Revised Course Structure of BTech in Electronics & Communication Engineering

New Course IDs	Course Title	Hours per week			Credit	Total
		L	T	P	C	
	Semester I and II					
EC-101	Basic Electronics	3	1	0	4	
EC-111	Basic Electronics Laboratory	0	0	3	2	
	Semester-III					
EC-201	Electronic Devices	3	0	0	3	
MA-2XX	Mathematics III	3	1	0	4	
EC-202	Network Analysis & Synthesis	3	1	0	4	
CS-XXX	Data Structures and Algorithms	3	0	0	3	
EC-203	Analog Electronic Circuits	3	1	0	4	
EC-204	Signals and Systems	3	1	0	4	
EC-221	Circuit Theory Lab	0	0	3	2	
EC-222	Analog Electronic Circuits Lab	0	0	3	2	
CS-XXY	Data Structure Lab	0	0	3	2	28
EC-231	Electronic Circuits & Switching	3	1	0	4	CSE
EC-232	Electronic Circuits & Switching Laboratory	0	0	3	2	CSE
	Semester-IV					
EC-205	Digital Electronic Circuits	3	0	0	3	
EC-206	Analog Communication	3	1	0	4	
EC-207	Control Systems	3	1	0	4	
EC-208	Probability and Random Process	3	1	0	4	
EC-209	Electrical & Electronic Materials	3	0	0	3	
EC-210	Electromagnetic Fields & Wave Propagation	3	1	0	4	
EC-223	Digital Electronics Lab	0	0	3	2	
EC-224	Control Lab	0	0	3	2	
EC-225	Analog Communication Lab	0	0	3	2	28
	Semester-V					
EC-301	Digital Communication	3	1	0	4	
EC-302	Microprocessors & Microcontrollers	3	1	0	3	
EC-303	Analog Integrated Circuits & Technology	3	0	0	4	
EC-304	Digital Signal Processing	3	1	0	4	
EC-305	Measurements and Instrumentation	3	0	0	3	
EC-306	Principles of Optoelectronics and Optical Fibers	3	0	0	3	
EC-321	Microprocessor Lab	0	0	3	2	
EC-322	DSP Lab	0	0	3	2	
EC-323	Digital Communication Lab	0	0	3	2	27
	Semester-VI					
EC-307	RF and Microwave Engineering	3	1	0	4	
EC-308	Data Communication and Network	3	1	0	4	

EC-309	VLSI Design	3	1	0	4	
EC-310	Power Electronics	3	1	0	4	
EC-35X	Professional Core Elective I	3	0	0	3	
EC-37X	Open Elective I	3	0	0	3	
EC-324	Design Lab	0	0	3	2	
EC-325	Data & Optical Communication. Lab	0	0	3	2	
EC-326	VLSI Design Lab	0	0	3	2	28
	Semester-VIII					
EC-401	Wireless Communication	3	1	0	4	
EC-45X	Professional Core Elective II	3	0	0	3	
EC-47X	Open Elective II	3	0	0	3	
HS-XXX	Engineering Economics / Management Studies	3	0	0	3	
EC-498	Project I	0	0	9	6	19
	Semester-VIII					
HS-XXY	Engineering Economics / Management Studies	3	0	0	3	
EC-46X	Professional Core Elective III	3	0	0	3	
EC-48X	Open Elective III	3	0	0	3	
EC-499	Project II	0	0	9	6	15
	Total Credits excluding First Year Credits					145

EC-101 **Basic Electronics** **L T P C**

First Year All Branches 1 0 0 4

Pre-requisite- None

Introduction to Electronic devices: passive devices, diode, bipolar junction transistor (BJT), metal oxide semiconductor field-effect transistor (MOSFET);

Diode: basic structure and operating principle, current-voltage characteristic, large and small-signal models, iterative and graphical analysis; Diode Applications : rectifier circuits (half-wave and full-wave rectifiers, rectifiers with capacitor filter), voltage regulator (using Zener diode), clipper (limiter) circuits, clamper circuits;

Bipolar Junction Transistors and their Applications: structure and modes of operation; n-p-n and p-n-p transistor in active mode, DC analysis of both transistor circuits; BJT as an amplifier, small-signal equivalent circuits, single-stage BJT amplifier (common-emitter mode); BJT as a switch; concepts of feedback amplifier

Metal Oxide Semiconductor Field-Effect Transistors and their Applications: structure and physical operation of n-type and p-type MOSFET; DC analysis of MOSFET circuits; MOSFET as an amplifier, small-signal equivalent circuits, single-stage MOSFET amplifier (common-source mode); MOSFET as a switch;

Operational Amplifier (Op Amp) : ideal op amp; inverting amplifier, amplifier with a T-network, effect of finite gain, summing amplifier; non-inverting configuration, voltage follower; op amp applications like current-to-voltage converter, voltage-to-current converter, difference amplifier, instrumentation amplifier, integrator and differentiator;

Digital Electronics: Boolean algebra and rules of simplification; combinational circuits like adder, decoder, encoder, multiplexer and demultiplexer; sequential circuits like flip-flops, counters and shift registers.

Text/Reference books:

1. Microelectronic Circuits, 7th Edition, Adel S Sedra and Kenneth C Smith, Oxford University Press
2. Microelectronics, 2nd Edition, Jacob Millman and Arvin Grabel, Tata McGraw Hills
3. Digital Design, 5th Edition, M. Morris Mano and Michael D Ciletti, Pearson
4. Fundamentals of Digital Circuits, 4th Edition, A Anand Kumar, PHI

5. Integrated Electronics, 2nd Edition, Jacob Millman and Christos Halkias, Tata McGraw Hills

EC-111	Basic Electronics Laboratory	L	T	P	C
	First Year All Branches	3	1	0	4
	Pre-requisite- ~~Basic Electrical Engineering~~				

1. Familiarization with electronic components and usage of multimeter
2. Familiarization with oscilloscope, signal generator and further usage of multimeters
3. Frequency-response and square-wave testing of R-C, C-R and R-L networks
4. Studies on Voltage Rectifiers
5. Studies on Common-Emitter amplifiers
6. Studies on analog circuits using OP-AMP
7. Studies on logic gates

