. ME 361N**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to manufacturing system's concepts, manufacturing automation, flow lines and assembly systems. CAD/CAM; NC, CNC and DNC, adaptive control;

Manual and computer assisted part programming. Automated storage/retrieval systems; materials handling system including AGV; robot applications in manufacturing. Process planning, CAPP, scheduling and sequencing. GT and its benefits. Cost analysis, break even analysis and depreciation. Material management; inventory; MRP and MRP II; Just in time(JIT). Quality assurance and control; SQC, control charts; sampling; T.Q.M, Manufacturing system Simulation. FMS, CIMS, network and database for Mfg. system.

ME 462 **TOOL DESIGN** **Prereq. ME 253 & ME 362**

L-T-P-D-[C]
3-0-0-0-[4]

General considerations in tool design. Work holding devices, design of jigs and fixtures. Design of press working tools. Blanking and piercing dies. Design of tooling for deep drawing. Design of limit guages.

ME 464 **MODERN MACHINING METHODS**

L-T-P-D-[C]
3-0-0-0-[4]

Introductive to unconventional machining processes. Abrasive jet machining, ultrasonic machining, abrasive water jet machining, abrasive flow machining, water jet machining, electro chemical machining, electro discharge machining. Electron beam machining, laser beam machining and plasma arc machining. Design of tooling.

ME 466 **FOUNDARY ENGINEERING, 3-0-0-0-4** **Prereq. ME 362**

L-T-P-D-[C]
3-0-0-0-[4]

Bond formation, properties of various moulding materials, principles of solidification and structure of castings, risering and gating, centrifugal casting, continuous casting, investment casting, pressure die casting. Introduction to powder metallurgy.

ME 471N **MECHANICAL ENGINEERING LAB** **Prereq.: ME 301N, ME 321, ME 341, ME 453N**

L-T-P-D-[C]
0-0-6-0-[4]

Experimentation in automation and control, Solid Mechanics, Heat transfer, Energy conversion.

ME 611 **REFRIGERATION SYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Thermodynamic analysis of vapour-compression, air and non-conventional refrigeration systems, application and optimization of multistage and cascade refrigeration systems, refrigerants, fan pump, evaporator and condenser selection, Solar powered refrigeration, heat pump.

ME 613 **THERMAL ENVIRONMENTAL CONTROL**

L-T-P-D-[C]
3-0-0-0-[4]

Moist air and psychrometric processes. Physiological principles of thermal comfort, calculation of cooling and heating loads; ADP determination, solar radiation and shading devices, duct design; Heat and mass transfer in air washers, cooling towers, finned heat exchangers; Air dehumidifi-cation.

ME 616 **THERMAL TURBOMACHINES**
L-T-P-D-[C]
3-0-0-0-[4]

Turbomachine theory, potential flow to two dimensional cascades and experimental correlation, Conformal mapping and similarity methods. Methods for solving direct and inverse cascade problems for compressible flow, Axi-symmetric through flow, Advanced cycles, Stress analysis of components.

ME 617 **ADVANCED THEORY OF TURBOMACHINERY**
L-T-P-D-[C]
3-0-0-0-[4]

The equations of motion in rotating coordinate system, effects of Coriolis and Centrifugal forces, energy equation, classification of turbomachines; two-dimensional cascade theory and experimental results; two dimensional flow analysis of axial impellers; three dimensional flow in axial turbomachines, radial equilibrium, secondary flows and loss estimation; off-design performance; radial and mixed flow machines; multistage axial compressors and turbines; prediction of stage performance and stacking; rotating stall and surge; turbine blade heat load and blade cooling;

ME 620 **MECHANICS OF MATERIALS**
L-T-P-D-[C]
3-0-0-0-[4]

Analysis of stress and strain; Constitutive relationships; Failure theories; Torsion of non-circular sections. Plane stress and plane strain problems; Viscoelasticity, Structure and behaviour of polymers, behaviour of unidirectional composite and orthotropic lamina; Failure theories for fibre composites.

ME 621 **INTRODUCTION TO SOLID MECHANICS**
L-T-P-D-[C]
3-0-0-0-[4]

Theory of constitutive equations with special emphasis on elasticity, plasticity and viscoelasticity. Solution of problems to illustrate effects of elasticity, thermo-elasticity, plasticity and viscoelasticity.

ME 622 **THEORY OF ELASTICITY**
L-T-P-D-[C]
3-0-0-0-[4]

Analysis of stress and strain; Equilibrium, Compatibility and constitutive equations; Plane problems; Stress functions; Applications; Complex potentials in two dimensional and axisymmetric problems; Variational methods; Anisotropic elasticity; Finite deformation elasticity.

ME 623 **FINITE ELEMENT METHODS IN ENGINEERING MECHANICS**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction to I-D FEM. Problems in structural mechanics using two dimensional elements; Plane stress, plane strain, axisymmetric analysis; Three dimensional stress analysis; Shell analysis; Solution of heat conduction, fluid flow, vibration, stability, and non-linear, large scale systems.

ME 625 **APPLIED DYNAMICS AND VIBRATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Review of single degree of freedom systems; Generalised coordinates, constraints, virtual work; Lagrange's equation; Continuous systems; strings, beams; Raleigh-Ritz and Galerkin's methods; Dynamics of rigid bodies in three dimensions; Euler angles; Euler's equations of motion, Gyrodynamics.

ME 626 **VIBRATION OF CONTINUOUS SYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Vibration of discrete systems with single and multi degree of freedom. Hamilton's principle, Langrange's equations. Longitudinal vibration of bars, lateral vibration of straight and curved beams, vibration of membranes and plates, free and forced vibrations. Effect of damping. Wave motion in continuous systems.

ME 627 **NON-LINEAR VIBRATION**

L-T-P-D-[C]
3-0-0-0-[4]

Phase space, singular points, limit cycle; Analytical methods, perturbation techniques, equivalent linearization; Duffing's equation, jump phenomenon, Van der Pol equation. Stability criterion; Floquet's theory, Hill's and Mathieu's equations, Bifurcation and chaos.

ME 628 **RANDOM VIBRATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to probability theory, random processes, response of single, multi and infinite degrees of freedom systems to stationary random excitations. Failure due to random excitation. Brief discussion on measurement and processing of random data.

ME 630 **NUMERICAL FLUID FLOW AND HEAT TRANSFER**

L-T-P-D-[C]
3-0-0-0-[4]

ODE, matrix methods, root finding. Classification of PDE, finite differences, Steady and unsteady conduction, explicit and implicit method, advection-diffusion problems, upwinding, boundary-layers, Navier-Stokes equations, MAC and SIMPLE finite element method for heat conduction.

ME 631 **VISCOUS FLOW THEORY**

L-T-P-D-[C]
3-0-0-0-[4]

Stress-deformation relations, Navier-Stokes equation, exact solutions, two dimensional and axisymmetric boundary layers, Separation, Compressible boundary layers, Elements of stability theory, Turbulent flow: logarithmic law of the wall, effect of wall roughness, two and three equation models, fluid-solid interaction.

ME 632 **HYDRAULIC TURBO MACHINES**

L-T-P-D-[C]
3-0-0-0-[4]

Classification, characteristics, Euler's equation, efficiencies, prerotation,vortex theory, methods to find the flow characteristics of a given runner geometry. Methods for finding plate profiles. Cavitation, prediction of cavitation inception, cavitation factor, similarity laws, NPSH, cavitation machines.

ME 634 **ADVANCED COMPUTATIONAL FLUID DYNAMICS**

L-T-P-D-[C]
3-0-0-0-[4]

Discretisation procedure in Finite-difference and Finite-volume. Navier-Stokes, Energy equations. Staggered rectilinear grids. Explicit methods : MAC, SMAC. Implicit Methods, SIMPLE and SIMPLER. Matrix methods, conjugate gradient method, strongly Implicit Procedure. Grid-Generation:Algebraic, Transfinite, Poisson equation methods. Finite-difference Navier-Stokes solution on non-orthogonal grids, transformation. Collocated grids. Finite-volume methods on non-orthogonal grids. Turbulence modelling, k-e modelling

ME 635 **INTRODUCTION TO FLUID MECHANICS**

L-T-P-D-[C]
3-0-0-0-[4]

Continuum, fluid deformation; Equations of continuity, momentum and energy, Navier-Stokes equations; Potential Theory: Blasius' theorem, method of images. Linearized N-S equations, lubrication theory, creeping flows. Boundary layers, Momentum Integral and similarity techniques; Turbulence, Reynold's equations, flow through pipes and over flat surfaces.

ME 636 **GAS DYNAMICS**

L-T-P-D-[C]
3-0-0-0-[4]

One dimensional steady isentropic flow, normal and oblique shock; Fanno and Rayleigh lines. Prandtl-Mayer expansion. Isentropic flow in ducts, design of nozzles. Shock tube, small disturbance theory, flow past thin bodies, similarity rules. Hodograph plane, method of characteristics.

ME 637 **ELEMENTS OF KINETIC THEORY AND RAREFIED GASDYNAMICS**

L-T-P-D-[C]
3-0-0-0-[4]

Velocity distribution function, B. element's equation, dynamics of collisions, standard molecular models, macroscopic equations, stress tensor and heat flux vector, slightly non-isentropic flow, dissipation coefficients, free molecular, near free molecular and near continuum flows, Couette flow, flow through tubes, S. Caption of B. element's equation.

ME 638 **STRUCTURAL DYNAMICS OF WIND TURBINE ROTORS**

L-T-P-D-[C]
3-0-0-0-[4]

Modelling of wind turbine rotor blade, Uncoupled equations of motion for flapping, lead-lag and feathering motions. Study of blade motion and deflection. Estimation of the Rotor, Hub and Tower loads. Blade instabilities in coupled motion.: Flap-lag, Pitch-lag, Pitch-flap flutter and divergence, stall flutter.

ME 640 **FUNDAMENTALS OF HEAT TRANSFER**

L-T-P-D-[C]
3-0-0-0-[4]

Governing equations. Extended surfaces, transient conditions. Convection in laminar and turbulent boundary layer and flow through tubes. Free and forced convection, correlations, Boiling and condensation. Heat exchangers. Radiation exchange between surfaces.

ME 641 **CONDUCTION AND RADIATION**

L-T-P-D-[C]
3-0-0-0-[4]

Conduction: Steady and unsteady problems and their solutions in cartesian, cylindrical and spherical coordinates. Separation of variables. Duhamel's theorem. Laplace transform. Problems involving change of phase. Inverse heat conduction, Microscale heat transfer, Radiation: Radiative exchange among black and grey and spectral surfaces, Shape factors. Applications to cavities and enclosures. Integral equations approach. Radiation from gases, vapours and flames.

ME 642 **CONVECTIVE HEAT AND MASS TRANSFER**

L-T-P-D-[C]
3-0-0-0-[4]

Conservation equations, boundary layers, free convection, forced convection. Heat transfer in laminar and turbulent, internal as well as external flows, mixed convection. Combined convection and radiation. Boiling and Condensation. Molecular diffusion in fluids, mass transfer coefficient. Simultaneous heat and mass transfer; Applications.

ME 643 **COMBUSTION AND ENVIRONMENT**

L-T-P-D-[C]
3-0-0-0-[4]

Flame phenomena in pre-mixed combustible gases. Diffusion flames-analysis of single fuel droplet, chemical reactions. Burning in convective atmosphere, spray combustion, fire modelling, radiation in flames, formation and control of pollution, Combustion chambers.

ME 644 **NATURAL CONVECTIVE HEAT AND MASS TRANSFER**

L-T-P-D-[C]
3-0-0-0-[4]

External flows, similarity, heat transfer from inclined surfaces, free convection flows, plumes, wakes, buoyant flows. Flow in stratified media. Stability of natural convection flows, transition, turbulent heat transfer correlations.

ME 645 **ADVANCED TECHNIQUES IN HEAT TRANSFER**

L-T-P-D-[C]
3-0-0-0-[4]

Perturbation methods, transform methods, complex variables, eigen functions and series solution methods. Measurements of flow and temperature fields, optical methods, interpretation of data, design of experimental methods. Numerical method.

ME 646 **DESIGN OF HEAT EXCHANGE EQUIPMENT**
L-T-P-D-[C]
3-0-0-0-[4]

Types of heat exchangers, definitions and quantitative relationships, analytical and numerical solution procedures. Thermal and hydraulic design of heat exchangers; Review of mechanical design, codes, materials for construction, corrosion damage, testing and inspection, costing.

ME 647 **INTRODUCTION TO TURBULENT FLUID MECHANICS**
L-T-P-D-[C]
3-0-0-0-[4]

Measure of turbulence, diffusivity, length scales. Reynolds equation. Mixing length models. Homogeneous, isotropic turbulence, correlation and energy spectrum functions, integral micro scales. Grid turbulence, jets, wakes and mixing layers, boundary layers, logarithmic-law near walls.

ME 648 **COMPUTER AIDED DESIGN OF THERMAL SYSTEMS**
L-T-P-D-[C]
3-0-0-0-[4]

Simulation of thermal processes, application to casting, extrusion, heat treatment, thermal design of heat exchangers, electronic circuitry. Optimization search method and geometric programming, control strategy, data storage and retrieval. Expert systems.

ME 649 **EXPERIMENTAL METHODS IN THERMAL SCIENCES**
L-T-P-D-[C]
3-0-0-0-[4]

Probes and transducers; Calibration; Turbulence measurement via statistical measures; Single and multi-point correlations; Signal conditioning; Optical methods, Interferometry, Schlieren, shadowgraph, LCT, Laser Doppler velocimeter; Transient and frequency response. Computer aided data acquisition, tomography.

ME 650 **SOLAR SYSTEM MECHANICS**
L-T-P-D-[C]
3-0-0-0-[4]

Introduction to the Solar System, The 2- and restricted 3- body problem; Application : Trajectory planning, Orbital transfers, Interplanetary missions; Hamiltonian Mechanics Perturbation methods and effects : The disturbing function, secular perturbations, resonance stability and chaos; Planetary rings.

ME 651 **KINEMATIC ANALYSIS AND SYNTHESIS OF MECHANISMS**
L-T-P-D-[C]
3-0-0-0-[4]

Kinematic elements and pairs, mechanisms with lower and higher pairs, geometry of motion, type number and dimensional synthesis of mechanisms, analytical and graphical methods of analysis and synthesis of linkages, Coupler curve synthesis, spatial mechanisms, cams and gears.

ME 652 **PRINCIPLES OF DYNAMICS**

L-T-P-D-[C]

3-0-0-0-[4]

Review of kinematics and kinetics of a particle and a rigid body in plane motion. Euler's equations; Methods of analytical dynamics, Lagranges equations; Hamilton's principle; Dynamics in phase space and introduction to stability theory; Applications to engineering problems.

ME 653 **ADVANCED DYNAMICS OF MACHINERY**

L-T-P-D-[C]

3-0-0-0-[4]

Kinematics and dynamics of rigid bodies and system of rigid bodies. Dynamic force and motion analysis of mechanisms and machines with rigid links. Elastodynamics and kineto-elastodynamic analysis of mechanisms with flexible members. Balancing of linkages.

ME 654 **MECHANICS OF GROUND VEHICLES**

L-T-P-D-[C]

3-0-0-0-[4]

Simple dynamical models of ground vehicles, mechanics of pneumatic tires, mechanics of vehicles-terrain interaction, performance characteristics of road vehicles, Handling characteristics. Directional stability, wheel shimmy, vehicle ride characteristics.

ME 655 **INTERACTIVE COMPUTER GRAPHICS AND DESIGN**

L-T-P-D-[C]

3-0-0-0-[4]

Interaction devices and techniques, geo-metrical transformations, viewing in three dimensions, modelling and object hierarchy, raster algorithms, display, representation of 3-D shapes, rendering of surfaces and solids, hidden lines, edge and surface removal, shading models, shadows.

ME 656 **DYNAMICS OF MULTIBODY SYSTEMS**

L-T-P-D-[C]

3-0-0-0-[4]

Vector functions, reference frames, derivatives of vector functions. Kinematics. Mass/Inertia distribution. Generalized forces and energy functions. Formulation of equations of motion. Linearization and integrals of equations of motion. Extraction of information from equations of motion. Computational issues. Dynamics of a combination of rigid and flexible bodies.

ME 657 **HYDRAULIC AND PNEUMATIC CONTROL SYSTEMS**

L-T-P-D-[C]

3-0-0-0-[4]

Linear and Rotary actuators, valves and their characteristics. Flow forces on valve spools, valve design, control actuators. Hydraulic power packs, torque motor, electrohydraulic valves, FES, DPF, SLEW servovalves, Electrohydraulic servo systems; Pneumatic control elements; Pneumatic servo systems.

ME 658 **NUMERICAL CONTROL OF MACHINE TOOLS**

L-T-P-D-[C]

3-0-0-0-[4]

Basic principle of numerical control, Classification of NC systems,. NC part programming-manual and computer aided. Drives, feedback devices, Counting devices used in NC system. Interpolators for Manufacturing system. Control loops for NC system, Adaptive control, Industrial robots.

ME 659 **GEOMETRIC MODELLING FOR COMPUTER AIDED DESIGN AND MANUFACTURE**
L-T-P-D-[C]
3-0-0-0-[4]

Geometric modelling, intrinsic and parametric representations, differential geometry of curves and surfaces. Bezier's curves, rational parametric curves and surfaces. Non-uniform rational B-splines (NURBS), Coon's and Bezier surface patches. Ruled, lofted, revolved and swept surfaces, solid modelling.

ME 661 **MACHINING SCIENCE I**
L-T-P-D-[C]
3-0-0-0-[4]

Mechanics of chip formation, chip curl. Bluntness and cutting forces. Thermal aspects of machining. Tool wear, tool life and economics of machining. Mechanics of grinding, forces and specific energy, temperature. wheel wear and surface finish.

ME 662 **MACHINING SCIENCE II**
L-T-P-D-[C]
3-0-0-0-[4]

General classification of unconventional machining, chemical machining, electric discharge machining, Abrasive Jet and Ultrasonic Machining, electron beam machining, laser beam machining, ion beam machining, plasma arc machining; Comparative evaluation of different processes; Conventional machining with modifications.

ME 663 **METAL FORMING**
L-T-P-D-[C]
3-0-0-0-[4]

Fundmentals of plasticity, yield and flow, anisotropy, instability, limit analysis, slipline field theory. Applications to forging, wire and tube drawing, deep drawing, extrusion and rolling. High velocity forming.

ME 666 **ANALYSIS AND DESIGN OF MACHINE TOOLS**
L-T-P-D-[C]
3-0-0-0-[4]

Considerations in designing spindle bearing. Functions of guides and slide ways. Static and dynamic analysis of m/c tool structures. Control and automation of m/c tools. Special topics.

ME 668 **VIBRATION AND NOISE IN MACHINE TOOLS AND PRESSES**
L-T-P-D-[C]
3-0-0-0-[4]

Forced vibrations; Machine tool chatter, dynamics of metal cutting; Chatter in some typical machine tools; Effect of flexible mounting on chatter; Chatter in coupled machine tool systems; Theory of chatter with several degrees of freedom; Theory of impact dampers; Dynamics of machine tool structures.

ME 671 **EXPERIMENTAL STRESS ANALYSIS**

L-T-P-D-[C]
3-0-0-0-[4]

Strain Gauge, strain rosettes and transducer applications. Photoelasticity, materials and their selection. Introduction to 3-D photoelasticity. Brittle coating methods, Moire method of strain analysis and non-destructive testing using x-rays and ultrasonic devices.

ME 672 **EXPERIMENTAL METHODS IN STRESS ANALYSIS**

L-T-P-D-[C]
3-0-0-0-[4]

Photoelasticity. Stress-optic law. Photoelastic coatings Strain-optic law, photoelastic materials. Role of Digital Image processing techniques for automation. Strain gauges, Rosette analysis, Transducers, Case studies. Introduction to Brittle coatings, Moire, Holography, Speckle and Caustics.

