Indian Institute of Technology Kanpur

COURSES OF STUDY

2025

Indian Institute of Technology Kanpur
KANPUR-208016

ELECTRICAL SCIENCE ENGINEERING

Template for the BT program in Electrical Engineering

Semester 1	Semester 2	Semester 3	Semester 4	Semester 5	Semester 6	Semester 7	Semester 8
SCHEME-1 (9) ELC111/ELC112/ ELC113 *	ETH111 (3)	SCHEME-2 HSS-I (9-11)	SCHEME-3 EME (9-11)	SCHEME-4 HSS-II (9)	DE-1 (9)**	SCHEME-5 HSS-II (9)	SCHEME-6 HSS-II (9)
MTH 111 (6)	MTH 113 (6)	ESC201 (14)	EE210 (11)	EE320 (11)	DE-2 (9)**	OE-2 (9)	DE-3 (9)
MTH 112 (6)	MTH 114 (6)	EE200 (11)	EE250 (11)	EE330 (11)	EE340 (11)	OE-3 (9)	DE/UGP-2 (9)
PHY 113 (11)	PHY 114 (11)	E/SO: TA212 (3)	ESO203 (13)	EE370 (11)	EE381 (12)	OE-4 (9)	OE-5 (9)
PHY 111 (3)	CHM 111 (3)	E/SO-1 (6): MSO202M	E/SO-3 (11) MSO201	EE380 Lab (12)	OE-1 (9)	DE/UGP-1 (9)	OE-6 (9)
TA 111 (9)	ESC 111 (7)	E/SO-2 (6) MSO203M	E/SO: TA211§ (3)	EE390 (2)			
CHM 112 (4)	ESC 112 (7)						
CHM 113 (4)	LIF111 (6)						
PE111 (3)	PE112 (3)						
55	52	49-51	58-60	56	50	45	45

**DE-1 and DE-2 (both) should be selected from Basket-A (Basket A: EE311, EE321, EE360, EE301)

Credit Table for BT Program in Electrical Engineering		
Course type	Recommended Credit range	Credit requirement for graduation
Institute Core (IC)	112	112
E/SO	18-45	42
Department	144-179	148 (103 DC + 45 DE)
Open electives (OE)	51-57	54
SCHEME	54-58	54-58
Total for 4-year BT/BS	391-420	410-414

Template for BTH program in Electrical Engineering

Template for 3rd to 8th semester for BTH program in Electrical Engineering					
Semester 3	Semester 4	Semester 5	Semester 6	Semester 7	Semester 8
SCHEME-2 HSS-I (9-11)	SCHEME-3 EME (9-11)	SCHEME-4 HSS-II (9)	DE-1 (9)**	SCHEME-5 HSS-II (9)	SCHEME-6 HSS-II (9)
ESC201 (14)	EE210 (11)	EE320 (11)	DE-2 (9)**	OE-2 (9)	DE-3 (9)
EE200 (11)	EE250 (11)	EE330 (11)	EE340 (11)	OE-3 (9)	UGP-2 (9)
E/SO: TA202 (3)	ESO203 (13)	EE370 (11)	EE381 (12)	OE-4 (9)	OE-5 (9)
E/SO-1 (6): MSO202M	E/SO-3 (11) MSO201	EE380 Lab (12)	OE-1 (9)	UGP-1 (9)	OE-6 (9)
E/SO-2 (6) MSO203M	E/SO: TA201 (3)	EE390 (2)	DEH-1 (9)	DEH-2 (9)	DEH-3 (9)
49-51	58-60	56	59	54	54

– CPI Criteria for BTH: ≥ 8.5

Remarks

- DEH courses should be level 6 or 7 EE courses
- **DE-1 and DE-2 (both) should be selected from Basket-A (Basket A: EE311, EE321, EE360, EE301)
- UGP-1 and UGP-2 are mandatory

Template for BTM program in Electrical Engineering

Template for 3rd to 8th semester for BTM program in Electrical Engineering					
Semester 3	Semester 4	Semester 5	Semester 6	Semester 7	Semester 8
SCHEME-2 HSS-I (9-11)	SCHEME-3 EME (9-11)	SCHEME-4 HSS-II (9)	DE-1 (9)**	SCHEME-5 HSS-II (9)	SCHEME-6 HSS-II (9)
ESC201 (14)	EE210 (11)	EE320 (11)	DE-2 (9)**	OE-2 (9)	MTB-3 (9)
EE200 (11)	EE250 (11)	EE330 (11)	EE340 (11)	OE-3 (9)	MTB-4 (9)
E/SO: TA202 (3)	ESO203 (13)	EE370 (11)	EE381 (12)	MTB-1 (9)	MTB-5 (9)
E/SO-1 (6): MSO202M	E/SO-3 (11) MSO201	EE380 Lab (12)	OE-1 (9)#	MTB-2 (9)	MTB-6 (9)
E/SO-2 (6) MSO203M	E/SO: TA201 (3)	EE390 (2)			
49-51	58-60	56	50	45	45

Remark:

- **DE-1 and DE-2 (both) should be selected from Basket-A (Basket A: EE311, EE321, EE360, EE301)
- MTB courses must be taken from the management course basket.
- # Students planning to convert to BTM-MT program should take OE-1 from the management

Template for five-year dual degree program in Electrical Engineering

Template for 3rd to 10th semester for five-year BT-MT program in Electrical Engineering								
Semester 3	Semester 4	Semester 5	Semester 6	Semester 7	Semester 8	Summer	Semester 9	Semester 10
SCHEME-2 HSS-I (9- 11)	SCHEME-3 EME (9- 11)	SCHEME-4 HSS-II (9)	DE-1 (9)**	SCHEME-5 HSS-II (9)	SCHEME-6 HSS-II (9)	M.Tech Thesis (9) EE699	M.Tech Thesis (27) EE699	M.Tech Thesis (36) EE699
ESC201 (14)	EE210 (11)	EE320 (11)	DE-2 (9)**	OE-2 (9)	OE-4 (9)		PG-6 (9)	
EE200 (11)	EE250 (11)	EE330 (11)	EE340 (11)	OE-3 (9)	OE-5 (9)			
E/SO: TA212 (3)	ESO203 (13)	EE370 (11)	EE381 (12)	DE/UGP-1 (9)	PG-3 (9)			
E/SO-1 (6): MSO202M	E/SO-3 (11) MSO201	EE380 Lab (12)	OE-1 (9)	DE PG-1 (9)	PG-4 (9)			
E/SO-2 (6) MSO203M	E/SO: TA211 (3)	EE390 (2)		DE PG-2 (9)	PG-5 (9)			
49-51	58-60	56	50	54	54	9	36	36

Remarks:

- **DE-1 and DE-2 (both) should be selected from Basket-A (Basket A: EE311, EE321, EE360, EE301)

- Minimum Credit Requirement in MTech Part for Graduation: PG component: 54 Credits; Thesis Component: 72 Credits
- PG-3, 4, 5 & 6 are to be taken with the permission of thesis supervisor.
- Total minimum BT-MT dual degree (Category A) credit requirement will be 509
- 18 DE credits and 9 Oe credits may be waived off in the UG part

Template for 3^{rd} to 10^{th} semester for five-year BTH-MT program in Electrical Engineering								
Semester 3	Semester 4	Semester 5	Semester 6	Semester 7	Semester 8	Summer	Semester 9	Semester 10
SCHEME-2 HSS-I (9- 11)	SCHEME-3 EME (9- 11)	SCHEME-4 HSS-II (9)	DE-1 (9)**	SCHEME-5 HSS-II (9)	SCHEME-6 HSS-II (9)	M.Tech Thesis (9) EE699	M.Tech Thesis (27) EE699	M.Tech Thesis (36) EE699
ESC201 (14)	EE210 (11)	EE320 (11)	DE-2 (9)**	OE-2 (9)	DE-3 (9)		PG-6 (9)	
EE200 (11)	EE250 (11)	EE330 (11)	EE340 (11)	OE-3 (9)	UGP-2 (9)			
E/SO: TA212 (3)	ESO203 (13)	EE370 (11)	EE381 (12)	UGP-1 (9)	DEH-3 (9)			
E/SO-1 (6): MSO202M	E/SO-3 (11) MSO201	EE380 Lab (12)	OE-1 (9)	DEH-2 (9)	PG-3 (9)			
E/SO-2 (6) MSO203M		EE390 (2)	DEH-1 (9)	DE PG-1 (9)	PG-4 (9)			
	E/SO: TA211 (3)			DE PG-2 (9)	PG-5 (9)			
49-51	58-60	56	59	63	63	9	36	36

Remarks:

- **DE-1 and DE-2 (both) should be selected from Basket-A (Basket A: EE311, EE321, EE360, EE301)
- DEH should be from level 6 or 7 EE Courses
- Minimum Credit Requirement in MTech Part for Graduation: PG component: 54 Credits; Thesis Component: 72 Credits
- PG-3, 4, 5 & 6 are to be taken with the permission of thesis supervisor.
- Total minimum BTH-MT dual degree (Category A) credit requirement will be 536 with graduating CPI ≥ 8.5 in BTH part
- 18 DE credits and 9 Oe credits may be waived off in the UG part
- UGP-1 and UGP-2 are mandatory

Template for 3rd to 10th semester for five-year BTM-MT program in Electrical Engineering								
Semester 3	Semester 4	Semester 5	Semester 6	Semester 7	Semester 8	Summer	Semester 9	Semester 10
SCHEME-2 HSS-I (9- 11)	SCHEME-3 EME (9- 11)	SCHEME-4 HSS-II (9)	DE-1 (9)**	SCHEME-5 HSS-II (9)	SCHEME-6 HSS-II (9)	M.Tech Thesis (9) EE699	M.Tech Thesis (27) EE699	M.Tech Thesis (36) EE699
ESC201 (14)	EE210 (11)	EE320 (11)	DE-2 (9)**	MTB-2 (9)	MTB-5 (9)		PG-6 (9)	
EE200 (11)	EE250 (11)	EE330 (11)	EE340 (11)	MTB-3 (9)	MTB-6 (9)			
E/SO: TA212 (3)	ESO203 (13)	EE370 (11)	EE381 (12)	MTB-4 (9)	PG-3 (9)			
E/SO-1 (6): MSO202M	E/SO-3 (11) MSO201	EE380 Lab (12)	MTB-1 (9)	DE PG-1 (9)	PG-4 (9)			
E/SO-2 (6) MSO203M	E/SO: TA211 (3)	EE390 (2)		DE PG-2 (9)	PG-5 (9)			
49-51	58-60	56	50	54	54	9	36	36

Remarks:

- **DE-1 and DE-2 (both) should be selected from Basket-A (Basket A: EE311, EE321, EE360, EE301)
- Minimum Credit Requirement in MTech Part for Graduation: PG component: 54 Credits; Thesis Component: 72 Credits
- PG-3, 4, 5 & 6 are to be taken with the permission of thesis supervisor.
- Total minimum BTM-MT dual degree (Category A) credit requirement will be 509
- 18 DE credits and 9 Oe credits may be waived off in the UG part

Template for double major: second major in Electrical Engineering

Template for double major in EE	
Odd Semester	Even Semester
Pre-requisites	
ESO203 (13)	MSO201 (11)
MSO202M (6)	
MSO203M (6)	
Mandatory EE courses	
EE200 (11)	EE210/EE250 (11)
EE320 (11)	Any ONE combination from Basket-B (33-41)
EE330 (11)	EE DE PG (9)
EE370 (11)	
EE380 (12)/EE480 (10)	
EE DE PG (9)/UGP-1 (9) (Optional)	
54-65	44-61

BASKET-B
1. Three PG courses + one course from Basket-A
2. Two PG courses + two courses from Basket-A
3. One PG course + three courses from Basket-A
4. One PG course + two courses from Basket-A + UGP-2
5. Two PG courses + one course from Basket-A + UGP-2
BASKET-A
EE321 (9)
EE301 (9)
EE340 (9)
EE311 (9)
EE360 (9)
EE381 (12)/EE481 (6)

Total mandatory Credits for Second Major in Electrical Engineering: 98 Credits

Remarks: Up to 27 OE credits may be waived from the parent department BT/BS graduation requirements.

ESO203 is a mandatory pre-requisite course for DM.

Minors in Electrical Engineering

Minors				
Minor in Microelectronics / Digital Systems	Minor in Power	Minor in Communications & Signal Processing	Minor in Controls	Minor in RF & Photonics
EE200 [11]	EE200 [11]	EE200 [11]	EE200 [11]	EE200 [11]
EE210 [11]	EE330 [11]	EE320 [11]	EE250 [11]	EE340 [11]
EE311 [09]/ EE370 [11]	EE360 [09]	EE321 [09]/ EE301 [09]	EE650A [09]	EE612A [09]/ EE642A [09]/ EE648A [09]
31/33	31	31	31	31

DEPARTMENT OF EE			
Courses ID	**Course Title**	**Credits L-T-P-D-[C]**	**Content**
EE100	INTRODUCTION TO PROFESSION		To be procured
EE200	SIGNALS, SYSTEMS AND NETWORKS	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, Twoport analysis.
EE200A	SIGNALS, SYSTEMS & NETWORKS	3-1-0-0-11	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.
EE210	ANALOG ELECTRONICS	3-1-0-0-11	1. 1V Characteristics and Large and SmallSignal Models of Diodes, BJTs, and MOSFETs; 2. Biasing; 3. Amplifiers; 4. Output Stages; 5. Frequency Response; 6. Feedback Amplifiers; 7. Stability and Compensation; 8. Operational Amplifier. **Course Reference**: 1. Analysis and Design of Analog Integrated Circuits; P.R. Gray, P.J. Hurst, S.H. Lewis, and R.G. Meyer; Jolm Wiley & Sons, 4th Edition, 2001; 2. MOS Analog Circuits for Signal Processing; R. Gregorian and G.C. Ternes; John Wiley & Sons, 1986; 3. Microelectronic Circuits; A.S. Sedra and K.C. Smith; Oxford University Press, 5th Edition,2004; 4. Microelectronics; J. Milbnan and A. Grabel; McGrawHill, 2nd Edition, 1987.
EE210A	ANALOG ELECTRONICS	3-1-0-0-11	1. 1V Characteristics and Large and SmallSignal Models of Diodes, BJTs, and MOSFETs; 2. Biasing; 3. Amplifiers; 4. Output Stages; 5. Frequency Response; 6. Feedback Amplifiers; 7. Stability and Compensation; 8. Operational Amplifier. **Course Reference**: 1. Analysis and Design of Analog Integrated Circuits; P.R. Gray, P.J. Hurst, S.H. Lewis, andR.G. Meyer; Jolm Wiley & Sons, 4th Edition, 2001; 2. MOS Analog Circuits for Signal Processing; R. Gregorian and G.C. Ternes; John Wiley & Sons, 1986; 3. Microelectronic Circuits; A.S. Sedra and K.C. Smith; Oxford University Press, 5th Edition,2004; 4. Microelectronics; J. Milbnan and A. Grabel; McGrawHill, 2nd Edition, 1987.
EE250	CONTROL SYSTEMS ANALYSIS	3-1-0-0-4	Negative feedback control systems, Linear time invariant dyanamic systems, Mason's gain formula, transfer function, frequency and time domain analysis, performance analysis, Nyquist stability criterion. Bode plots, Root locus. Feedback system design using Bode plotsand root locus. PID control. Nonlinear systems, circle criterion, anti windup schemes. Statespace models.
EE250A	CONTROL SYSTEMS	3-1-0-0-11	Negative feedback control systems, Linear time invariant dyanamic systems, Mason's gainformula, transfer function,