EC-201	Electronics Devices	L	T	P	C
	III Semester ECE	3	1	0	4
	Pre-requisite- EE-101, EC-101				

Review of semiconductor Physics: Solids, crystals, energy band, electrons, holes, effective mass, doping, Fermi level, Equilibrium carrier concentration, Direct and indirect semiconductors, Recombination and Generation of carriers, Carrier transport – Drift and Diffusion, mobility, Lifetime Equations of state – Continuity and Poisson equation.

p-n Junctions: Thermal equilibrium conditions, depletion regions, depletion capacitance, current-voltage characteristics, charge storage and transient behavior, junction breakdown

Metal-Semiconductor contacts: The Schottky barrier, the ohmic contact and rectifying contacts

Metal-Insulator-Semiconductor Capacitors: Introduction, Ideal MIS Capacitor, Silicon MOS capacitor, capacitance voltage characteristics of MOS structure

MOSFET: Introduction, MOSFET structure and basic characteristics, Device Scaling and Short-Channel Effects

Bipolar Junction Transistor: The transistor action, static characteristics of BJT, frequency response and switching of BJT, the heterojunction BJT.

Other devices: LEDs, Solar cells, Solid State Memories.

Text / Reference Books

1. Semiconductor Physics and Devices, Donald A Neamen, McGraw-Hill Education
2. Solid State Electronics Devices, Streetman and Banerjee, PHI
3. Introduction to Semiconductor Materials and Devices, M. S. Tyagi, Wiley India Pvt Ltd
4. Physics of Semiconductor Devices, S. M. Sze and K. K. Ng, John Wiley & Sons

EC-202	Network Analysis and Synthesis	L	T	P	C
	Third Semester ECE	3	1	0	4
	Pre-requisite- EE-101				

Network Topology: Graph of a network; Concept of tree; Incidence matrix; Tie-set matrix; Cut-set matrix; Formulation and solution of network equilibrium equations on loop and node basis; Coupled Circuits: Substitution theorem; Tellegen's theorem; Millman's theorem; Coupled Circuits; Dot convention for representing coupled circuits; Coefficient of coupling.

Laplace Transform & Its Application: Introduction to laplace transform; Laplace transform of some basic function; Laplace transform of periodic functions; Inverse laplace transform; Application of laplace transform:Circuit analysis (Steady State and Transient)

Two Port Network Functions and Responses:z, y, ABCD, and h parameters; Reciprocity and Symmetry; Interrelation of two port parameters; Interrelation of two port networks; Network functions; Significance of poles and zeroes, Restriction on location of poles and zeroes, Time domain behaviour from Pole-Zero plots.
Fourier Series and Fourier Transform: Fourier Series, Fourier analysis and evaluation of coefficients; Steady state response of network to periodic signals; Fourier transform and convergence; Fourier transform of some functions; Brief idea about network filters (Low pass, High pass, Band pass, and Band elimination) and their frequency response.
Network Synthesis: On network syntnesis, Synthesis of passive network, Copncept of stability, Positive real function, and its property, Foster and Cauer form of Synthesis

Text Book(s)

1. Network Analysis and Synthesis: A Chakraborty
2. Network Analysis, M E Van Valkenburg, PHI, third edition
3. Fundamentals of Electric Circuits, Charles K Alexander & Mathew N.O. Sadiku, Tata McGraw Hill, fifth edition.
4. Network theory, Smarajit Ghosh, first edition (2005).
5. Network Analysis and Synthesis, Franklin F. Kuo, Wiley Student Edition, second edition, 2006.

EC-203	Analog Electronic Circuits	L	T	P	C
	Third Semester ECE	3	1	0	4
	Pre-requisite- EC-101, EE-101				

Diodes: Basics of diode, Clipper, Clamper, Voltage multiplier, Zener diode and voltage regulator, LED, Photodiode, solar cell.
BJT and MOSFET: Basics of BJT and MOSFET, Biasing schemes and Bias stability, Mid-frequency small signal analysis of various BJT and MOSFET amplifier configurations using hybrid π-model, Multistage BJT and MOSFET amplifiers, Differential amplifier, Low and High frequency response of BJT and MOSFET circuits.
Feedback and Stability: Introduction to feedback, Ideal Feedback Topologies, Analysis of MOSFET based feedback amplifiers for Series-Shunt, Series-Series, Shunt-Shunt and Shunt-Series configurations, Stability Analysis, Compensation Technique.
Op-Amp and Oscillators: Basics of Op-Amp, Log-antilog amplifier, Square-root amplifier, Amplifier with T-network, Instrumentation amplifier, Precision rectifier, Active filters, Schmitt trigger circuits, Wein bridge and Phase shift oscillator, Colpitts, Hartley and Crystal oscillator, The 555 timer Astable and Monostable multivibrator.
Large Signal and power amplifiers: Introduction to power amplifiers, Harmonic distortion and power output, Class A, Class B, and Class AB amplifiers and their analysis. Thermal design considerations.

Text / Reference Books

1. Microelectronics: Circuit Analysis and Design (4th edition), Donald A. Neamen, McGraw-Hill Education
2. Microelectronic Circuits (7th edition), Adel S. Sedra and Kenneth C. Smith, Oxford University Press
3. Fundamentals of Microelectronics, Behzad Razavi, Wiley India Pvt Ltd
4. Microelectronic Circuits: Analysis and Design, Muhammad H. Rashid, Cengage Learning (2nd edition)

EC-204	Signals and Systems	L	T	P	C
	Third Semester ECE	3	1	0	4
	Pre-requisite- EE-101, ~~Network Theory and Mathematics~~				

CLASSIFICATION OF SIGNALS AND SYSTEMS: Continuous time signals (CT signals)- Discrete time signals (DT signals) – Step, Ramp, Pulse, Impulse, Exponential - classification of CT and DT signals – periodic and a periodic signals, random signals, Energy & Power signals - CT systems and DT systems, Classification of systems.
ANALYSIS OF CONTINUOUS TIME SIGNALS: Fourier series analysis- Spectrum of Continuous Time (CT) signals- Fourier and Laplace transforms in Signal Analysis.