ME 681 **MATHEMATICS FOR ENGINEERS**

L-T-P-D-[C]
3-0-0-0-[4]

Properties of Vector Algebra, Vector space, subspace, basis, null and range space, invertibility and matrix representation; Cartesian Tensor notation and vector analysis; Matrices and Matrix algebra, Echelon form, orthogonalization; Eigen values and eigenvectors of a linear operator; First and second order ODEs, Linear Differential equations with constant coefficients and equidimensional equations; Second order linear homogenous differential equations and their solutions; Methods of Taylor and Frobenius, Laplace and Fourier transforms, Fourier series; Legendre and Bessel functions; Sturm Louville Problem; classification of PDEs; Analytical solution of linear PDEs.

ME 683 **COMPUTATIONAL TOPICS IN ENGINEERING APPLICATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Elementary Matrix Computation, Systems of Linear Equations, Eigenvalue Problems and singular Value Decomposition, Numerical Differentiation, and Integration, System of Polynomial Equations, Systems of Nonlinear Equations, Nonlinear Optimization, Curve and surface Approximations, Numerical solution of Ordinary Differential Equations, Boundary Value Problems, Differential Algebraic Equations, Numerical Solution of Partial Differential Equations.

ME 685 **PROGRAMMING AND NUMERICAL ANALYSIS**

L-T-P-D-[C]
3-0-0-0-[4]

MATLAB, Mathematical modeling, algorithms, Taylor series expansion, root finding, interpolation, extrapolation; Solution of linear algebraic systems, determinant, inverse: norms and condition number; Solution of non-linear algebraic systems. Numerical integration. R. K. Method, Solution of ODE and linear PDEs by finite differences.

ME 686 **MODELLING AND SIMULATION FOR ENGINEERING PROBLEM SOLVING**

L-T-P-D-[C]
3-0-0-0-[4]

Black box and distributed parameter models, transient response. Model testing; stochastic vs deterministic models; Inverse problems; Experimental techniques;

Geometrical modelling and configuration design; Principles of simulation, discrete event simulation. Applications.

ME 687 **HEAT TRANSFER IN MATERIALS PROCESSING**

L-T-P-D-[C]

3-0-0-0-[4] Review of Fundamentals. Finite Difference and Finite Element Methods. Modelling of thermal transport in manufacturing of metal based components, plastics, chemicals; drying, waste processing, glass fibre making, crystal growing, food processing. Design of a material processing equipment.

ME 688 **OPTICAL MEASUREMENT TECHNIQUES IN MECHANICAL ENGINEERING**

L-T-P-D-[C]

3-0-0-0-[4] Introduction to lasers, Mach-Zender Interferometer, schlieren, Shadowgraph, Mie scattering, Image processing, scattered light photo-elasticity, method of caustics, speckle, holography, optical comparators, transmission tomography, 3-D temperature profile measurements, direct/iterative reconstruction algorithms, limited data problem, error analysis.

ME 689 **MICROSCALE THERMAL ENGINEERING**

L-T-P-D-[C]

3-0-0-0-[4] Micro-Mechanical systems (MEMS), Micro Channels, Heat pipes, jets, valves, Heat Sinks, Solar cells, Bearings, Pumps, Heat pipes, Jets, valves, Heat sinks, Solar Cells, Bearings, Pumps, Flow Sensors and actuators, Fins, Drug delivery systems, Mass, Momentum, Heat and charge transport equations, Characteristic Non-dimensional parameters, Microscale Heat conduction, Heat transport in thin films and at solid-solid interfaces, Convective diffusion phenomena, Enzyme-substrate reactions, channel flow with soluble or rapidly reacting walls, solutions of electrolytes, Electric double layer, Electrokinetic phenomena, electroosmosis, Electro-osmotic pumps, Surface tension driven flows, Coating flows, Thermocapillary flows, Molecular dynamics simulations.

ME 690 **Alternative Fuels and Advances in IC Engines**

L-T-P-D-[C]

3-0-0-0-[4] Combustion and Fuels, Combustion process in SI and CI engines, Petroleum based liquid fuels and refining, Liquid alternative Fuels, Advantages, potential, problems associated with utilization, Vegetable oils, Biodiesel, Emulsified fuels, Effect on Lubricating oils, Gaseous Alternative Fuels, Hydrogen, Compressed Natural Gas, Liquified petroleum Gas, Di-methyl ether, Hythane, Multi-fuel engines, Modern developments in IC Engines, EGR, MPFI, GDI, HCCI, Turbocharged engines, Optical Measurement techniques, Fuel atomization and spray visualization techniques, Laser doppler Anemometry, Particle image velocimetry, 3D and Holographic PIV, optical engines, sources and Nature of various types of pollutants: Pollution monitoring instruments and techniques, Control measures, emission legislations.

ME 698 **ADVANCED TOPICS ON ENGINEERING OPTIMIZATION**

L-T-P-D-[C]

3-0-0-0-[4]

Multi-objective optimization, Robust design techniques (variation reduction techniques), Optimal control, stochastic programming. Role of Optimization in CAD: Why optimization? Optimization-Geometric modeling-Analysis. Implementation Issues: computational time versus accuracy, Interfacing with geometric modelling and analysis softwares, Graphics interfacing, Choice of Hardware platform. Application to engineering design problems, comparison with existing solutions.

ME 698A **SPECIAL TOPICS**

L-T-P-D-[C]

3-0-0-0-[4]

ME 699 **M. TECH. THESIS**

ME 721 **THEORY OF PLASTICITY**

L-T-P-D-[C]

3-0-0-0-[4]

Yield surfaces. Deformation and flow theories; Theory of plastic constitutive equations; Axisymmetric and spherically symmetric problems; Slipline theory and application to problems of extrusion, drawing and indentation; Wave propagation in plastic materials.

ME 722 **FRACTURE MECHANICS**

L-T-P-D-[C]

3-0-0-0-[4]

Introduction to linear Elastic Fracture Mechanics. Elasto-Plastic fracture mechanics. Dynamic and Comutational fracture. fracture of composite materials. Damage mechanics and experimental analysis.

ME 723 **WAVE PROPAGATION IN SOLIDS**

L-T-P-D-[C]

3-0-0-0-[4]

Waves in infinite and semi-infinite elastic media. Reflection and refraction at plane interface. Dispersion of waves in bounded solids. Waves in rods and plates. Solution of transient problems. Rayleigh waves. Waves in anisotropic materials. Introduction to waves in viscoelastic and plastic media.

ME 727 **COMPOSITE MATERIALS**

L-T-P-D-[C]

3-0-0-0-[4]

Structures and method of preparation of fibres and fibre reinforced composites. Micromechanics and prediction of elastic constants; Strength of composites; Properties of laminated composites and their constitutive equations; Laminates; Interfacial mechanics and properties; Applications.

ME 728 **FRACTURE AND FATIGUE**

L-T-P-D-[C]

3-0-0-0-[4]

Fracture: Energy release rate, crack tip stresses and deformation fields, plastic zone, Elasto-plastic fracture through J-integral and CTOD, Dynamic fracture, Testing for Fracture. Toughness. Fatigue: Crack nucleation and growth, Fatigue life prediction, Statistical analysis.

ME 729 **MODELLING OF MECHANICAL PROPERTIES OF MATERIALS**
L-T-P-D-[C]
3-0-0-0-[4]

Prereq. ME 621

Introduction, Homogenisation, Ductile Materials, Dislocations, single crystal plasticity, Size effects on mechanical properties, Thermodynamics of constitutive modelling, Examples of constitutive models, Modelling of very small structures.

ME 741 **COMBUSTION ENGINES AND POLLUTION**
L-T-P-D-[C]
3-0-0-0-[4]

Thermo-chemistry, Chemical Equilibrium, Kinetics; Laminar and Tarbulent Flame propagation in SI Engines, Unburned and Burned Mixture States, Flame Quenching; Fuel Injection, Spray Atomization, Penetration and Evaporation, Fuel-Air-Mixing and Burning Rates in CI Engines; Pollutant Formation in Engines, Zeldovich Mechanism, Soot Formation; Vehicle Emissions and standards; Emission control Technologies, Catalytic Control, Engine Design and Fuel effects,New Advances; Emission Measurement

ME 742 **BOILING AND CONDENSATION**
L-T-P-D-[C]
3-0-0-0-[4]

Pool boiling: Nukiyama Experiment, theory of vapour bubble formation, Mechanism of CHF, various models and correlations. Flow Boiling, Homogeneous, and hetrogeneous models, Boiling enhancement techniques. Heat Pipes. Design of boilers, Film and dropwise condensation. Nusselt's analysis of laminar film condensaion on vertical flat plate, single horizontal tube and vertical array of tubes. Laminar-wavy and turbulent film condensation. Film condensation inside horizontal tubes, condensation enhancement techniques, design of condensers, special topics: Computer simulation of boiling.

ME 751 **COMPUTER AIDED ENGINEERING DESIGN**
L-T-P-D-[C]
3-0-0-0-[4]

Methodology of interactive, graphical, engineering design; Discretization, optimization, simulation in CAED. Design of curves and surfaces. Applications in conveyor systems, sheet metal working, tool design, pumps etc. Design of volumes. Intersection of surface and interference of volumes.

ME 752 **OPTIMIZATION METHODS IN ENGINEERING DESIGN**
L-T-P-D-[C]
3-0-0-0-[4]

Classical optimization methods, unconstrained minimization; Univariate, conjugate direction, gradient and variable metric methods, constrained minimization, Feasible direction and projections. Integer and Geometric programming, genetic algorithms, simulated annealing techniques, design applications.

ME 753 **RELIABILITY BASED DESIGN**
L-T-P-D-[C]
3-0-0-0-[4]

Determination of reliability. Reliability analysis of weakest-link and fail systems.

Reliablity based design of mechanical and structural components. Application of statistical methods to stability problems. Reliability engineering in production and manufacturing systems. Dynamic reliability.

ME 754 **OPTIMAL CONTROL SYSTEMS**
L-T-P-D-[C]
3-0-0-0-[4]

Principles of optimality, Hamilton-Jacobi-Bellman equation. Calculus of variations: Piecewise smooth extermal. Constrained extrema, Two point boundary value problems, linear regulator problems, linear tracking problems. Pontryagin's minima principle, Numerical methods for finding optimal controls. Quasilinearization techniques.

ME 755 **SPECIAL TOPICS IN TRIBOLOGY**
L-T-P-D-[C]
3-0-0-0-[4]

Friction and wear in boundary lubrication, tribological properties of materials. Friction instabilities and stick slip; Rolling motion. Macro and micro-slip; Tyre-road interactions. Elasto-hydrodynamic lubrication; Friction-induced thermomechanical interactions; Foil bearings.

ME 756 **VIBRATION CONTROL**
L-T-P-D-[C]
3-0-0-0-[4]

Factors affecting level of vibration, vibration reduction at the source, vibration control by structural design, selection of materials. Vibration control by additive damping; Dynamic vibration absorbers, vibration and shock isolators, Active control.

ME 757 **DYNAMICS OF ROTATING MACHINERY**
L-T-P-D-[C]
3-0-0-0-[4]

Rotor-bearing interaction. Flexural vibration, critical speeds of shafts, Effects of anisotropic bearings, unbalanced response of an assymetric shaft. Gyroscopic effects. Aerodynamic effects. Equivalent discrete system. Geared and branched systems. Fluid film bearings: Steady state characteristics of bearings. Rigid and flexible rotor balancing. Measurement techniques.

ME 758 **ADVANCED METHODS IN ENGINEERING DESIGN**
L-T-P-D-[C]
3-0-0-0-[4]

Principles of Design, Optimum Design, Failure Considerations in Design, Robust design, Reliability, Ergonomics Considerations in design.

ME 759 **ADVANCED TOPICS IN NON-TRADITIONAL MACHINING PROCESSES**
L-T-P-D-[C]
3-0-0-0-[4]

A brief review of non-traditional machining processes, Analysis of mechanical, thermal and Electrochemical type non-traditional machining processes. Analysis of micro-machining processes. Tool design for selected non-traditional machining processes. Modeling and simulation of selected processes. A comparative study of various processes. Application of CNC concepts to non-traditional machining processes machines. Computer aided process planning of non-traditional processes.

ME 760 **MODERN CONTROL OF DYNAMIC SYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Concepts from Linear system Theory. Modern Control systems: Solution of state-space equations, State transition matrix. State-space analysis of multi-variable systems; Multi-loop systems and multi-variable block diagrams. State-space representation of control systems, Transfer matrices, Transformation from continuous to discrete time representations; Impulse and pulse response matrix; Modal decomposition, State feedback regulators; Constant gain state-feedback design. Design of controllers: Full and reduced order observer design; Integration of controller and observer; Eigen-structure assignment; Optimum controller design; Robust control. Distributed Parameter Systems:

ME 761 **COMPUTER AIDED MANUFACTURING**

L-T-P-D-[C]
3-0-0-0-[4]

Direct numerical control (DNC) and computer numerical control (CNC): adapative control of manufacturing processes. Manufacturing system concepts. Computer processes monitoring and control, off-line use of computers. Computer aided design. Computer-process interface; programming, introduction to FMS.

ME 762 **INTRODUCTION TO ROBOTICS**

L-T-P-D-[C]
3-0-0-0-[4]

Types of Robots. Spatial transformation and kinematics of open chain linkages. Mobile robots, Actuators, sensors, programming and control. Applications - motion planning, grasping and industrial automation.

ME 763 **ROBOT MANIPULATORS: DYNAMICS AND CONTROL**

L-T-P-D-[C]
3-0-0-0-[4]

Review of robot manipulators. Manipulator kinematics, dynamics and control. Singularity and workspace analysis. Introduction to manipulator design.

ME 764 **COMPUTER INTEGRATED MANUFACTURING SYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Software tools for CIMS. Basics of DBMS, DSS, distributed computing and LAN and FAN. Shop floor automation and automatic identification techniques, CAD/CAM. Industrial robotics: Single and mixed product manufacturing, robotized assembly. GT applications. FMS: analysis. Automated material handling.

ME 765 **MANUFACTURING AUTOMATION**

L-T-P-D-[C]
3-0-0-0-[4]

Automation strategies, flow lines, automated assembly systems, transfer systems; Vibratory bowl feeders, non-vibratory feeders. Part orienting, feed track, part placing and part escapement systems; Programmable automation, industrial robotics; Flexible manufacturing systems; Automation equipment.

ME 766 **ROBOT MOTION PLANNING**

L-T-P-D-[C]
3-0-0-0-[4]

Configuration spaces of mobile vehicles and manipulators, Geometric modelling and sensor based map building. Path planning and obstacle avoidance. Object manipulation and grasping. Design of user interfaces and simulation. Algorithms for assembly and biological aspects of motion and intelligence.

ME 767 **EVOLUTIONARY ALGORITHMS IN SEARCH AND OPTIMIZATION**

L-T-P-D-[C]
3-0-0-0-[4]

Traditional optimization methods. Simple genetic algorithms- reproduction, crossover and mutation. Analysis of GA-operators; Deception; Multimodel and multiobjective optimization; Engineering applications. Introduction with applications for Evolution strategy and Simulated annealing.

ME 768 **ARTIFICIAL INTELLIGENCE IN ENGINEERING**

L-T-P-D-[C]
3-0-0-0-[4]

Computational techniques for representing and solving problems. Biological Perspectives. Representation, production systems and search. Heuristics. First order logic and resolution. Fuzzy logics. Planning spatio temporal reasoning, learning. Qualitative reasoning. Neural nets. Applications from engineering.

ME 769 **ADVANCED TOPICS IN ROBOTICS**

L-T-P-D-[C]
3-0-0-0-[4]

Advanced techniques of kinematics and dynamics of mechanical systems. Parallel-actuated and closed-loop manipulators. Redundant manipulators. Mobile robots and path planning. Complaint motion and grasping. Sensing and vision. Nonlinear control of robots. Any other relevant topic.

ME 770 **MATERIALS SELECTION IN MECHANICAL DESIGN**

L-T-P-D-[C]
3-0-0-0-[4]

The evolution of engineering materials; Materials and the design process; Functional requirements of engineering materials; Materials selection based on properties alone; Materials selection based on properties & shape; Processing, materials & design; Materials property data. Latest developments in the use of materials; New materials; Case studies.

ME 771 **SMART MATERIALS AND STRUCTURES**

L-T-P-D-[C]
3-0-0-0-[4]

Materials for both actuation and sensing: Piezoelectric Materials, Magnetostrictive Materials, Materials for actuation: Shape Memory alloys Magnetic shape memory material, Electro/Magneto rheological fluids; Materials for sensing: Optical fibre; Composite smart materials and micromodelling related issues; Energy based approach: Hellinger-Reissner Principle, Variational Formulation, Finite Elements Modelling of Vibration of smart Laminates; state space based analysis & design of smart controllers, Concepts of Controllability & observability; Pole placement Techniques; Intelligent system with integrated sensors & actuators; Self-sensing actuators; Placement of Smart Actuators/Sensors - Vibration damping.

ME 772 **MECHATRONICS**
L-T-P-D-[C]
3-0-0-0-[4]

Fundamentals of the integration of mechanical and electronic subsystems using computer based control. Details of different types of sensors, actuators, DAC/ADC and micro controllers. Control systems design and modeling of computer controlled electro-mechanical systems. Industrial automation and robotics. Practical applications of mechatronics, design issues and industrial techniques currently in use.

ME 777 **PLASTIC PART MANUFACTURING AND TOOL DESIGN**
L-T-P-D-[C]
3-0-0-0-[4]

Fundamentals of Polymer Technology; Properties of Solid and Molten Polymers; Selection of Materials and Manufacturing Methods; Extrusion Equipment and Processing techniques; Injection Moulding; Blow Moulding, Rational Moulding, Compression and Transfer Moulding, Thermoforming; Resin Transfer Moulding; Rapid Prototyping and Tooling processes. Other Manufacturing methods (Machining, Joining, Finishing, Assembly) CAD/CAM of Dies/Moulds/Tools; Flow analysis.

ME 778 **ENGINEERING ACOUSTICS AND ITS CONTROL**
L-T-P-D-[C]
3-0-0-0-[4]

Wave propagation in solids and fluids. Admittance and impedance concepts for infinite and finite acoustic waveguides. Sound radiation from vibrating structures: Measurement of radiated power, elementary radiators, sound radiation from bending waves. Passive attenuation of structure-borne sound : Damping models, effect of elastic interlayers, blocking masses, changes of material and cross-section. Active control of structure-borne sound : Elements of frequency domain control system analysis and synthesis, wave absorbing controllers for rods, beams, and plates.

ME 780 **MULTIOBJECTIVE OPTIMISATION: THEORY, METHODS AND APPLICATIONS**
L-T-P-D-[C]
3-0-0-0-[4]

Fundamentals of optimisation with single objective. Karush-Kuhn-Tucker Conditions, Lagrangian Multipliers. Introduction to multiobjective optimisation problem. Solution concepts (Efficiency, Weak Efficiency and Proper Efficiency). Scalarization Techniques. Sturcture of Efficient set. Karush-Kuhn-Tucker Conditions for multiobjective problems. Lexicographic ordering

ME 799 **Ph. D. Thesis**

NUCLEAR ENGINEERING & TECHNOLOGY PROGRAM (Inter-Disciplinary Programme)

PROFESSORS

Kalra MS	msk	7527
Munshi P	pmunshi	7243
Vyas NS (Head)	vyas	7040
Qureshi S	qureshi	7339

Emeritus Fellow

Sengupta A	osegu	7035

PROGRAMME COMMITTEE :

M.S. Kalra (ME)	msk	7527
P. Munshi (ME)	pmunshi	7243
A. Sengupta (ME/NET)	osegu	7035
S. Qureshi (EE)	qureshi	7339
K. Muralidhar	kmurli	7775

Convenor, DUGC :	P. Munshi (ME)	pmunshi	7243
Convenor, DPGC :	P. Munshi (ME)	pmunshi	7243

Faculty Counsellor:

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In view of the rapidly expanding nuclear energy programme in India and the growing need for qualified engineers, an inter-disciplinary postgraduate programme in Nuclear Engineering and Technology leading to the M.Tech. and Ph.D. degrees was initiated in July 1974. Admission requirement for the M.Tech. programme is either a Bachelor's degree in any branch of engineering or a Master 's in Physics.