	ANALYSIS		frequency and time domain analysis, performance analysis, Nyquist stability criterion. Bode plots, Root locus. Feedback system design using Bode plotsand root locus. PID control. Nonlinear systems, circle criterion, anti windup schemes. Statespace models.
EE301	DIGITAL SIGNAL PROCESSING	3-0-0-0-4	Sampling and Reconstruction of continuous time signals, Characterization and properties of discrete time signals and systems, Computation of the discrete time Fourier transform andits properties, Computation of the discrete Fourier transform and its properties, Fast Fourier transform algorithms, The Ztransform and its properties, Transform analysis of linear timeinvariant systems, Implementation of structures for discrete time systems, Digital filter design techniques, Homomorphic filtering, Applications of DSP in speech and image processing. 1. DiscreteTime Signal Processing (Second Edition), Alan V. Oppenheim, Ronald W. Schafer, and John R. Buck, Pearson Education India
EE301A	DIGITAL SIGNAL PROCESSING	3-0-0-0-9	Sampling and Reconstruction of continuous time signals, Characterization and properties of discrete time signals and systems, Computation of the discrete time Fourier transform andits properties, Computation of the discrete Fourier transform and its properties, Fast Fourier transform algorithms, The Ztransform and its properties, Transform analysis of linear time invariant systems, Implementation of structures for discrete time systems, Digital filter design techniques, Homomorphic filtering, Applications of DSP in speech and image processing. **Course Reference**: 1. DiscreteTime Signal Processing (Second Edition), Alan V. Oppenheim, Ronald W. Schafer, and John R. Buck, Pearson Education India
EE311	SEMICONDUCTOR DEVICES	3-0-0-0-9	1. Semiconductors and Crystal Structures; 2. Basic Semiconductor Physics ; 3. Excess Carriers and Transport Processes in Semiconductors; 4. Junction Diode; 5. Bipolar Junction Transistor (BJT); 6. MOS Capacitor (MOSCAP); 7. MetalOxideSemiconductor FieldEffect Transistor (MOSFET); 8. Some Important Devices Tunnel Diode, Varactor Diode, Light Emitting Diode (LED), Photodetector, and Solar Cell **Course Reference**: 1. Solid State Electronic Devices, B.G. Streetman arid S. Banerjee, Prentice Hall, 2000; 2. Device Electronics for Integrated Circuits, R.S. Muller and T.I. Kamins, John Wiley, 2003; 3. Introduction to Semiconductor Materials and Devices, M.S. Tyagi, John Wiley, 1991; 4. Physics of Semiconductor Devices, M. Shur, Prentice Hall.J 990.
EE311A	SEMICONDUCTOR DEVICES	3-0-0-0-9	1. Semiconductors and Crystal Structures; 2. Basic Semiconductor PhysicsEE311; 3. Excess Carriers and Transport Processes in Semiconductors; 4. Junction Diode; 5. Bipolar Junction Transistor (BJT); 6. MOS Capacitor (MOSCAP); 7. Metal Oxide Semiconductor FieldEffect Transistor (MOSFET); 8. Some Important Devices Tunnel Diode, Varactor Diode, Light Emitting Diode (LED), Photodetector, and Solar Cell **Course Reference**: 1. Solid State Electronic Devices, B.G. Streetman arid S. Banerjee, Prentice Hall, 2000; 2. Device Electronics for Integrated Circuits, R.S. Muller and T.I. Kamins, John Wiley, 2003; 3. Introduction to Semiconductor Materials

			and Devices, M.S. Tyagi, John Wiley, 1991; 4. Physics of Semiconductor Devices, M. Shur, Prentice Hall,1990.
EE320	PRINCIPLES OF COMMUNICATION S	3-1-0-0-4	Fourier transform theory for communication systems, Analog communication systems. Amplitude Modulation, Envelope Detection, Double Sideband (DSB), Single sideband (SSB) and Vestigial Sideband (VSB) systems, Baseband Passband equivalence. Angle Modulation, Frequency Modulation, Phase Modulation, Spectrum of FM signals. Pulse Modulation, Quantization, Compression, Delta and DPCM Modulation. Probability, MAP detection, Random Processes, Strict and Wide Sense Stationarity Ergodicity, AWGN. Digital Communication systems, Optimality of Matched filter, BitError Rate (BER), Signal constellation theory, BPSK and QPSK modulation. GSM/TDMA and IS95/CDMA cellular systems. Statistical Multiplexing and packet switching, ALOHA, slotted ALOHA, Basics of queueing and trunking systems.
EE320A	PRINCIPLES OF COMMUNICATION	3-1-0-0-11	Fourier transform theory for communication systems, Analog communication systems. Amplitude Modulation, Envelope Detection, Double Sideband (DSB), Single sideband (SSB) and Vestigial Sideband (VSB) systems, Baseband Passband equivalence. Angle Modulation, Frequency Modulation, Phase Modulation, Spectrum of FM signals. Pulse Modulation, Quantization, Compression, Delta and DPCM Modulation. Probability, MAP detection, Random Processes, Strict and Wide Sense Stationarity Ergodicity, AWGN. Digital Communication systems, Optimality of Matched filter, BitError Rate (BER), Signal constellation theory, BPSK and QPSKmodulation. GSM/TDMA and IS95/CDMA cellular systems. Statistical Multiplexing and packet switching, ALOHA, slotted ALOHA, Basics of queueing and trunking systems.
EE321	COMMUNICATION SYSTEMS	3-0-0-0-4	Information measures. Source coding. ISI & channel equalization, partial response signalling. Mary 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.
EE321A	COMMUNICATION SYSTEMS	3-0-0-0-9	Information measures. Source coding. ISI & channel equalization, partial response signalling. Mary 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.
EE330	POWER SYSTEMS	3-1-0-0-11	1. Introduction to power system structure, types of components; 2. Different types of transformers and transformer Connections, per-unit analysis; 3. Inductance and capacitance calculations for transmission lines; 4. Models for short and long transmission lines, steadystate operation, shunt and series compensation, transients on transmission lines; 5. Network models of power system using admittance matrix; 6. The Load flow problem, Equations for bus powers and their numerical solution using Gauss Siedeland Newton Raphson methods; 7. Analysis of faulted power systems using sequence networks; 8. Basic stability analysis, derivation of swing equation ,equal area

			criteria, calculation of criticalclearing angle, numerical solution of swing equation; 9. Basics of Economic operation, incremental fuel cost, allocation ofload between generators ina plant. **Course Reference**: 1. Power System Analysis John J. Grainger & William D Stevenson Jr, McGraw Hill1994; 2. Power System Analysis and design J Duncan Glover, M. Sarma zd edition, PWS PublishingCo Boston 2001; 3. Power System Engineering, D. P Kothari & I.J. Nagrath, Tata McGraw Hill,2008.
EE330A	POWER SYSTEMS	3-1-0-0-11	1. Introduction to power system structure, types of components; 2. Different types of transformers and transformer Connections, per-unit analysis; 3. Inductance and capacitance calculations for transmission lines; 4. Models for short and long transmission lines, steady state operation, shunt and series compensation, transients on transmission lines; 5. Network models of power system using admittance matrix; 6. The Load flow problem, Equations for bus powers and their numerical solution using Gauss Siedeland NewtonRaphson methods; 7. Analysis of faulted power systems using sequence networks; 8. Basic stability analysis, derivation of swing equation ,equal area criteria, calculation of criticalclearing angle, numerical solution of swing equation; 9. Basics of Economic operation, incremental fuel cost, allocation ofload between generators ina plant. **Course Reference**: 1. Power System Analysis John J. Grainger & William D. Stevenson Jr, McGraw Hill1994; 2. Power System Analysis and design J. Duncan Glover, M. Sarma zd edition, PWS PublishingCo Boston 2001; 3. Power System Engineering, D.P. Kothari & I.J. Nagrath, Tata McGraw Hill,2008.
EE340	ELECTROMAGNE TIC THEORY	3-1-0-0-4	I. Overview of Static Electric and Magnetic Fields, Steady Electric Currents; 2. Time Varying Electromagnetic Fields, Maxwell’s Equations, Boundary Conditions; 3. Plane Electromagnetic Waves, Propagation in Free Space and in Matter; 4. Reflection and Refraction of Waves at Conducting and Dielectric Boundary; 5. Transmission Lines: TEM waves, Transmission Line Equations, Wave Propagation along Finite Transmission Lines, Transients on Lines, The Smith Chart; 6. Waveguides, Waves in Guided Media, Parallel Plate Waveguide, Rectangular Waveguide, Cavity Resonators; 7. Basic Theory of Antennas and Radiation Characteristics, Elementary Types of Antennas. **Course Reference**: I. Field and Wave Electromagnetics David K. Cheng, Second Edition, Pearson Education, 2008; 2. Engineering Electromagnetics W A Haytt & J A Buck, Seventh Edition, Tata McGrawHill, 2006; 3. Electromagnetic Waves and Radiating Systems by E. C. Jordan and K. G. Bahnain,Second Edition, Prentice Hall Inc., Tata McGraw Hill; 4. Principles ofE!ectromagnetics Mathhew N.O. Sadiku, Fourth Edition, OxfordUniversity Press; 5. Electromagnetics with Applications Kraus and Fleisch, Fifth Edition, McGraw Hill,1999.
EE340A	ELECTROMAGNE TIC THEORY	3-1-0-0-11	I. Overview of Static Electric and Magnetic Fields, Steady Electric Currents; 2. Time Varying Electromagnetic Fields, Maxwell’s Equations, Boundary Conditions; 3. Plane Electromagnetic Waves, Propagation in Free Space and in Matter; 4. Reflection and Refraction ofWaves at Conducting and Dielectric Boundary; 5. Transmission Lines: TEM waves,

			Transmission Line Equations, Wave Propagation alongFinite Transmission Lines, Transients on Lines, The Smith Chart; 6. Waveguides, Waves in Guided Media, Parallel Plate Waveguide, Rectangular Waveguide,Cavity Resonators; 7. Basic Theory of Antennas and Radiation Characteristics, Elementary Types of Antennas. **Course Reference**: 1. Field and Wave Electromagnetics David K. Cheng, Second Edition, Pearson Education, 2008; 2. Engineering Electromagnetics W A Haytt & J A Buck, Seventh Edition, Tata McGrawHill, 2006; 3. Electromagnetic Waves and Radiating Systems by E. C. Jordan and K. G. Bahnain,Second Edition, Prentice Hall Inc., Tata McGraw Hill; 4. Principles of E!ectromagnetics Mathhew N.O. Sadiku, Fourth Edition, Oxford University Press; 5. Electromagnetics with Applications Kraus and Fleisch, Fifth Edition, McGraw Hill,1999.
EE360	POWER ELECTRONICS	3-0-3-0-11	Converter Configurations, basic DC-DC converters: Buck, Boost, Buck-Boost, Cuk, steady-state analysis, ripple, CCM and DCM operation; Converter components – 1: Switches – diode, thyristor, MOSFET, IGBT, their VI characterisctics, generic switch model, switching and conduction losses, soft switching – ZVS and ZCS operation; Converter components – 2: Magnetics – single winding and coupled, real model, capacitors – real model, types; Line commutated converters: AC-DC rectifiers – single and three-phase configurations, operation with various loads, effect of source inductance, overlap angle, AC-AC regulator; Inverters: VSI and CSI structures, Modulation techniques, steady-state operation.
EE360A	POWER ELECTRONICS	3-0-0-0-9	Converter Configurations, basic DC-DC converters: Buck, Boost, Buck-Boost, Cuk, steady-state analysis, ripple, CCM and DCM operation; Converter components – 1: Switches – diode, thyristor, MOSFET, IGBT, their VI characterisctics, generic switch model, switching and conduction losses, soft switching – ZVS and ZCS operation; Converter components – 2: Magnetics – single winding and coupled, real model, capacitors – real model, types; Line commutated converters: AC-DC rectifiers – single and three-phase configurations, operation with various loads, effect of source inductance, overlap angle, AC-AC regulator; Inverters: VSI and CSI structures, Modulation techniques, steady-state operation.
EE370	DIGITAL ELECTRONICS	3-1-0-0-11	Introduction, Quality metrics, MOSFET as a switch, CMOS inverter, chain of inverters, Combinational circuits: CMOS design, ratioed-logic design, pass-transistor design, and dynamic logic design, Sequential circuit design: static timing analysis (STA), Bi-stable circuits: static and dynamic latch and registers, pipelinining, and non-bistable sequential circuits, Array based logic designs: field-programmable gate array (FPGA), CMOS memory design: memory hierarchy and organization, peripheral circuitry, static random-access memory (SRAM) design, dynamic RAM (DRAM) design, System level design: Datapath and register transfer operation, Introduction to circuit simulators (SPICE), Hardware description languages (HDL) such as VHDL and Verilog.
EE370A	DIGITAL	3-1-0-0-11	Introduction, Quality metrics, MOSFET as a switch, CMOS

	ELECTRONICS		inverter, chain of inverters, Combinational circuits: CMOS design, ratioed-logic design, pass-transistor design, and dynamic logic design, Sequential circuit design: static timing analysis (STA), Bi-stable circuits: static and dynamic latch and registers, pipelinining, and non-bistable sequential circuits, Array based logic designs: field-programmable gate array (FPGA), CMOS memory design: memory hierarchy and organization, peripheral circuitry, static random-access memory (SRAM) design, dynamic RAM (DRAM) design, System level design: Datapath and register transfer operation, Introduction to circuit simulators (SPICE), Hardware description languages (HDL) such as VHDL and Verilog.
EE380	ELECTRICAL ENGINEERING LAB I	0-2-6-0-4	Experiments from various areas of Electrical Engineering with emphasis on electronic devices, circuits, control systems and machines. This course has three labs: Electronic Circuits Lab. (7 experiments), Control Systems Lab. (6 experiments) and EMEC Lab.(6 experiments)
EE380.	ELECTRICAL ENGINEERING LAB I	0-2-6--4	Experiments from various areas of Electrical Engineering with emphasis on electronic devices, circuits, control systems and machines. This course has three labs: Electronic Circuits Lab. (7 experiments), Control Systems Lab. (6 experiments) and EMEC Lab (6 experiments)
EE380A	ELECTRICAL ENGINEERING LAB I	0-2-6-0-12	Experiments from various areas of Electrical Engineering with emphasis on electronic devices, circuits, control systems and machines. This course has three labs: Electronic Circuits Lab. (7 experiments), Control Systems Lab. (6 experiments) and EMEC Lab (6 experiments)
EE381	ELECTRICAL ENGINEERING LAB II	0-2-6-0-4	Experiments from various areas of Electrical Engineering with emphasis on digital electronics, communication, machines, drives and power systems, and electromagnetics. This course has three labs: Electronic Circuits Lab.II (7 experiments), DCMP Lab. (7 experiments) and EMEC Lab (6 experiments)
EE381A	ELECTRICAL ENGINEERING LABORATORY -II	0-3-6-0-12	Experiments from various areas of Electrical Engineering with emphasis on digital electronics, communication, machines, drives and power systems, and electromagnetics. This course has three labs: Electronic Circuits Lab.II (7 experiments), DCMP Lab. (7 experiments) and EMEC Lab (6 experiments)
EE390A	ELECTRICAL ENGINEERING COMMUNICATION SKILLS	0-0-2-0-2	Technical Communication, definition and attributes. Ethics in communication. Technical Writing. Report and Article composition. How to write a Technical Brochure. Writing summary and abstracts of technical documents. Software tools for technical report writing. Listening Comprehension. Oral Communication and Presentation. Technical Presentation and use of multimedia.
EE391A	ELECTRICAL ENGINEERING UNDER GRADUATE PROJECT I		To be procured
EE392A	UNDER GRADUATE PROJECT II	0-0-0-0-9	UG PROJECT (UGP II)