LINEAR TIME INVARIANT–CONTINUOUS TIME SYSTEMS: Differential Equation-Block diagram representation-impulse response, convolution integrals, Fourier and Laplace transforms in Analysis.
ANALYSIS OF DISCRETE TIME SIGNALS: Baseband Sampling of CT signals- Aliasing, Reconstruction of CT signal from DT signal DTFT and properties, Z-transform & properties.
LINEAR TIME INVARIANT –DISCRETE TIME SYSTEMS: Difference Equations-Block diagram representation-Impulse response-Convolution sum-DTFT and Z Transform analysis of Recursive and Non-Recursive systems

TEXT BOOKS:

1. Allan V. Oppenheim, S. Wilsky and S.H. Nawab, ―Signals and Systems‖, Pearson, Indian Reprint, 2007
2. B. P. Lathi, Principles of Linear Systems and Signals‖, Oxford, Second Edition, 2009.

REFERENCES:

1. H P Hsu, Signals and Systems‖, Schaum's Outlines, Tata McGraw Hill, 2006
2. S. Haykin and B. Van Veen, "Signals and Systems", Second Edition, Wiley, 2003.
3. P. Ramakrishna Rao, Signals and Systems , Tata Mc Graw Hill Publications, 2008.
4. Edward W. Kamen, Bonnie S. Heck, Fundamentals of Signals and Systems Using the Web and MATLAB, Pearson, Indian Reprint, 2007
5. John Alan Stuller, An Introduction to Signals and Systems‖, Thomson, 2007
6. M.J. Roberts, Signals & Systems, Analysis using Transform methods & MATLAB, Tata McGraw Hill (India), 2007.

EC-205	**Digital Electronic Circuits**	**L**	**T**	**P**	**C**
	Fourth Semester ECE	3	1	0	4
	Pre-requisite- EC-101				

Data and number systems: Binary, Octal and Hexadecimal representation and their conversions; BCD,ASCII, EBDIC, Gray codes and their conversions; Signed binary number representation with 1's and 2's complement methods, Binary arithmetic, An overview of Boolean algebra, Venn diagram, Simplification of logic variable using K-map method, Quine McCluskey method.
Combinational circuits: Decoder, Comparator, Multiplexer, De-Multiplexer and Parity Generator, Memory Systems: RAM, ROM, EPROM, EEROM, Design of combinational circuits-using ROM, Programming logic devices and gate arrays (PLAs and PLDs).
Sequential Circuits: Basic memory element-S-R, J-K, D and T Flip Flops and their conversions. Various types of Registers, Counters and their design.
Analog and Digital Converters: Different types of A/D and D/A conversion techniques.
Logic families: TTL, ECL, MOS and CMOS, their operation and specifications.

Text / Reference Books

1. Modern Digital Electronics, R.P Jain, McGraw-Hill
2. Fundamentals of Digital Circuits, Anand Kumar, PHI
3. Digital Electronics, A.K.Maini, Wiley India
4. Digital Electronics, Kharate, Oxford
5. Digital Design, M. Morris Mano, and Michael D Ciletti, Pearson

EC-206	**Analog Communication**	**L**	**T**	**P**	**C**
	Fourth Semester ECE	3	1	0	4
	Pre-requisite- *EC-204*				

Elements of an electrical communication system; Characteristics of communication channel and their mathematical modeling;
Signal models: deterministic and random; signal classification; Convolution Integral and response of LTI system; Fourier series representation, Parseval's theorem; Fourier transform; Hilbert transform; Random Process: mean, correlation and covariance; stationary and ergodic processes; power spectral density; Gaussian Process.
Concept of modulation and demodulation, Continuous wave (CW) modulation: amplitude modulation (AM) - double sideband (DSB); double sideband suppressed carrier (DSBSC); single sideband suppressed carrier

(SSBSC) and vestigial sideband (VSB) modulation, angle modulation - phase modulation (PM) & frequency modulation (FM); narrow and wideband FM.
Sampling process, sampling theorem for band limited signals; pulse amplitude modulation (PAM); pulse width modulation (PWM); pulse position modulation (PPM), Basics of time division multiplexing,
Representation of narrowband noise; receiver model, signal to noise ratio (SNR), noise figure, noise temperature, noise in DSB-SC, SSB, AM & FM receivers, pre-emphasis and de-emphasis. Effect of Noise on AM, Effect of Noise on DSB-SCM, Effect of Noise on SSB-AM, Effect of Noise on Angle Modulation, Threshold Effect in Angle Modulation, Pre-emphasis and De-emphasis in FM. noise consideration in PAM and PCM systems.

Text Books:

1. Communication Systems Simon Haykin, John Willey & Sons
2. Modern Digital and Analog Communications Systems, B P Lathi & Zhi Ding, Oxford University Press

Reference Books:

1. Communication Systems Engineering, Proakis & Salehi, Pearson Education
2. Communication Systems, A.B. Carlson, TMH/MGH
3. Communication Theory, T.G. Thomas & S Chandrasekhar, TMH/MGH
4. Principle of Communication Systems, H. Taub & D.L.Schilling, TMH/MGH

EC-207	**Control Systems**	**L**	**T**	**P**	**C**
	Fourth Semester ECE	3	1	0	4
	Pre-requisite- ~~Mathematics~~, EC-204				

Introduction to control system, Basic control system components; block diagrammatic description, Reduction of block diagrams. Open loop and closed loop (feedback) systems, Examples of automatic control system, Basic elements of servo machines models of physical systems, differential equations.
Signal flow graphs and their use in determining transfer functions of systems; Mason's Gain formula, standard test signals, Order of systems, concept of time constant, dynamic characteristics of a system, transient and steady state analysis of LTI control systems, Definition and significance of Frequency response.
Time-domain impulse- and step responses of 1- and 2-pole systems; Settling time, over-shoot etc. in terms of damping coefficient and natural frequency; Effect of zero near the origin (and in rhp).;
Relation between time and frequency-response features (of 2-pole plants); Principles of feedback; transfer function; block diagrams; steady-state errors, Stability of a system, sensitivity, characteristic equation,
Tools and techniques for LTI control system analysis: Relative stability issues, root loci, Routh-Hurwitz criterion, Characterization of plants: Asymptotic and BIBO stability; Significance of poles and eigenvalues; Routh-Hurwitz test. Bode and Nyquist plots. Pole placement Design
Control system compensators: Design of phase lead and lag compensators, Proportional-Integral-Derivative (PID) control
State variable representation and solution of state equation of LTI control systems, state transition matrix, controllability, observability, Introduction to digital control system, adaptive And Fuzzy control, Neural control