Laboratories for research and teaching in Nuclear Engineering include the facilities of the central nuclear physics laboratory, a 5 Curie Pu-Be neutron source, data processing equipment, various types of radiation detecting and counting equipment. Other relevant Institute facilities such as digital computers, material science laboratory and electronics laboratory are also available. Potential areas of research are: Nuclear reactor, transport theory, theory of kinetic equations, plasma physics, safety and controls, computerized tomography, solitons, reliability engineering, two phase flow, radiation physics, radiation detection and instrumentation.

The course work consists of a set of required subjects covering the basic concepts of nuclear science and engineering, experimental techniques and a set of electives that may be taken from within or outside of the Programme. A brief description of these courses is given below :

STRUCTURE OF THE PROGRAM

Compulsory Courses	Elective Courses
NT 601	NT 612
NT 602	NT 615
NT 611	NT 631
NT 621	NT 632
NT 614	NT 633
NT 699	NT 634
NT 799	NT 641
	NT 642
	NT 651
	NT 652
	NT 698

NT 601	or (ME 681) Mathematical methods	NT 602	Nuclear and Reactor Physics
NT 611	Nuclear Power Engineering I	NT 621	Nuclear Measurements Lab.
NT 614	Nuclear Power Engineering II	NT 699 799	Thesis research
NT 612	Reactor Physics	NT 615	Nuclear Power Engineering III
NT 631	Neutron Transport Theory	NT 632	Radioisotope Application in Engineering
NT 633	Nuclear Fusion	NT 634	Nuclear Reactions & Interaction of Radiation with Matter
NT 641	Introduction to Computerized Tomography	NT 642	Nondestructive Evaluation
NT 651	Fast Reactor Technology	NT 652	Nuclear Fuel Cycle
NT 698	Special Topics (Reliability Engineering, Theory of Kinetic Equations, Introduction to Fully Ionized Plasmas)		

Electives (Outside Department)
Numerical Methods for Engineers (ME)
Numerical Analysis (Maths)
Nuclear Materials (Met)
Optimal Control Theory (EE)
Nuclear Reactions (Phy)
Electronics (Phy)

Students are expected to have an adequate background in Mathematics, Nuclear Physics and Heat Transfer.

In order to meet the degree requirements, students will have to take additional courses. The purpose of the additional courses is to gain knowledge in a particular area which will facilitate research work in that area of specialization. Some of these courses are given below :

NT 612 L-T-P-D-[C] 3-0-0-0-[4]

REACTOR PHYSICS

Neutron transport equation and its approximate methods of solution: spherical harmonics and discrete ordinates methods. Diffusion equation and criticality studies, numerical criticality search. Energy dependent diffusion equation, multi-group method. Two group analysis, criticality equation, Collapsing of groups. Slowing down equation and its solution by the step-by -step methods exact and approximate. Methods of solution.approximate methods. Variational calculus, Euler-Lagrange equation and Raleigh Ritz method. Optimization methods. Analytic functions, conformal mappings. Cartesian tensors, order, transformation rules, calculus. Nonliear maps, local inverse and implicit function theorem. Bifurcation and Liapunov-Schmidt reduction.

NT 602 L-T-P-D-[C] 3-0-0-0-[4]

NUCLEAR AND REACTOR PHYSICS

Introduction to quantum mechanics, Schrodinger equation and its solution by separation of variables. Potential well, quantum states. Nuclear charge, radius and mass. Binding energy. Nuclear forces and the deuteron problem. Semiempirical mass formula. Energetics of nuclear stability. Reaction channels, Compound nucleus. Energy dependence of neutron cross sections and Brecit-wigner formula. The fission process.

Neutron diffusion theory showing down length. Critical mass and size. Numerical criticality search. Four-factor formula. Energy dependent diffusion. Multigroup diffusion, group constants and matrix formulation. Two-group analysis. Age theory. Slowing down theory.

NT 611 L-T-P-D-[C] 3-0-0-0-[4]

NUCLEAR POWER ENGINEERING I

Types of nuclear reactors. Heat generation in fuel elements and temperature distributions. Heat removal, Reactor coolants. Single phase and two phase heat transfer. Boiling and flow regimes. Heat transfer and fluid flow correlations. Pressure drops due to friction and pumping power. Reactor core

NT 601 L-T-P-D-[C] 3-0-0-0-[4]

MATHEMATICAL METHODS

Sets, relations, mappings and inverses. Systems of linear equations. Vector space, subspace, basis, null and range space, invertibility and matrix representation. Echelon form, Fredholm Alternative and orthogonalization. Eigenvalues and eigenfunctions. First and second order ODE. Laplace and Fourier methods; series solution and orthogonal polynomials. Sturn Lioville problem. Classification of PDEs. Solution in finite and semi-infinite media. Fredholm and Volterra integral equations. Iterative and thermal hydraulic analysis. Hot spot factors.

NT 614 **NUCLEAR POWER ENGINEERING II** **Prereq. NT 611**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to control theory. Point reactor kinetics with introduction to feedback effects. Non-linear effects. Shielding. Introduction to reactor reliability and safety analysis. Radioactive waste disposal. Economics of nuclear power. Introduction to nuclear fuel cycles.

NT 615 **NUCLEAR POWER ENGINEERING III**

Health Physics: introduction, radiation protection, regulatory aspects, radiation biology, operational radiation protection, radiation protection monitoring.
Process Instrumentation and Control: basic concepts, sensing and transmission/ receiving of temperature, flow, liquid level, pressure, force, viscousity, humidity.
Nuclear Materials: fabrication and properties of zircaloy, metallic fuels, ceramic fuels, applications.
Nuclear Chemistry: role of chemistry in nuclear engineering, chemical processes in the nuclear fuel cycle, production of uranium, plutonium, thorium, heavy water, water treatment, corrosion, decontamination.

NT 621 **NUCLEAR MEASUREMENTS LABORATORY**

L-T-P-D-[C]
1-0-6-0-[4]

Biological effects of radiation; Radiation monitoring; G-M Counter characteristics, counting statistics. Scintillation detectors and gamma spectrometry. Multi-channel analysis. Semiconductor detectors for alpha and gamma spectrometry. Coincidence measurements. BF 3 counters. Foil Activation. Cadmium ratio measurements. Neutron diffusion length and age measurements. Experiments using Van de Graaff. Radioisotope applications, Computer simulation studies.

NT 631 **NEUTRON TRANSPORT THEORY**

L-T-P-D-[C]
3-0-0-0-[4]

Neutron transport equation and its derivation. Case's singular eigen function method for the 1 speed transport equation. Spherical harmonics approximation: diffusion and higher order P_N approximations and their relation to Case's method. TP_N and F_N approximations. The neutron slowing down equation: its analysis as a differential- difference equation. Exact and approximate solution and their inter-relationship. Energy dependent spatial neutron transport.

NT 632 **RADIOISOTOPE APPLICATION IN ENGINEERING**

L-T-P-D-[C]
3-0-0-0-[4]

Nuclear detectors. Counting statistics. Radiation safety. Radiotracer principles. Flow measurements. Applications in analysis. Process studies. Wear measurements and other production engineering applications. Selected examples of Industrial radiotracer applications.

Radiogauging principles, Alpha particle gauges based on transmissions. Scattering and ionization effects. Beta transmission gauges for measurements of sheets thickness, density and composition analysis. X-ray fluorescence principles. Neutron gauges. Well logging. Gamma and neutron radiography. Radioisotope power packs. High level radio-isotope applications including radiation therapy sterilization plants, radiation processing and food irradiation.

NT 633 **NUCLEAR FUSION**

L-T-P-D-[C]
3-0-0-0-[4]

Basic physics of fusion reactions, thermonuclear cross-sections. Radiation losses: bremsstrahlung and cyclotron radiation. Energy balance: Lawson criterion, neutronnics in a fusion reactor. Plasma confinement: Pinch effect, stellarator and magnetic mirrors. Plasma heating ohmic and adiabatic compression: Tokamaks. Inertial confinement of plasma microexplosion and laser fusion.

NT 634 **NUCLEAR REACTION AND INTERACTION OF RADIATION WITH MATTER**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction of nuclear Properties, Angular momentum and spin, Shell model, Nuclear Reactions, Kinematics, Cross-sections, and decay, Resonances, Energy loss of radiation going through matter, Shielding Concepts Geometries, and shield attenuation calculations.

NT 641 **INTRODUCTION TO COMPUTERIZED TOMOGRAPHY**

L-T-P-D-[C]
3-0-0-0-[4]

Overview, medical imaging, nondestructive testing, radiographic techniques, various applications, data collection, design of CT scanners for materials testing, flow measurement, related instrumentation, Radon's inversion formula, central-slice theorem, fan-beam inversion, filter functions, convolving functions transform methods, series-expansion methods, convolution algorithms, error estimates, direct theorems, inverse theorems.

NT 642 **NON DESTRUCTIVE EVALUATION**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction, various NDE techniques- ultrasonics, eddy current, magnetic flux leakage, radiography, optical, tomographic extensions of classical NDE/NDT methods Radon inversion, data collection mechanisms, applications in industrial situations.

NT 651 **FAST REACTOR TECHNO-LOGY**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction, Core design, Fuel-element design, Fuel management, Heat transport systems, Steam-generators, IHX design, Sodium pumps & piping, Instrumentation & controls, safety, extractive and physical metallurgy of nuclear materials, Metallic fuels, cladding, post irradiation examination, fabrication of fuel, Steels for nuclear environment, advanced NDT techniques, corrosion.

NT 652 **Nuclear Fuel Cycle**

L-T-P-D-[C]

3-0-0-0-[4]

Introduction, nuclear fuels, uranium technology, xirconium process, babrication of fuel assemblies, PWR fuel, mixed-oxide fuel, irradiated fuel, reprocessing, radioactivity, contamination, waste management, enrichment of uranium, thorium cycle, fast reactor fuel cycle and fuel fabrication, environmental impact and safety.

DEPARTMENT OF PHYSICS

PROFESSORS

Budhani, R.C.	rcb	7185
Chowdhury, D.	debch	7039
Harbola, M.K.	mkh	7823
Jain, P.	pkjain	7663
Joglekar, S.D.	sdj	7014
Kulkarni, V.N.	vnk	7985
Kumar, S.	satyen	7654, 7947
Mohapatra, Y.N. (Head)	ynm	7563, 7033
Prasad, R.	rprasad	7065, 7092
Ravishankar, V.	vravi	7083
Sahdev, D.	ds	7006
Shahi, K.	kshahi	7042, 7809
Singh, A.	avinas	7047
Thareja, R.K.	thareja	7143, 7989
Verma, H.C.	hcverma	7681

ASSOCIATE PROFESSORS

Banerjee, S.	satyajit	7559
Dutta, A.	dutta	7471
Pradhan, A	asima	7691, 7971
Ramakrishna,S.A.	sar	7449
Rajeev, K.P.	kpraj	7929
Raychaudhuri, S.	sreerup	7276
Sengupta, G.	sengupta	7139
Subrahmanyam, V	vmani	7912
Verma, M.K.	mkv	7396

ASSISTANT PROFESSORS

Bhattacharya, K	kaushikb	7306
Bhattacharjee, S.	sudeepb	7602
Ghosh, T. K.	tkghosh	7276
Gupta, A.K.	anjankg	7549
Gupta, R	guptaraj	6095
Hossain, Z.	zakir	7464
Mukherji, S.	sutapam	7119
Sarkar, T.	tapo	6103
Wanare, H.	hwanare	7885

LECTURER

Dhamodaran, S.	dams	7986

Convenor, DUGC :	Gupta, A.K.	anjankg	7549
Convenor, DPGC :	Singh, A.	avinas	7047

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The Department of Physics at the Indian Institute of Technology, Kanpur has 39 faculty positions, including a few positions filled jointly with the Materials Science and the Laser Technology Interdisciplinary programs of the Institute. In addition, the Department has one Principal Scientific Officer. The faculty is also assisted by Research Associates and doctoral Fellows as part of the academic staff.

The Physics department participates in the undergraduate core programme and runs a select five-year Integrated M. Sc. course in Physics, making effective use of the features of the core programme which includes Basic Sciences, Workshop practice, Engineering graphics and Computer programming as well as courses on Humanities and Social Sciences. The department also runs a two-year M.Sc. programme as well as an active Ph.D. programme with specialisation in many major and frontline areas of Physics. In addition, the Department offers an M.Sc.-Ph.D. (Dual Degree) Programme to highly motivated and bright students who wish to combine a thorough training in basics with an early entry into research. A large variety of courses offered by the Physics faculty are of interest to a number of inter-disciplinary programmes of the Institute.

A brief description of the course structure for various programmes and courses run by the Physics Department is given in this bulletin.

M.Sc. PROGRAMMES

The Integrated (Five-year) M.Sc. programme admits 19 students every year (out of this 4 seats are reserved for candidates in the SC/ST Category). Admission for candidates is after school-leaving through the IIT-JEE Examination. Students in this ten-semester programme have to go through a core programme in the first four semesters. The next four semesters are devoted to intensive Physics courses at the M.Sc. level and the last two semesters are exclusively devoted to elective courses and project work. Over the years, the Integrated M.Sc. Programme of I.I.T. Kanpur has acquired a considerable international reputation and has produced many of the eminent physicists living and working in India and abroad.

The M.Sc. (Two-year) programme admits 19 students every year (out of which 3 seats are reserved for candidates in the SC/ST Category). Admission is through the All-India JAM Examination. For admission to this programme, candidates must have done a three-year B.Sc. programme, securing at least 55% marks in Physics Honours/Major (or in aggregate if there is no Honours/Major). Students in the final year of their B.Sc. programme may also apply, but can be admitted only if they have appeared for their B.Sc. final examinations before joining the M.Sc. Programme. Admission is provisional to securing 55% marks as stipulated. The students of this programme do four intensive semesters of Physics courses only, and receive a thorough training which has also produced eminent scientists of no less repute than the Integrated M.Sc. programme.

Ph. D. PROGRAMME

The Department of Physics offers many subdisciplines in the Ph.D. programme. The requirements in the programme are prescribed to ensure that the scholars acquire a professional maturity which will enable them to deal with a wide range of problems in physical sciences in their respective fields of specialization. The research interests of the department include topics in Condensed Matter Physics, Quantum Field Theory, Nuclear and High Energy Physics, Dynamical Systems and Statistical Physics, Lasers and Laser Spectroscopy, with emphasis on interdisciplinary activity.

Students with good academic record and strong motivation for a career in physics after earning Master's degree can apply for admission to the Ph.D. programme. Admission is through a written test and interview conducted twice a year, in May and December. There is also a provision for a walk-in interview for exceptional cases. The Ph.D. programme combines course work, guided research, independent study and teaching assignments, all designed with a view to making the scholar a professional physicist. The compulsory courses consist of review of mathematical physics, classical mechanics, quantum mechanics, statistical mechanics, solid state physics and nuclear physics while the elective courses cover the ongoing research areas in the department.

M.Sc. Ph. D. (DUAL DEGREE) PROGRAMME

Since 2001, the Department of Physics has started a new M.Sc. Ph.D. (Dual Degree) programme for bright and motivated students who have done a three-year B.Sc. programme, securing at least 55% marks in Physics Honours/Major or in aggregate if there is no Honours/Major. Students in the final year of their B.Sc. programme may also apply, but can be admitted only if they have appeared for their B.Sc. final examinations before joining the M.Sc. Programme. Admission is provisional to securing 55% marks as stipulated. Admission in through All-India JAM Examination and around 9 students are admitted each year. Students in this programme get a thorough training in basics together with the students of the M.Sc. (Two-year) programme, before moving on to the Ph.D. programme. M.Sc. degree will be awarded on completion of all academic requirements of the first six semesters. The entire programme is designed with attractive financial and time-saving features.

STRUCTURE OF THE Ph. D. PROGRAMME

YEAR I		AFTER YEAR I	
Semester I	**Semester II**	**Semester I**	**Semester II**
PHY 601 **PHY 603** **PHY ***** **PHY 799**	**PHY 602** **PHY 604** **PHY ***** **PHY 799**	**PHY 799**	**PHY 799**

PHY 601	Review of Classical Physics I	PHY 603	Review of Classical Physics II
PHY 602	Review of Quantum Physics I	PHY 604	Review of Quantum Physics II
PHY***	Departmental Elective	PHY 799	Research Credits

† Departmental Electives can be any 6th level course or otherwise as advised by the Convenor, DPGC

STRUCTURE OF THE INTEGRATED M. Sc. (Five Year) PROGRAMME

	FIRST	SECOND	THIRD	FOURTH	FIFTH
	CHM101	PHY103	MTH203	HSS-I-2	PHY315
	PHY101	MTH102	CHM201	TA201	PHY401
	PHY102	TA101	ESO212/ ESO214	PHY204	PHY421
	MTH101	ESC102	PHY210	PHY431	
	ESC101	PHY100	ESO-2	PHY218	†
	PE101	PE102	PHY224		
	HSS-I-1/ ENG112				

	SIXTH	SEVENTH	EIGHTH	NINTH	TENTH
	PHY412	PHY461	PHY462	PHY563	PHY566
	PHY422	PHY543	PHY524	PHY565	PHY568
	PHY432	PHY552	PHY553	†	†
	†	†	†	†	†
	†	†	†	†	†

† IN ADDITION TO ABOVE THE STUDENT MUST COMPLETE:

DE	07 CREDITS
OE	27 CREDITS
HSS-2	08 CREDITS
NDE	08 CREDITS

CHM 201	General Chemistry-I
E S O #	Engineering Sc. Option
ESO 212	Fluid Mechanics
ESO 214	Nat. & Prop. of Materials
H S S	Hum. & Social Sciences
TA 201	Manufacturing Processes
DE-I & II	Departmental Electives*
NDE	Non-Dept. Elective
O E	Open Elective (any course in any Dept.)

PHY 224	Optics
PHY 204	Quantum Physics
PHY 210	Thermal Physics
PHY 218	Optics Laboratory
PHY 315	Modern Physics Laboratory
PHY 401	Classical Mechanics
PHY 412	Statistical Mechanics
PHY 421	Mathematical Methods I
PHY 422	Mathematical Methods II
PHY 431	Quantum Mechanics I
PHY 432	Quantum Mechanics II
PHY 461	Experimental Physics I
PHY 462	Experimental Physics II
PHY 524	Intro to Atomic & Nucl Physics
PHY 552	Classical Electrodynamics I
PHY 553	Classical Electrodynamics II
PHY 563	Experimental Project I
PHY 565	Experimental Project II
PHY 566	Experimental Project III
PHY 568	Experimental Project IV

Engineering Science options must be chosen from the list of courses as advised by the Convener, DUGC

STRUCTURE OF THE M. Sc. (Two Year) AND THE M.Sc.-Ph.D. (DUAL DEGREE) PROGRAMMES

M. Sc. (Two Year)

YEAR I		YEAR II	
Sem I	**Sem II**	**Sem III**	**Sem VI**
PHY 401	PHY 412	PHY 543	PHY 524
PHY 421	PHY 422	PHY 552	PHY 553
PHY 431	PHY 432	PHY 563	PHY 566
PHY 441	PHY 462	PHY 565	PHY 568
PHY 461	PHY 473	PHY ***	PHY ***
			PHY ***

†IN ADDITION TO ABOVE THE STUDENT MUST COMPLETE DE 11 CREDIT

M.Sc.-Ph.D. (DUAL DEGREE) (For Admission in 2008-09)

YEAR I		YEAR II		YEAR III	
Sem I	**Sem II**	**Sem III**	**Sem V**	**Sem IV**	**V**
PHY 400	PHY 412	PHY 543	PHY 553	PHY 599N	PHY 422 or PHY 692
PHY 401	PHY 432	PHY 552	PHY 524	PHY ***	PHY 599N
PHY 421	PHY 461	PHY 462	PHY 502N	PHY ***	PHY ***
PHY 431	PHY 473	PHY 501	PHY ***		
PHY 441	PHY 500				

PHY 400 Introduction to the Department
PHY 401 Classical Mechanics
PHY 412 Statistical Mechanics
PHY 421 Mathematical Methods I
PHY 422 Mathematical Methods II
PHY 431 Quantum Mechanics I
PHY 432 Quantum Mechanics II
PHY 441 Electronics
PHY 473 Computational Physics
PHY 524 Intro to Atomic & Nucl Physics
PHY 543 Condensed Matter Physics
PHY 552 Classical Electrodynamics I
PHY 553 Classical Electrodynamics II
PHY *** Departmental Elective*
PHY 224 Optics
PHY 461 Experimental Physics I
PHY 462 Experimental Physics II
PHY 563 Experimental Project I
PHY 565 Experimental Project I
PHY 566 Experimental Project III
PHY 568 Experimental Project IV
PHY 500 M.Sc. Experimental Project I
PHY 501 M.Sc. Experimental Project II
PHY 502 M.Sc. Experimental Project III
PHY 599N M.Sc. Research Project
PHY 799 Research Credits

* One of PHY 407 (Special & General Relativity) and PHY 680 (Particle Physics) must be taken as DE courses; the other can be any Departmental elective.