EE393A	ELECTRICAL ENGINEERING UNDER GRADUATE PROJECT I	0-0-2-0-4	ELECTRICAL ENGINEERING UNDER GRADUATE PROJECT I
EE395A	ELECTRICAL ENGINEERING UNDER GRADUATE PROJECT III	0-0-0-0-9	ELECTRICAL ENGINEERING UNDER GRADUATE PROJECT III
EE399A	ELECTRICAL ENGINEERING COMMUNICATION SKILLS	0-0-0-0-9	ELECTRICAL ENGINEERING COMMUNICATION SKILLS
EE401A	ELECTRICAL ENGINEERING COMMUNICATION SKILLS		To be procured
EE416	OPTO-ELECTRONICS	3-0-0--4	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.
EE416A	OPTO-ELECTRONICS	3-0-0-0-9	LEDs, semiconductor lasers, modulation of laser sources. Avalanche and PIN photo detectors and their characteristics. Solar cells. Optical fibers and their characteristics. Integrated optics. Fiber optic communication systems, system design consideration.
EE420	MODERN CONVEX OPTIMIZATION FOR ENGG/ SCIENCE APPLICATIONS		To be procured
EE420A	MODERN CONVEX OPTIMIZATION FOR ENGINEERING / SCIENCE APPLICATIONS		To be procured
EE442A	ANTENNAS AND PROPAGATION	3-0-0-0-9	Retarded potential, radiation from current element and dipole, radiation patterns, impedance, reciprocity. Various types of antennas, interferometers and multielement arrays, Antenna Measurements. Ground wave propagation, terrain and earth curvature effects. Tropospheric propagation; fading, diffraction and scattering; Ionospheric Propagation refractive index, critical frequencies, effectsof magnetic field.
EE455	TRANSDUCERSA ND INSTRUMENTATIO N	3-0-0--4	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.
EE480A	ELECTRICAL ENGINEERING LAB I		To be procured
EE490.	PROJECT WORK	0-0-0--8	PROJECT WORK
EE491	PROJECT I	0-0-0--3	PROJECT I
EE491A	UNDER GRADUATE PROJECT -III	0-0-0-0-9	UG PROJECT (UGPIII)
EE492	PROJECT II	0-0-0--5	PROJECT II
EE492A	UNDER GRADUATE PROJECT-IV		To be procured
EE600	MATHEMATICAL STRUCTURES OF SIGNALS & SYSTEMS	3-0-0--4	Nature of definitions; Theory of measurement and scales; Symmetry, invariance and groups; Groups in signals and systems; Algebraic and relational structuresof signal spaces and convolutional systems; Representation theory of groups, harmonic analysis and spectral theory for convolutional systems.
EE600A	MATHEMATICAL STRUCTURES OF SIGNALS & SYSTEMS	3-0-0-0-9	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.
EE601	MATHEMATICAL METHODS IN SIGNAL PROCESSING	3-0-0--4	Generalized inverses, regularization of illposed 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.
EE601A	MATHEMATICAL METHODS IN SIGNAL PROCESSING	3-0-0-0-9	Generalized inverses, regularization of illposed 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.
EE602	STATISTICAL SIGNAL PROCESSING-I	3-0-0--4	Power Spectrum Estimation Parametric and Maximum Entropy Methods, Wiener, Kalman Filtering, Levinson Durban Algorithms Least Square Method, Adaptive Filtering, Nonstationary Signal Analysis, WignerVille Distribution, WaveletAnalysis.
EE602A	STATISTICAL SIGNAL PROCESSING-I	3-0-0-0-9	Power Spectrum Estimation Parametric and Maximum Entropy Methods, Wiener, Kalman Filtering, Levinson Durban Algorithms Least Square Method, Adaptive Filtering, Nonstationary Signal Analysis, WignerVille Distribution, Wavelet Analysis.
EE604	IMAGE PROCESSING	3-0-0--4	Human visual system and image perception, image formation models, image sampling and quantization, 2D systems, image transforms, image enhancement, colour vision models, colour representation, edge detection, restoration, denoising, image segmentation, multiresolution techniques, image coding, image compression, image quality, image features, morphological image processing.
EE604A	IMAGE PROCESSING	3-0-0-0-9	Human visual system and image perception, image formation

			models, image sampling and quantization, 2D systems, image transforms, image enhancement, colour vision models, colour representation, edge detection, restoration, denoising, image segmentation, multiresolution techniques, image coding, image compression, image quality, image features, morphological image processing.
EE605	INTRODUCTION TO SIGNAL ANALYSIS	3-0-0--4	Discrete and Continuous time signals and systems, LTI systems, Convolution, Difference equations. Frequency domain representation: Fourier transform andits properties. Random discrete signals. Sampling and reconstruction: Change of sampling rate. Normed vector spaces, basis, linear independence, orthogonality. Linear systems of equations. Over and Under determined systems. Row and Column spaces, Null spaces. Least square and minimum norm solutions. Inverse and pseudo inverse, Symmetry transformations. Eigen vectors and eigenvalues. Hilbert transforms, band pass representations and complex envelope. Base bandpulse transmission, matched filtering, ISI, equalization. Coherent and noncoherent detection.
EE605A	INTRODUCTION TO SIGNAL ANALYSIS	3-0-0-0-9	Discrete and Continuous time signals and systems, LTI systems, Convolution, Difference equations. Frequency domain representation: Fourier transform andits properties. Random discrete signals. Sampling and reconstruction: Changeof sampling rate. Normed vector spaces, basis, linear independence, orthogonality. Linear systems of equations. Over and Under determined systems. Row and Column spaces, Null spaces. Least square and minimum norm solutions. Inverse and pseudo inverse, Symmetry transformations. Eigen vectors and eigenvalues. Hilbert transforms, band pass representations and complex envelope. Base bandpulse transmission, matched filtering, ISI, equalization. Coherent and noncoherent detection.
EE606	ARCHITECTURE AND APPLICATIONS OF DIGITAL SIGNAL PROCESSORS	3-0-3-0-5	DSP Architecture: Von Neumann vs. Harvard architecture, VelociTI architecture Memory management of TI DSP processors C2X, C6X. Peripheral overview of TI C2X, C6X processor. Code Composer Studio (CCS) overview, writing simple programs in assembly, linear assembly and C. Instruction set of TI C2X/C6X processor. Optimization of assembly and C code. Pipelining. General Extension Language (GEL). Assembler, Linker. Interrupts RTDX. DSP/BIOSList of Experiments Introduction to Code Composer Studio1 Introduction to Code Composer Studio11 Introduction to the Addressing Modes FFT and Bit Reversal Operation FFT and its Applications Audio Codec and its Applications Real Time Data Exchange Using Matlab and Labview FIR filtering by interfacing Matlab with Code Composer Studio Introduction to Interrupts Digital communication using Binary Phase Shift Keying Current control of a threephase inverter with passive load Current control of a singlephase inverter with passive load PLL for a threephase ac system PLL for a singlephase system Current control of a threephase STA TCOM Speed control of an induction motor by V/f method Rulph Chassaing; Digital Signal Processing And Applications With The C6713 And C6416 DSK. **Course Reference**: 1. Wiley Interscience, 2004. Thad B. Welch, Wright, H.G. Cameron, and Michael G. Morrow; 2.Real Time DigitalSignal Processing from Matlab to C with the TMS320C6x

			DSK, CRC, 2005; 3. Steven A. Tretter;Communication System Design Using DSP Algorithms:With Laboratory Experiments for the TMS320C6701 and TMS320C6711, Springer, 2003; 4. Nasser Kehtarnavaz, RealTime Digital Signal Processing Based On The TMS320C6000; Newnes Publishers, 2004; 5. Rulph Chassaing, DSP Applications Using C And The TMS320C6x DSK, Wiley Interscience, 2002; 6. Shehrzad Qureshi; Embedded Image Processing On The TMS320C6000 DSP: Examples in Code Composer Studio and MATLAB, Springer, 2006.
EE606A	ARCHITECTURE AND APPLICATIONS OF DIGITAL SIGNAL PROCESSORS	3-0-3-0-5	DSP Architecture: Von Neumann vs. Harvard architecture, Velocity architecture Memory management of TI DSP processors C2X, C6X. Peripheral overview of TI C2X, C6X processor. Code Composer Studio (CCS) overview, writing simple programs in assembly, linear assembly and C. Instruction set of TI C2X/C6X processor. Optimization of assembly and C code. Pipelining. General Extension Language (GEL). Assembler, Linker. Interrupts RTDX. DSP/BIOS. List of Experiments Introduction to Code Composer Studio1. Introduction to Code Composer Studio11. Introduction to the Addressing Modes FFT and Bit Reversal Operation FFT and its Applications. Audio Codec and its Applications. Real Time Data Exchange Using Matlab and Labview FIR filtering by interfacing Matlab with Code Composer Studio. Introduction to Interrupts Digital communication using Binary Phase Shift Keying. Current control of a threephase inverter with passive load. Current control of a singlephase inverter with passive load. PLL for a threephase ac system. PLL for a singlephase system. Current control of a threephase STA TCOM Speed control of an induction motor by V/f method Rulph Chassaing, **Course Reference**: 1.Digital Signal Processing And Applications With The C6713 And C6416 DSK;, WileyInterscience, 2004; 2. Thad B. Welch, Wright, H.G. Cameron, and Michael G. Morrow,Real Time DigitalSignal Processing from Matlab to C with the TMS320C6x DSK;, CRC, 2005; 3. Steven A. Tretter;Communication System Design Using DSP Algorithms:With Laboratory Experiments for the TMS320C6701 and TMS320C671, Springer, 2003; 4. Nasser Kehtarnava; RealTime Digital Signal Processing Based On The TMS320C6000;, Newnes Publishers, 2004; 5. Rulph Chassaing, DSP Applications Using C And The TMS320C6x DSK, Wiley Interscience, 2002; 6. Shehrzad Qureshi;Embedded Image Processing On The TMS320C6000 DSP: Examples in Code Composer Studio and MATLAB, Springer, 2006.
EE607	WAVELET TRANSFORMS FOR SIGNAL & IMAGE PROCESSING	3-0-0--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
EE607A	WAVELET TRANSFORMS FOR SIGNAL & IMAGE PROCESSING	3-0-0-0-9	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

EE608	DIGITAL VIDEO SIGNAL PROCESSING	3-0-0--4	Representation of digital video including modeling of video image formation, spatiatem poral sampling over lattices, conversion of signals sampled on different lattices and sampling rate conversion of video signals.Twodimensional Motion Estimation: 2D Motion vs Apparent Motion, occlusion/Aperture problems, 2D Motion field Models, optical flow methods; blockbased methods, pelrecursive methods and Bayesian methods.Video filtering: Motion compensated filtering, including spatiatem poral spectrum, filtering along motion trajectories; Nois.e filtering, Video Restoration, including Modeling, Intraframe shift invariant I variant restoration, multiframe restoration; Standards conversion including practical Up/Down conversion Methods.Video compression: Basic concepts and techniques of video coding, Interframe Compression Methods, Video Compression Standards (MPEG2, MPEG4, H.264) Low bit rate Video Codecs,Embedded Video Codecs, Scalable Video coding. **Course Reference**: 1. Image and Video Processing, A.I. Bovik, Elosovier Academic Press, 2005; 2. Digital Pictures A.N. Netravali, B.G. Haskell, Plenum Press, 1997; 3. Digital Video Transcoding; 4. H. Sun, X. Chen and T. Chiang, CRC Press 2005; 5. Digital Video Processing; A. Murat Tekalp, Prentice Hall Signal Processing Series, 1995. 6. Wireless Video Communications; L. Hanzo, P.J. Cherriman, J. Streit, IEEE Series on Digital and Mobile Communication, 2001 .
EE608A	DIGITAL VIDEO SIGNAL PROCESSING	3-0-0-0-9	Representation of digital video including modeling of video image formation, spatiatemporal sampling over lattices, conversion of signals sampled on different lattices and sampling rate conversion of video signals.Two dimensional Motion Estimation: 2D Motion vs Apparent Motion, occlusion/Aperture problems, 2D Motion field Models, optical flow methods; blockbased methods, pelrecursive methods and Bayesian methods.Video filtering: Motion compensated filtering, including spatiatemporal spectrum, filtering along motion trajectories; Nois.e filtering, Video Restoration, including Modeling, Intraframe shift invariant I variant restoration, multiframe restoration; Standards conversion including practical Up/Down conversion Methods.Video compression: Basic concepts and techniques of video coding, Interframe Compression Methods, Video Compression Standards (MPEG2, MPEG4, H.264) Low bit rate Video Codecs,Embedded Video Codecs, Scalable Video coding. **Course Reference**: 1. Image and Video Processing, A.I. Bovik, Elosovier Academic Press, 2005; 2. Digital Pictures A.N. Netravali, B.G. Haskell, Plenum Press, 1997; 3. Digital Video Transcoding; H. Sun, X. Chen and T. Chiang, CRC Press 2005; 4. Digital Video Processing A. Murat Tekalp, Prentice Hall Signal Processing Series, 1995; 5. Wireless Video Communications; L. Hanzo, P.J. Cherriman, J. Streit, IEEE Series onDigital and Mobile Communication, 2001.
EE609	CONVEX OPTIMIZATION IN SIGNAL PROCESSING AND COMMUNICATION		To be procured

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EE609A	CONVEX OPTIMIZATION IN SIGNAL PROCESSING AND COMMUNICATIONS		To be procured
EE610	ANALOG/DIGITAL VLSI CIRCUITS	3-0-0--4	Analog MOS circuits, opamps, 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.
EE610A	ANALOG/DIGITAL VLSI CIRCUITS	3-0-0-0-9	Analog MOS circuits, opamps, frequency and transient responses, stability and compensation. Analog switches, sample and hold circuits, switched capacitor circuits. MOS inverters and gate circuits, interfacing, transmission gates. MOSmemory 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.
EE611	ORGANIC ELECTRONICS	3-0-0--4	Lectures: General Overview of Organic Semiconductors and Electronics; Introduction to some of the basics of Molecular Quantum Mechanics; Optical and Electrical Properties of Organic Semiconductor Material; Organic Thin Film Transistor (OTFT) physics and processing; Organic Light Emitting Diode (OLED) physics and processing; OLED passive and active matrix displays, OTFT circuits; Organic Solar Cell physics and processing; Research opportunities in organic electronics and the associated technologies.Labs: Fabrication of an organic device and its characterisation The purpose of this course is (i) to give the student an introduction to the world of organic electronics and (ii) to help students appreciate practical organic electronic devices and th associated technologies. **Course Reference**: 1. This course was started for the first time by Prof. Baquer Mazhari who offered it as EE698A I Spring 2005 and 2006. It was offered as EE698W by Dr. S. Sundar Kumar Iyer in Spring 2007 Summer courses have also been offered on this topic in the summers of 2005, 2006 and 2007 the faculty members involved in Samtel Centre for Display Technology, IIT Kanpur
EE611A	ORGANIC ELECTRONICS	3-0-3-0-12	Lectures: General Overview of Organic Semiconductors and Electronics; Introduction to some of the basics of Molecular Quantum Mechanics; Optical and Electrical Properties of Organic Semiconductor Material; Organic Thin Film Transistor (OTFT) physics and processing; Organic Light Emitting Diode (OLED) physics and processing; OLED passive and active matrix displays, OTFT circuits; Organic Solar Cell physics and processing; Research opportunities in organic electronics and the associated technologies.Labs: Fabrication of an organic device and its characterisation The purpose of this course is (i) to give the student an introduction to the world of organi

			electronics and (ii) to help students appreciate practical organic electronic devices and th associated technologies. **Course Reference**: 1. This course was started for the first time by Prof. Baquer Mazhari who offered it as EE698A I Spring 2005 and 2006. It was offered as EE698W by Dr. S. Sundar Kumar Iyer in Spring 2007 Summer courses have also been offered on this topic in the summers of 2005, 2006 and 2007 the faculty members involved in Samtel Centre for Display Technology, IIT Kanpur
EE612	FIBER OPTIC SYSTEMS I	3-0-0--4	Review of semiconductor physics radiative recombination. LEDs, optical cavity, DH and other lasers. PIN 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.
EE612A	FIBER OPTIC SYSTEMS I	3-0-0-0-9	Review of semiconductor physics radiative recombination. LEDs, optical cavity, DH and other lasers. PIN and APD detectors, detector noise. Optical fibers ray and mode theories, multimode and singlemode fibers, attenuation, dispersion. Gaussian beams. Power coupling, splices and connectors.
EE614	SOLID STATE DEVICES I	3-0-0--4	Basic semiconductor physics. Diodes (PN junction, Schottky, contact), Junction Transistors (BJT, HBT), Field Effect Transistors (JEFT, MESFET, MOSFET, HEMT). Other, semiconductor devices.
EE614A	SOLID STATE DEVICES I	3-0-0-0-9	Basic semiconductor physics. Diodes (PN junction, Schottky, contact), JunctionTransistors (BJT, HBT), Field Effect Transistors (JEFT, MESFET, MOSFET, HEMT). Other, semiconductor devices.
EE615	HIGH FREQUENCY SEMICONDUCTOR DEVICES AND CIRCUITS	3-0-0--4	Review of Semiconductor properties Crystal structure of semiconductors, bandtheory, occupation statistics, electrical properties, optical properties, recombination kinetics, avalanche process in semiconductors, photon statistics; MESFETs;Transport in low dimensional structures: HEMTs: Hetrojunction BJTs; Design ofhigh frequency amplifiers and oscillators, Resonant tunneling structures, RTD oscillators; Intervalley scattering, Gunn diodes, IMPATT diodes; TRAPATTs; Mixerdiodes; Step recovery diodes; Introduction to epitaxial growth for these structures; elements of device fabrication.
EE616	SEMICONDUCTOR DEVICE MODELLING	3-0-0--4	Models for metal semiconductor contacts and heterojunctions. MOSFET quantum theory of 2DEG, gradual channel approximation, charge control models, BSIM model, secondorder effects. MESFET Shockley, velocity saturation anduniversal models. HEFT Basic and universal models. SPICE and small signal models.
EE616A	SEMICONDUCTOR DEVICE MODELLING	3-0-0-0-9	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.
EE617	INDUSTRIAL AUTOMATION AND CONTROL	3-0-0-0-9	Introduction to Industrial Automation and Control, Architecture of Industrial Automation Systems, Measurement Systems, Specifications, Temperature, Pressure, Force, Flow, pH,