Text Books/References:

1. A Text Book of Control system, K. Ogata, PHI
2. Control System and Design, Nagrath and Gopal , TMH
3. Automatic Control System , B.C Kuo, PHI

EC-208	**Probability and Random Process**	**L**	**T**	**P**	**C**
	Fourth Semester ECE	3	1	0	4
	Pre-requisite- ~~Mathematics~~				

RANDOM VARIABLES: Discrete and continuous random variables, Moments, Moment generating functions and their properties. Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and normal distributions, Function of Random Variable.

TWO DIMENSIONAL RANDOM VARIBLES: Joint distributions, Marginal and conditional distributions, Covariance, Correlation and Regression, Transformation of random variables, Central limit theorem

CLASSIFICATION OF RANDOM PROCESSES: Definition and examples, first order, second order, strictly stationary, wide sense stationary and ergodic processes, Markov process, Binomial, Poisson and Normal processes, Sine wave process, Random telegraph process.

CORRELATION AND SPECTRAL DENSITIES: Auto correlation, Cross correlation, Properties, Power spectral density, Cross spectral density, Properties, Wiener- Khintchine relation, Relationship between cross power spectrum and cross correlation function

LINEAR SYSTEMS WITH RANDOM INPUTS: Linear time invariant system, System transfer function, linear systems with random inputs, Auto correlation and cross correlation functions of input and output, white noise.

TEXT BOOKS

1. Peebles Jr. P.Z., "Probability Random Variables and Random Signal Principles", Tata McGraw,Hill Publishers, Fourth Edition, New Delhi, 2002.
2. Oliver C. Ibe, "Fundamentals of Applied probability and Random processes", Elsevier, First Indian Reprint (2007)

REFERENCES

1. Miller,S.L and Childers, S.L, "Probability and Random Processes with applications to Signal Processing and Communications", Elsevier Inc., First Indian Reprint 2007.
2. Stark. H., and Woods. J.W., "Probability and Random Processes with Applications to Signal Processing", 3rd Edition, Pearson Education, Asia, 2002.
3. Hwei Hsu, "Schaum"s Outline of Theory and Problems of Probability, Random Variables and Random Processes", Tata Mc Graw Hill Edition, New Delhi, 2004.

EC-209	**Electronic and Electrical Materials**	**L**	**T**	**P**	**C**
	Fourth Semester ECE	3	0	0	4
	Pre-requisite- *EC-101*				

Introduction to materials science, classification of materials. Important properties of engineering materials and materials structures. Crystal geometry and structure: crystal structure, crystal symmetry, lattice planes and directions. Important feature of miller indices and interplanar spacing. Structural determination by X-ray diffraction: Bragg's law of X-ray diffraction, powder method of structure determination.

Crystal imperfection: introduction, Types of imperfection: point, line, surface and grain boundary defects, Frank-Read source, some salient points in relation to the theory of dislocation. Bonds in Solids: type of bonds, mechanism of bond formation.

Electric and magnetic properties of materials: Introduction, electrical conduction, electrical conductivity, electronic and ionic conduction, band structure of solids. Electrical resistivity of metals. Insulator, dielectrics. Magnetism: Magnetic properties, Basic theory of magnetic material, Hard and soft magnetic materials.

Optical properties of materials: Optical properties, interaction of light with solids. Atomic and electronic interactions; optical properties of metal and non-metals. Photoelectric effects and its characteristics. Einstein photoelectric emission, photoelectric cells and their applications.

Thermal and mechanical properties of materials, Introduction, Heat capacity, thermal expansion, theoretical model, thermal conductivity, Definition of common terms used in mechanical properties, fundamental mechanical properties.

Text/Reference books:

1. Electrical Engineering Materials, A.J. Dekker, Prentice Hall India Learning Private Limited
2. Material Science, G.K. Narula, K. Narula and V. Gupta, McGraw Hill Education, First edition
3. Introduction to Materials Science, H.B. Lal, Dominant Publishers & Distributors
4. Materials Science and Engineering: A First Course, V. Raghavan, Prentice Hall India Learning Private Limited, 6th Revised Edition
5. Material Science, S. L. Kakani and Amit Kakani, New Age International

EC-210	**Electromagnetic Field Theory and Wave Propagation**	**L**	**T**	**P**	**C**

Fourth Semester ECE 3 1 0 4

Pre-requisite- ~~*Vector Calculus and Mathematics*~~

Fundamental Concepts of static fields: Physical interpretation of gradient, divergence and curl; Coordinate systems; Review of static fields; Current continuity equation; Displacement current;

Maxwell's equations & Plane Waves: Maxwell's equations in static & time varying fields, Maxwell's equation in phasor form Wave equation in an isotropic homogeneous medium and its solution, polarization of waves, Poynting vector.

Reflection of Electromagnetic Waves: Reflection and refraction of plane waves at plane boundaries, Normal incidence, standing waves, laws of reflection, reflection of obliquely incident waves, Brewster's angle.

Transmission lines: Circuit model for transmission lines, loss less and lossy lines, field analysis of transmission lines, Smith chart, impedance matching.

Antenna & Wave Propagation: Retarded potential, Hertzian dipole, Antenna parameters, Ground Wave Propagation, Space Wave Propagation, Propagation over Plane Earth and spherical earth, Duct Propagation, Troposphere Propagation.