† Engineering Science options must be chosen from the list of courses as advised by the Convener, DUGC

COURSES IN PHYSICS

L = Lectures; T = Tutorials; D = Discussions; P = Laboratory; [C] = Credits

Note: # indicates that consent of the Instructor is required

PHY 100: **INTRODUCTION TO PROFESSION (PHYSICS)**
L-T-P-D-[C]
1-0-2-0-[0]
Core

Frontiers of physics at various scales, unifying themes and tools of physics, significant discoveries, which shaped our current understanding of the physical World. physics-induced technologies.

The course will include physics demonstrations along with some hands-on experience in the Nuclear, Laser, Low Temperature, and Condensed Matter laboratories of the Physics Department.

PHY 101: **PHYSICS LABORATORY**
L-T-P-D-[C]
0-0-0-3-[2]
Core

Introduction to error analysis and graph-drawing; spring oscillation apparatus; trajectory of a projectile on an inclined plane; moment of inertia of a bicycle wheel; bar pendulum; torsional pendulum; coupled pendulum; study of collisions on an air track; gyroscope; current balance; measurement of capacitance using galvanometer; charging of a plate capacitor; electromagnetic induction; prism spectro-meter; Fraunhofer diffraction using He-Ne laser; magnetic field in Helmholtz coil; resonance in electrical circuits.

PHY 102: **PHYSICS I**
L-T-P-D-[C]
3-1-1-0-[4]
Core

Coordinate systems, elements of vector algebra in plane polar, cylindrical, spherical polar coordinate systems, dimensional analysis; solutions for one- dimensional equation of motion in various forms, frames of reference, relative velocity and accele-rations; Newton's laws and applications (to include friction, constraint equations, rough pulleys), line integrals, gradient, curl, conservative forces, pot-ential, work-energy theorems, energy diagrams; conservation of linear momentum and collisions, variable mass problems; central forces, gravitation, Kepler's law, hyperbolic, elliptic and parabolic orb-its, forced oscillations, damping, resonance; waves: motion in non-inertial frames, centrifugal and Coriolis forces; conservation of angular momentum and elementary rigid body dynamics; special theory of relativity.

PHY 103: **PHYSICS II**
L-T-P-D-[C]
3-1-1-0-[4]
Core

Vector calculus; electrostatics; Gauss' law and applications, electrostatic potential and curl of E; work and energy in electrostatics, Laplace's equa-tion and (first) uniqueness theorem, method of im-ages, multipoles (introduction), force and torque on dipoles; polarization, bound charges, electric dis-placement and boundary conditions, linear dielec-trics, force on dielectrics; motion of charges in elec-tric & magnetic fields; magnetostatics: current density, curl and divergence of B, Ampére's law and applications, magnetization, bound currents and bound pole densities, magnetic field H, magnetic susceptibility, ferro-, para- and dia-magnetism, boundary conditions on B and H, Faraday's law, energy in magnetic field, displacement current, Maxwell's equations in media, Poynting's theorem, e.m. waves: wave equation, plane waves, polarization and types of polarization, energy and mom-entum of plane e.m. waves. propagation through linear media and conductors. reflection and trans-mission at normal incidence from dielectric and metal interfaces. magnetism as a relativistic phenol-menon, relativistic transformations of E and B fields (simple illustrations only), diffraction, quantum mechanics, photons, uncertainty principle, electron diffraction experiments, de Broglie hypothesis, Born interpretation, Schrödinger equation and application to 1-d box problem.

PHY 204: **QUANTUM PHYSICS**

L-T-P-D-[C]
3-1-1-0-[4]
Professional

(SE 301)

Origin of quantum theory and related experiments, wave-particle duality for photons and material particles, wave function and its Born interpretation, relation with measurement of dynamical variables, delta-function as definite position and plane wave as definite momentum wave function, wave-packet as superposition of delta-functions and of plane waves, position-momentum uncertainty principle, Gaussian wave packets, applicability of classical physics on the basis of uncertainty product, operator formulation, commuting operators, simultaneous eigen-functions, degenerate eigenfunctions, Schrödinger equation for time evolution, stationary states, spread of free particle wave packets, time energy uncertainty, natural line width of spectral lines. probability currents and their relation with the flux in beams of particles. square well potentials, practical examples like metal-vacuum interface, contact potential between metals, bilayer and sandwiched, thin film etc., bound states in deep potential well and finite potential well, double, well potentials and examples like ammonia inversion, delta function potentials and examples like electron sharing in covalent bonds. Krönig-Penney model of 1-d crystals and formation of energy bands. Linear harmonic oscillator, outline of getting stationary states, molecular vibrations and spectroscopy. barrier tunneling, examples of alpha-decay, nuclear fission, fusion in the sun, cold emission, scanning tunneling microscope, principle of tunnel diode etc. angular momentum operators, eigenvalues and eigenfunctions, spin angular momentum, hydrogen atom using coulomb interaction, structure of H line due to I-S interaction (derivation not needed). identical particles, indistinguishability in quantum mechanics, bosons and fermions, Pauli exclusion principle, simple examples of filling up of quantum states by classical particles, bosons and fermions. statistics of non-interacting gas, density of states from particle in a box, stationary states, occupation probability in M-B, B-E, F-D statistics, distribution functions, criteria for applicability of classical statistics, derivation of U = 3/2NkT for classical gas, Fermi gas, Fermi energy, electronic contribution to specific heat of metals, energy bands in conductors, insulators and semiconductors, modifications at metal-metal contact, p-n junction, details of tunnel diode.

PHY 210: **THERMAL PHYSICS**

L-T-P-D-[C]
3-1-0-0-[4]
Professional

(SE 321)

Principles of thermodynamics (with applications to simple fluids), applications of thermodynamics: concept of thermodynamic state, extensive and intensive variables; heat and work, internal energy function and the first law of thermodynamics; fundamental relation and equations of state; concepts of entropy and temperature as conjugate pair of variables; second law of thermodynamics, entropy maximum and energy minimum principles; thermodynamic potentials: enthalpy, Helmholtz potential, Gibbs potential; conditions of equilibrium, concepts of stable, meta-stable and unstable equilibrium; components and phases, Gibbs-Duhem relations; first-order phase transitions and Clausius-Clapeyron equation; concepts associated with critical and multi-critical phenomena, some chosen applications from surfaces and interfaces, chemical reactions (magnetic, dielectric and super-conducting); heat engines and black body radiation; elementary kinetic theory of gases: equilibrium properties — pressure and equation of state; transport processes – momentum transport and viscosity, energy transport and thermal conductivity, charge transport & electrical conductivity (without using Boltzmann transport equation); entropy, multiplicity and disorder: entropy measures multiplicity rather than disorder, illustration with simple examples; Maxwell's demon; qualitative justifications of laws of thermodynamics (without introducing ensembles), thermodynamics of irreversible processes: entropy production.

PHY 218: **OPTICS LABORATORY** **Prereq.: Phy 103**

L-T-P-D-[C]
1-0-0-4-[4]
Professional

Experiments based on Fresnel's equations, study of optical surfaces, Fraunhofer and Fresnel diffraction, interferometers, modulation transfer function, fibre optics, spatial filtering, characteristics of He-Ne and diode lasers, etc.

PHY 224: **OPTICAL PHYSICS** **Prereq.: PHY 103**

L-T-P-D-[C]
3-1-0-0-[4]
Professional

Review of Maxwell's equations, wave equation, optical resonators, polarization, optics of planar interfaces, coherence properties of light, Michelson interferometer, two- & multiple beam interference, Fabry-Pérot interferometer, optics of multilayer thin films; AR, HR coatings, ray matrix, paraxial optics, optical instruments, diffraction and Fourier optics.

PHY 301: **ENERGY**
L-T-P-D-[C]
3-0-0-0-[4]
Elective
(SE 308)

Indian and global energy resources, current energy exploitation, energy demand, energy planning, renewable energy sources, wind energy, energy from water, solar energy, energy from mineral oils, nuclear energy, energy for sustainable development, environmental concerns.

PHY 303: **PRINCIPLES OF LASERS AND THEIR APPLICATIONS**
L-T-P-D-[C]
3-0-0-0-[4]
Elective
(SE 309)

Gaussian optics, optical resonators and their mode structure, atomic levels, absorption, spontaneous and stimulated emission, Einstein coefficients, rate equations, population inversion, gain media, 3 and 4 level lasers CW & pulsed Lasers, Q-switching, mode-locking, short pulses Ar+, CO2, Nd:YAg, diode lasers, etc.; metrology, optical communication, materials processing, holography, medical applications.

PHY 304: **INTRODUCTION TO ATMOSPHERIC SCIENCE** **Prereq.: PHY102N, ESO102**
L-T-P-D-[C]
3-0-0-0-[4]
Elective
(SE 310)

Atmospheric constitution, Pressure and temperature distribution, Heat budget, Precipitation, Clouds, Atmospheric dynamics Global circulation, Tropical weather systems, Remote sensing applications, Ozone hole, global warming and pollution.

PHY 305: **PHYSICS OF THE UNIVERSE**
L-T-P-D-[C]
3-0-0-0-[4]
Elective
(SE 311)

Astronomical observations and instruments, photometry, stellar spectra and structure; stellar evolution, nucleosynthesis and formation of elements, variable stars, compact stars, star clusters and binary stars, galaxies, their evolution and origin, active galaxies and quasars, Big Bang model, early Universe and CMBR.

PHY 306: **ORDER AND CHAOS**
L-T-P-D-[C]
3-0-0-0-[4]
Elective
(SE 312)

Dynamical systems, importance of nonlinearity, nonlinear dynamics of flows (in 1, 2 and 3 dimen-sions) and maps (in 1, 2 dimensions) in phase space (equilibrium, periodicity, bifurcation, catastrophe, deterministic chaos, strange attractor), routes to chaos (period doubling, quasi-periodicity/inter-mittency, universality, renormalization), meas-urement of chaos (Poincaré section, Lyapunov index, entropy), fractal geometry and fractal dimension, examples from physicalsciences, engineering and biology.

PHY 307: **MODERN OPTICS**
L-T-P-D-[C]
3-0-0-0-[4]
Elective
(SE 313)

Review of Maxwell's and electromagnetic wave equations, wave propagation in anisotropic media, polarized light, diffraction from circular aperture and concept of resolution, Fourier transforms and Fourier optics, spatial filtering, and image processing, coherence, holography, optical wave-guides and integrated optics, optical fibres, optical communication sources (LED, lasers etc.) and detectors, and optical, electro- and magneto-optic effects, laser-matter interaction.

PHY 308: **MODERN THEORIES OF MATERIAL DESIGN**

L-T-P-D-[C]
3-0-0-0-[4]
Elective
(SE 302)

(1) Schrödinger equation: review of basics of quantum-mechanics (2) Introduction to many-electron problem, example of helium, exchange; Idea of mean field, Hartree and density functional theory; Schrodinger equation for solids: jellium model of metals (homogeneous electron gas); calculations for metal surfaces, properties such as the work function and surface energies (surface tension); jellium model of metallic clusters; Bloch's theorem, Krönig-Penney model; bands, pseudopotentials, semiclassical dynamics: DC conductivity; effective mass and holes; Bloch oscillations etc,.; semiconductors: Introduction; Some devices. (3) Band-gap engineering: quantum wells and superlattices; nanotechnology - quantum dots and wires, dynamics of atoms: classical molecular dynamics; Born-Oppenheimer approximation, Hell-mann-Feynman theorem; Carr-Parinello method; assembling atoms to make clusters; super-conductivity: introduction to superconductivity; high Tc superconductivity; some applications; introduction to polymers, optical materials, superionic conductors etc.

PHY 309: **INTRODUCTORY BIOPHYSICS**

L-T-P-D-[C]
3-0-0-0-[4]
Elective
(SE 303)

Exponential growth and decay, homogeneous function of two and more variables, scaling laws in animal world; chaos, fractal nature of mammalian organs; biomechanics: statics and human anatomy. mechanics of motion. Mechanistic view of athletic events; fluid mechanics. blood circulation and Reynold's number. blood pressure, electrocardio-graphy and haemodynamics; heat transfer, energy from metabolism. Kleiber's scaling law; electromagnetism at the cellular level, Impulses in nerve and muscle cells. the Hodgkin-Huxley equations. biomagnetism.; interaction of photons and charged particles with living matter; spectroscopic techniques applied to biology. microscopy. NMR, EPR, scattering, Raman spectroscopy, ultrafast spectroscopy, IR spec-troscopy, UV-visible absorption spectroscopy, fluorescence.; medical use of X-rays, nuclear medicine, computerized axial tomography and magnetic resonance imaging. optical imaging.

PHY 310: **PHYSICS OF BIO-MATERIALS: STRUCTURE AND DYNAMICS**

L-T-P-D-[C]
3-0-0-0-[4]
Elective
(SE 304)

Physics of bio-molecules; molecular biophysics, physics of sub-cellular structures and processes, physics of the cellular structure and processes, super-molecular self assemblies, shapes of cells, active cell membrane and transport, interaction of cells, movement of cells, physics of multi-cellular phenomena, brain: a network of cells.

PHY 311: **PHYSICS OF NON-EQUILIBRIUM PHENOMENA**

L-T-P-D-[C]
3-0-0-0-[4]
Elective
(SE 305)

Introduction: examples of non-equilibrium phenomena(i) glass transition; (ii) nucleation; (iii) phase separation; experimental probes: dynamic scattering; inelastic neutron scattering, theoretical tools: two alternative theoretical approaches (a) Langevin equation - dissipation, nonlinearity and noise; illustration with translational Brownian motion; (b) Fokker-Planck equation-diffusion and drift; illustration with (i) translational Brownian motion, (ii) rotational Brownian motion; master equation - loss and gain of probabilities; concept of detailed balance . metastability and bi-stability: Kramers' theory of thermally activated barrier crossing applications in (i) chemical reactions (ii) rock magnetism. "enhancing signals with the help of noise" - applications of stochastic resonance in (a) nonlinear optics, (b) solid state devices, (c) neuro-science, (d) molecular motors and biological locomotion; Becker-Doring theory of homogeneous nucleation and its modern extensions - applications in (a) condensation and (b) crystallization. unstable states: Allen-Cahn scenario of interfacial dynamics and domain growth- applications to domain growth in quenched magnets; Lifshitz-Slyozov arguments for phase separation controlled by topological defects: application to liquid crystals; theory of coarsening of cellular patterns- applications to soap froths (e.g., shaving foams); non-equilibrium steady-states in driven system: driven
systems of interacting particles - applications to vehicular traffic; driven surfaces- applications in molecular beam epitaxy (MBE).

PHY 312: **QUANTUM PROCESSES IN LOW DIMENSIONAL SEMICONDUCTORS**

L-T-P-D-[C] 3-0-0-0-[4] Elective (SE 307)

L-T-P-D-[C]
3-0-0-0-[4]
Elective
(SE 307)

Characteristic length scales for quantum phenomena; scaling as a heuristic tool; scientific and technological significance of nanostructures and mesoscopic structures. brief introduction to quantum view of bulk solids, introduction to key ideas in transport and interaction of photons with material. Quantum structures: electronic properties: science and technology realizing low dimensional structures; MBE, MOCVD, Langmuir-Blodgett films, novel processes; electronic properties of heterostructures, quantum wells, quantum wires, quantum dots, and superlattices, strained layer super-lattices; transport in mesoscopic structures. resonant tunneling, hot electrons, conductance and transmission of nano-structures; principles of application of electronic devices. quantum structures: optical properties: optical process in low dimensional semiconductors. absorption. luminescence, excitons. application to lasers and photodetectors, transport in magnetic field: megneto-transport: transport in magnetic field, semiclassical description, quantum approach, Aharonov-Bohm effect, Shubnikov- de Haas effect; introduction to quantum Hall effect.

PHY 313: **PHYSICS OF INFORMATION PROCESSING** **Prereq.: PHY 103**

L-T-P-D-[C]
3-0-0-0-[4]
Elective
(SE 320)

Basic interactions, order of magnitude estimates; noise in physical systems; information in physical systems; Shannon's theory of information, information and thermodynamics, basics of electromagnetic fields and waves; transmission lines. waveguides and antennas, optics and imag-ing, inverse problems, generation, detection and modulation of light; sol-id state devices; magnetic storage; measurement and coding, cryptography, physical limitations of information devices; new technologies.

PHY 314: **NATURAL NANO-MACHINES**

L-T-P-D-[C]
1-0-0-4-[4]
(SE 322)

Examples of nano-machines in living cells; differences between macroscopic and nano machines; world of nano-meter and pico-Newton; stochastic dynamics of nano-machines; experimental, computational and theoretical techniques; imaging and manipulating single machines; Power stroke versus Brownian ratchet mechanism; mechano-chemistry of nano-machines; energetics and efficiency of nano-machines; intra-cellular cargo transporters; nano-size unzippers; nano-size engines for polymerization of macromolecules; exporters/importers of macromolecules; packaging machines; switches and latches; ion pumps; flagellar motor; rotary motors of ATP synthesizer; molecular sensors- hair cells; nano-pistons and cell crawling.

PHY 315: **MODERN PHYSICS LABORATORY**

L-T-P-D-[C]
1-0-0-4-[4]
Professional

Modern experimental techniques with a view to demonstrate the basic concepts in physics through experiments. this course has three components: a) one lecture per week: observation, measurements, quantification and accuracies in physics, error analysis. experiments that changed classical physics: black body radiation, the discovery of electron, quantization of charge, e/m ratios, Millikan's oil drop experiment, Stern-Gerlach experiment, Rutherford scattering, Davisson- Germer experiment, discovering atomic nature through optical spectroscopy; production and measurement of high pressure and high vacuum, low and high temperatures; femtoseconds to light years. b) laboratory work (twice a week): a current list of experiments is available with the Department. c) small project/open ended experiments: These experiments will be chosen by students after brief library search in consultation with the associated faculty. These may be carried out in research labs and using central facilities.

PHY 322 **NONLINEAR SYSTEMS** **Prereq.: PHY 102 & 103, MTH 203**

L-T-P-D-[C]
3-1-0-0-[4]
Effective
(SE 306)

Maps as dynamical systems: chaos and complexity, area-preserving maps,Hamiltonian systems, regular & stochastic motion, perturbation theory & KAM, cellular automata, self-organization, quantum chaos.

PHY 400: **INTRODUCTION TO THE DEPARTMENT**
L-T-P-D-[C]
2-0-0-0-[3]
Professional

The course will expose the students to research areas being pursued in the Department, and issues relevant to research as a profession. Faculty members from different sub-disciplines would deliver lectures. Visits to Laboratories of the Department and relevant acilities may be arranged. Course will be zero credits; S/X grade to be given.

PHY 401: **CLASSICAL MECHANICS**
L-T-P-D-[C]
3-1-0-0-[4]
Professional
(SE 314)

Review of Newtonian mechanics, Lagrangian mechanics, generalized coordinates, constraints, principle of virtual work, Lagrange's equation, calculus of variations, central forces, collisions, scattering small oscillations, anharmonic oscillators. perturbation theory, forced oscillators. Hamilton's equations, phase space & phase trajectories, canonical trans-formations, Poisson brackets, Hamilton-Jacobi theory, rigid body dynamics, nonlinear dynamics.