			Humidity, Current, Voltage, Power, Frequency, Speed, Displacement (Linear and Angular) Instruments, Signal Conditioning Circuits, Data Acquisition System, Error and Calibration, Basics of Pattern Recognition and Knowledge Discovery. Monitoring, Automation and Control, Introduction to Process Control, PID Control, Controller Tuning, Implementation of PID Controllers, Special Control Structures (Feed Forward, Ratio Control, Predictive Control, Control of Systems with Inverse response, Cascade, Override and Split Range Control), Sequence and Logic Control, PLCs, CNC machines, Actuators (Control Valve, Hydraulic Actuator Systems, Industrial Hydraulic Circuits, Pneumatic Control Components and Pneumatic Control Systems), Electrical Machine Drives, Electrical Actuators, Introduction to Real Time Embedded Systems, Real-Time Operating Systems. Smartphones for Automation and Control. Impact of wireless Internet and broadband access on distributed control systems and new SCADA/DCS architectures, Use of animation and other advanced techniques for operator interface and predictive control, real time IF and THEN analysis
EE617A	INDUSTRIAL AUTOMATION AND CONTROL	3-0-0-0-9	Introduction to Industrial Automation and Control, Architecture of Industrial Automation Systems, Measurement Systems, Specifications, Temperature, Pressure, Force, Flow, pH, Humidity, Current, Voltage, Power, Frequency, Speed, Displacement (Linear and Angular) Instruments, Signal Conditioning Circuits, Data Acquisition System, Error and Calibration, Basics of Pattern Recognition and Knowledge Discovery. Monitoring, Automation and Control, Introduction to Process Control, PID Control, Controller Tuning, Implementation of PID Controllers, Special Control Structures (Feed Forward, Ratio Control, Predictive Control, Control of Systems with Inverse response, Cascade, Override and Split Range Control), Sequence and Logic Control, PLCs, CNC machines, Actuators (Control Valve, Hydraulic Actuator Systems, Industrial Hydraulic Circuits, Pneumatic Control Components and Pneumatic Control Systems), Electrical Machine Drives, Electrical Actuators, Introduction to Real Time Embedded Systems, Real-Time Operating Systems. Smartphones for Automation and Control. Impact of wireless Internet and broadband access on distributed control systems and new SCADA/DCS architectures, Use of animation and other advanced techniques for operator interface and predictive control, real time IF and THEN analysis
EE618	INTEGRATED CIRCUIT FABRICATION TECHNOLOGY	3-0-0--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.
EE618A	INTEGRATED CIRCUIT FABRICATION TECHNOLOGY	3-0-0-0-9	IC components their characterization and design. Anaysis and design of basic logic circuits. Linear ICs. Large Scale Integration. Computer simulation of ICsand layout design. High Voltage ICs. GaAs MESFET and GaAs ICs. Failure, reliability and yield of ICs. Fault modeling and testing.

EE619	VLSI SYSTEM DESIGN	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.
EE619A	VLSI SYSTEM DESIGN	3-0-0-0-9	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.
EE620	OPTICAL COHERENT IMAGING	3-0-0-0-9	Introduction to Fourier transforms, linear and spatially invariant systems, transfer function, fundamentals of light wave propagation, coherence theory, spatial and temporal field correlations, Abbe's imaging theory, point spread function, resolution, optical phase contrast, phase retrieval methods using phase-shifting and integral transforms, phase unwrapping, coherent imaging techniques, such as holography, speckle interferometry and shearography, and their applications
EE620A	OPTICAL COHERENT IMAGING	3-0-0-0-9	Introduction to Fourier transforms, linear and spatially invariant systems, transfer function, fundamentals of light wave propagation, coherence theory, spatial and temporal field correlations, Abbe's imaging theory, point spread function, resolution, optical phase contrast, phase retrieval methods using phase-shifting and integral transforms, phase unwrapping, coherent imaging techniques, such as holography, speckle interferometry and shearography, and their applications
EE621	REPRESENTATIO N AND ANALYSIS OF RANDOM SIGNALS	3-0-0--4	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. KLand sampling theorem representations, matched filter, ambiguity functions, Markov sequences, linear stochastic dynamical systems.
EE621A	REPRESENTATIO N AND ANALYSIS OF RANDOM SIGNALS	3-0-0-0-9	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. KLand sampling theorem representations, matched filter, ambiguity functions, Markov sequences, linear stochastic dynamical systems.
EE622	COMMUNICATION THEORY	3-0-0--4	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.
EE622A	COMMUNICATION THEORY	3-0-0-0-9	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.
EE623	DETECTION & ESTIMATION THEORY	3-0-0--4	Classical Detection and Estimation Theory, Signal Representation, Detection ofsignals in Gaussian noise, Waveform estimation, Linear estimation problems, Wiener filtering, Kalman filtering.
EE623A	DETECTION & ESTIMATION THEORY	3-0-0-0-9	Classical Detection and Estimation Theory, Signal Representation, Detection of signals in Gaussian noise, Waveform estimation, Linear estimation problems, Wiener filtering, Kalman filtering.
EE624	INFORMATION AND CODING THEORY	3-0-0--4	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.
EE624A	INFORMATION AND CODING THEORY	3-0-0-0-9	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.
EE626	TOPICS IN STOCHASTIC PROCESSES	3-0-0--4	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.
EE626A	TOPICS IN STOCHASTIC PROCESSES	3-0-0-0-9	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.
EE627	SPEECH SIGNAL PROCESSING	3-0-0-0-4	Spectral and nonspectral 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.
EE627A	SPEECH SIGNAL PROCESSING	3-0-0-0-9	Spectral and nonspectral 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.
EE628	TOPICS IN CRYPTOGRAPHY AND CODING	3-0-0--4	Cryptography and error control coding in communication and computing systems. Stream and block ciphers; DES; publickey cryptosystems; key management, authentication and digital signatures. Codes as ideals in finite commutative rings and group algebras. Joint coding and cryptography.
EE628A	TOPICS IN		To be procured

	CRYPTOGRAPHY AND CODING		
EE629	DIGITAL SWITCHING	3-0-0--4	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.
EE629A	DIGITAL SWITCHING	3-0-0-0-9	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.
EE630	SIMULATON OF MODERN POWER SYSTEMS	3-0-3-0-5	Modern power systems operation and control, Power system deregulation; static and dynamic modeling; Load flow and stability studies; Electromagnetic phenomenon; Insulation and partial discharge.
EE630A	SIMULATON OF MODERN POWER SYSTEMS	3-0-3-0-12	Modern power systems operation and control, Power system deregulation; static and dynamic modeling; Load flow and stability studies; Electromagnetic phenomenon; Insulation and partial discharge.
EE631	ADVANCED POWER SYSTEM STABILITY	3-0-0--4	Detailed machine modeling, Modeling of turbine generator and associated systems, excitation systems and PSS, Transient stability and small signal stabilityfor large systems, SSR and system modeling for SSR studies, Voltage stability: PV and QV curves, static analysis, sensitivity and continuation method; Dynamic analysis, local and global bifurcations, Control area, Margin prediction, Stability of ACDC systems.
EE631A	ADVANCED POWER SYSTEM STABILITY	3-0-0-0-9	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: PV and QV curves, static analysis, sensitivity and continuation method; Dynamic analysis, local and global bifurcations, Control area, Margin prediction, Stability of ACDC systems.
EE632	ECONOMIC OPERATION & CONTROL OF POWER SYSTEMS	3-0-0--4	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.
EE632A	ECONOMIC OPERATION & CONTROL OF POWER SYSTEMS	3-0-0-0-9	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.
EE633	ELECTRIC POWER SYSTEM OPERATION AND MGMT. UNDER RESTRUCTURED ENVIRONMENT	3-0-0--4	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 andcontrol: Old vs New, Available Transfer Capability,

			Congestion management, Ancillary services; Wheeling charges and pricing: Wheeling methodologies, pricing strategies.
EE633A	ELECTRIC POWER SYSTEM OPERATION AND MGMT. UNDER RESTRUCTURED ENVIRONMENT	3-0-0-0-9	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, Microeconomic Basics for Power Systems
EE634	ELECTRICAL INSULATION IN POWER APPARATUS AND SYSTEMS	3-0-0--4	Properties of dielectrics and breakdown mechanisms; composites and novelmaterials; 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 andpulsed. Testing and Evaluation: Procedures and standards, ageing studies. On line and off-line condition monitoring of substation equipment. Advances in measurement and diagnostic technologies: partial discharge monitoring, space charge charge measurements, dielectric spectroscopy etc. Lab demonstrations.
EE634A	ELECTRICAL INSULATION IN POWER APPARATUS AND SYSTEMS	3-0-0-0-9	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 andpulsed. Testing and Evaluation: Procedures and standards, ageing studies. On line and off-line condition monitoring of substation equipment. Advances in measurement and diagnostic technologies: partial discharge monitoring, space charge charge measurements, dielectric spectroscopy, etc. Lab demonstrations.
EE635	HVDC TRANSMISSION & FLEXIBLE A C TRANSMISSION SYSTEMS	3-0-0--4	General aspects of DC transmission, converter circuits and their analysis, DClink controls, faults and abnormal operation and protection; Mechanism of activeand 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.
EE635A	HVDC TRANSMISSION & FLEXIBLE A C TRANSMISSION SYSTEMS	3-0-0-0-9	General aspects of DC transmission, converter circuits and their analysis, DClink controls, faults and abnormal operation and protection; Mechanism of activeand 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.
EE636	ADVANCED PROTECTIVE	3-0-0-0-9	Advanced protective relaying, basic protection schemes, relay terminology, relays as comparators, static relays, application of

	RELAYING		solid-state devices, differential relaying systems, distance relaying schemes, protection of multiterminal lines, new types of relaying criteria, special problems, digital protection, Protection – transformer, busbar, transmission line, generator, motor; Static relays; Numeric relays; Challenges and differences in AC and DC grid protection
EE636A	ADVANCED PROTECTIVE RELAYING	3-0-0-0-9	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, Protection – transformer, busbar, transmission line, generator, motor; Static relays; Numeric relays; Challenges and differences in AC and DC grid protection
EE637A	SYNCHROPHASOR TECHNOLOGY AND ITS APPLICATIONS		To be procured
EE638A	ADVANCED RF ANTENNAS	3-0-0-0-9	Revision of fundamental parameters: antenna gain, directivity, radiation patterns, beamwidth, efficiency, input impedance, antenna aperture, Friis transmission equations etc; Circularly Polarized Wire Antennas: uniform plane wave, RHCP and LHCP waves, radiation pattern of crossed dipole (turnstile) antenna, single-element and two-element turnstile antennas; measurement of axial ratio, gain and co & cross-polar radiation pattern of CP antenna, printed CP antenna, corporate feed for antenna array, sequentially rotated feed for broadband CP antenna; CP antenna using electric and magnetic currents; Metamaterial Antennas: Introduction to metamaterials, concept of negative permittivity and permeability, negative phase constant, left handed transmission line, composite right left handed (CRLH) transmission line, zeroth order resonance (ZOR) antenna, size reduction of printed antenna using ZOR, loading of metamaterial unit cells for single and multi-band applications, metamaterial inspired antennas for performance improvement of printed antennas; MIMO Antennas: Basics of MIMO Antennas, Channel matrix and channel capacity for multiple-input multiple-output (MIMO) system; Effect of correlation matrices at transmitter and receiver ends, Polarization and Pattern diversity; MIMO antenna performance parameters like Envelope Correlation Coefficient (ECC), Channel Capacity Loss (CCL), Total Active Reflection Coefficient (TARC), Mean Effective Gain (MEG); Examples of printed MIMO Antennas; Base Station Antennas: Basics of cellular networks, operating frequencies, concept of cell, frequency reuse, cell sectoring; dipole antenna with reflector for sectorial pattern; dual-polarized antennas; beam tilt, electronic and mechanical tilt, pattern synthesis for nulls, etc.; Antennas for Modern Communication Systems: Printed Inverted F Antenna (PIFA), Mobile antenna, Wi-Fi Router Antenna, WLAN antenna, Laptop antenna, Blue-tooth antenna, antenna for GPS application etc
EE639	NONLINEAR FIBER OPTICS	3-0-0-0-4	1. Introduction: Linear vs Nonlinear effects in optical fiber, Important nonlinear effects and their impact on optical

			communication, applications of optical nonlinearities to signal processing; 2. Electromagnetic wave propagation in fibers: Wave equation for linear media, phase and group velocities, reflection and transmission of waves, structure of an optical fiber, wave equation in cylindrical coordinates, fiber modes, characteristics of LPm mode; 3. Dispersion in optical fibers: Chromatic dispersion in single mode fibers, effect on pulse propagation, dispersion management and compensation, polarization mode dispersion first and second order models, effect on communication system , mitigation of PMD; 4. FourWave mixing (FWM): Mathematical description, phase matching, fiber parametric am plifiers using FWM, squeezed state and entangled photon pair generation using FWM , impact on communication system; 5. Nonlinear phase modulation: SelfPhase modulation, impact on communication system, modulation instability, Cross Phase modulation, impact on communication system; 6. Nonlinear Schrodinger equation (NLSE): Nonlinear polarization, nonlinear refractive in dex, derivation of NLSE, effect of dispersion only, effect of nonlinearity only, soliton solutions,numerical .solution of the NLSE.
EE639A	NONLINEAR FIBER OPTICS		To be procured
EE640	COMPUTATIONAL ELECTROMAGNE TICS	3-0-0-0-4	Review of complex variables, conformal mappings, matrix calculus; Sturm Liouville equation; Eigenvalue problem; Guiding structures; Scattering media; Greens function approach; Variational formulation, FEM, Generalised scattering matrix and planar circuit approach.
EE640A	COMPUTATIONAL ELECTROMAGNE TICS	3-0-0-0-9	Review of complex variables, conformal mappings, matrix calculus; SturmLiouville equation; Eigenvalue problem; Guiding structures; Scattering media; Greens function approach; Variational formulation, FEM, Generalised scattering matrix and planar circuit approach.
EE641	ADVANCED ENGINEERING ELECTROMAGNE TICS	3-0-0--4	Transmission line theory; Greens 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.
EE641A	ADVANCED ENGINEERING ELECTROMAGNE TICS	3-0-0-0-9	Transmission line theory; Greens 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.
EE642	ANTENNAS ANALYSIS & SYNTHESIS	3-0-0--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.
EE642A	ANTENNAS ANALYSIS & SYNTHESIS	3-0-0-0-9	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.

