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 PHY101 PHY102	PHY103 MTH102 TA101	MTH203 CHM201 ESO212/ ESO214	HSS-I-2 TA201 PHY204	PHY315 PHY401 PHY421
	MTH101 ESC101 PE101 HSS-I-1/ ENG112	ESC102 PHY100 PE102	PHY210 ESO-2 PHY224	PHY431 PHY218	†

	SIXTH	SEVENTH	EIGHTH	NINTH	TENTH
	PHY412 PHY422 PHY432 † †	PHY461 PHY543 PHY552 † †	PHY462 PHY524 PHY553 † †	PHY563 PHY565 † † †	PHY566 PHY568 † † †

† 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 l-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: L-T-P-D-[C] **3-0-0-0-[4] Elective (SE 305)**

PHYSICS OF NON-EQUILIBRIUM PHENOMENA

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: L-T-P-D-[C] **3-0-0-0-[4] Elective (SE 307)**

QUANTUM PROCESSES IN LOW DIMENSIONAL SEMICONDUCTORS

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

MATHEMATICAL METHODS II **Prereq.: PHY 421**

Functions of a complex variable, ordinary differential equations, special functions, differential operations and Sturm-Liouville theory, partial differential equations, Green's functions.

PHY 431: L-T-P-D-[C] **3-1-0-0-[5]** **Professional** **(SE 318)**

QUANTUM MECHANICS I

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

QUANTUM MECHANICS II **Prereq.: PHY 431**

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: L-T-P-D-[C] **2-1-0-4-[5]** **Professional**

ELECTRONICS

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: L-T-P-D-[C] **0-0-0-8-[4]** **Professional**

EXPERIMENTAL PHYSICS I

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: L-T-P-D-[C] **0-0-0-8-[4]** **Professional**

EXPERIMENTAL PHYSICS II

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]
0-0-0-8-[4]
Professional

L-T-P-D-[C] 0-0-0-8-[4] Elective

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]

L-T-P-D-[C] 2-1-0-4-[5] Elective

2-1-0-4-[4]

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 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.