PHY 407: **SPECIAL AND GENERAL RELATIVITY**
L-T-P-D-[C]
2-1-0-0-[3]
Professional

Special Relativity: empirical evidence for the constancy of c, frames of reference; Lorentz transformations; relativity of simultaneity; twin and other paradoxes, transformation laws for velocity, momentum, energy; mass-energy equivalence; force equations, kinematics of decays and collisions, Maxwell's equations in covariant form, repre-sentations of the Lorentz group and SL(2,C). Introduction to General Relativity: principle of equivalence; Mach's principle, Riemannian geometry; Christoffel symbols, the curvature and stress-energy tensors; the gravitational field equations; geodesics and particle trajectories, Schwarzchild solution; experimental tests, basic cosmology, FRW metric; cosmological expansion; cosmic microwave background; helium abundance; anisotropies in the CMBR.

PHY 412: **STATISTICAL MECHANICS**
L-T-P-D-[C]
3-1-0-0-[4]
Professional
(SE 316)

Review of thermodynamics, basic principles and applications of statistical mechanics, ideal quantum gases, interacting systems, theories of phase transitions, computer simulations, elementary concepts of non-equilibrium statistical mechanics.

PHY 421: **MATHEMATICAL METHODS I**
L-T-P-D-[C]
3-1-0-0-[4]
Professional

Vector analysis; curvilinear coordinates; matrices and vector spaces, tensors, function spaces; Hilbert spaces; orthogonal expansions; operators in infinite dimensional spaces, Fourier series and Fourier transform, generalized functions; Dirac delta function, groups and their representations; discrete groups, Lie groups and Lie algebras, applications.

PHY 422: **MATHEMATICAL METHODS II** **Prereq.: PHY 421**

L-T-P-D-[C]
3-1-0-0-[4]
Professional

Functions of a complex variable, ordinary differential equations, special functions, differential operations and Sturm-Liouville theory, partial differential equations, Green's functions.

PHY 431: **QUANTUM MECHANICS I**

L-T-P-D-[C]
3-1-0-0-[5]
Professional
(SE 318)

Origins of quantum theory, Schrödinger equation, wave mechanics, one-dimensional problems, central potentials; hydrogen atom, Hilbert space formalism for quantum mechanics, symmetries in quantum mechanics, general treatment of angular mom-entum; spin, identical particles; Pauli exclusion principle.

PHY 432: **QUANTUM MECHANICS II** **Prereq.: PHY 431**

L-T-P-D-[C]
3-1-0-0-[4]
Professional

WKB approximation, bound state perturbation theory; variation method, time-dependent perturbation theory; semiclassical treatment of radiation, scattering theory, relativistic wave equations, elementary ideas about field quantization and particle processes, foundational issues in quantum mechanics.

PHY 441: **ELECTRONICS**

L-T-P-D-[C]
2-1-0-4-[5]
Professional

Survey of network theorems and network analysis, basic differential amplifier circuit, op amp characteristics and applications, simple analog computer, analog integrated circuits, PLL, etc., digital electronics, gates, flip-flops, counters etc., transducers, signal averaging, lock-in amplifier, D/A & A/D converter, multichannel analyzer etc., introduction to micro-processors.

PHY 461: **EXPERIMENTAL PHYSICS I**

L-T-P-D-[C]
0-0-0-8-[4]
Professional

Experiments in General Physics, Optics, Nuclear Physics and Condensed Matter Physics (List of current experiments available with the Physics Department in the form of a manual).

PHY 462: **EXPERIMENTAL PHYSICS II**

L-T-P-D-[C]
0-0-0-8-[4]
Professional

Experiments in General Physics, Optics, Nuclear Physics and Condensed Matter Physics (List of current experiments available with the Department in the form of a manual).

PHY 473: **COMPUTATIONAL METHODS IN PHYSICS**

L-T-P-D-[C]
2-1-0-3-[4]
Professional

Introduction to computers, FORTRAN/C; finite difference calculus, interpolation and extrapolation, roots of equations, solution of simultaneous linear algebraic equation, least squares curve fitting, numerical integration, numerical solution of ordinary differential equations, matrix eigenvalue problems.

PHY 500, 501, 502: **MSC REVIEW PROJECT I, II & III**

L-T-P-D-[C]
0-0-0-8-[4] /
0-0-8-0-[4]
Professional

L-T-P-D-[C] 0-0-0-8-[4] /0-0-8-0-[4] Professional

Student must carry out review of an advanced topic of current interest and make a presentation to an Evaluation Committee. Letter Grades will be awarded.

PHY 500 : M.Sc. Review Project I
PHY 501 : M.Sc. Review Project II
PHY 502 : M.Sc. Review Project III

These projects will involve literature survey and collection of material, Detailed study of the material, verification of results and writing of the review. Review Projects will include exposure to and conduct of Experiments as required.

PHY 524: **INTRODUCTION TO ATOMIC AND NUCLEAR PHYSICS**

L-T-P-D-[C]
3-1-0-0-[4]
Professional
(SE 317)

Atomic Physics:- Review of atomic structure of H, atomic structure of two electron system, alkali system, Hartree-Fock method, L-S coupling, molecular binding, LCAO, LCMO; molecular spectra (electronic, rotational, vibrational etc.), Raman effect, modern experimental tools of spectroscopy. Nuclear Physics: General properties of nuclei, nuclear two body problem, nuclear force and nuclear models, nuclear decay, nuclear reaction kinematics and classification of nuclear reactions (compound nuclear, direct etc), heavy ion reactions, nuclear fission and fusion, brief overview of ion beam applications for materials and solid state studies, modern experimental tools of pure and applied nuclear physics.

PHY 543: **CONDENSED MATTER PHYSICS**

L-T-P-D-[C]
3-1-0-0-[4]
Professional
(SE 319)

Free electron model; heat capacity; transport properties; Hall effect; elementary concepts of quantum Hall effect, structure and scattering; crystalline solids, liquids and liquid crystals; nanostructures; buckyballs, electrons in a periodic potential; Bloch's theorem; nearly-free electron model; tight-binding model; semiclassical dynamics; notion of an electron in a DC electric field; effective mass, holes, crystal binding; types of solids; van der Waals solids, ionic and covalent solids, metals, lattice vibrations; adiabatic & harmonic approximations, vibrations of mono and diatomic lattices, lattice heat capacity, Einstein and Debye models, semiconductors; intrinsic & extrinsic semiconductors, laws of mass action, electron & hole mobilities. impurity levels, p-n junctions, superconductivity: experimental survey, Meissner effect, London's equation, BCS theory, Ginzburg-Landau theory, flux quantization, Magnetism: exchange interaction, diamagnetism, paramag-netism, ferromagnetism & anti-ferromagnetism, Hund's rules, Pauli paramagnetism, Heisenberg model, mean field theory, spin waves, giant and colossal magneto-resistance.

PHY 552: **CLASSICAL ELECTRODYNAMICS I**

L-T-P-D-[C]
3-1-0-0-[4]
Professional

Coulomb law and electrostatics, Laplace and Poisson equations, uniqueness theorem, boundary-value problems, method of images, dielectrics, steady currents; and magnetostatics, time-varying fields, Maxwell's equations, electromagnetic waves, partial polarization, Lorentz force, Poynting theorem. gauge transformations and gauge invariance, electromagnetic potentials, wave propagation in conductors and dielectrics, Lorentz theory of dispersion, complex refractive index.

PHY 553: **CLASSICAL ELECTRODYNAMICS II** **Prereq.: PHY 552**

L-T-P-D-[C]
3-1-0-0-[4]
Professional

Special relativity, Minkowski space and four vectors, concept of four-velocity, four acceleration and higher rank tensors, relativistic formulation of electrodynamics, Maxwell equations in covariant form, gauge invariance and four-potential, the action principle and electromagnetic energy momentum tensor. Liénard-Weichert potentials, radiation from an accelerated charge, Larmor formula, bremsstrahlung and synchrotron radiation, multipole radiation, dispersion theory, radiative reaction, radiative damping, scattering by free charges; applications to wave-guides, fibres and plasmas.

PHY 563: **EXPERIMENTAL PROJECT I** **Prereq.: PHY 462**

L-T-P-D-[C]
0-0-0-8-[4]
Professional

Experimental project in a research laboratory: 1. Literature survey and preparation for the project.

PHY 565: **EXPERIMENTAL PROJECT II** **Prereq.: PHY 462**

L-T-P-D-[C]
0-0-0-8-[4]
Professional

Experimental project in a research laboratory: 2. Development and testing of experimental setup.

PHY 566: **EXPERIMENTAL PROJECT III** **Prereq. : PHY 565**
L-T-P-D-[C]
0-0-0-8-[4]
Professional

Experimental project in a research laboratory: 3. Data acquisition and analysis.

PHY 568: **EXPERIMENTAL PROJECT IV** **Prereq. : PHY 565**
L-T-P-D-[C]
0-0-0-8-[4]
Professional

Experimental project in a research laboratory: 4. Preparation of report and interpretation of results.

PHY 570: **THEORETICAL PROJECT I** **Prereq.: #**
L-T-P-D-[C]
0-0-0-8-[4]
Professional

Study of a research-oriented topic in Theoretical Physics with an aim to bring the student in contact with a concrete research area of current interest. Solving a small problem in this area is required, detailing the explicit statement of the problem, relevance and context, steps involved, tools employed, proposed work plan, and results obtained.

PHY 571: **THEORETICAL PROJECT II Prereq.:** **PHY 570 & #**
L-T-P-D-[C] L-T-P-D-[C] 0-0-0-8-[4] Elective
0-0-0-8-[4]
Professional

Advanced research oriented theoretical study in continuation of project work undertaken in PHY 570, or study of another research-oriented topic in Theoretical Physics with an aim to bring the student in contact with a concrete research area of current interest. Solving a small problem in the area is required, detailing the explicit statement of the problem, relevance and context, steps involved, tools employed, proposed work plan and results obtained.

PHY 590: **SPECIAL TOPICS IN PHYSICS** **Prereq.: #**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Details of contents will be announced when the course is offered. If the number of students is less than 5, this may be floated as a Reading Course for students with CPI = 8.0 or above.

PHY 599N : **MSC RESEARCH PROJECT I & II**

Student must work on a research topic of current interest in Experimental, Computational or Theoretical Physics. This must culminate in writing of an M.Sc. Project Report to be presented to an Evaluation committee.

PHY 601: **REVIEW OF CLASSICAL PHYSICS I**
L-T-P-D-[C]
1-3-0-0-[4]
Professional

Problem oriented review of mechanics and methods of mathematical physics: vector analysis, tensors, special functions, linear vector spaces, matrices, complex variables, particle mechanics, system of particles, rigid body motion, Lagrangian and Hamiltonian formulation, special relativity.

PHY 602: **REVIEW OF QUANTUM PHYSICS I**
L-T-P-D-[C]
1-3-0-0-[4]
Professional

Problem-oriented review of basic quantum mechanics: Schrödinger equation, simple potential problems, quantum dynamics, angular momentum, perturbation theory, scattering, applications to atoms and molecules.

PHY 603: **REVIEW OF CLASSICAL PHYSICS II**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Problem-oriented review of electromagnetism, optics and thermodynamics: electric fields, potentials, Gauss's law, dielectrics, magnetic fields, Ampére's law, Faraday's law, Maxwell's equations, electromagnetic waves, interference, diffraction, polarization.

PHY 604: **REVIEW OF QUANTUM PHYSICS II**
L-T-P-D-[C]
1-3-0-0-[4]
Professional

Problem-oriented survey of statistical mechanics, deuteron problem, nuclear scattering, alpha and beta decay, elementary particle phenomenology, crystal structure, symmetry, periodic potential, bands, metals and semiconductors.

PHY 611: **ADVANCED QUANTUM MECHANICS** **Prereq.: PHY 432**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Second quantization; interaction picture; S-matrix; diagrammatic methods; many-particle Green's functions; basic techniques in many-body physics; additional topics (at the discretion of the Instructor).

PHY 612: **INTRODUCTORY GROUP THEORY & ITS APPLICATION TO QUANTUM MECHANICS**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Elements of finite groups. representation theory. applications to physical systems: crystal symmetries. continuous groups. Lie algebras and their elementary applications. global properties of groups.

PHY 613: **ADVANCED STATISTICAL MECHANICS**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Equilibrium statistical mechanics, phase transitions, critical phenomena, superfluidity, super conductivity, non-equilibrium statistical mechanics, Langévin equations, Fokker-Planck equations, ergodic hypothesis and the basic postulate.

PHY 614: **SPECIAL TOPICS IN QUANTUM MECHANICS**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Path integral method of formulating quantum mechanics and its application to elementary quantum systems, formal scattering theory; Lippmann-Schwinger formulation, scattering of particles with spin, stationary states, analytic properties of partial wave amplitudes, resonances, dispersion relations.

PHY 615: **NON-EQUILIBRIUM STATISTICAL MECHANICS**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Linear response theory, Fokker-Planck and Langévin equations, master equation; nucleation and spinodal decomposition, critical dynamics, Boltzmann equation.

PHY 617: **PHYSICS OF NATURAL NANOMACHINES**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Examples of sub-cellular nanomachines of life; difference between macroscopic and nanomachines: world of nanometer and picoNewton, stochastic dynamics at low Reynold's number; experimental, computational and theoretical techniques: imaging and manipulating single-molecules, fluorescence microscopy, optical tweezers, and AFM; Langevin and Fokker-Planck equations for Brownian rectifiers; power stroke vs. Brownian ratchet mechanisms for directed movements. mechano-chemistry of sub-cellular machines, energetics and efficiency of isothermal chemical machines far from equilibrium cytoskeleton-associated nanomachines: intra-cellular motor transport; nucleotic-based machines- DNA/ RNA helicase/polymerase, ribosome G-proteins -switches and latches; membrane-bound machines, translocation machines, molecular pumps, ATP synthase, flagellar motor; molecular sensors: hair cells; nano-pistons and crawling of cells.

PHY 619: **STATISTICAL PHYSICS OF BIOMOLECULES AND CELLS**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Review of elementary statistical thermodynamics,; entropic elasticity-stretch, bend, twist; persistence length; DNA supercoiling; proteins; coil, helix, globule, folding. plasma membranes; in-plane structure and out-of-plane fluctuations-crumpling,; interactions of bio-membranes-unbinding transition; cell shapes andshape transformations; cyto-skeleton: polymerization of actin and microtubules-force generation. molecular motors: kinesin, dynein and myosins; DNA/ RNA helicase and polymerase; molecular motors as stochastic machines - Brownian ratchet; membrane-bound machines and transport; Ion channels and pumps; H pump and ATP synthase; flagellar motor of bacteria; cell motility: swimming and crawling, life at low Reynold's number. nanotechnology inspired by Nature's design principles.

PHY 622: **CONDENSED MATTER PHYSICS II** **Prereq.: PHY 543**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Fermi liquid, second quantization, interaction picture, electron-electron interaction; plasmons; electron-phonon interactions; polarons, advanced methods of band structure calculations. Cooperative phenomena; magnetism and paramagnetism, superconductivity: experimental background, cooper pairs, BCS and Ginzburg-Landau theories.

PHY 621: L-T-P-D-[C] **3-0-0-0-[4]** **Elective**

ELECTRONIC STRUCTURE OF MATERIALS

Prereq. (M. Sc. Students only): PHY 543

One electron model, Born-Oppenheimer approx-imation, Hartree & Hartree-Fock approximation, density functional theory, local density approximation, beyond LDA. electrons in periodic solids, Bloch's theorem, nearly-free electron model, energy bands, Fermi surface, The tight-binding method, APW method, OPW method, pseudo-potential method, KKR method, LMTO method, the full-potential methods. applications to different types of solids; electron in disordered solids, mean-field theories, coherent potential approximation, KKR-CPA. Applications of KKR-CPA, tight-binding molecular dynamics, applications to clusters and solids, Car-Parinello methods and its applications to clusters and amorphous semiconductors, app-lications of electronic structure methods to materials design.

PHY 624: L-T-P-D-[C] **3-0-0-0-[4]** **Elective**

MAGNETISM IN MATERIALS **Prereq.: PHY 204 /432/ 602**

Magnetism in atoms and ions; crystal field; dia and paramagnetism, ferro- and antiferromagnetism; complex orders; experimental techniques; molecular fields and exchange interaction; direct interaction - localized and itinerant electrons, band model of ferromagnetism. indirect interactions, R.K.K.Y. theory.

PHY 625: L-T-P-D-[C] **3-0-0-2-[5]** **Elective**

COMPUTATIONAL METHODS FOR PHYSICAL SCIENCES

FORTRAN language, C language, computer graphics, computational methods for the solution of Schrödinger equation for electrons in atoms by Hartree-Fock-Slater approximation; in clusters and molecules by MS-X, SCF method and by extended Hückel method.

PHY 627: L-T-P-D-[C] **3-0-0-2-[5]** **Elective**

COMPUTER SIMULATIONS IN PHYSICS

FORTRAN/C programming, structured programming, errors, numerical analysis, differentiation, integration, solution of differential equations, solution of Schrödinger equation, simulations of planetary motion, oscillatory motion, chaotic motion, molecular dynamics simulation, classical and tight binding molecular dynamics, simulation of Ar, density functional theory, Car-Parrinello simulation, Monte Carlo simulation, simulation of Ising model, quantum Monte Carlo simulation, genetic algorithms.

PHY 628: **TOPICS IN SEMICONDUCTOR PHYSICS**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Tight-binding band structure; shallow impurities, deep impurities, density functional theory, many-body theory of impurities, quantized Hall effect, metastability.

PHY 629: **PHYSICS AND TECHNOLOGY OF THIN FILMS**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Introduction to thin films, nucleation theories and growth processes, PVD and CVD processes, epitaxial growth, microstructure, electronic transport, optical properties of thin films, size effects, physics and applications of thin films in selected areas.

PHY 630: **DISORDERED SYSTEMS**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Recent advances in the experiments and theory of disordered solids will be discussed with special reference to the following :

(a) Structural and compositional classification of amorphous semiconductors and metals
(b) Electronic structure of disordered solids,
(c) Magnetic disorder, amorphous magnets and spin glasses.

PHY 631: **PHYSICS OF SEMICONDUCTOR NANOSTRUCTURES**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Review of condensed matter and semiconductor physics, fabrication of quantum nanostructures, quantum structures and bandgap engineering. transport in quantum structures with applications, optical properties and applications, quantum mechanical effects in magneto-transport, frontiers in current research.

PHY 634: **LOW TEMPERATURE PHYSICS**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Production of low temperatures; cryostat design and experimental techniques applied to low temperature; thermometry; specific heat, transport phenomena, thermal, electrical and magnetic properties; superconductivity, applications of superconductivity; superfluidity and associated phenomena.

PHY 638: **NUCLEAR TECHNIQUES IN SOLID STATE STUDIES**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Different solid state physics/materials science aspects which can be studied using nuclear techniques. Rutherford back-scattering, channeling, elastic recoil detection analysis, positron annihilation, Mössbauer spectroscopy, ESCA etc.

PHY 641: **ELEMENTS OF BIO-AND MEDICAL PHYSICS**

L-T-P-D-[C]

3-0-0-0-[4]

Elective

Exponential growth and decay. fractal nature of mammalian organs, scaling laws in the animal world. Bio-statics: modeling static aspects of anatomy; jaw, forearm, spinal column, hip, Achilles tendon etc. biodynamics: mechanics of motion, dynamic phenomenon such as walking, jumping, swimming etc. fracture and impulsive, forces. airbags and automobile collisions, ballistocardiography, basal metabolic rate. thermobiology. viscosity and turbulence, haemodynamics. the human circulatory system, blood pressure. the heart as a pump. Arteriosclerosis and coronary bypass. electro-cardio-graph, life at low Reynolds number. Modern physics: interaction of photons and charged particles with living matter, medical uses of X-rays, nuclear medicine, computerized axial tomography and magnetic resonance imaging. optical imaging; optical and thermal laser-tissue interactions. spectroscopic techniques applied to biology, NMR, EPR, scattering, Raman spectroscopy, microscopy, ultrafast spectroscopy, IR spectroscopy, UV-visible absorption spectroscopy, fluorescence.