EE643	SMART ANTENNAS FOR MOBILE COMMUNICATION	3-0-0--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.
EE643A	SMART ANTENNAS FOR MOBILE COMMUNICATION	3-0-0-0-9	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 angleand delay estimation. Smart antenna array configurations. Mobile communication systems with smart antennas.
EE644	DISCOUNTINUED		To be procured
EE644A	ELECTROMAGNE TIC INTERFERENCE AND COMPATIBILITY TECHNIQUES	3-0-0-0-9	Introduction to electromagnetic compatibility (EMC): basic aspects of EMC design, significance of electrical dimensions for EMC applications, common EMC units; EMC requirements for electronic systems: standards for EMI/EMC in various geographical regions, basic requirements and test procedures required for compliance with the limits imposed by various agencies and organizations, brief introduction of test parameters such as radiated and conducted emissions, susceptibility, electrostatic discharge etc., EMC design applications, significance of the effects of spectral contents of a signal; Modeling and the effects of non-ideal behavior of various circuits and components: wires, PCB lands, component leads, resistors, capacitors, inductors, ferrites, electromechanical devices, digital circuit devices, mechanical switches, radiated emission and susceptibility models for wires and PCB lands; Power supplies: conducted emissions, the line impedance stabilization network (LISN), filters, linear and switched-mode power supplies; Antennas and testing procedures: a brief overview of antennas relevant for EMC applications, near and far field analysis, RF emission and RF immunity measurements, applications of spectrum analyzer for EMC measurements, sources of uncertainty in measurements; Crosstalk: three conductor lines, inductive and capacitive coupling, shielded wires, twisted wires, multi-conductor transmission lines; Shielding: basic concept and definition, effectiveness of shielding, near field and far field effects, electric and magnetic field sources; Frequency selective surfaces (FSS): basic theory, periodic surfaces and arrays, applications of periodic structures, FSS based shielding structures; System design for EMC: electrostatic discharge event, grounding, basic diagnostic tools, PCB design, System configuration
EE645	MONOLITHIC MICROWAVE ICS	3-0-0--4	Scattering parameters of nports, Conductor and dielectric losses in planar transmission lines, coupled lines, multiconductor lines, discontinuities, GaAsMESFET fabrication devices, High electron mobility transistor, Heterojunction bipolar transistor fabrication and modeling, NMIC technology and design.
EE645A	MONOLITHIC MICROWAVE ICS	3-0-0-0-9	Scattering parameters of nports, Conductor and dielectric losses in planar transmission lines, coupled lines, multiconductor lines, discontinuities, GaAsMESFET fabrication devices, High electron mobility transistor, Hetero junction bipolar transistor fabrication

			and modeling, NMIC technology and design.
EE646	PHOTONIC NETWORKS & SWITCHING	3-0-0--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, T opologies, Single channel networks, Multichannel networks, FTFR, FTTR, TTFRand TTTR, Single hop networks, Multihop networks, Multiaccess protocols forWDM networks, Switched optical networks. Optical amplification in alloptical networks. Alloptical subscriber access networks. Design issues. Optical switching: Motivation, Spatial light modulator, Relational and nonrelational switching devices, Fundamental limits on optical switching elements, Switching architectures, Freespace optical switching. Wavelength routed networks and other special topics. Soliton based networks, Optical networks management issues.
EE646A	PHOTONIC NETWORKS & SWITCHING	3-0-0-0-9	Optical communications: Introduction to basic optical communications anddevices. Optical multiplexing techniques Wavelength division multiplexing, Optical frequency division multiplexing, time division multiplexing, code divisionmultiplexing. Optical Networks: Conventional optical networks, SONET / SDH, FDDI, IEEE 802.3, DQDB, FCS, HIPPI etc. Multiple access optical networks, T opologies, Single channel networks, Multichannel networks, FTFR, FTTR, TTFRand TTTR, Single hop networks, Multihop networks, Multiaccess protocols for WDM networks, Switched optical networks. Optical amplification in all optical networks. Alloptical subscriber access networks. Design issues. Optical switching: Motivation, Spatial light modulator, Relational and nonrelational switching devices, Fundamental limits on optical switching elements, Switching architectures, Freespace optical switching. Wavelength routed networks and other specialtopics. Soliton based networks, Optical networks management issues.
EE647	MICROWAVE MEASUREMENTS AND DESIGN	2-0-3-0-4	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.
EE647A	MICROWAVE MEASUREMENTS AND DESIGN	2-0-3-0-9	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.
EE648	MICROWAVE CIRCUITS	3-0-0--4	Transmission lines for microwave circuits; waveguides, stripline, microstrip, slotline; microwave circuit design principles; passive circuits; impedance transformers, filters, hybrids, isolators etc., active circuits using semiconductor devices andtubes, detection and measurement of microwave signals.
EE648A	MICROWAVE CIRCUITS	3-0-0-0-9	Transmission lines for microwave circuits; waveguides, stripline, microstrip, slotline; 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.
EE649	THE FINITE ELEMENT METHOD FOR ELECTRIC AND MAGNETIC FIELDS	3-0-0-0-4	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 Magnets, scalar and vector potentials; Electromagnetic fields. eddy current problems, modeling of moving parts; modeling ofelectrical circuits.
EE649A	THE FINITE ELEMENT METHOD FOR ELECTRIC AND MAGNETIC FIELDS	3-0-3-0-12	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 Magnets, scalar and vector potentials; Electromagnetic fields. eddy current problems, modeling of moving parts; modeling of electrical circuits.
EE650	BASICS OF MODERN CONTROL SYSTEMS	3-0-0--4	Vector spaces, Linear systems, similarity transformations, Canonical forms, Controllability, Observability, Realisability etc. Minimal realization, Digital systems, Nonlinear systems, Phaseplane analysis, Poincare theorems, Lyapunov theorem, Circle and Popov criterion; Robust control, Linear Quadratic Regulator (LQR), Linear Quadratic Gaussian (LQG) control, Loop Transfer Recovery (LTR), Hinfinitycontrol.
EE650A	BASICS OF MODERN CONTROL SYSTEMS	3-0-0-0-9	Vector spaces, Linear systems, similarity transformations, Canonical forms, Controllability, Observability, Realisability etc. Minimal realization, Digital systems, Nonlinear systems, Phaseplane analysis, Poincare theorems, Lyapunov theorem, Circle and Popov criterion; Robust control, Linear Quadratic Regulator (LQR), Linear Quadratic Gaussian (LQG) control, Loop Transfer Recovery (LTR), Hinfinity control.
EE651A	NONLINEAR SYSTEMS	3-0-0-0-9	Nonlinearity in the system, Nonlinearity induced dynamical beh Existence and Uniqueness, Sensitivity to Parameter and Initial Con Local Linearization: Perturbation, Local Linearization: Describing Fu Global Linearization: Feedback, Global Linearization: Carleman, plane Analysis and Nullclines, Poincare Map, Poincare-Bendixson T and higher versions, Bifurcations, Different notions of stabili significance, Lyapunov theory and applications for stability, Inv theorem, Barbalat’s lemma, Contraction theory and Incremental S Convergent Dynamics, Passivity-based analysis, Periodic syster Lyapunov exponents, Multistability, Scale-invariance
EE652A	PROBABILISTIC MOBILE ROBOTICS		To be procured
EE653	DIGITAL CONTROL	3-0-0-0-4	Discretetime signals and systems, Ztransform, pulse transfer functions. Compensator design by root locus, error coefficients and frequency response. Statespace models of discrete time systems, controllability, observability, stability, state estimation,

			Kalman filtering. Linear regulation. Parameter estimation.
EE653A	DIGITAL CONTROL	3-0-0-0-9	Discrete time signals and systems, Ztransform, pulse transfer functions. Compensator design by root locus, error coefficients and frequency response. Statespace models of discrete time systems, controllability, observability, stability, state estimation, Kalman filtering. Linear regulation. Parameter estimation.
EE654	ROBUST CONTROL SYSTEMS	3-0-0--4	Linear Quadratic Regulators: return ratio & difference, sensitivity function. Kalmans optimality condition. Gain/phase margins, robustness to time delayand nonlinearity. Characterization of sensitivity. Kharitonov theorem robustness. Singular values properties, application in stability, robustness and sensitivity. Robustness of discrete time LQR systems.
EE654A	ROBUST CONTROL SYSTEMS	3-0-0-0-9	Linear Quadratic Regulators: return ratio & difference, sensitivity function. Kalmans 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.
EE656A	ARTIFICIAL INTELLIGENCE, MACHINE LEARNING, DEEP LEARNING & ITS APPLICATIONS	3-0-0-0-9	Artificial Intelligence (AI): Introduction, History, and Evolution, Ag Artificial Intelligence, Introduction to Fuzzy System (FS), Artificial Network (ANN), Evolutionary Computing (EC), Genetic Algorithm Simulated Annealing (SA), Particle Swarm Algorithm (PSO), etc., M Learning: Unsupervised Learning, Supervised Learning, Semi sup Learning, Reinforcement Learning, Clustering and Biclustering: K- Fuzzy c-means (FCM), Self-organizing maps (SOM), and other Clu Algorithms, Classification: Support Vector Machines (SVM), K N Neighbour (KNN), ANN, Fuzzy Rule Based, and other Classifiers fitting, Regression models, Prediction/Forecasting: ANN and Fuzz Based Regression Models, Performance Measures for Clu Biclustering, Classification, and Regression Algorithms, Deep Learn Transfer Learning: Deep Neural Networks (DNN), Fuzzy Neural Ne (FNN), etc., Case studies in the areas of signal processing, co vision, intelligent control, transportation, prognosis and management, bioinformatics, etc.
EE658	FUZZY SET, LOGIC & SYSTEMS & APPLICATIONS	3-0-0--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 back ground of Fuzzy Systems, Classical (Crisp) vs, Fuzzy sets, Representation of Fuzzy sets, Typesof Membership Functions, Basic Concepts (support, singleton, height, acut projections), Fuzzy set operations, Sand 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 IFTHEN 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).
EE658A	FUZZY SET, LOGIC & SYSTEMS & APPLICATIONS	3-0-0-0-9	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 back ground of Fuzzy Systems, Classical (Crisp) vs, Fuzzy sets, Representation of Fuzzy sets, Typesof Membership Functions, Basic Concepts (support, singleton, height, acut projections), Fuzzy set operations, Sand 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 IFTHEN 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. FuzzyEvents, Fuzzy Measures, Possibility Distributions as Fuzzy Sets, Possibility vs, Probability, Fuzzy Systems as Universal Approximators, Additive Fuzzy Systems (standard additive model).
EE659	COMPUTATIONAL ASPECTS OF TOMOGRAPHIC IMAGING : MODELS TO INVERSIONS	3-0-0-0-4	1. Motivations and overview of of tomography, limited data settings, approximate tomography, multimodal tomography; 2. Typical Models : Maxwells equations, Helmholtz equation, eikonal equation,radiative transfer equation and its diffusion approximation; 3. Brief review of numerical solutions to the above models: finite element schemes and the method of moments (boundary element method); 4. Linear tomography: Straight path tomography, Born and Rytov approximations in diffraction tomography, algebraic reconstruction techniques; 5. Regularized linear and nonlinear least squares solutions; 6. Frechet derivative calculations, method of adjoints; 7. Approximate tomography: Shape based tomography and topological derivatives; 8. Introduction to stochastic reconstruction schemes, maximum likelihood and Bayesian methods, posterior sampling; 9. Applications: Diffuse optical tomography, electrical impedance tomography,refraction tomography, electromagnetic wave tomography, elastography,multimodal tomography.
EE659A	COMPUTATIONAL ASPECTS OF TOMOGRAPHIC IMAGING : MODELS TO INVERSIONS	3-0-0-0-9	1. Motivations and overview of of tomography, limited data settings, approximate tomography, multimodal tomography; 2. Typical Models : Maxwells equations, Helmholtz equation, eikonal equation,radiative transfer equation and its diffusion approximation; 3. Brief review of numerical solutions to the above models: finite element schemesand the method of moments (boundary element method); 4. Linear tomography: Straight path tomography, Born and Rytov approximations in diffraction tomography, algebraic reconstruction techniques; 5.

			Regularized linear and nonlinear least squares solutions; 6. Frechet derivative calculations , method of adjoints; 7. Approximate tomography: Shape based tomography and topological derivatives; 8. Introduction to stochastic reconstruction schemes, maximum likelihood and Bayesian methods, posterior sampling; 9. Applications: Diffuse optical tomography, electrical impedance tomography,refraction tomography, electromagnetic wave tomography, elastography, multimodal tomography.
EE660	BASICS OF POWER ELECTRONIC CONVERTERS	3-0-3--5	Power semiconductor devices, BJT, MOSFET, IGBT, GTO and MCT: ACDC Converters; Forced communication; synchronous link converters, DCAC converters, buck, boost, buckboost, cuk, flyback configuration, resonant converters, PWM inverters; active filters.
EE660A	BASICS OF POWER ELECTRONIC CONVERTERS	3-0-3-0-12	Power semiconductor devices, BJT, MOSFET, IGBT, GTO and MCT: ACDC Converters; Forced communication; synchronous link converters, DCAC converters, buck, boost, buckboost, cuk, flyback configuration, resonant converters, PWM inverters; active filters.
EE661	POWER ELECTRONICS APPLICATIONS IN POWER SYSTEMS	3-0-0--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 Inter line power flow controller, Power quality conditioners, Power electronics in power generation.
EE661A	POWER ELECTRONICS APPLICATIONS IN POWER SYSTEMS	3-0-0-0-9	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.
EE662	CONTROL TECHNIQUES IN POWER ELECTRONICS	3-0-0--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.
EE662A	CONTROL TECHNIQUES IN POWER ELECTRONICS	3-0-0-0-9	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.
EE663	POWER ELECTRONICS IN SOLAR PHOTOVOLTAIC SYSTEMS		To be procured
EE663A	POWER ELECTRONICS IN SOLAR PHOTOVOLTAIC SYSTEMS		To be procured
EE664	FUNDAMENTALS	3-0-0--4	Motor load dynamics, starting, braking & speed control of dc and

	OF ELECTRIC DRIVES		ac motors. DC drives: converter and chopper control. AC Drives: Operation of inductionand synchronous motors from voltage and current inverters, slip power recovery, pump drives using ac line controller and self-controlled synchronous motor drives.
EE664A	FUNDAMENTALS OF ELECTRIC DRIVES	3-0-0-0-9	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.
EE665	ADVANCED ELECTRIC DRIVES	3-0-0--4	Closed loop control of solidstate 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.
EE665A	ADVANCED ELECTRIC DRIVES	3-0-0-0-9	Closed loop control of solidstate 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.
EE666	SPECIAL TOPICS IN POWER ELECTRONICS	3-0-0-0-4	PWM inverters, Multilevel inverters, Neutral point -controlled inverters, Softswitching converters: DC-DC resonant link inverters, Hybrid resonant link inverters, Quasi resonant link converters, Switched mode rectifiers, Synchronous link converters.
EE666A	SPECIAL TOPICS IN POWER ELECTRONICS	3-0-0-0-9	PWM inverters, Multilevel inverters, Neutral point -controlled inverters, Softswitching converters: DCDC resonant link inverters, Hybrid resonant link inverters, Quasi resonant link converters, Switched mode rectifiers, Synchronous link converters.
EE667	INFORMATION THEORY	3-0-0-0-4	Introduction: Entropy, Relative Entropy, Mutual Information Inequalities, Entropy rate. Ansymptotic Equipartition Property (AEP): Consequences of the AEP, Typical Sequences, Shannon McMillan Breiman Theorem. Data Compression: Block to variable lenght codes, Shannon Fano code, Huffman code, variable to fixed lenght coding Tunstal code, variable to variable length codes/ arithmetic code. Channel capacity: Discrete Memoryless Channel, Joint Typicality, Channel Coding Theorem and its converse, Feedback capacity, Source Channel Separation Theorem. Differential Entropy: Difinition, Properties. Gaussian Channel: Definition, Parallel Gaussian Channels, Channels with Colored Gaussian Noise, Gaussian Channels with Feedback. Rate Distortion Theory: Rate Distortion Function, Rate Distortion theorem and its converse, Blahut Arimoto Algorithm. Universal Source Coding: Universal codes, LempelZiv codes; LZ 78, LZW, Slinding Window Lempel Ziv algorithm (LZ77). Network Information Theory: Gaussian MultiUser Channels, Multiple Access Channel, Broadcast Channel, Encoding of Correlated Sources. **Course Reference**: 1. Thomas M. Cover, Joy A. Thomas; Elements of Information Theory, 2nd Edition , John Wiley & Sons, 2006; 2. James L. Massey, Lecture notes on Applied