Text/Reference Books:

1. Electromagnetic Waves and Radiating Systems, E. C. Jordan & K. G. Balman, PHI
2. Engineering Electromagnetics, W. H. Hayt & J. A. Buck, TMH
3. Elements of Electromagnetics, M. N. O. Sadiku, Oxford Uni. Press
4. Microwave Devices and Circuits, S. Y. Liao, Pearson
5. Antenna Theory: Analysis and Design, Constantine A. Balanis, Wiley

EC-221 **Circuit Theory Laboratory** **L T P C**

Third Semester ECE 0 0 3 2

Pre-requisites- None

List of Experiments

1. Verification of Network Theorems (Superposition, Thevenin's, Norton's, Maximum Power Transfer).
   2. Study of DC and AC Transients.
2. Determination of circuit parameters: Open Circuit and Short Circuit parameters.
3. Determination of circuit parameters: Hybrid and Transmission parameters.
4. Frequency response of Low pass and High Pass Filters.
5. Frequency response of Band pass and Band Elimination Filters.
6. Determination of self-inductance, mutual inductance and coupling coefficient of a single phase two winding transformer representing a coupled circuit.
7. Study of resonance in R-L-C series circuit.
8. Study of resonance in R-L-C parallel circuit.
9. Spectral analysis of a non-sinusoidal waveform

EC-222 **Analog Electronic Circuit Laboratory** **L T P C**

Third Semester ECE 3 1 0 4

Pre-requisite- *EC-111*

List of Experiments:

1. To study the multi-stage RC coupled amplifier circuit using CE configuration npn transistor.
2. To design a current-biased emitter follower circuit
3. To measure and understand the current-vs-voltage (I-V) operating curves of the MOSFET
4. To realize Different applications of Op-Amps – Adder, Subtractor, Differentiator, Integrator etc.
5. To study Schmitt's Trigger Circuit

6. To study Phase Shift Oscillator Circuits
7. To design Active filter circuit with IC 741 (Low pass and High pass)
8. To realize Astable Multivibrator circuit using BJT/Op-Amp
9. To realize Monostable Multivibrator circuit using BJT/Op-Amp
10. To design an Analog to Digital Converter (Any one method)
11. To design Digital to Analog Converter(Any one method)
12. One innovative experiment based on electronics circuit

EC-223	Digital Electronic Circuit Laboratory	L	T	P	C
	Fourth Semester ECE	3	1	0	4
	Pre-requisite- *EC-111*				

List of Experiments:

1. Code conversion circuits- BCD to Excess-3 and vice-versa.
2. Four-bit parity generator and comparator circuits.
3. Construction of simple Decoder and Multiplexer circuits using logic gates.
4. Realization of RS-JK and D flip-flops using Universal logic gates.
5. Realization of Universal Register using JK flip-flops and logic gates.
6. Realization of Universal Register using multiplexer and flip-flops.
7. Construction of Adder circuit using Shift Register and full Adder.
8. Realization of Asynchronous Up/Down counter.
9. Realization of Synchronous Up/Down counter.
10. Design of Sequential Counter with irregular sequences.
11. Realization of Ring counter and Johnson's counter.
12. Any innovative experiment related to digital circuits.

EC-224	Control Laboratory	L	T	P	C
	Fourth semester ECE	0	0	3	2
	Pre-requisite-				

EC-225	Analog Communication Laboratory	L	T	P	C
	Fourth semester ECE	0	0	3	2
	Pre-requisite-				

EC-231	Electronic Circuits & Switching	L	T	P	C
	Third Semester Computer Science & Engineering	3	1	0	4
	Pre-requisite-				

Number System: Introduction to various number systems and their Conversion. Arithmetic Operation using 1's and 2's Compliments, Signed Binary and Floating Point Number Representation Introduction to Binary codes and their applications.

Boolean Algebra and Logic Gates: Boolean algebra and identities, Complete Logic set, logic gates and truth tables. Universal logic gates, Algebraic Reduction and realization using logic gates (3 Hours) Combinational Logic Design: Specifying the Problem, Canonical Logic Forms, Extracting Canonical Forms, EX-OR Equivalence Operations, Logic Array, K-Maps: Two, Three and Four variable K-maps, NAND and NOR Logic Implementations.

Logic Components: Concept of Digital Components, Binary Adders, Subtraction and Multiplication, An Equality Detector and comparator, Line Decoder, encoders, Multiplexers and De-multiplexers.

Synchronous Sequential logic Design: sequential circuits, storage elements: Latches (SR, JK, T, D), Storage elements: Flip-Flops inclusion of Master-Slave, characteristics equation and state diagram of each FFs and Conversion of Flip-Flops. Analysis and synthesis of Clocked Sequential circuits and Mealy and Moore Models of Finite State Machines

Binary Counters: Introduction, Registers and shift registers, universal shift register, Principle and design of synchronous and asynchronous counters, Design of MOD-N counters, Ring counters. Decade counters, State Diagram of binary counters

IC Logic Families: Properties DTL, RTL, TTL, I2L and CMOS and its gate level implementation.

Text/References:

1. Modern Digital Electronics, R.P Jain, McGraw-Hill
2. Fundamentals of Digital Circuits, Anand Kumar, PHI
3. Digital Electronics, A.K.Maini, Wiley India
4. Digital Design, M. Morris Mano, and Michael D Ciletti, Pearson

EC-232	**Electronic Circuits & Switching Laboratory**	**L**	**T**	**P**	**C**
	Third Semester Computer Science & Engineering	0	0	3	2
	Pre-requisite-				

EC-301	**Digital Communication**	**L**	**T**	**P**	**C**
	Fifth Semester ECE	3	1	0	4
	Pre-requisite-EC-208, EC-204 and EC-206				

Introduction: A historical perspective in the development of Digital Communication, elements of a digital communication system, analog versus digital communication system.

Pulse modulation: Introduction, quantization process, PCM, DPCM, DM, Adaptive DPCM, Quantization noise, output signal power, output SNR in PCM, quantization noise in DM, output SNR in DM and DPCM.

Base band pulse transmission: Introduction, matched filter, error rate due to noise, inter symbol interference, Nyquist's criterion for distortion less base band binary transmission.

Digital pass-band transmission: Introduction, pass band transmission model, Gram Schmidt orthogonalization procedure, geometric representation of signals, BPSK, DPSK (Differential Encoded PSK), QPSK, $\pi/4$ QPSK, OQPSK, M-ary PSK, BFSK, Minimum shift keying (MSK), GMSK, QAM, power spectra, bit error rate probability, Comparison of modulation schemes in terms of probability of error and spectral efficiency.