PHY 642: **CONDENSED MATTER PHENOMENA IN LOW-DIMENSIONAL SYSTEMS**

L-T-P-D-[C]

3-0-0-0-[4]

Elective

Characteristic length scales for quantum phenomena; scaling as a heuristic tool; scientific and technological significance of nanostructures and mesoscopic structures. brief introduction to quantum view of bulk solids, introduction to key ideas in transport and interaction of photons with material. Quantum structures: electronic properties: science and technology realizing low dimensional structures; MBE, MOCVD, Langmuir-Blodgett films, novel processes; electronic properties of heterostructures, quantum wells, quantum wires, quantum dots, and superlattices, strained layer super-lattices; transport in mesoscopic structures. resonant tunneling, hot electrons, conductance and transmission of nano-structures; principles of application of electronic devices. quantum structures: optical properties: optical process in low dimensional semiconductors. absorption. luminescence, excitons. application to lasers and photodetectors, transport in magnetic field: megneto-transport: transport in magnetic field, semiclassical description, quantum approach, Aharonov-Bohm effect, Shubnikov- de Haas effect; introduction to quantum Hall effect.

PHY 643: **LASERS AND LASER SPECTRA**

L-T-P-D-[C]

3-0-0-0-[4]

Elective

Principles of laser action in atoms and molecules. He-Ne laser and other inert gas laser, atomic halogen lasers; elements of group theory, masers and maser beam spectra, molecular lasers, nitrogen lasers, tunable dye lasers, Lamb shift spectroscopy, laser interactions in atoms and molecules.

PHY 644: **QUANTUM ELECTRONICS** **Prereq.: PHY 524 or equivalent**

L-T-P-D-[C]
3-0-0-0-[4]
Elective

Semi-classical theory of lasers, single and multi-mode operation, gas laser theory, ring and Zeeman lasers, coherence in lasers. non-linear optical phenomena, Feynman diagrams in multiphoton problems.

PHY 646: **COHERENT OPTICS**

L-T-P-D-[C]
3-0-0-0-[4]
Professional

Fourier transforms, diffraction theory, coherence theory, two-dimensional systems theory, optical processing, holography, holographic interferometry and its applications; astronomical correlation interferometry, optical resonators, non-linear optics, phase conjugation.

PHY 647: **ELECTRONICS**

L-T-P-D-[C]
2-1-0-4-[4]
Professional

L-T-P-D-[C] 2-1-0-4-[5] Elective

Survey of network theorems and network analysis, basic differential amplifier circuit, op amp characteristics and applications, simple analog computer, analog integrated circuits, PLL, etc., digital electronics, gates, flip-flops, counters etc., transducers, signal averaging, lock-in amplifier, D/A & A/D converter, multichannel analyzer etc., introduction to microprocessors.

PHY 651: **NUCLEAR PHYSICS**

L-T-P-D-[C]
3-0-0-0-[4]
Elective

Nuclear forces, two-body problems. meson theory. nuclear models: Single particle model and Hartree Fock theory, liquid drop model, unified models, rotational and vibrational models. nuclear supermultiplets. experimental methods of nuclear physics.

PHY 654: **QUARKS, NUCLEONS AND NUCLEI**

L-T-P-D-[C]
3-0-0-0-[4]
Elective

Symmetries of strong interactions. quark model and hadron spectroscopy. quantum electrodynamics, Feynman rules for QED. form factors. deep inelastic scattering. Bjørken scaling. quark-parton model. quantum chromodynamics, Feynman rules for QCD. scaling violation, Altarelli-Parisi equation, effective models for hadrons.

PHY 660: **GENERAL RELATIVITY AND COSMOLOGY**

L-T-P-D-[C]
3-0-0-0-[4]
Elective

Mach's principle. Riemannian-geometry. energy-momentum tensor and Einstein's equations. Schwarzschild metric and singularities of space time. post-Newtonian approximations. spherically symmetric solutions of Einstein equations. Introduction to cosmology.

PHY 670: **ATMOSPHERIC SCIENCE**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Atmospheric constitution, pressure & temperature distribution, radiation, heat budget, cloud physics, equations of motion in earth frame, wind types, global circulation, monsoon, cyclones prediction, pollution, change of climate.

PHY 680: **PARTICLE PHYSICS** **Prereq.: PHY 681 or #**

Natural units; evidence for 4 fundamental interactions, leptons and hadrons, historical introduction to particle zoo, relativistic kinematics, Lorentz-invariant phase space, calculation of 2 and 3-body phase space, Dalitz plot, Mandelstam variables, crossing symmetry, isospin, flavour SU(2), strangeness & flavour SU(3), product representations and Young tableaux, the Gell-Mann eightfold way, prediction of ?-, quark model, construction of hadronic wave functions, magnetic moment of the neutron, statistics of baryons & concept of colour; discovery of weak interactions, Fermi theory. IVB hypothesis, parity violation, mass problem, and decay; gauge theory, local U(1) gauge theory and Maxwell equations, Yang-Mills theories, SU(2) and SU(3) gauge theories, construction of SU(2)xU(1) gauge theory, gauge boson self-interactions, spontaneous breaking of gauge symmetry, Abelian and non-Abelian cases, Goldstone theorem, Higgs mechanism, Ginzburg-Landau theory, construction of the Glashow-Salam-Weinberg model (outline only).

PHY 681: **QUANTUM FIELD THEORY** **Prereq.: PHY 432 or #**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

Lorentz and Poincaré groups; relativistic wave equations; Lagrangian formalism for fields; symmetry transformations and Nöther's theorem; quantization of fields; divergences and renorm-alization; Yang-Mills fields, spontaneous breakdown of symmetries and Goldstone theorem; Higgs phenomenon; unified models of fundamental interactions.

PHY 690: **SPECIAL TOPICS IN PHYSICS**
L-T-P-D-[C]
3-0-0-0-[4]
Elective

The course will deal with specialized topics of current interest in solid state, theoretical physics, molecular physics, or structure of matter. Detailed contents will be given by the instructor when the course is announced. If the number of students is less than 5, this may be floated as a Reading Course with the permission of DPGC.

Every new course, other than Reading Courses, offered is numbered PHY 690A, PHY 690B, and so on, until PHY 690Z is reached. After that the cycle repeats from PHY 690A onwards.

PHY 692: **MEASUREMENT TECHNIQUES** **Prereq.: PHY 441/647 or equivalent**

L-T-P-D-[C]
3-0-0-3-[5]
Effective

Typical experiments in various areas is physics; vacuum techniques; transducers: temperature, pressure, charge particles, photons, etc; electronic noise; survey of analog and digital I/C's; signal processing, data acquisition and control systems; data analysis evaluation.

PHY 694: **DIGITAL ELECTRONICS FOR SCIENTISTS**

Prereq.: PHY 441/647 or equivalent

L-T-P-D-[C]
3-0-0-3-[5]
Effective

Boolean algebra; half-adders and full adders; registers and counters; memories; microprocessor instructions; the Intel 8085; I/O operations; support chips; the analog interface; microcomputer and its software.

PHY 696: **MEAN FIELD THEORIES IN RANDOM ALLOYS**

Prereq.: (M.Sc. Students only): PHY 543

L-T-P-D-[C]
3-0-0-0-[4]
Effective

Tight-binding approximation and Green function techniques; virtual crystal approximation (VCA); averaged T-matrix approximation (ATA); coherent potential approximation (CPA); beyond the CPA. augmented space formation; KKR method and KKRCPA. density functional techniques; beyond KKR-CPA.

PHY 751: **ADVANCED LOW TEMPERATURE PHYSICS**

Prereq.: PHY 543 or equivalent

L-T-P-D-[C]
3-0-0-0-[4]
Effective

Thermodynamics and liquefaction of gases; cryostat design and vacuum techniques; materials; transport phenomena, Fermi surfaces, magnetism, optical properties of solids, techniques of measurement, superconductivity, superfluidity, paramagnetic and nuclear adiabatic demagnetization.

PHY 781: **HIGH ENERGY PHYSICS II**

L-T-P-D-[C]
3-0-0-0-[4]
Effective

Current topics in Particle Physics and quantum field theory.

PHY 799: **RESEARCH**

To be registered by Ph,D. students from Semester I itself, and by M.Sc-Ph.D.(Dual Degree) students from Semester V onwards.

SCIENCE ELECTIVES

SE 301 QUANTUM PHYSICS

L-T-P-D-[C]
3-1-0-0-[4]

Origin of quantum theory and related experiments, Wave-Particle duality for photons and material particles, Wave function and its born interpretation, Relation with measurement of dynamical variables, d-function as definite position and plane wave as definite momentum wave function, Wavepacket as superposition of d-functions and of plane waves, Position-momentum Uncertainty Principle, Gaussian wave packets, Applicability of classical physics on the basis of uncertainty product. Operator formulation, commuting operators, simultaneous eigenfunctions, degenerate eigenfunctions. Schrodinger equation for time evolution, Stationary states, Spread of free particle wave packets, Time energy uncertainty, Natural line width of spectral lines. Probability currents and their relation with the flux in beams of particles. Square well potentials, Practical examples like metal-vacuum interface, Contact potential between metals, Bilayer and sandwiched thin film etc., Bound states in deep potential well and finite potential well, Double well potentials and examples like Ammonia inversion, Delta function potentials and examples like electron sharing in covalent bonds. Kronig Penny model of 1-D crystals and formation of energy bands. Linear harmonic oscillator, outline of getting stationary states, Molecular vibrations and spectroscopy. Barrier Tunneling, Examples of a-decay, nuclear fission, fusion in the Sun, Cold emission, Scanning tunneling microscope, principle of tunnel diode etc.; Angular momentum operators, eigenvalues and eigenfunctions, Spin angular momentum, hydrogen atom using Coulomb interaction, structure of Ha line due to l-s interaction (derivation not needed). Identical particles, indistinguishibility in quantum mechanics, Bosons and Fermions, Pauli Exclusion Principle, Simple examples of filling up of quantum states by classical particles, Bosons and Fermions. Statistics of noninteracting gas, Density of states from particle in a box stationary states, Occupation probability in M-B, B-E, F-D statistics, Distribution functions, Criteria for applicability of classical statistics, Derivation of U = 3NkT/2 for classical gas, Fermi gas, Fermi energy, Electronic contribution to specific heat of metals. Energy bands in conductors, insulators and semi conductors, modifications at metal-metal contact, p-n junction, details of tunnel diode.

SE 302 MODERN THEORIES OF MATERIAL DESIGN

L-T-P-D-[C]
3-1-0-0-[4]

Course Outline: Schrodinger Equation: Review of basics of quantum-mechanics (2); Introduction to Many-electron problem, Example of helium, exchange; Idea of mean field, Hartree and Density functional theory; Schrodinger equation for solids: Jellium model of metals (Homogeneous-electron gas); calculations for metal surfaces, properties such as the work function and surface energies (surface tension); Jellium model of metallic clusters; Bloch's theorem, Kronig-Penny model; Bands, Pseudopotentials, Semiclassical dynamics: DC conductivity; Effective mass and holes; Bloch Oscillations etc,. Semiconductors: Introduction; Some devices (3); Band-gap engineering: Quantum wells and superlattices; Nanotechnology -Quantum dots and wires, Dynamics of atoms: Classical Molecular Dynamics (2); Bom-Oppenheimer approximation, Hellman-Feynman theorem; Carr-Perrinello method; Assembling atoms to make clusters; Superconductivity: Introduction to superconductivity ; High Tc superconductivity; Some applications; Introduction to Polymers, optical materials, superionic conductors etc.

SE 303 **INTRODUCTORY BIOPHYSICS**

L-T-P-D-[C]
3-0-0-0-[4]

Exponential growth and decay. Homogeneous function of two and more variables. Scaling laws in animal world. Chaos, Fractal nature of mammalian organs Biomechanics. Statics and Human Anatomy. Mechanics of motion. Mechanistic view of Athletic events, Fluid mechanics. Blood circulation and Reynold's number. Blood Pressure, electro-cardiography and Hemodynamics, Heat Transfer. Energy from Metabolism. Kleiber's scaling Law Electomagnetism at the cellular level, Impulses in nerve and muscle cells. The Hodgkin-Huxley equations. Biomagnetism. Interaction of photons and charged particles with living matter. Spectroscopic techniques applied to Biology. Microscopy. NMR, EPR, Scattering, Raman Spectroscopy, Ultra fast Spectroscopy, IR Spectroscopy, UV-Visible Absorption Spectroscopy, Fluorescence. Medical use of X-rays. Nuclear medicine. Computerised Axial Tomography and Magnetic Resonance Imaging. Optical Imaging.

SE 304 **PHYSICS OF BIO-MATERIALS: STRUCTURE AND DYNAMICS**

L-T-P-D-[C]
3-1-0-0-[4]

Physics of biomolecules : Primary, secondary and tertiary structures; coil, helix and globule; DNA and RNA: Conformation- effects of elasticity, bending and twisting; entropic elasticity, fluctuations and supercoiling of DNA; Computing with DNA? Adleman's idea; Proteins: Fibrous and globular proteins, energy landscape and protein folding; Lipids: Hydrophobicity and supra-molecular self-assemblies. Physics of sub-cellular structures and processes; The cell membrane: Composition and in-plane structure, lipid incompatibility and segregation; lipid-protein interactions; Out-of-plane undulations; mean and Gaussian curvature, bending energy and crumpling of the moduli of bending elasticity; Edge energy, defects in membranes and their classification; Interplay of in-plane order and our-of-plane undulations. Membrane electrostatics; Can we "hear" the shape of a membrane? Transport across cell membrane- passive and active transport, ion channels and pumps, transport by vesicles-endocytosis and exocytosis; Drug delivery into the cell. Physics of the cellular structure and processes: Structure of the cell and cell organelles: cytoskeleton, microtubules, cilia and flagella; Cellular traffic-filamentary "highway" and molecular motors; Calculation of efficiency of isothermal engines; Shapes of cells; Budding; Cell-substrate interactions; contacts and adhesion; Interaction of cells- entropic repulsions and adhesion; Movement of cells-swimming and crawling. Physics of multi-cellular phenomena : Brain: a network of cells- Adaptive learning, content- addressable memory, Neural computers- a “dream machine”? .

SE 305 **PHYSICS OF NON-EQUILIBRIUM PHENOMENA**

L-T-P-D-[C]

3-1-0-0-[4]

INTRODUCTION: Examples of non-equilibrium phenomena(i) Glass transition; (ii) Nucleation; (iii) Phase separation; Experimental probes: Dynamic scattering; inelastic neutron scattering, THEORETICAL TOOLS: Two alternative theoretical approaches (a) Langevin equation-dissipation, nonlinearity and noise; Illustration with translational Brownian motion; (b) Fokker-Planck equation-diffusion and drift; Illustration with (i) translational Brownian motion, (ii) rotational Brownian motion. Master equation-loss and gain of probabilities; concept of detailed balance . META-STABILITY AND BI-STABILITY: Kramers’ theory of thermally activated barrier crossing-applications in (i) chemical reactions (ii) rock magnetism. “Enhancing signals with the help of noise” - applications of stochastic resonance in (a) nonlinear optics, (b) solid state devices, (c) neuro-science, (d) molecular motors and biological locomotion. Becker-Doring Theory of homogeneous nucleation and its modern extensions-applications in (a) condensation and (b) crystallization. UNSTABLE STATES: Allen-Cahn scenario of interfacial dynamics and domain growth-applications to domain growth in quenched magnets; Lifshitz-Slyozov arguments for phase separation and its generalizations-applications to (a) alloys, (b) fluid mixtures, (c) polymer mixtures. Theory of phase separation controlled by topological defects- application to liquid crystals. Theory of coarsening of Cellular Patterns- applications to soap froths (e.g., shaving foams). NON-EQUILIBRIUM STEADY-STATES IN DRIVEN SYSTEM: Driven systems of interacting particles - applications to vehicular traffic; Driven surfaces- applications in molecular beam epitaxy (MBE).

SE 306 **NONLINEAR SYSTEMS**

L-T-P-D-[C]

3-0-0-0-[4]

Maps as dynamical systems modeling chaos and complexity; Area preserving maps, Hamiltonian Systems Regular and Stochastic Motion; Perturbation theory and KAM; Cellular Automata. Self organization; Quantum Chaos.

SE 307 **QUANTUM PROCESSES IN LOW DIMENSIONAL SEMICONDUCTORS**

L-T-P-D-[C]

3-0-0-0-[4]

Course Outline: Characteristic length scales for quantum phenomena; Scaling as a heuristic tool; Scientific and Technological significance of nanostructures and meso-scopic structures. Brief introduction to quantum view of bulk solids, Introduction to key ideas in transport and interaction of photons with material. Quantum Structures: Electronic Properties: Science and technology realizing low dimensional structures; MBE, MOCVD, Langmuir-Bloddgett films, novel processes;

Electronic properties of Heterostructures, Quantum wells, Quantum wires, Quantum dots, and superlattices, Strained Layer Super-lattices; Transport in Mesoscopic Structures. Resonant Tunneling, Hot Electrons, Conductance and Transmission of Nano-structures. Principles of application of electronic devices. Quantum Structures: Optical Properties: Optical process in low dimensional semiconductors. Absorption. Luminescence, Excitons. Application to lasers and photodetectors, Transport in Magnetic Field: Megneto-transport: Transport in Magnetic Field, Semiclassical description, Quantum Approach, Abaranov-Bohm effect, Subnikov- de Haas effect; Introduction to Quantum Hall effect.

SE 308 **ENERGY**
L-T-P-D-[C]
3-0-0-0-[4]

Indian and global energy resources, current energy exploitation, energy demand, energy planning, renewable energy sources, wind energy, energy from water, solar energy, energy from mineral oils, nuclear energy, energy for sustainable development, environmental concerns.

SE 309 **PRINCIPLES OF LASERS AND THEIR APPLICATIONS**
L-T-P-D-[C]
3-0-0-0-[4]

Gaussian Optics, Optical Resonators and their Mode Structure; Atomic levels, Absorption, Spontaneous and Stimulated emission, Einstein coefficients; Rate Equations, Population Inversion, Gain media, 3 and 4 level lasers; CW & Pulsed Lasers, Q-Switching, mode-locking, Short pulses; Ar+, CO2, Nd:YAG, diode lasers, etc.; Metrology, Optical Communication, Materials Processing, Holography, Medical Applications.

SE 310 **INTRODUCTION TO ATMOSPHERIC SCIENCE**
L-T-P-D-[C]
3-0-0-0-[4]

Atmospheric constitution; Pressure and temperature distribution; Heat budget; Precipitation, Clouds; Atmospheric dynamics; Global circulation; Tropical weather systems; Remote sensing applications; Ozone hole, global warming and pollution.

SE 311 **PHYSICS OF UNIVERSE**
L-T-P-D-[C]
3-0-0-0-[4]

Astronomical observations and instruments, Photometry; Stellar spectra and structure; Stellar evolution, nucleosynthesis and formation of elements; Variable stars; Compact stars (white dwarfs. Neutron stars, black holes; Star clusters and Binary stars; Galaxies, their evolution and origin; Active galaxies and quasars; Big bang model of the universe, early history of the universe, cosmic microwave background radiation.

SE 312 **ORDER AND CHAOS**
L-T-P-D-[C]
3-0-0-0-[4]

Dynamical Systems; Nonlinear dynamics of one dimensional flows, Fixed point, linear stability analysis, bifurcations; Nonlinear dynamics of two dimensional flows, Phase space, equilibrium, Limit cycle, stability, bifurcations; Periodicity, disturbed periodicity; Non-linear dynamics of 1-D and 2D maps, fixed point, stability, Poincare section ; Routes to chaos- Period doubling, quasiperiodicity and intermittency, Universality, Renormalization; Measurement of chaos,Lyapunov exponent, entropy; Strange attractors, fractal geometry and fractal dimension; Examples from Sciences and Engineering.

SE 313 **MODERN OPTICS**

L-T-P-D-[C]

3-0-0-0-[4]

Review of Maxwell's and electromagnetic wave equations; Wave propagation in anisotropic media; Polarized light; Diffraction from circular aperture and concept of resolution; Fourier transforms and Fourier optics, Spatial filtering, and Image Processing; Coherence, Holography; Optical Waveguides and integrated optics; Optical fibres, Optical sources (LED, Lasers etc.) and detectors, and optical communication; Electro- and magneto- optic effects; Laser-matter interaction.