			Digital Information Theory; 3. Robert G. Gallager, Information Theory and Reliable Communication, John Wiley & Sons, 1968; 4. David J.C. MacKay, Information Theory, Inference, and Learning Algorithms,Cambridge University Press; 5. Robert Ash, Information Theory;, Dover Publications, 1965; 6. Raymond W. Yeung,Information Theory and Network Coding, Springer, 2006; 7. Abbas El Gamal and YoungHan Kim, Network Information Theory, Cambridge University Press, 2012; 8. I. Csiszar and J. Korner,Information Theory: Coding Theorems for Discrete Memoryless Systems, 2nd edition, Cambridge Univ. Press; 9. Papers from IEEE Transactions on Information Theory.
EE667A	INFORMATION THEORY	3-0-0-0-9	Introduction: Entropy, Relative Entropy, Mutual Information Inequalities, Entropy rate. Ansymptotic Equipartition Property (AEP): Consequences of the AEP, Typical Sequences, Shannon McMillanBreiman Theorem. Data Compression: Block to variable lenght codes, ShannonFano code, Huffman code, variable to fixed lenght coding Tunstal code, variable to variable length codes/ arithmetic code. Channel capacity: Discrete Memoryless Channel, Joint Typicality, Channel Coding Theorem and its converse, Feedback capacity, Source Channel Separation Theorem. Differential Entropy: Difinition, Properties. Gaussian Channel: Definition, Parallel Gaussian Channels, Channels with Colored Gaussian Noise, Gaussian Channels with Feedback. Rate Distortion Theory: Rate Distortion Function, Rate Distortion theorem and its converse, BlahutArimoto Algorithm. Universal Source Coding: Universal codes, LempelZiv codes; LZ 78, LZW, Slinding Window Lempel Ziv algorithm (LZ77). Network Information Theory: Gaussian MultiUser Channels, Multiple Access Channel, Broadeast Channel, Encoding of Correlated Sources. **Course Reference:** 1. Thomas M. Cover, Joy A. Thomas, Elements of Information Theory, 2nd Edition , John Wiley & Sons, 2006; 2. James L. Massey, Lecture notes on, Applied Digital Information Theory; 3. Robert G. Gallager, Information Theory and Reliable Communications, John Wiley & Sons, 1968; 4. David J.C. MacKay, Information Theory, Inference, and Learning Algorithms, Cambridge University Press; 5. Robert Ash, Information Theory,Dover Publications, 1965; 6. Raymond W. Yeung, Information Theory and Network Coding, Springer, 2006; 7. Abbas El Gamal and YoungHan Kim, Network Information Theory.Cambridge University Press, 2012; 8. I. Csiszar and J. Korner, ;Information Theory: Coding Theorems for Discrete Memoryless Systems 2nd edition, Cambridge Univ. Press; 9. Papers from IEEE Transactions on Information Theory.
EE668	CODING THEORY	3-0-0-0-9	1.Introduction: Types of codes, channel models, maximum likelihood decoding, Shannon's noisy channel coding theorem, FEC, ARQ, HARQ; 2. Linear Blaock Codes: Generator matrix, parity check matrix, syndrome, error detection, error correction, minimum distance of the code, dual code, weight enumeration and Mac Williams theorem. Examples of simple linear block codes; 3. Some linear block codes: Construction, properties and decoding of some popular block codes; Hamming codes, Reed Muller codes; 4. Bonds on codes: Hamming bound, Plotkin bound, Singleton Bound, Elias Bound, GilbertVarshmov Bound,

			Linear programming bounds; 5. New codes from old codes: Extending a code, puncturing a code, expunging a code, augmenting a code, shortening a code, direct sum construction. **Course Reference**: 1. Shu Lin and Daniel J. Costello, Jr; Error Control Coding, second ed., Prentice Hall, 2004; 2. F.J. Mac Williams, N.J.A. Sloance;The Theory of Error Correcting Codes, NorthHolland, Amsterdam, 1977; 3. R.E. Blahut, Algebraic Codes for Data Transmission, 1st Ed., Cambridge Univ. Press 2003; 4. Todd K. Moon, Error Correction Coding, 1st Ed., WileyInter science, 2006; 5. Cary W. Huffman, Vera Pless; Fundamentals of ErrorCorrecting Codes,1st Edi. Cambridge Univ. Press, 2003; 6. Ezio Biglieri; Coding for Wireless Channels, Springer, 2005; 7. Tom Richardson and Rudiger Urbanke; Modern Coding Theory, Cambridge Univ. Press, 2008; 23.09.14
EE668A	CODING THEORY	3-0-0-0-9	1.Introduction: Types of codes, channel models, maximum likelihood decoding, Shannon's noisy channel coding theorem, FEC, ARQ, HARQ; 2. Linear Blaock Codes: Generator matrix, parity check matrix, syndrome, error detection, error correction, minimum distance of the code, dual code, weight enumeration and Mac Williams theorem. Examples of simple linear block codes; 3. Some linear block codes: Construction, properties and decoding of some popular block codes; Hamming codes, Reed Muller codes; 4. Bonds on codes: Hamming bound, Plotkin bound, Singleton Bound, Elias Bound, GilbertVarshmov Bound, Linear programming bounds; 5. New codes from old codes: Extending a code, puncturing a code, expunging a code, augmenting a code, shortening a code, direct sum construction. **Course Reference:** 1. Shu Lin and Daniel J. Costello, Jr, Error Control Coding, second ed., Prentice Hall, 2004; 2. F.J. Mac Williams, N.J.A. Sloance; The Theory of Error Correcting Codes, North Holland, Amsterdam, 1977; 3. R.E. Blahut, Algebraic Codes for Data Transmission,1st Ed., Cambridge Univ. Press 2003; 4. Todd K. Moon; Error Correction Coding, 1st Ed., WileyInter science, 2006; 5. Cary W. Huffman, Vera Pless; Fundamentals of ErrorCorrecting Codes, 1st Edi. Cambridge Univ. Press, 2003; 6. Ezio Biglieri, Coding for Wireless Channels, Springer, 2005; 7. Tom Richardson and Rudiger Urbanke Modern Coding Theory, Cambridge Univ. Press, 2008; 23.09.14
EE669	SIMULATION OF COMMUNICATION SYSTEMS	3-0-0-0-9	Introduction to simulation. Discrete time signals and systems. Modeling linear time invariant system. Modeling linear time varying system. Modeling memoryless nonlinear systems. Modeling nonlinear system with memory. Nonlinear differential equation models. Review of probability and randon processes. Monte Carlo simulation and randon number generation. Testing of random number generators. Modeling of functional blocks in communication systems. Wireless fading channel models. Discrete Markov fading channel models. Estimation of parameters in simulation. Estimation of performance measures from simulation. Importance sampling. Other performance estimation methods. Variance reduction techniques. Simulation optimization. Case Study. **Course Reference:** 1. P. Balaban, K.S. Shanmugan, and B.W. Stuck, eds., ComputerAided Modeling, Analysis, and Design of

			Communication Systems, vol. 6, IEEE Journal on Selected Areas in Communications, Jan. 1984; 2. P. Balaban, E. Biglieri, M.C. Jeruchim, H.T. Mouftah, C.H. Sauer, and K.S. Shanmugan, eds., ComputerAided Modeling, Analysis, and Design of Communication Systems II, vol. 6, IEEE Journal on Selected Areas in Communications, Jan. 1988; 3. J.K. Townsend, A.F. Elrefaic, H. Meyr, and M. Pent, eds., ComputerAided Modeling, Analysis, and Design of Communication Links, vol.11, IEEE Journal on Selected Areas in Communications Apr. 1993; 4. K.S. Shanmugan, eds., Simulation and Implementation of Communication and Signal Processing Systems, vol. 32, IEEE Communication Magazine, July 1994; 23.09.14
EE669A	SIMULATION OF COMMUNICATION SYSTEMS	3-0-0-0-9	Introduction to simulation. Discrete time signals and systems. Modeling linear time invariant system. Modeling linear time varying system. Modeling memoryless nonlinear systems. Modeling nonlinear system with memory. Nonlinear differential equation models. Review of probability and randon processes. Monte Carlo simulation and randon number generation. Testing of random number generators. Modeling of functional blocks in communication systems. Wireless fading channel models. Discrete Markov fading channel models. Estimation of parameters in simulation. Estimation of performance measures from simulation. Importance sampling. Other performance estimation methods. Variance reduction techniques. Simulation optimization. Case Study. **Course Reference**: 1. P. Balaban, K.S. Shanmugan, and B.W. Stuck, eds., Computer Aided Modeling, Analysis, and Design of Communication Systems, vol. 6, IEEE Journal on Selected Areas in Communications, Jan. 1984; 2. P. Balaban, E. Biglieri, M.C. Jeruchim, H.T. Mouftah, C.H. Sauer, and K.S. Shanmugan, eds., Computer Aided Modeling, Analysis, and Design of Communication Systems II, vol. 6, IEEE Journal on Selected Areas in Communications, Jan. 1988; 3. J.K. Townsend, A.F. Elrefaic, H. Meyr, and M. Pent, eds., ComputerAided Modeling, Analysis, and Design of Communication Links, vol.11, IEEE Journal on Selected Areas in Communications Apr. 1993; 4. K.S. Shanmugan, eds., Simulation and Implementation of Communication and Signal Processing Systems, vol. 32, IEEE Communication Magazine, July 1994. 23.09.14
EE670	WIRELESS COMMUNICATION S	3-0-0--9	Introduction to wireless communication, multipath propagation, fading channel model, Rayleigh fading, bit error rate (BER) in AWGN and fading channels, multiple antenna wireless systems, maximal ratio combiner (MRC), diversity, BER with diversity, orthogonal frequency division multiplexing (OFDM), transmit/ receive processing, multiple input multiple output (MIMO), ZF/LMMSE receivers, SVD processing, MIMO optimization, Alamouti code, MIMO-OFDM technology, wireless channel characterization in delay and Doppler domains**Course Reference**: Fundamentals of Wireless Communication By David Tse and Pramod Viswanath, Cambridge University Press, 2005; Wireless Communications By Andrea Goldsmith, Cambridge University Press
EE670A	WIRELESS COMMUNICATION	3-0-0-0-9	Introduction to wireless communication, multipath propagation, fading channel model, Rayleigh fading, bit error rate (BER) in

	S		AWGN and fading channels, multiple antenna wireless systems, maximal ratio combiner (MRC), diversity, BER with diversity, orthogonal frequency division multiplexing (OFDM), transmit/ receive processing, multiple input multiple output (MIMO), ZF/LMMSE receivers, SVD processing, MIMO optimization, Alamouti code, MIMO-OFDM technology, wireless channel characterization in delay and Doppler domains **Course Reference**: Fundamentals of Wireless Communication By David Tse and Pramod Viswanath, Cambridge University Press, 2005; Wireless Communications By Andrea Goldsmith, Cambridge University Press
EE671	NEURAL NETWORKS	3-0-0--4	Theory of representation; Two computational pradigms; Multilayer networks; Autoassociative and hetero associative nets; Learning in neural nets: Supervised and unsupervised learning; Application of neural nets; Neural network simulators.
EE671A	NEURAL NETWORKS	3-0-0-0-9	Theory of representation; Two computational pradigms; Multilayer networks; Auto associative and hetero associative nets; Learning in neural nets: Supervised and unsupervised learning; Application of neural nets; Neural network simulators.
EE673	DIGITAL COMMUNICATION NETWORKS	3-0-0--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/IPprotocols, ATM.
EE673A	DIGITAL COMMUNICATION NETWORKS	3-0-0-0-9	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.
EE674	ARCHITECTURE OF MICRO-PROCESSORS & MICROCOMPUTE RS		To be procured
EE674A	ARCHITECTURE OF MICRO-PROCESSORS & MICROCOMPUTE RS		To be procured
EE677	KNOWLEDGE BASED MAN MACHINE SYSTEMS	3-0-0--4	Knowledge representation, statespace 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 ofa microcomputer system, Instruction sets, Machine cycles, Interrupt structures. Parallel /serial I/O, Analog I/O, DMA operation. Peripheral controllers.

EE677A	MIMO WIRELESS COMMUNICATION		To be procured
EE678A	POWER MANAGEMENT CIRCUITS	3-0-0-0-9	Introduction to Motivation. Solar Radiations: Composition, spectrum Air Mass, optimal angle of panel, solar constant, Indias solar resource. Solar PV cell: Direct vs Indirect Band, Generation of carriers, drift and diffusion currents, PN Junction, IV characteristics of cell, fill factor, maximum short circuit current, maximum open circuit voltage, efficiency, fundamental and technological losses, electrical model of cell, effect of series and shunt resistances, optical losses and minimization techniques, Soloar PV Module: Series/parallel connection, IV characteristics of module, mismatching due to temperature and shading, Bypass and blocking diodes, overview of PV module fabrication, IV equation of module, standard test conditions, Review of dcdc buck & boost converters Maximum power point tracking: motivation, power extracted with resistive load, implementing variable resistance load, tracking using dcdc converter, direct vs indirect control, fractional open circuit voltage control, hill climbing method and issues, incremental conductance method, mppt extraction efficiency, effect of voltage ripple on efficiency. Battery charging: types and characteristics of battery, comparison of charging characteristics, popular technique for charging lead acid battery, charging using dcdc converter, PV charging circuits, stable operation of chargers. Solar Inverters: standalone vs grid connected, days of autonomy, payback period, Parity, grid feeding inverter, central inverters circuits, string inverters, earth leakage current, module inverters, features of grid feeding inverter, relevant standards, islanding. **Course Reference**: 1.Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, Prentice Hall of India, 2011; 2. N. Mohan, T.M. Undeland & W.P. Robbins, Power Electronics: Converter, Applications & Design, John Wiley & Sons, 1989; 3. Chenming Calvin Hu, Moden Semiconductor Devices ofr Integrated Circuits, Prentice Hall, 2009 (Chapters1, 2 and 4); 4. Chenming Hu and Richard M White, Solar Cells: From basics to advanced systems, McGraw Hill Book Company, 1983 (Section 3, 7 and 3.8); 5. Antonio Luque and Steven Hegedus, Handbook of Photovoltaic Science and Engineering, John Wiley & Sons Ltd, 2010; 6. Erickson and Maksimovic, Fundamentals of Power Electronics, Springer, 2001 (Chapter 2, 3, 5 and 6); 7. T. Esram and P.L. Chapman, Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques, IEEE Trans, Energy Conversion, Vol.22, no.2, pp.439449, June 27. 24-MAR-15
EE679	SMART GRID TECHNOLOGY	3-0-0--4	History of Smart Grid, Conventional Grid Vs. Smart Grid, Features of Smart Grid, Key Characteristics of Smart Grid, Smart Grid Elements, Forces behind Smart Grid Evolution, Smart Grid Stake Holders, Smart Grid Building Blocks, Smart Grid Resources, Conventional Power System Architecture, IT Layer, Communication Layer, distributed architecture design, Synchrophasor Technology, Smart Meters and Advanced Metering Infrastructure, Wireless Sensor Network (WSN), GIS/Google mapping, Wired Communication (e.g. PLCC, Ethernet, Optical Fibre), Wireless Communication (e.g. WiFi,