Source coding: Mathematical models of information sources, a logarithmic measure of information, source coding theorem, source coding algorithms - the Huffman source coding algorithm.

Channel capacity & coding: Modelling of communication channels, channel capacity, bounds on communication, coding for reliable communication, linear block codes

Multiplexing: Introduction, frequency division multiplexing (FDM), time division multiplexing (TDM), Introduction to Spread Spectrum Techniques.

Text Books:

1. Digital Communication, *Simon Haykin,* John Willey & Sons
2. Digital communication, *John G Proakis,* McGraw Hill
3. Communication System, *Simon Haykin,* John Willey - 4th edition

Reference Books:

1. Modern Analog & Digital Communication System, *B.P.Lathi,* Oxford University Press- 4th edition
2. Introduction to Digital Communication, *M.B.Pursley,* PHI
3. Digital and Analog Communication Systems, *L.W.Couch,* Pearson
4. Principles of Communication Systems, *H. Taub & D.L. Schilling, G.Saha,* 4th edition,2013 - McGraw Hill

EC-302	**Microprocessors and Microcontrollers**	**L**	**T**	**P**	**C**
	Fifth Semester ECE	3	1	0	4
	Pre-requisite- EC-205				

Introduction to 8 bit and 16 bit Microprocessors-H/W architecture Introduction to microprocessor, computer and its organization, Programming system; Address bus, data bus and control bus, Tristate bus; clock generation;

Connecting Microprocessor to I/O devices; Data transfer schemes; Architectural advancements of microprocessors. Introductory System design using microprocessors; 8086 – Hardware Architecture; External memory addressing; Bus cycles; some important Companion Chips; Maximum mode bus cycle; 8086 system configuration; Memory Interfacing; Minimum mode system configuration, Interrupt processing.

16-bit microprocessor instruction set and assembly language programming: Programmer's model of 8086; operand types, operand addressing; assembler directives, instruction Set-Data transfer group, Arithmetic group, Logical group.

Microprocessor peripheral interfacing: Introduction; Generation of I/O ports; Programmable Peripheral Interface (PPI)- Intel 8255; Sample-and-Hold Circuit and Multiplexer; Keyboard and Display Interface; Keyboard and Display Controller (8279).

8-bit microcontroller- H/W architecture instruction set and programming: Introduction to 8051 Micro-Controllers, Architecture; Memory Organization; Special Function register; Port Operation; Memory Interfacing, I/O Interfacing; Programming 8051 resources, interrupts; Programmer's model of 8051; Operand types, Operand addressing; Data transfer instructions, Arithmetic instructions, Logic instructions, Control transfer instructions; Programming.

Maximum mode system configuration, Direct memory access, Interfacing of D-to-A converter, A-to-D converter, CRT Terminal Interface, Printer Interface, Programming of 8051 timers, 8051 serial interface.

Text Book(s):

1. Microprocessor Architecture, Programming and application with 8085, R.S. Gaonkar, PRI Penram International publishing PVT. Ltd., 5th Edition
2. The 8051 Microcontroller Architecture, Programming and Application, Kenneth J. Ayala, Cengage Learning, 3rd Ed.
3. Microprocessors and Interfacing, Programming and Hardware, Douglas V Hall, TMH Publication, 2006.

Reference Book(s):

1. Microprocessors and Interfacing, N. Senthil Kumar, M. Saravanan, S. Jeevananthan and S.K. Shah, Oxford University Press.
2. The 8051 Microcontroller and Embedded Systems, Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, Pearson Education, Second Edition, 2008.
3. The 8051 Microcontroller, Architecture and Programming and Application

EC-303	ANALOG INTEGRATED CIRCUITS & TECHNOLOGY	L	T	P	C
	Fifth Semester ECE	3	1	0	4

Pre-requisite- EC-210, EC-202 and EC-203

Overview of IC fabrication Technology*:* Electronic Grade Silicon preparation, Czochralski technique of crystal growth, wafer preparation and identification, Oxidation, Epitaxy: Molecular beam Epitaxy, Vapour phase Epitaxy, diffusion, ion implantation, deposition, NMOS, CMOS fabrication and BiCMOS Technology.

Introduction to IC: Difference between discrete circuits and integrated circuits, IC biasing of common MOS and BJT amplifier configurations, Switched capacitor filters.

Current sources and Active load: Introduction, Two transistor MOS current source, Current steering, Cascode current source, Wilson current source, Active loads.

Differential And Operational Amplifier: Basics of differential amplifier, Differential amplifier with passive load, Differential amplifier with active load, Calculation of common mode gain, differential mode gain and CMRR using π model, Two stage CMOS Op-Amp, Calculation of common mode gain, differential mode gain and CMRR of two stage CMOS Op-Amp using π model, Problem with more gain stages, output stage, Importance of negative feedback in Op-Amp.

Non ideal effects in Op-Amp: Practical Op-Amp Parameters, Finite Open-Loop Gain, Offset Voltage, Input Bias Current, Finite Slew rate, Additional Non ideal Effects.

Analog Multipliers: Introduction, Log-Antilog single quadrant multipliers, Emitter coupled two quadrant multipliers, Gilbert four quadrant current multiplier, Current to voltage conversion, Complete four quadrant voltage multiplier, Applications of multipliers in various communication networks.

Text/Reference books:

1. Microelectronics: Circuit Analysis and Design, Donald A Neamen, McGraw-Hill Education(4th edition)
2. Microelectronic Circuits, Adel S. Sedra and Kenneth C. Smith, Oxford University Press (7th edition)
3. Design of Analog CMOS Integrated Circuits, Behzad Razavi, Tata McGraw Hill
4. Analog Electronics with Op-Amps, A.J. Peyton and V. Walsh, Cambridge University Press
5. Analysis and Design of Analog ICs, Gray and Meyer, Wiley India Pvt Ltd
6. Silicon VLSI Technology, Plummer, Deal and Griffin, Prentice Hall

EC-304	Digital Signal Processing	L	T	P	C
	Fifth Semester ECE	3	1	0	4
	Pre-requisite- EC-204				

DISCRETE FOURIER TRANSFORM: Review of discrete-time signals & systems - DFT and its properties, FFT algorithms & its applications, Overlap-add & overlap-save methods.