SE 314 **CLASSICAL MECHANICS**

L-T-P-D-[C]

3-0-0-0-[4]

Review of the Newtonian mechanics; Lagrangian Mechanics, Generalized coordinates, constraints, Principle of virtual work, Lagrange's equation, Calculus of variations; Central forces, Collisions, Scattering; Small oscillations, Anharmonic oscillators, Perturbation theory, Forced oscillators; Hamilton's Equations, phase space & phase trajectories, canonical transformations, Poisson brackets, Hamilton-Jacobi theory; Rigid body dynamics; Non-linear Dynamics.

SE 315 **SPECIAL & GENERAL RELATIVITY**

L-T-P-D-[C]

3-1-0-0-[4]

Special Relativity, Empirical evidence for the constancy of c, Frames of references; Lorentz transformations; relativity of simultaneity; twin and other paradoxes; Transformation laws for velocity, momentum, energy; Mass-energy equivalence; force Equations; Kinematics of decays and collisions; Maxwell's equations in covariant form; Representations of the Lorenz Group and SL(2,C); Introduction to General Relativity; Principle of equivalence; Mach's principle; Riemannian geometry; Christoffel symbols, the curvature and stress-Energy tensors; the gravitational field equations; Geodesics and particle trajectories; Schwarzchild solution; Experimental tests; Basic cosmology; FRW-metric; Cosmological expansion; Cosmic Microwave background; Helium abundance; anisotropies in the CMB.

SE 316 **STATISTICAL MECHANICS**

L-T-P-D-[C]

3-1-0-0-[4]

Review of Thermodynamics 2. Basic Principles and Applications of Statistical Mechanics 3. Ideal Quantum Gases 4. Interacting Systems5. Theories of Phase

Transitions 6. Computer Simulations 7. Elementary Concepts of Non-equilibrium Stat. Mechanics

SE 317 **INTRODUCTION TO ATOMIC AND NUCLEAR PHYSICS**

L-T-P-D-[C]
3-1-0-0-[4]

Quantum mechanics of one and two electron atoms, Many electron atoms, Central field approximation, Thomas-Fermi approximation, Molecular binding, LCAO, LCMO and VB methods, Hydrogen molecules, Molecular spectra, Raman effect, Lasers.

SE 318 **QUANTUM MECHANICS-I**

L-T-P-D-[C]
3-1-0-0-[4]

Origins of Quantum Theory , Schroedinger equation, wavemechanics, One-dimensional problems, Central potentials; Hydrogen atom, Hilbert space formalism for quantum mechanics, Symmetries in quantum mechanics, General treatment of angular momentum; spin, Identical particles; Pauli exclusion principle

SE 319 **CONDENSED MATTER PHYSICS**

L-T-P-D-[C]
3-1-0-0-[4]

Free electron model; Heat capacity; Transport properties; Hall Effect; Elementary concepts of quantum Hall effect, Structure and Scattering; Crystalline solids, liquids and liquid crystals; Nanostructures; Bucky balls, Electrons in a periodic potential; Bloch's theorem; Nearly free electron Model; Tight-binding model; semiclassical dynamics; Motion of an electron in a dc electric field; Effective mass, holes, Crystal binding; Types of solids; vander-waals solids,Ionic covalent solids, Metals, Lattice vibrations; Adiabatic & harmonic approximations, Vibrations of mono and diatomic lattices, Lattice Heat Capacity, Einstein and Debye models, Semiconductors; Intrinsic & extrinsic semiconductors, Laws of mass action, Electron & hole mobilities. Impurity levels, p-n junctions, Superconductivity; Experimental Survey, Meissner effect, London's equation, BCS theory, Ginzberg Landau theory, Flux quantization, Magnetism; Exchange interaction, Diamagnetism, paramagnetism, ferro- Magnetism & antiferromagnetism, Hund's rules, Pauli paramagnetism, Heisenberg model, Mean field theory, Spin waves, Giant and colossal magneto resistance.

SE 320 **PHYSICS OF INFORMATION PROCESSING, 3-0-0-0-4** **Prereq. PHY 103**

L-T-P-D-[C]
3-0-0-0-[4]

Basic Interactions: Order of magnitude estimates, Noise in physical systems, Information in physical systems: Shannon's Theory of information; Information and Thermodynamics, Basics of Electromagnetic fields and waves, Transmission lines. Waveguides and Antennas, Optics and Imaging; Inverse problems, Generation, Detection and Modulation of light, Solid state devices; Magnetic storage, Measurement and Coding; Cryptography, Physical limitations of information devices; New technologies.

SE 331 **BASIC PHYSICAL CHEMISTRY**

L-T-P-D-[C]
3-0-0-0-[4]

States of matter and properties of gases: Description of states of matter, perfect gas equation of state, The Maxwell distribution of speeds, diffusion and effusion, real gases, intermolecular interactions, critical temperature, the van der Waals and the Virial equation of states.

Thermodynamics: First law and its implications, various relations between q, w, U, H, T, Cp and Cv. Second law; entropy and free energy changes. Chemical potential phase equilibrium. Raoult's law, Henry's law and colligative properties. Chemical equilibrium. Electrochemisty, Debye-Huckel limiting law, electrochemical cells.

Chemical Kinetics: Phenomenological kinetics- 1st, 2nd and 3rd order laws. Methods of determining order of chemical reactions. Chain reactions and explosions, photochemical reactions and catalysis. Fast reactions, flow techniques, flash photolysis. Collision theory and fundamentals of activated complex theory.

SE 332 **BASIC ORGANIC CHEMISTRY**

L-T-P-D-[C]
3-0-0-0-[4]

Nomenclature of organic molecules, structure and bonding, stereochemistry, reactive intermediates, substitution and elimination reactions, molecular rearrangements, photochemistry.

SE 333 **INDUSTRIAL ORGANIC CHEMISTRY**

L-T-P-D-[C]
3-0-0-0-[4]

Various aspects of the energy and raw material supply: Coal, oil, natural gas, nuclear, and biomass as energy sources; Basic products of industrial synthesis: synthesis gas, methanol, formaldehyde, halogen derivatives of methane, chlorofluorohydrocarbons; Olefins: Historical perspective, cracking of hydrocarbons, ethylene, butanes, higher olefins, unbranched higher olefins and their use in metathesis reactions, Acetylene: Significance and manufacturing process for acetylene, manufacture through calcium carbide, thermal process, applications of acetylene, 1, 3-Diolefins: 1, 3-Butadiene, industrial manufacture from cracking, dehydrogenation, applications of butadiene, Synthesis using carbon monoxide: Hydroformylation, industrial operations, utilization of oxo products, carbonylation of olefins;Oxidation products of ethylene: Ethylene oxide, process operation, ethylene glycol, ethylene glycol ethers, acetaldeyde, acetic acid, acetic anhydride, Alcohols: Ethanol, propanol, butanols, amyl alcohols, aldol synthesis, polyhydric alcohols, neopentyl glycol Vinyl-halogen and oxygen compounds: Vinyl chloride, vinylidene chloride, vinylacetate, vinyl ethers; Polyamides: Adipic acid, hexamethy-lenediamine, adiponitrile, lactams; Propene conversion products: Propylene oxide, acetone, acrolein, allylchloride, acrylonitrile.; Aromatics: Source of feedstocks, coking of hard coal, isolation, special separation techniques, condensed aromatics, naphthalene, anthracene, hydrodealkylation.

Benzene derivatives: Styrene, cumene, cyclohexane, phenol, maleic anhydride, nitrobenzene, aniline, diisocyanates. Oxidation products of xylene and naphthalene: Phthalic anhydride, esters of phthalic acid and derivatives, terephthalic acid.

SE 334 **BIOSYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Buffers (their use in study of biomolecules), pH, pKa of aminoacids, D and L amino acid nomenclature ; Proteins: protein sequencing by chemical and mass & NMR spectroscopic methods, Use of spectroscopic tools in studying bimolecules. Primary (single letter amino acid codes), Ramachandran plot, secondary (alpha-, 310-, Beta-helices, parallel and antiparallel beta-sheets, gamma 1 turns, beta-turns), circular Dichroism of proteins, super-secondary structural motifs, tertiary (motifs and domains: some Important motifs like Rossman fold, helix turn helix, 4 helix bundles, beta barrel) and quaternary structure (Hemoglobin and Myoglobin). Protein Engineering; Biophysical techniques to purify and study proteins. Dialysis, salting out and precipitation by organic solvents, Ion exchange, gel filtration, reversed phase, affinity chromatography, ultracentrifugation, gel electrophoresis; Nucleic acids: A, B and Z- DNA structures, Method of replication, sequencing of nucleic acids (chemical, dideoxy and fluorescence), Prokaryotic Transcription, translation, genetic code, genomes, genes, over expression of recombinant proteins, mutagenesis (random and site directed). Polymerase chain reaction (PCR); Enzymes and their kinetics: Michaelis-Menten kinetics, Reaction order, competitive, un-competitive, non-competitive and irreversible inhibition of enzymes. Effect of pH, temperature on enzymes activity; Metabolism: Photosynthesis, Calvin's cycle, Glycolysis, Krebs cycle, electron transport, cofactors;

SE 335 **SYMMETRY IN CHEMISTRY, 3-0-0-0-4**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to symmetry: Symmetry elements, symmetry operations and symbols, multiple symmetry operations, symmetry operations on molecules; Symmetry and group theory: Definition of groups. Molecular point groups, classification of molecules into point groups, matrix representation of symmetry operations, characters and character tables, reducible and irreducible representations; Symmetry and molecular structure calculations: Introduction to quantum mechanics, Symmetry of wave functions of atoms and molecules, symmetry adapted linear combinations, molecular orbitals of diatomic and polyatomic molecules, Molecular orbitals of conjugated molecules (Huckel MOs) and of transition metal complexes; Symmetry and spectroscopy: Transition between stationary states, Microwave, Infrared and Raman spectra, The symmetry of normal vibrations, Selection rules from symmetry considerations, illustrative examples. The electronic spectra of some diatomic and polyatomic molecules, selection rules of electronic transition, vibronic analysis. Some important special effects such as the exclusion rule for centrosymmetric molecules, Fermi resonance etc.; Conservation of orbital symmetry and chemical reactions: Some illustrative examples such as Woodward-Hoffmann rule of electrocyclic reactions;

SE 336 **PHOTONS, MOLECULES AND CHEMICAL DYNAMICS**

L-T-P-D-[C]
3-0-0-0-[4]

Classical theory of light, light as collection of photons, energy and momentum of photons, elementary quantum mechanical studies of atoms and molecules, interaction of photons with atoms and molecules; Molecular basis of elementary chemical reactions, relation between the microscopic and macroscopic observables, initial state selection and final state analysis with and without laser, concept of potential energy surfaces and reaction dynamics.

SE 337 **MOLECULAR MODELING**

L-T-P-D-[C]
3-0-0-0-[4]

Basic concepts in molecular modeling, coordinate systems, potential energy surfaces, molecular graphics, units of length and energy and basic mathematical concepts; Quantum mechanical models: Polyelectron atoms and molecules, the concept of interatomic and intermolecular interactions, modeling of calculated interaction energies by model potentials for simple atoms, ions and molecules; Empirical force field models: Molecular Mechanics. General features of molecular mechanics force fields, bond stretching, angle bending and torsion, electrostatic interactions, effective pair potentials. Force field models of water and other simple molecular systems; Computer simulation methods: Concept of microstates of macroscopic systems, averages and basic ideas of simulations. The Monte Carlo and molecular dynamics methods. Applications to various molecular and macromolecular systems. Calculation of free energy through molecular modeling and simulations.

The use of molecular modeling to discover and design new molecules: Molecular modeling in drug discovery, deriving and using three dimensional pharmacophores, molecular docking, quantitative structure-activity relationships etc.

SE 338 **LASERS AND CHEMISTRY AND BIOLOGY**

L-T-P-D-[C]
3-0-0-0-[4]

Fundamental Properties of light: Maxwell's equations in vacuum, transverse electromagnetic wave, flow of electromagnetic energy. Maxwell's equations in dielectric medium, absorption and dispersion of light. Temporal and spatial coherence; Absorption and emission of light: Cavity radiation, Planck's law, spontaneous and stimulated emission coefficients. Homogenous and inhomogeneous broadening of spectral lines, Fundamentals of Lasers: Population inversion, gain and condition of laser oscillation. Laser cavities and cavity modes. Generation of short pulses: Q-switching and mode locking. Specific Laser Systems: He-Ne laser, Ar+-ion laser and Nd:YAG laser. Tunable dye lasers and

Optical Parametric Oscillators; Laser in chemistry: Laser-induced fluorescence and multi-photon ionization process of molecules. Probing the dynamics of chemical processes in liquid and molecular beam. Spectroscopy of single molecules. Non-linear optical process in molecules and material medium; Lasers in biology: Application of ultra-fast spectroscopy of probe protein dynamics, energy and electron transfer processes in natural photo-biological process. Optical trapping and manipulation of biological macromolecules and organelles. Identification and manipulation of single molecules in confocal microscopy. Fluorescence correlation spectroscopy and applications to diagnostics and biotechnology;

SE 339 **MAGNETIC RESONANCE IN CHEMISTRY, BIOLOGY & MEDICINE**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to magnetic resonance, chemical shift, coupling constants, relaxation phenomena, CW and FT methods; Introduction to pulse NMR, phase cycling, window functions, phase correction, quadrature detection, dynamic range problem; One dimensional NMR experiments, double resonance, polarization transfer experiments, NOE and difference spectroscopy.

Two dimensional experiments, homo and hetero nuclear COSY, J-spectroscopy, NOESY and multiple quantum experiments, Structure determination of biological molecules using NMR spectroscopy, NMR imaging, medical applications of NMR imaging.

SE 351 **LINEAR ALGEBRA**

L-T-P-D-[C]
3-1-0-0-[4]

Fields and linear equations. Vector spaces. Linear transformations and projections, relations, etc. Determinants. Elementary canonical forms: diagonalization, triangulation, primary decomposition etc. Secondary decomposition theorem, Rational canonical forms, Jordan canonical forms and some applications. Inner product spaces, Selfadjoint, Unitary and normal operators, Orthogonal projections. Bilinear forms, Symmetric, Skew-symmetric, Positive and semi-positive forms etc.

SE 352 **DISCRETE MATHEMATICS**

L-T-P-D-[C]
3-1-0-0-[4]

Permutations and combinations and basic definitions. Generating functions. Polya’s enumeration theory. Recurrence relations. Principle of inclusion and exclusion. Balanced incomplete block design. Difference sets. System of distinct representatives. Orthogonal Latin squares. Hadamard matrices.

SE 353 L-T-P-D-[C] 3-1-0-0-[4]

BASIC STRUCTURE OF MATHEMATICS

Finite and Infinite Sets: Finite sets, Countable sets, Uncountable sets. Groups and Symmetry: Groups, Subgroups, Lagrange theorem, Normal subgroups, Quotient groups, Group actions, Homomorphisms, Group of symmetry - rigid motion group, finite subgroups of the rotation group, symmetric group. Metric Spaces: Open sets, Closed sets, Sequences, Continuity, Complete metric spaces, Contraction principle and applications, Connectedness and compactness. Fractals: Metric space of fractals and its completeness, Iterated function systems, Attractor, Algorithms to generate fractals. Topology of Surfaces: Euler's theorem, Construction of surfaces by identification: Torus, mobius strip, Klein bottle.

SE 354 L-T-P-D-[C] 3-1-0-0-[4]

MATHEMATICAL LOGIC

Formal theories, consequence and deduction. Classical Propositional Calculus: Syntax, truth, validity, Adequacy of connectives, normal forms, applications to circuit design, Axiomatic treatment, deduction theorem, derived rules of inference, Soundness, Independence of axioms, Consistency, completeness, Completeness w.r.t. Boolean algebras, Computer-assisted formal proofs: tableaux, resolution. Classical first order theories: Syntax, satisfaction, truth validity, Axiomatic treatment, Equality, Examples of first-order theories : Peano arithmetic, Groups, Orderings, Basis of axiomatic set theory, Deduction theorem, derived rules of inference, soundness, Consistency, completeness, Lowenheim-Skolem theorems, compactness, First-order theories with equality, Decidability, Computer-assisted formal proofs: tableaux, resolution. Godel's incompleteness theorems. Examples of other/non-classical logics. Other proof techniques - natural deduction, sequent calculus.

SE 356 L-T-P-D-[C] 3-1-0-0-[4]

OPERATIONS RESEARCH - I

Linear Models: Formulation and Examples, Basic Polyhedral Theory- Convexity, Extreme points, Supporting hyperplanes etc, Simplex Algorithm- Algebraic and Geometrical approaches, Artificial variable technique, Duality Theory: Fundamental theorem, Dual simplex method, Primal-dual method, Sensitivity Analysis, Bounded Variable L.P.P. Transportation Problems: Models and Algorithms, Network Flows: Shortest path Problem, Max-Flow problem and Min-cost Flow problem, Dynamic Programming: Principle of optimality, Discrete and continuous models.

SE 357 L-T-P-D-[C] 3-1-0-0-[4]

PRINCIPLES OF NUMERICAL COMPUTATION

Root find problem for transcendental and polynomial equations - methods and analysis. Interpolation: Lagrange, divided difference, finite difference, Hermite and Spline interpolation, Inverse interpolation. Approximation - Least squares and minimax approximation. Numerical differentiation. Numerical integration-

Newton-Cotes and Gauss quadratures. Numerical methods (direct and iterative) for solving linear systems with error analysis. Eigen values and eigen vectors for linear algebraic systems. Numerical methods for initial value problems.

SE 358 **REGRESSION ANALYSIS**

L-T-P-D-[C]

3-1-0-0-[4]

Generalized Inverses, Cochran's theorem, Gauss Markov Setup, Least squares estimators with restriction on parameters, Test of Hypothesis of linear parameteric function, ANOVA, power of tests, Confidence Intervals and Regions, Multiple comparison, Linear, Polynomial and Multiple Regression, Residual Analysis, Multi co- llinearity, Ridge Regression and Principal Component Analysis, Subset Selection, Non-linear Regression.

SE 359 **APPLIED STOCHASTIC PROCESSES**

L-T-P-D-[C]

3-1-0-0-[4]

Definition and classification of general stochastic processes. Markov Chains: definition, transition probability matrices, classification of states, limiting properties. Markov Chains with Discrete State Space: Poisson process, birth and death processes. Renewal Process: renewal equation, mean renewal time, stopping time. Markov Process with Continuous State Space: Introduction to Brownian motion.

SE 360 **MATHEMATICAL METHODS**

L-T-P-D-[C]

3-1-0-0-[4]

Multiple Integral Theorems and their Applications: Green's theorem, Stoke's theorem and Gauss divergence theorem. Integral Transforms: Fourier, Fourier sine/cosine and Hankel Transforms with their inverse transforms (properties, convolution theorem and application to solve differential equation). Perturbation Methods: Perturbation theory, Regular perturbation theory, Singular perturbation theory, Asymptotic matching. Calculus of Variation: Introduction, Variational problem with functionals containing first order derivatives and Euler equations. Functionals containing higher order derivatives and several independent variables. Variational problem with moving boundaries. Boundaries with constraints. Higher order necessary conditions, Weirstrass function, Legendre's and Jacobi's condition. Existence of solutions of variational problems. Rayleigh-Ritz method, statement of Ekeland's variational principle and applications.

SE 361 **STATISTICAL SIMULATION AND DATA ANALYSIS**

L-T-P-D-[C]

3-1-0-0-[4]

Simulation of random variables from discrete, continuous, multivariate distributions and stochastic processes, Monte-Carlo methods. Regression analysis, scatter plot, residual analysis. Computer Intensive Inference Methods - Jack-Knife, Bootstrap, cross validation, Monte Carlo methods and permutation tests. Graphical representation of multivariate data, Cluster analysis, Principal component analysis for dimension reduction.