			Zigbee, GSM/GPRS, WAN), Machine to Machine Communication, Overview of Protocols such as IEC 61850, IEC 60870, IEEE C37.118, IEC 62351, IEEE 1588, DNP 3.0, IEC 61970/ 61968, IEC 62056, Interoperability issues in Smart Grid and its solutions, Common Information Model, Multispeak, Green Button, SunSpec, SEP 2.0
EE680	INTELLIGENT INSTRUMENTATIO N	2-3-0--4	Introduction, data flow and graphical programming techniques, Virtual instrumentation (VI), advantages, VIs and SubVIs, Data acquisition methods, DAQ hardware, PC hardware; Structure, Operating system, ISA, PCI, USB, PCMICAbuses, Instrumentation buses. IEEE 488.1 and
EE680A	INTELLIGENT INSTRUMENTATIO N	2-0-3-0-9	Introduction, data flow and graphical programming techniques, Virtual instrumentation (VI), advantages, VIs and SubVIs, Data acquisition methods, DAQ hardware, PC hardware; Structure, Operating system, ISA, PCI, USB, PCMICAbuses, Instrumentation buses. IEEE 488.1 and
EE681	COMPACT MODELING	3-0-0-0-9	Introduction to Simulation. Introduction to SPICE and Compact Modeling. Integrated Resistor Modeling. Integrated MOS Varactor Modeling. MOSFET Modeling approaches: Threshold Voltage based modeling (BSIM3, MSIM4), Charge based modeling (BSIM6, EKV), Surface Potential based modelling (PSP). Quality of MOSFET Compect Models and Benchmark Tests. Layout Effects and Parameter Extraction. High Frequency Effects and RF Modeling. SOI MOSFET Modeling. Noise Modeling. Multigate MOSFETs. C. Hu; Modern Semiconductor Devices for Integrated Circuits; Pearson/Prentice Hall, New Jersey.Compac Modeling: Priciples, Techniques and Applications by Gennady Gildenblat, Springer. MOSFET Models for SPICE Simulation: Including BSIM3v3 and BSIM4 by William Liu, Wiley IEEE Press.Chargebased MOS Transistor Modeling: The EKV Model for LowPower and RF IC Design by Christian C. Enz and Eric A. Vittoz, John Wiley & Sons.BSIM4 and MOSFET Modeling for IC Simulation by W. Liu and C. Hu, World Scientific Publishing Co. FinFETs and Other MultiGate Transistors (Integrated Circuits and Systems) by J.P. Coling (Editor).
EE681A	COMPACT MODELING	3-0-0-0-9	Introduction to Simulation. Introduction to SPICE and Compact Modeling. Integrated Resistor Modeling. Integrated MOS Varactor Modeling. MOSFET Modeling approaches: Threshold Voltage based modeling (BSIM3, MSIM4), Charge based modeling (BSIM6, EKV), Surface Potential based modelling (PSP). Quality of MOSFET Compect Models and Benchmark Tests. Layout Effects and Parameter Extraction. High Frequency Effects and RF Modeling. SOI MOSFET Modeling. Noise Modeling. Multigate MOSFETs. C. Hu; Modern Semiconductor Devices for Integrated Circuits; Pearson/Prentice Hall, New Jersey.Compac Modeling: Priciples, Techniques and Applications by Gennady Gildenblat, Springer. MOSFET Models for SPICE Simulation: Including BSIM3v3 and BSIM4 by William Liu, Wiley IEEE Press.Charge based MOS Transistor Modeling: The EKV Model for LowPower and RF IC Design by Christian C. Enz and Eric A. Vittoz, John Wiley & Sons. BSIM4 and MOSFET Modeling for IC Simulation by W. Liu and C. Hu, World Scientific Publishing CoFinFETs and Other Multi Gate Transistors

			(Integrated Circuits and Systems) by J.P. Coling (Editor). 24.09.14
EE682	GAME THEORY FOR WIRELESS COMMUNICATIONS	3-0-0-0-4	Introduction: Games with Perfect Information (Theory with examples) 1. Brief Revision ofNormal Games, Nash Equilibrium, Utility Theory; 2. Mixed Strategies; 3. Introduction to Basics of Wireless Communications; 4. Fading Channels and Diversity ;5. BitError Rate Calculation for Wireless Communications; 6. CDMA, OFDM and MIMO technologies in Wireless; 7. Wireless Sensor Networks; 8. Supermodular and Potential Games and applications in CDMA wireless communications. Applications 1. Market Equilibrium and Pricing 7; 2. Auctions for Wireless Spectrum; 3. Wireless Networks: Introduction to Basics of Wireless; 4. Resource Allocations in Wireless; 5. Admission Control, Routing in Sensor and AdHoc Networks; 6. Modeling Network Traffic and Strategic Network Formation; 7. Electoral Competitions and applications in Wireless Sensor Networks Games with Imperfect Informational. Bayesian Games, Extensive Games with Imperfect Information Application I. Auctions: Radio Spectrum, With Arbitrary Distribution of Valuations 6; 2. Signaling Games Nash Bargaining with Applications(I). Rubinstein Bargaining Model with Alternating Offers; 2. Nash Bargaining Solution 63. Relation of Axiomatic and Strategic Model; 4. Bargaining in Wireless Network.Auctions [III] and Mechanism Design with Applications1. Revenue Equivalence. Mechanism and Optimal Mechanisms for Wireless3. Efficient Mechanism: VickreyClarkeGroves Auction for Wireless 124. Application of VCG in Resource Allocation for Wireless; 5. Dynamic Spectrum Auction in Cognitive Radio Networks; 6. Mechanisms in Networking and Wireless; 7. Applications and Case Studies in Wireless
EE683	QUANTUM AND WAVE PHENOMENA	3-0-0-0-9	1. Introduction to quantum mechanics and its tools: Motivation for quantum mechanics: early experiments; general principles of quantum mechanics: operator algebra, eigenstates, superposition, observables and expectation values, uncertainty relations, commutators, angular momentum, Dirac notation; potential wells and barriers, harmonic oscillator, Hydrogenic atom; time independent and dependent perturbation theory. 2. Device applications of quantum and wave phenomena : Density of states; practical examples of lowdimensional systems such as quantum wells, wires and dots: design, fabrication and characterization techniques; engineered electronic and optical properties of these lowdimensional materials; application in electronic, optoelectronic and photonic devices; current research efforts towards using quantum mechanical effects for developing efficient devices
EE683A	QUANTUM AND WAVE PHENOMENA	3-0-0-0-9	1. Introduction to quantum mechanics and its tools: Motivation for quantum mechanics: early experiments; general principles of quantum mechanics: operator algebra, eigenstates, superposition, observables and expectation values, uncertainty relations, commutators, angular momentum, Dirac notation; potential wells and barriers, harmonic oscillator, Hydrogenic atom; time independent and dependent perturbation theory. 2. Device applications of quantum and wave phenomena: Density of states; practical examples of low dimensional systems such as

			quantum wells, wires and dots: design, fabrication and characterization techniques; engineered electronic and optical properties of these low dimensional materials; application in electronic, optoelectronic and photonic devices; current research efforts towards using quantum mechanical effects for developing efficient devices. **Course Reference**: 1. R.L. Liboff, Introductory Quantum Mechanics (Addison Wesley); 2. A. Yariv, An Introduction to Theory and Applications of Quantum Mechanics (John Wiley & Sons); 3. S. Gasiorowicz, Quantum Physics (Wiley); 4. D.J. Griffiths, Introduction to Qauntum Mechanics (Pearson Prentice Hall); 5. J.H. Davies, The Physics of Low dimensional Semiconductors (Cambridge University Press). 07-OCT-2015
EE684	FIBER-OPTIC COMMUNICATION S		To be procured
EE684A	FIBER-OPTIC COMMUNICATION S	3-0-0-0-9	1. Introduction. 2. Light propagation in optical fibers. Single and multimode fibers, light guiding by fibers, material and waveguide dispersion, Polarization mode dispersion, Nonlinear effects: self and cross phase modulation, Raman and Brillouin scattering, four wave-mixing etc. 3. Optical transmitters and modulation. External modulators: phase and intensity, bias control, Pulse shaping, pulse carving, Modulation formats Intensity modulation, RZ and NRZ amplitude modulation, Mary modulation using MachZehnder modulator, MSK, IQ modulation and optical OFDM. 4. Detection of optical signals. Direct detection: receiver structure, data recovery, signal to noise ratio, performance calculations for binary digital optical systems. Coherent detection: heterodyne, homodyne, DSP assisted coherent optical receiver, performance analysis. 5. Optical amplifiers. Principles of SOA and EDFA, single and double pump configurations, ASE noise in SOA and EDFA, OSNR calculations. 6. Optical link design. Power budget under linear and nonlinear effects, power penalty, dispersion tolerance in DWDM systems. **Course Reference**: 1. M. Cvijetic and I.B. Djordjevic, Advanced optical communication systems and networks, Artech House, 2013; 2. S. Kumar and M.J. Deen, Fiberoptic communications: Fundamentals and applications, Wiley, 2014. 07-OCT-2015
EE685	SEMICONDUCTOR OPTICAL COMMUNICATION DEVICES		To be procured
EE685A	SEMICONDUCTOR OPTICAL COMMUNICATION DEVICES	3-0-0-0-9	1. Introduction. 2. Review of Semiconductors. 3. Epitaxial Growth of Semiconductors. 4. Semiconductor Optical Waveuides. 5. LED. 6. Diode Lasers. 7. Fabrication and Packaging. 8. Single mode Laser diodes plus Reliability. 9. PhotoDetectors. 10. External Modulators. 11. Photonic Integrations. **Course Reference**: 1. Modular Series on Solid State Devices, Vol. VI, Ed: G.W. Neudek & R.F Pierret: R.F. PIERRET, Addision Wesley; 2. Optical Fiber Communication Systems: W.B. JONES, HRW (1988); 3. Semiconductor Optoelectronic Devices: P.K. BHATTACHARYA, Prentice Hall; 4. Elements of Optoelectronics and Fiber Optics: C.L. CHEN, Irwin; 5. Handbook of

			Semiconductor Lasers and Photonic Integrated Circuits: Y. SUEMATSU & A.R. ADAMS, Chapman & Hall; 6. Optical Electronics in Modern Communication: A. YARIV, Oxford University Press; 7. Semiconductor Devices for HighSpeed Optoelectronics: GIOVANNI GHIONE, Cambridge Univ. Press. 07-OCT-2015
EE686	MICROWAVE IMAGING CHARACTERIZATION AND NONDESTRUCTIVE TESTING	3-0-0-0-4	I. Introduction to electromagnetic theory and microwaves; review of Maxwell's equations, interaction of microwaves with the dielectric materials and the concept of effective permittivity, definition of microwave imaging, characterization and testing, the concept of using microwaves as the imaging and testing tool; basic parameters required for themicrowave imaging and their practical equivalents. 2. Review of transmission line theory and the equivalent network representation of field quantities at microwave frequencies, scattering parameters and the transmission matrix, the relationship between the scattering and transmission matrices. 3. Electromagnetic scattering theory: direct and inverse problems, the inverse problem from the mathematic point of view, basis of the electromagnetic scattering problem formulation for the microwave characterization and imaging applications. 4. Overview of the microwave methods for the material characterization and testing, resonant methods, cavity perturbation approach, reflection methods, transmission reflection methods. 5. Theory of transmission reflection methods for determining the permittivity and permeability of materials, various available algorithms, analytical approach, numerical optimization methods, formulation for the dispersive and anisotropic media. 1.2.3.4.5. **Course Reference**: 1.Jaleel Akhtar, Microwave Imaging: Reconstruction of One Dimensional Permittivity Profiles,Vdm Verlag Dr. Mueller, Germany, 2008; 2.L.F. Chen, C.K. Ong, C.P. Neo, V.V. Vardhan and V.K. Verdhan, Microwave Electronics:Measurement and Materials Characterization, John Wiley & Sons, 2004; 3.K.I. Hopcraft and P.R. Smith, Introduction to Electromagnetic Inverse Scattering, Kluwer Academic Publishers, The Netherlands, 1992; 4. Matteo Pastorino, Microwave Imaging, John Wiley & Sons, 2010; 5.Literature from various Journals relevant to specific topics.
EE686A	MICROWAVE IMAGING CHARACTERIZATION AND NONDESTRUCTIVE TESTING	3-0-0-0-9	I. Introduction to electromagnetic theory and microwaves; review of Maxwell's equations ,interaction of microwaves with the dielectric materials and the concept of effective permittivity, definition of microwave imaging, characterization and testing, the concept of using microwaves as the imaging and testing tool; basic parameters required for the microwave imaging and their practical equivalents; 2. Review of transmission line theory and the equivalent network representation of field quantities at microwave frequencies, scattering parameters and the transmission matrix, the relationship between the scattering and transmission matrices; 3. Electromagnetic scattering theory: direct and inverse problems, the inverse problem from the mathematic point of view, basis of the electromagnetic scattering problem formulation for the microwave characterization and imaging applications; 4. Overview of the microwave methods for the material characterization and testing, resonant methods,

			cavity perturbation approach, reflection methods, transmission reflection methods; 5. Theory of transmission reflection methods for determining the permittivity and permeability of materials, various available algorithms, analytical approach, numerical optimization methods, formulation for the dispersive and anisotropic media. 1.2.3.4.5. **Course Reference**: 1.Jaleel Akhtar, Microwave Imaging: Reconstruction of One Dimensional Permittivity Profiles,Vdm Verlag Dr. Mueller, Germany, 2008; 2.L.F. Chen, C.K. Ong, C.P. Neo, V.V. Vardhan and V.K. Verdhan, Microwave Electronics: Measurement and Materials Characterization, John Wiley & Sons, 2004; 3.K.I. Hopcraft and P.R. Smith, Introduction to Electromagnetic Inverse Scattering, KluwerAcademic Publishers, The Netherlands, 1992; 4.Matteo Pastorino, Microwave Imaging, John Wiley & Sons, 2010; 5.Literature from various Journals relevant to specific topics.
EE698	POWER MANAGEMENT CIRCUITS		To be procured
EE698A	HIGH FREQUENCY ANALOG CIRCUIT DESIGN		To be procured
EE698B	SMART GRID TECHNOLOGY APPLICATIONS		Initial Overview of various smart grid measurement and communication technologies, smart grid protocols Overview of Multi-agent System, Distributed Intelligence, Big Data Analysis, Cloud Computing, Software-Defined Networks (SDN) Concepts of Visualization, Self-Healing, Congestion Management, Dynamic OPF, Security Assessment, Contingency Analysis, Dynamic State estimation, Stability Analysis, Intelligent Fault Management, Feeder Reconfiguration, Short Circuit Analysis, Topology Processing, Power Quality, Voltage VAR Control, advanced control of generators, improved FACTS devices Computational Intelligence, Wide Area Monitoring and Control Techniques, Demand Response Management, Predictive Asset Management, Forecasting Techniques Renewable Integration, Plug-in Electric Vehicle, Smart home and Smart City concepts, Cooperative grids Energy market overview, Role of System Operators, DSO, and TSO under the smart grid, Transactive Energy
EE698C	PEER TO PEER NETWORKS		To be procured
EE698D	SMART GRID TECHNOLOGY	3-0-0-0-4	Solar radiations, solar PV modules, maximum power point tracking, partial shading, leakage currents, grounding techniques, panel optimizers, grid integration issues, module integrated inverters, standalone inverters and battery charge controllers.
EE698E	QUANTUM CRYPTOGRAPHY: THEORY AND PRACTICE		To be procured

EE698F	RF MICROELECTRONICS	3-0-0--9	Solar radiations, solar PV modules, maximum power point tracking, partial shading, leakage currents, grounding techniques, panel optimizers, grid integration issues, module integrated inverters, standalone inverters and battery charge controllers.
EE698G	ADVANCED FIBRE-OPTIC COMMUNICATION SYSTEMS		To be procured
EE698H	SIMULATION BASED DESIGN OF 4G/5G WIRELESS STANDARDS		To be procured
EE698I	SOLAR PHOTOVOLTAIC TECHNOLOGIES		To be procured
EE698J	KALMAN FILTERING & APPLICATIONS		To be procured
EE698K	CONTROL SYSTEMS: PERFORMANCE LIMITATIONS & ORDER REDUCTION		To be procured
EE698L	INTRODUCTION TO FLEXIBLE ELECTRONICS		To be procured
EE698M	SELECTED TOPICS IN IMAGE & SIGNAL PROCESSING		To be procured
EE698N	INTRODUCTION TO FLEXIBLE ELECTRONICS		To be procured
EE698O	ANALYSIS OF MODERN WIRELESS NETWORKS		To be procured
EE698P	ADAPTIVE SIGNAL PROCESSING		To be procured
EE698Q	5G WIRELESS TECHNOLOGIES		To be procured
EE698R	SMART GRID MONITORING AND VISUALIZATION		To be procured
EE698S	ANALYSIS OF MODERN WIRELESS NETWORK		To be procured