DESIGN OF INFINITE IMPULSE RESPONSE FILTERS: Analog filters – Butterworth filters, Chebyshev Type I filters (up to 3rd. order), Analog Transformation of prototype LPF to BPF /BSF/ HPF. Transformation of analog filters into equivalent digital filters using Impulse invariant method and Bilinear Z transform method - Realization structures for IIR filters – direct, cascade, parallel forms.

DESIGN OF FINITE IMPULSE RESPONSE FILTERS: Design of linear phase FIR filters windowing and Frequency sampling methods - Realization structures for FIR filters – Transversal and Linear phase structures, Comparison of FIR & IIR.

FINITE WORDLENGTH FFECTS: Representation of numbers-ADC Quantization noise-Coefficient Quantization error, Product Quantization error-truncation & rounding errors -Limit cycle due to product round-off error- Round off noise power.

INTRODUCTION TO DIGITAL SIGNAL PROCESSORS: DSP functionalities–TMS320C64xx architecture– Fixed and Floating point architecture principles – addressing modes, instructions, Programming– Application examples.

MULTIRATE SIGNAL PROCESSING: Introduction to Multirate signal processing- Decimation- Interpolation- Polyphase implementation of FIR filters for interpolator and decimator –Multistage implementation of sampling rate conversion- Design of narrow band filters - Applications of Multirate signal processing.

TEXT BOOKS:

1. John G Proakis and Manolakis, —Digital Signal Processing Principles, Algorithms and Applications‖, Pearson, Fourth Edition, 2007
2. A.V.Oppenheim, R.W. Schafer and J.R. Buck, Discrete-Time Signal Processing, 8 th Indian Reprint, Pearson, 2004.
3. Rulph Chassaing and Donald Reay, Digital signal processing and applications with TMS320C6713 and TMS320C6416, Wiley, 2008.

REFERENCES:

1. Steven W. Smith, —Digital Signal Processing – A practical guide for Engineers and Scientist, Newnes publications, 2003
2. I.C.Ifeachor and B.W. Jervis, Digital Signal Processing- A practical approach, Pearson, 2002.
3. D.J. De Fatta, J.G.Lucas and W.S. Hodgkiss, Digital Signal Processing- A system Design Approach, John Wiley & sons, Singapore, 1988.
4. M. H. Hayes, Digital Signal Processing, Schaums outlines, Tata McGraw Hill, 2007. 5. Sanjit K. Mitra, Digital Signal Processing: A Computer-Based Approach, 4th Edition, Copyright© 2011, The McGraw-Hill Companies, Inc
5. TMS320C64x Technical Overview, Texas Instruments, Dallas, TX, 2001.

EC-305	Measurements and Instrumentation	L	T	P	C
	Fifth Semester ECE	3	1	0	4
	Pre-requisite- EC-101, EE-101				

INTRODUCTION: Functional elements of an instrument – Static and dynamic characteristics – Errors in measurement – Statistical evaluation of measurement data – Standards and calibration- Principle and types of analog and digital voltmeters, ammeters.

ELECTRICAL AND ELECTRONIC INSTRUMENTS: Principle and types of multi meters – Single and three phase watt meters and energy meters – Magnetic measurements – Determination of B-H curve and measurements of iron loss – Instrument transformers – Instruments for measurement of frequency and phase.

COMPARATIVE METHODS OF MEASUREMENTS: D.C potentiometers, D.C (Wheat stone, Kelvin and Kelvin Double bridge) & A.C bridges (Maxwell, Anderson and Schering bridges), transformer ratio bridges, self-balancing bridges. Interference & screening – Multiple earth and earth loops – Electrostatic and electromagnetic Interference – Grounding techniques.

STORAGE AND DISPLAY DEVICES: Magnetic disk and tape – Recorders, digital plotters and printers, CRT display, digital CRO, LED, LCD & Dot matrix display – Data Loggers.

TRANSDUCERS AND DATA ACQUISITION SYSTEMS: Classification of transducers – Selection of transducers – Resistive, capacitive & inductive Transducers – Piezoelectric, Hall effect, optical and digital transducers – Elements of data acquisition system – Smart sensors-Thermal Imagers.

TEXT BOOKS:

1. A D Helfric and W D Cooper, Modern Electronic Instrumentation and Measurement Techniques, PHI
2. A.K. Sawhney, 'A Course in Electrical & Electronic Measurements & Instrumentation' Dhanpat Rai and Co 2004.
3. J. B. Gupta, 'A Course in Electronic and Electrical Measurements', S. K. Kataria & Sons, Delhi,2003
4. Doebelin E.O. and Manik D.N., Measurement Systems – Applications and Design, Special Indian Edition, Tata McGraw Hill Education Pvt. Ltd., 2007.

REFERENCES:

1. H.S. Kalsi, 'Electronic Instrumentation', Tata McGraw Hill, II Edition 2004.
2. D.V.S. Moorthy, 'Transducers and Instrumentation', Prentice Hall of India Pvt Ltd, 2007.
3. A.J. Bouwens, 'Digital Instrumentation', Tata McGraw Hill, 1997.
4. Martin Reissland, 'Electrical Measurements', New Age International (P) Ltd., Delhi, 2001.

EC-306	**Principles of Opto-Electronics and Fibre optics**	L	T	P	C
	Fifth Semester ECE	3	0	0	3
	Pre-requisite- EC-201				

Introduction to Optical Communication: Brief introduction to opto-electronics and optical communication, advantages of optical communication. Ray theory transmission, Electromagnetic mode theory for optical propagation, Cylindrical fiber, Single Mode fibers.

Transmission characteristics of optical fibers: Attenuation, Material absorption losses in silica glass fiber, linear scattering losses, Rayleigh scattering, Chromatic dispersion, Intermodal dispersion, Overall fiber dispersion, Dispersion modified Single mode fibers, Polarization.