SE 362 **NUMERICAL LINEAR ALGEBRA**

L-T-P-D-[C]

3-1-0-0-[4]

Computer arithmetic. Vector and matrix norms. Condition number of a matrix and its applications. Singular value decomposi- tion of a matrix and its applications. Linear least-squares problem. Householder matrices and their applications. Numerical methods for matrix eigenvalue problem. Numerical methods for systems and control.

SE 363 **FINITE ELEMENT METHOD**

L-T-P-D-[C]

3-1-0-0-[4]

Introduction and motivation, Weak formulation of BVP and Galerkin approximation, Piecewise polynomial spaces and finite element method, Computer implementation of FEM, Results from Sobolev spaces, Variational formulation of elliptic BVP, Lax-Milgram theorem, Estimation for general FE approximation, Construction of FE spaces, Polynomial approximation theory in Sobolev spaces, Variational problem for second order elliptic operators and approximations, Mixed methods, Iterative techniques.

SE 364 **MATHEMATICAL MODELING** **Prereq. MTH-203**

L-T-P-D-[C]

3-1-0-0-[4]

Elementary mathematical models. Role of mathematics in problem solving. Concepts of mathematical modeling. System approach. Formulation. Analysis of models. Sensitivity analysis & parameter estimation. Design of experiment, Validation. Simulation approach. Pitfalls in modeling. Illustrations.

SE 365 **COMPLEX ANALYTIC DYNAMICS AND FRACTALS**

L-T-P-D-[C]

3-1-0-0-[4]

Chordal & spherical metrics, Normal families. Iteration of polynomials and rational functions, Periodic points & orbits, Julia & Fatou's sets and their characterizations, Dynamics of Julia and Fatou's sets for quadratic, Rational & entire functions; The Mandelbrot set. Julia sets & fractals, Self-similarity and fractal dimension.

SE 366 **DIGITAL IMAGE PROCESSING**

L-T-P-D-[C]

3-1-0-0-[4]

Introduction, Two-dimensional Systems and Mathematical Preliminaries, Image Perception, Image Sampling and Quantization, Image Transforms, Image Representation by Stochastic Models, Image Enhancement, Image Filtering and Restoration, Image Analysis and Computer Vision, Image Reconstruction from Projections, Image Compression.

SE 376 **INFORMATION THEORY AND ERGODIC PHENOMENON**

L-T-P-D-[C]

3-0-0-0-[4]

Shannon's information measure -history and axiomatic development, Relative entropy and mutual information, Law of large numbers and ergodic theorem, Shannon-McMillan-Breiman (Funda-mental) theorem for countable and uncountable alphabet, Noiseless coding theorem and data compression, Kolmogorov complexity, A universal (Lempel-Ziv) compression algorithm and optimality for ergodic processes, Differential entropy, Rate distortion theorem (and quantization), Channel capacity, Coding theorems for discrete and continuous (in time and with alphabet) channels and Gaussian channels, Large deviations and relative entropy, application to statistics and statistical mechanics, Extension of Shannon's information (e.g. Renyi's information), Distance measures and applications

SE 377 **STOCHASTIC PROCESSES AND APPLICATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Classification of stochastic Processes; Convergence of random variables- in probability, almost sure, in weak topology, in norm, complete convergence and r-quick convergence, rate of convergence; Martingales- convergence theorems. Markov Property, asymptotic stationarity, ergodicity. Wiener process and stochastic (Ito) intergral, Ergodic hypothesis, Measure preserving transformations, Poincare's recurrence theorem, ergodic theorem, mixing conditions.

Applications to sequential analysis, change detection problem, signal detection, source and channel coding, control problem, queueing networks and statistical physics.

SE 378 **OPTICAL FIBERS**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction, Overview , Geometrical optics, Light guiding in fibres-ray theory, Basic electromagnetic theory , Wave propagation in fibres, Modes, Dispersion in fibres, Bandwidth, Fiber manufacturing, Attenuation, Basics of LEDs and lasers, Thick and thin lens, Light coupling, Photodetectors and noise, Optical communication, Intensity based fibre optic sensors, Interferometry, interferometric sensors, Nonlinearity in fibres, Soliton propagation in fibres, Optical amplification.

SE 379 **FOURIER ANALYSIS, TRANSFORMS AND APPLICATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

INTRODUCTION: Who was Fourier? PRELIMINARIES: Hilbert Spaces: Orthonormal Bases, Operators on Hilbert Spaces. The spaces L2[0,1], L2(z). Examples of Orthonormal Bases: the Fourier series, the Hear System; Cesaro Summability, Plancherel theorem, computing Fourier Coefficients; Fourier Transforms, Placherel and Inversion Theorems (d) Schwarz Class Functions and other dense subspaces. Sobolev Spaces - different norms; Fast Fourier Transform.

Poisson summation Formula, Shannon sampling Theorem, The 'global' character of the Fourier Transform. Time, frequency, and Scale. Localization. The Gabor Transform and the Short time Fourier Transform. Scaling Functions and Wavelets. The multiresolution concept. Discrete and continuous wavelet transforms. Filter

Banks and trees of filter banks, Other orthogonal transforms and fast transform computation. The computational complexity of a transform. Symmetries in the Fourier Transform, and their exploitation: the Fast Fourier transform. Associated real transforms: the cosine and sine transforms and their fast computation. Dyadic transforms: the Walsh Hadamard transform and its fast computation. The fast wavelet transform, Spectrum Estimation: the problem of estimation of spectra from finite-duration observations. The periodogram. Frequency resolution. Nonparametric estimation: Bartlett, Welch and Blackman-Tukey estimates. Performance of nonparametric estimation techniques. Parametric estimation: AR, MA and ARMA modeling, maximum entropy estimation. Minimum variance spectral estimation.

SE 380 **SCIENCE AND TECHNOLOGY AT NANOSCALES**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to Nanotechnology, Physics and Mechanics of nanoscale Devices, Micro/Nanoelectromechanical System, Nanoscale measurements, Materials Issues at Nanoscales, Modeling Strategies for Nanoscales, Current Trends and Future Directions.

SE 381 **MICROSCALE THERMAL SCIENCES**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction: Micro Electro-Mechanical Systems (MEMS), Micro channels, Heat pipes, Jets, Valves, Heat sinks, Solar cells, Bearings, Pumps, Flow sensors and actuators, Fins, Drug delivery systems; Transport Equations: Mass, Momentum, Heat and Charge transport equations, Multi-component systems, Characteristic Non-dimensional parameters; Microscale Heat Conduction: Microscale energy transport in solids, Heat transport in thin films and at solid-solid interfaces, Heat conduction in semiconductor devices and interconnects; Convective diffusion Phenomena: Enzyme-substrate reactions, External flow, Internal flow, Channel flow with soluble or rapidly reacting walls, Flow past reacting flat plate; Solutions of Electrolytes: Electric double layer of Debye sheath, Electro-kinetic phenomena, Electro osmosis, Electro-osmotic microchannel systems, Electro-osmotic Pumps; Surface Tension Driven Flows: Coating flows, Themo-capillary flows, Thermo capillary pump, Diffuso-capillary flows, Marangoni convection and instability; Modeling: Continuum model, Molecular model, Introduction to molecular dynamics simulations and direct simulation Monte Carlo method (DSMC); Assorted Journal Papers.

SE 382 **PRINCIPLES OF COMPUTERIZED TOMOGRAPHY**

L-T-P-D-[C]
3-0-0-0-[4]

Overview, medical imaging, nondestructive testing, radiographic techniques, Various applications, Data collection, Design of CT scanners for materials testing and flow-measurement, Related instrumentation, Radon's inversion formula, Central slice theorem, Fan-beam inversion, Filter functions, Convolving functions, Transform methods, Series expansion methods, Convolution algorithm, Error estimates, Direct theorems, Inverse theorems

SE 383 **INTRODUCTION TO SOFT COMPUTING FOR PROBLEM SOLVING IN SCIENCE AND ENGINEERING**

L-T-P-D-[C]

3-0-0-0-[4]

Part I: Basics - Mathematical preliminaries: Universal approximation of multivariate functions, Nonlinear error surface and optimization principle, Statistical learning theory and classification.

Part II: Neural Networks: Back-propagation network, Radial Basis function network, Recurrent network.

Part III: Fuzzy logic: Primer- Fuzzy set theory, Fuzzy rule base and inference mechanism, Fuzzy neural networks.

Part IV: Genetic Algorithm: Primer, Evolutionary neural networks.

Part V: A project work that involves implementation of soft-computing principle in real-world application.

SE 384 **PRINCIPLES OF MATERIAL SELECTION**

L-T-P-D-[C]

3-0-0-0-[4]

Introuduction: evolution of materials, design process, engineering materials and properties.

Materials selection basics: strategy, property limits, materials indices, case studies (important emphasis on this aspect, 20 examples); Material selection charts: construction, applications. Multiple constraints and compound objectives: method of weight factors, selection of materials shape, case studies, Materials process attributes: evaluation, screening, ranking, case studies. Selection strategy.

Aesthetics, environment and industrial considerations, recycling and reuse, Data sources: estimation, checking, case studies; Conclusions: forces for change.

SE 385 **SCIENCE AND TECHNOLOGY OF PARTICULATE MATERIALS**

L-T-P-D-[C]

3-0-0-0-[4]

Particle characterization - particle size distribution in single and multiple particle attributes; measurement principles and techniques involving size, density, pore structure, morphology and specific surface area. Surface charge of particle and charge modification. Theory of particle fracture and stress distributions; Particle in fluids-theory of forces on particle and setting phenomenon; Population balance concept: classifying particulate processes by birth, death and continuous growth rates, Particle mechanics - inter -particle forces and their effects at contacts; bed friction; yield criteria for packing, adhesion. Modeling particulate assembly with the Discrete Element Method; Bulk properties and behaviour: storage and flow of particles in chutes, silos, and bins; Conveying; dust explosion; flow metering.

Principles of unit operations: crushing and grinding, classification, gravity concentration, heavy medium separation, agglomeration, pelletization and compaction, mixing, extrusion of pastes, magnetic and electrostatic separation, filtration, froth flotation; Particulate materials of future: nanoparticles, magnetic, electro-rheological fluids;

SE 386 **SURFACE SCIENCE**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to atomic molecular phenomena at surface: Physical and Chemical Adsorption, Statistical Thermodynamics of Adsorption, Elementary Rate Processes - Energy exchange, Scattering, Condensation, Evaporation, Atom Motion, Experimental Methods - UHV Techniques; Chemical Interactions: Kinetic Phenomena: Adsorption, Desorption, Diffusion, Chemical and Structural specificity, Equilibrium Phenomena - Phase Transformation, Mechanical phenomenon at surfaces; Characterization of Solid Surfaces: Structural characterization techniques such as LEED, RHEED, FIM, STM, AFM, Composition - electron emission, electron spectroscopies; Applications: Growth of Layers and Crystals, Chemical Surface Reactions, Catalysis, Various Sensors.

SE 387 **PRINCIPLES OF ECOLOGY AND ENVIRONMENTAL SCIENCE**

L-T-P-D-[C]
3-0-0-0-[4]

Ecology; Autecology: theory, life form types, ecological factors. Population Ecology: population growth, demography, ecological niche and niche partitioning, intra-specific and inter-specific competition, extinction, conservation, harvesting and control. Evolution of population: origin of life, micro-evolution, natural selection, population genetics and genetic systems, speciation; Ecosystem: natural ecosystems, climax concept, microcosmic and seral succession, statics and dynamics of ecosystem, case studies. Natural Resources and Anthropogenic Impact; Types of Resources: air, water, soil, minerals and biodiversity; Impact of Development Activities: impacts of agriculture, mining, traditional sources of energy, population, industrialization, transportation structures, big dams etc.; Introduction to Sustainable Development: renewable energy sources, sustainable agricultural practices, integrated pollution control in the industries, sustainable irrigation, protection of biodiversity etc.; Global Environment Problems: global warming, pollution in the ocean, ozone hole, loss of biodiversity, overfishing in international waters, pesticide use and bioconcentration in the food chain etc.

SE 388 **INTRODUCTION TO POLYMER SCIENCE & TECHNOLOGY**

L-T-P-D-[C]
3-0-0-0-[4]

Polymer Fundamentals: Chemistry of Polymer synthesis, Polymer Reaction Kinetics: Step-growth polymerization, free-radical chain growth polymerization, Emulsion Polymerization, Ionic and cationic polymerization. Chain statistics and rubber elasticity. Physical pro-perties and characterization of polymers.

SE 389 **ATMOSPHERE AND ENVIRONMENT**

L-T-P-D-[C]
3-0-0-0-[4]

This course introduces students to aspects of atmospheric physics and chemistry that are related to air pollution: local and global dispersion of pollutants, global warming, acid rain and ozone hole formation; Atmospheric chemistry, pressure and temperature distribution, heat budget, precipitation, global wind circulation, tropical weather systems, atmospheric dynamics. Atmospheric chemistry; Local and global dispersion of pollutants, global warming, acid rain and ozone hole formation.

SE 390 **ORDER AND CHAOS**

L-T-P-D-[C]
3-0-0-0-[4]

Dynamical Systems: Importance of Nonlinearity, Nonlinear dynamics of Flows (in 1, 2, and 3 dimensions) and Maps (in 1, 2 dimensions) in Phase Space, Equilibrium, Periodicity, Bifurcation, Catastrophe, Deterministic Chaos, Strange Attractor, Routes to Chaos [Period doubling Quasi periodicity, Intermittency, Universality, Renormalization]; Measurement of Chaos [Poincare section, Lyapunov index, Entropy] Fractal geometry and Fractal dimension; Examples from Physical Sciences, Engineering and Biology.

SE 391 **TRANSDUCERS AND SENSORS: PRINCIPLES AND APPLICATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

The need for sensors and transducers, Classes of sensors and transducers, Precision and Accuracy, Calibration of sensors and transducers, Basics of Statistical data analysis, Basics of Reliability of Sensors, Basics of Electronics, Electrical Noise and signal detection, Physical Mechanism of Transduction, Passive electrical transducers: thermistor, strain gauge, LVDT, Accelerometer , Pirani gauge, Active electrical transducers: thermocouple, photo diode, Fiber optic sensors for displacement, pressure, temperature, flow rate, liquid level, angular velocity, current, voltage, and distributed stress measurements, Optical biosensors, Ultrasonic sensors, MEMS based micro sensors, Multisensor fusion, Case studies: Robotic soccer, Power distribution automation.

SE 392 **SCIENCE OF METTALLIC CORROSION**

L-T-P-D-[C]
3-0-0-0-[4]

Definitions and importance; Electrochemical mechanisms; Corrosion tendencies; Electrode Potentials; Corrosion rates; Passivation;

SE 393 **PHYSICS OF REMOTE SENSING**

L-T-P-D-[C]

3-0-0-0-[4]

Electromagnetic spectrum; Controlled and Uncontrolled sources of Electromagnetic waves; Maxwell's Wave Equation; Electromagnetic Wave Propagation; Emission, Reflectance and Scattering Properties; Active and Passive Sensors; Airborne and Satellite-borne Platforms and Sensors; Various kinds of Remote sensing Satellites; Remote sensing and Optical Microwave data; Application of Remote sensing to Ocean, Earth, Snow and Atmosphere.

SE 394 **INTRODUCTION TO CONTINUUM MECHANICS**

L-T-P-D-[C]

3-0-0-0-[4]

Vectors and Tensors; Stress, principal stresses, invariants, deviatoric stresses, plane stress, simplified theory; Strains and Deformation, rotation, material and spatial derivatives, deformation tensor, spin and rate of deformation, finite strain and deformation, rotation and stretch tensors, compatibility conditions; General principles, continuity equation and momentum principles, transport theorems, virtual work, basic thermodynamics for solids; Constitutive equations, Rational mechanics approach, Classical elasticity, Generalized Hooke's law, isotropy, hyperelasticity, thermal stresses, ideal frictionless fluids, Newtonian fluids, Stokes condition.

SE 395 **MOLECULAR FLUID DYNAMICS AND MICROFLUIDICS**

L-T-P-D-[C]

3-0-0-0-[4]

Introductory Kinetic Theory, Equilibrium Kinetic Theory, Equation of State for a Perfect Gas, Maxwellian Distribution, Collision Rate and Mean Free Path, Nonequilibrium Kinetic Theory, Boltzmann Equation, Moments of Boltzmann Equation, Collision Integrals, Flow with Translational Non equilibrium, Bhatnagar-Gross-Krook Collision Model, Chapman-Enskog Solution of Krook Equation, Chapman-Enskog Solution of Boltzmann Equation, Navier-Stokes Equation, Transport Properties, Continuum Mechanics, Fundamentals of Microfluidics, Continumm Fluid Mechanics at Small Scales, Molecular Approaches, Electrokinetics.

SE 396 **CONCEPTUAL FOUNDATIONS OF MECHANICS**

L-T-P-D-[C]

3-0-0-0-[4]

Introduction: a brief history of the evolution of the science of motion; early notions of space, matter and motion; evolution of the language of mechanics: acceleration- Merton school of thought and Galileo; concept of inertia - Galileo and Descarte; momentum, force, mass and energy - Heugens, Newton and Leibniz; relational mechanics and the absolute - relative debate; Universal gravitation and action-at-a-distance: gravitational and inertial mass and their equivalence; Mach's principle and origin of inertia; inertia as a manifestation of dynamic gravitational interaction. Emergence of analytical mechanics; variational principles of mechanics; Lagrangian and Hamiltonian formulations; generalized coordinates and momenta; evolution of the concept of momentum;

phase space; birth of statistical mechanics. Matter waves in classical mechanics; optics-mechanics analogy; Hamilton-Jacobi theory; Hamilton - Schroedinger equation; Frames of reference and principle of relativity; concept of space-time continuum; special theory of relativity; relativistic dynamics - concepts; mass energy equivalence; physical foundation of general theory of relativity; principle of equivalence and a metric theory of gravity; some relevant cosmological problems and open questions. Quantum mechanics - conceptual foundations; Relation with classical mechanics.

SE 397 **EARTH SYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Earth as a system; Earth-atmosphere interaction; The Rock cycle; Dynamic Earth system: continental drift and plate tectonics, internal structure and evolution of earth, crustal deformation and mountain building, rates and frequency of earth processes, Solid Earth System: magmatism and volcanism, sedimentary and metamorphic processes, rock-forming minerals; Fluid Earth System: weathering, erosion and mass movement processes; geomorphic processes and landforms; Hazardous Earth System: earthquakes, floods and landslides; Human interaction with the environment; Global and environment change.

SE 398 **PRINCIPLES OF COMPLEX MATERIALS**

L-T-P-D-[C]
3-0-0-0-[4]

The list of topics will change from one year to another and will depend on the interest and expertise of the instructors. The list of topics given below in different units of the course content, is one that the proposers of the course may want to choose from.

i. Basic Principles Structure & Binding, relationship to properties;
ii. Organic & Polymeric materials: Conducting Polymers, Bio-molecular Electronics,
iii. Light Emitting Diodes;
iv. Sensors & Actuators: Electro-rheological,
v. Piezoelectric materials, Bio-sensors, Chemical sensors, Micro Electromagnetic Sensors, Acoustic sensors, Thermoelectric materials, Magnetostrictive Materials, Shape-memory alloys;
vi. Nano materials: Physics of Nanostructures, Nanotechnology, Carbon Nanotubes.
vii. Structural materials: Intermetallics, Ceramics, Polumers, Composites.

SE 421 **INTRODUCTION TO MODERN BIOLOGY**

L-T-P-D-[C]
3-0-0-0-[4]

Course Content:Concepts annd Methods in Biology: Principles of Cellular Life, Chemical Foundation for cells, Carbon compounds in cells, Cell structure and function, ground rules for metabolism, source of energy for cells; Principles of inheritance: Cell division, observable patterns of inheritance, chromosomes and genetics; Principles of evolution: Microevolution, speciation, macro-evolutionary puzzle. Evolution and diversity: Origin and evolution of life, prokaryotic and eukaryotic life forms. Plant structure and function: Plant tissues, nutrition and transport; Animal structure and function: Tissues and organs, sensory reception, endocrine control, circulation, immunity, respiration, digestion and nutrition, reproduction and development, integration and control.; Ecology: Ecosystem, biosphere, human impact on biosphere, population ecology, ecology and behavior, evolutionary view of behavior.