EE698T	CHARGE AND HEAT TRANSPORT IN SEMICONDUCTOR S		To be procured
EE698U	OPTIMIZATION FOR BIG DATA		To be procured
EE698UA	SPINTRONICS AND QUANTUM TRANSPORT APPLICATION TO SEMICONDUCTOR DEVICES		To be procured
EE698V	MACHINE LEARNING FOR SIGNAL PROCESSING		To be procured
EE698W	ANALOG CIRCUITS FOR SIGNAL PROCESSING		To be procured
EE698X	POWER CONVERTERS FOR CONSUMER ELECTRONIC		To be procured
EE698Y	INTRODUCTION TO QUANTUM OPTICS	3-0-0-0-9	Quick recap of Quantum mechanics: Particle wavefunction (probability density), Schrodinger equation, Operators, Commutators, Eigenfunctions and eigenvalues of Hermitian operators, Orthogonality and complete set, time-evolution of eigenstates and a general wavefunction, Simple Harmonic Oscillator, Dirac Notation (bra-ket algebra), Perturbation theory; Semi-classical interaction of electromagnetic field (classical) with matter (quantized): Interaction Hamiltonian, Transition rates, Fermi-'s Golden rule, Two-level model of an atom, Density matrix and Bloch equations, Rabi frequency, Spontaneous decay, lineshape in fluorescence, Seminal experiments; Quantization of electromagnetic field (light): Single-mode and multi-mode quantized field (light); Classical and non-classical states of light: Interferometry experiments, Beam-splitters, single-photon based devices; Quantum mechanical interaction of electromagnetic field (quantized) with matter (quantized): Interaction Hamiltonian, Cavity QED
EE698Z	NONLINEAR SYSTEMS II		To be procured
EE699	M TECH THESIS	-0-0--	M. Tech. Thesis
EE699.	M TECH THESIS (FOR DUAL DEGREE ONLY)	0----9	M TECH THESIS (FOR DUAL DEGREE ONLY)
EE705	INTELLIGENT SYSTEMS & CONTROL	3-0-0-0-4	Norms of Signals, Vectors and Matrices,Positive Definite Functions, Positive Definite Matrices; Continuous time Statespace Model, LTI Statespace Model, Nonlinear Statespace

			model, Equilibrium point and Linearization using first order Taylor series, Linearization technique for operating points other than origin; Lyapunov Stability Theory, Lyapunov stability of time invariant system, LaSalle's Invariance Theorem, Chetaev's Instability Theorem, Lyapunov stability of time varying system, Lyapunov's indirect method, Lyapunov stability for linear systems; Discretetime Systems, Discrete time LTI Statespace Model, Discretetime Nonlinear Statespace model, ARMAX and NARMAX Models, Lyapunov Stability for Discrete Time Systems; Modeling of Different Nonlinear Systems: Inertial Wheel Pendulum, Two Link Manipulator, Inverted Pendulum Mounted on A Cart, Induction Motor; Nonlinear Control Strategies: Feedback Linearization, Back stepping Design, State feedback linearizable systems.FeedForward Networks: Multilayered Neural Networks, Radial Basis Function Networks. Adaptive Learning Rate; Feedback Networks, Back Propagation Through Time (BPTT), Real Time Recurrent Learning (RTRL); Kohonen Self Organizing Map; System Identification Using Neural Networks Classical sets, Fuzzy Sets, Concept of a fuzzy number, Operations on Fuzzy sets, Properties of Fuzzy Sets, Some Typical Membership Functions; Extension Principle of Fuzzy Sets, Crisp Relation, Fuzzy Relations, Projection of Fuzzy Relations, Cylindrical Extension of Fuzzy Relations, Relation Inference; FUzzy Rule Base and Approximate Reasoning, Fuzzy Linguistic Variables, Linguistic modifier, Rule base systems, Fuzzy Rulebase, Fuzzy Implication Relations, Fuzzy Compositional Rules, Inference mechanism compared, Approximate Reasoning; Fuzzy Logic Control (FLC), Mamdani Model, Takagi Sugeno (TS) Fuzzy Model; System Identification Using TS Fuzzy Models,The TS Model From InputOutput Data, The TS Fuzzy Model Using Linearization. **Course Reference**: 1. Alexander M. Meystel and James S. Albus, Intelligent Systems: Architecture, Design, Control, WileyInterscience, 2001; 2. Pedro Ponce Cruz and Fernando D. Ramirez Figueroa, Intelligent Control Systems with LabVIEW (TM), Springer, 2009.
EE705A	INTELLIGENT SYSTEMS & CONTROL	3-0-0-0-9	Norms of Signals, Vectors and Matrices,Positive Definite Functions, Positive Definite Matrices; Continuous time Statespace Model, LTI Statespace Model, Nonlinear Statespace model, Equilibrium point and Linearization using first order Taylor series, Linearization technique for operating points other than origin; Lyapunov Stability Theory, Lyapunov stability of time invariant system, LaSalle's Invariance Theorem, Chetaev's Instability Theorem, Lyapunov stability of time varying system, Lyapunov's indirect method, Lyapunov stability for linear systems; Discretetime Systems, Discretetime LTI Statespace Model, Discretetime Nonlinear Statespace model, ARMAX and NARMAX Models, Lyapunov Stability for Discrete Time Systems; Modeling of Different Nonlinear Systems: Inertial Wheel Pendulum, Two Link Manipulator, Inverted Pendulum Mounted on A Cart, Induction Motor; Nonlinear Control Strategies: Feedback Linearization, Back stepping Design, State feedback linearizable systems. Feed Forward Networks: Multilayered Neural Networks, Radial Basis Function Networks. Adaptive

			Learning Rate; Feedback Networks, Back Propagation Through Time (BPTT), Real Time Recurrent Learning (RTRL); Kohonen Self Organizing Map; System Identification Using Neural Networks Classical sets, Fuzzy Sets, Concept of a fuzzy number, Operations on Fuzzy sets, Properties of Fuzzy Sets, Some Typical Membership Functions; Extension Principle of Fuzzy Sets, Crisp Relation, Fuzzy Relations, Projection of Fuzzy Relations, Cylindrical Extension of Fuzzy Relations, Relation Inference; FUzzy Rule Base and Approximate Reasoning, Fuzzy Linguistic Variables, Linguistic modifier, Rulebase systems, Fuzzy Rulebase, Fuzzy Implication Relations, Fuzzy Compositional Rules, Inference mechanism compared, Approximate Reasoning; Fuzzy Logic Control (FLC), Mamdani Model, TakagiSugeno (TS) Fuzzy Model; System Identification Using TS Fuzzy Models,The TS Model From InputOutput Data, The TS Fuzzy Model Using Linearization. **Course Reference**: 1. Alexander M. Meystel and James S. Albus, Intelligent Systems: Architecture, Design, Control, WileyInterscience, 2001; 2. Pedro Ponce Cruz and Fernando D. Ramirez Figueroa, Intelligent Control Systems with LabVIEW (TM), Springer, 2009.
EE799	PHD THESIS	-0-0--	Ph. D. Thesis
EE899	MS - RESEARCH THESIS		To be procured
ESC102N	INTRODUCTION TO ELECTRONICS	3-1-3-0-5	Stored program concept (with simple computer simulator), machine language and instruction formats, assembly language for the simple computer. Integer representation, finite representation of real numbers, overflow, underflow, errors due to finite representations. Expressions, values and variables, types, lvalue, rvalue, unary, binary, ternary operations. Conditionals, ifthen, if then else, nested conditionals, switchcase. Loops, for, while, repeat, loopinvariants, precondition, postcondition. Functions and return values, arguments, passbyvalue, effect of passing pointers (like pass by reference). Recursion. Arrays, enums, searching, sorting. Pointers, lists, dynamic data structures, stack, queue, graphs, trees related algorithms, memory and its management. Elementary complexity motivation, concrete complexity, big O notation. Linux tools, introduction to shell programming. Elementary numerical problem solving will addressed largely through some labs e.g. root finding, solutions of systems of linear equations, integration, solution of ODEs. **Course Reference:** 1. Brian W Kernighan and Dennis M Ritchie, The C Programming Language,2nd Ed. ANSI C version, Pearson, 2006.
ESC201A	INTRODUCTION TO ELECTRONICS	3-1-3-0-14	Circuit analysis techniques (nodal, mesh, superposition, Thevenins, and Nortons theorems); Transient analysis of capacitive and inductive circuits; Sinusoidal steadystate analysis of circuits containing resistors, capacitors, and inductors; Transfer functions andfrequency response; Semiconductors; Diodes and diode circuits; MOSFETs and amplifiers; IC fabrication; Operational amplifier circuits and waveform generators; Number system, logic gates,logic minimization,

			combinational circuits; Field programmable gate arrays (FPGAs); Flipflops, sequential circuits, counters, shift registers; data converters (DAC, ADC).
ESO203A	INTRODUCTION TO ELECTRICAL ENGINEERING	3-1-2-0-13	Introduction to Single Phase AC Circuits and phasors, Three-phase AC circuits and analysis, Magnetic Circuits,Mutually Coupled Circuits, Transformers, Equivalent Circuit and Performance, 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.
ESC102N	INTRODUCTION TO ELECTRONICS	3-1-3-0-5	Stored program concept (with simple computer simulator), machine language and instruction formats, assembly language for the simple computer. Integer representation, finite representation of real numbers, overflow, underflow, errors due to finite representations. Expressions, values and variables, types, lvalue, rvalue, unary, binary, ternary operations. Conditionals, if then, if then else, nested conditionals, switchcase. Loops, for, while, repeat, loop invariants, pre-condition, post condition. Functions and return values arguments, pass by value, effect of passing pointers (like pass by reference). Recursion. Arrays, enums, searching, sorting. Pointers, lists, dynamic data structures, stack, queue, graphs, trees related algorithms, memory and its management. Elementary complexity motivation, concrete complexity, big-notation. Linux tools, introduction to shell programming. Elementary numerical problem solving will addressed largely through some labs e.g. root finding, solutions of systems of linear equations, integration, solution of ODEs. **Course Reference:** 1. Brian W Kernighan and Dennis M Ritchie, The C Programming Language,2nd Ed. ANSI C version, Pearson, 2006.
ESC201A	INTRODUCTION TO ELECTRONICS	3-1-3-0-14	Circuit analysis techniques (nodal, mesh, superposition, Thevenins, and Nortons theorems); Transient analysis of capacitive and inductive circuits; Sinusoidal steady state analysis of circuits containing resistors, capacitors, and inductors; Transfer functions andfrequency response; Semiconductors; Diodes and diode circuits; MOSFETs and amplifiers; IC fabrication; Operational amplifier circuits and waveform generators; Number system, logic gates,logic minimization, combinational circuits; Field programmable gate arrays (FPGAs); Flipflops,sequential circuits, counters, shift registers; data converters (DAC, ADC).
EE708	Fundamentals of Data Science and Machine Intelligence	3-0-0-0 [9]	Objectives: This course aims to equip students with the fundamental concepts and techniques central to the fields of exploratory data analysis, statistical inference, and machine learning leading to machine intelligence. Students from all disciplines, both engineering and sciences can develop proficiency in data analysis/visualization, statistical data analysis, machine learning algorithms, and machine learning tools, enabling them to obtain

actionable insights from complex datasets in various domains by completing this course. Students will be exposed to the design and implementation of machine learning models, and handling AI frameworks in Python via a course project. By the end of the course, students are expected to be able to design, implement, and evaluate machine intelligence in general and thus preparing them for careers in data science, artificial intelligence, and related disciplines. The course is targeted at all engineering and science disciplines who wish to understand the emerging and popular paradigm of Data Science and Machine Intelligence.

Contents: (40 lectures, each of 50 minutes duration)

SN	**Broad Title**	**Topics**	**No. of lecture**
1	Foundational principles of data science and machine intelligence	1. Introduction to Data Science (DS), and Machine Intelligence (MI) 2. Introduction to Algorithms, Models, Optimization Techniques for DS/MI.	3
2	Statistical data analysis, visualization, and inference	1. Statistical Data Analysis: Descriptive Statistics, Exploratory Data Analysis (EDA), Hypothesis Testing, Correlation and Covariance 2. Data Visualization: Histogram, Scatter Plot, Box Plot and other plots 3. Model Visualization: Confusion Matrix, ROC curve Inference: Point Estimation, Confidence intervals, Bayesian Inference	6
3	Regression analysis and modeling	1. Linear Regression Modeling 2. Non-Linear Regression Modeling 3. Logistic Regression 4. The Bias-Variance Decomposition 5. Bayesian Linear Regression	6
4	Clustering, Decision Trees, PCA, ICA, Vector Quantization	1. Distance Measures 2. Clustering: K-Means, clustering variants, Hierarchical clustering 3. Decision Tree: Tree construction, Pruning 4. Random Forests: Ensemble learning, Out-of-	9

		bag error, Feature Importance 5. Bosting/Bagging	
5	Gaussian Mixture modeling	1. Probabilistic distance measures 2. Univariate and Multivariate distributions 3. EM algorithm 4. Gaussian Mixture modeling and applications in machine intelligence	3
6	Artificial Neural Networks	1. Feed Forward neural networks 2. Network training 3. Error backpropagation, regularization.	2
7	Deep Neural Networks, Convolutional Neural Networks, Recurrent Neural Networks, and Auto encoders	1. Deep feed forward networks, Regularization and optimization for training deep models 2. Convolutional Neural Networks: Convolution operation, convolution and pooling, variants of convolution function. 3. Recurrent Neural Networks 4. Auto encoders and Applications	9
8	Applications of machine intelligence in science and engineering	1. Case studies of data science/machine intelligence in pure sciences 2. Case Studies of data science/machine intelligence in engineering	2

Recommended pre-requisites :
Undergraduate/Graduate Mathematics, Calculus, Linear Algebra, Probability, Statistics and Programming

Short summary for including in the Courses of Study Booklet:
The course on Data Science and Machine Intelligence aims to equip students with a comprehensive understanding of the foundational principles and advanced techniques in machine learning/AI. The course will blend theory with practical issues such as AI frameworks and programming. The course will provide a detailed understanding of exploratory statistical data analysis, visualization, and inference. Regression analysis and modeling, Classification Modeling, Decision Trees and Random Forests, Boosting/Bagging, Clustering, LDA, PCA, vector quantization, Gaussian Mixture modeling, Artificial Neural

			Networks, Deep Neural Networks, Convolutional Neural Networks, and Recurrent Neural Networks. Applications of machine intelligence covering areas in both science and engineering will be discussed using data spread across disciplines and applications. This course will have significant focus on regular hands on assignments and end with a course mini project to be implemented in Python using AI/ML frameworks. Recommended Books (Reference Books) : 1) Alpaydin, E., Introduction to Machine Learning. Cambridge, MA: MIT Press. ISBN: 9780262043793, Mar. 2020 2) Duda and Hart, Pattern Classification, Wiley, 2001 3) C. Bishop, Pattern Recognition and Machine Learning, Springer, 2006. 4) Goodfellow, I.; Bengio, Y. & Courville, A., Deep Learning, MIT Press, 2016. 5) S. Theodoridis and K. Koutroumbas, Pattern Recognition Second Edn, Elsivier, 2003 6) B. Yegnanarayana, Artificial Neural Networks, PHI, 1999. 7) Simon Haykin, Neural Networks and Learning Machines, Pearson, 1999. 8) Joel Grus, Data Science from Scratch: First Principles with Python, O'Reilly Media, Inc 2019 9) Andreas C. Muller, Sarah Guido, Introduction to machine learning with Python : a guide for data scientists, O'Reilly Media, Inc., 2016 10) Andriy Burkov, The Hundred-Page Machine Learning Book, 2019 11) Jake VanderPlas, Python Data Science ficndbook: Essential Tools for Working with Data, O'Reilly Media, Inc 2016 12) Wes McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and (Python, O'Reilly Media, Inc 2017 13) Aurelien Geron, Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, O'Reilly Media, Inc 2017 14) Thomas Nield, Essential Math for Data Science, O'Reilly Media, Inc., 2022 15) Peter Bruce and Andrew Bruce, Practical Statistics for Data Scientists, O'Reilly Media, Inc, 2017 16) John D. Kelleher, Brian Mac Namee, Aoife D'Arcy, Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies, MIT Press, 2015 17) John Hearty, Advanced Machine Learning with Python, Packt Publishing, 2016 18) Kevin Patrick Murphy, Probabilistic Machine Learning: Advanced Topics, MIT Press, 2023 Any other remarks: Hands on assignments and a mini project to be implemented in Python/AI Frameworks will form an important part of the grading scheme for this course.