Fiber Optics Technology: Preparation of optical fibers, liquid phase techniques, Vapor-phase deposition techniques, Optical fiber cable. *couplers and isolators:* Fiber alignment and joint loss, Fiber splices, Fiber connectors, Fiber couplers, Optical isolators and circulators.

Optical Sources *:* Basic concepts: absorption and emission of radiation, the Einstein relations, population inversion, optical feedback and laser oscillation, threshold condition for laser oscillation. Optical emission from semiconductors, The semiconductor injection laser, Some injection laser structures, Injection laser characteristics. LED power and efficiency, LED structures, LED, Modulation and problems.

Optical Detectors: Device types, optical detection principles, Absorption, III-V alloys, Quantum efficiency, Responsivity, Long wavelength cut-off, Semiconductor photodiodes without internal gain: p-n photodiode, p-i-n photodiode speed of response and travelling wave photodiode, Noise.

Receiver Performance: *Direct detection receiver performance considerations:* Noise: Thermal noise, dark current noise, quantum noise, digital signaling quantum noise, analog signaling transmission quantum noise. Receiver noise: p-n and p-i-n photodiode receiver, APD, Gain bandwidth product

Optical system design*:* Point-to- point links- Component choice and considerations, Dispersion and attenuation limited systems, Bit error rate, Link power budget, Rise time budget, WDM, Eye pattern, recent advances.

Text Books:

1. Optical Fiber communications , J.M.Senior , PEARSON
1. Optical Fiber Communication, Gerd keiser, McGraw Hill

Reference Books:

1. Introduction to Fiber Optics, Ajoy Ghatak & K. Thyagarajan , Tata McGraw-Hill
2. An Introduction to fiber optics , Shotwell , PHI
3. Semiconductor Optoelectronic devices , P. Bhattecharjee , PHI
4. Fiber-Optic Communication Systems , G. P. Agrawal , John Wiley & Sons
5. Optical Networks , R.Ramaswami , Elsevier

EC-307	RF and Microwave Engineering	L	T	P	C
	Sixth Semester ECE	3	1	0	4
	Pre-requisite- EC-206, EC-210				

Introduction: Review of Maxwell's Equations, RF & Microwave Spectrum. Historical Background. Typical applications of RF & Microwaves

Waveguides and Resonators: Rectangular and Circular Waveguides. Node structures, Cut-off frequency, Propagation characteristics, Wall current, Attenuation constant, Waveguide excitations. Waveguide Resonators - Rectangular & Cylindrical; Resonant frequencies, Mode structures, *Q* factor, Co-axial Resonators; Excitation & Coupling of cavities, Design of resonators

Planar Structures: Strip Lines: Microstrip lines, coplanar structures, Slot lines, Suspended strip lines, Fin lines - configurations, Field patterns, Propagation characteristics, Design considerations. Comparison of characteristics of lines

Microwave Passive Components: Low frequency parameters: Impedance, Admittance, Hybrid and ABCD parameters; High Frequency parameters-S parameters, Formulation and Properties of S parameters, Reciprocal and lossless Network

E-plane, H-plane Tees, Magic Tee, Hybrid ring, Directional couplers, Power dividers, Attenuators, Phase shifter, Circulators and Isolators.

Semiconductor Microwave Components: PIN diode, Tunnel diode, Gunn diode, IMPATT diode, TRAPATT diode, Varactor diode, Schottky diode, Microwave bipolar Transistor, hetero junction bipolar transistor, Microwave field effect transistor.

Microwave Tubes: Limitations of conventional tubes in microwaves; Multi cavity Klystron, Reflex Klystron; Magnetron; Travelling Wave Tube; Backward Wave Oscillator- working principles and characteristics.

Basic Microwave Measurements: Measurement of frequency, impedance, SWR, Power, S-parameters, Attenuation, Dielectric Constant.

Text/Reference Books:

1. Microwave Engineering, D.M. Pozar, Wiley India Pvt Ltd
2. Foundations for Microwave Engineering, RE Collin, Wiley India Pvt Ltd
3. Microwave Devices and Circuits, S.M. Liao, Pearson
4. Microwave Engineering: Passive Circuits, Peter A. Rizzi, PHI

EC-308	Data Communication and Networks	L	T	P	C
	Sixth Semester ECE	3	1	0	4
	Pre-requisites-EC-205, EC-206 and EC-301				

Overview of data communication and Networking: Data communications components, data representation (ASCII, ISO etc.), direction of data flow (simplex, half duplex, full duplex), networks: distributed processing, network criteria, physical structure (type of connection, topology), categories of network (LAN, MAN, WAN), Internet: brief history, internet today, protocols and standards, reference models: OSI reference model, TCP/IP reference model, their comparative study

Physical layer: Overview of data (analog & digital), signal (analog & digital), transmission (analog & digital) & transmission media (guided & non-guided), Review of data transmission principles, transmission components, different line coding techniques, digital carrier modulation techniques: ASK, PSK, QPSK, QAM, M-ary digital modulation, data compression techniques, TDM, FDM, WDM, Circuit switching: time division & space division switch, packet switching

Data link layer: Types of errors, framing (character and bit stuffing), error detection & correction methods, flow control, protocols: stop & wait ARQ, go-back-NARQ selective repeat ARQ, HDLC, point to point protocol, token bus, token ring, reservation, polling

Multiple access protocols: Pure ALOHA, slotted ALOHA, CSMA, CSMA/CD, FDMA, TDMA, CDMA, traditional Ethernet, fast Ethernet

Network layer: Internetworking & devices: repeaters, hubs, bridges, switches, router, gateway, addressing: Internet address, classful address, subnetting, routing: techniques, static vs. dynamic routing, and routing table for classful address

Routing algorithms: shortest path algorithm, flooding, distance vector routing, link state routing, protocols: ARP, RARP, IP, ICMP, IPV6, unicast and multicast routing protocols

Transport layer: Process to process delivery, UDP, TCP, congestion control algorithm: leaky bucket algorithm, token bucket algorithm

Application layer: DNS, SMTP, SNMP, FTP, HTTP & WWW

Text Books:

1. Computer Networks, *A. S. Tanenbaum*, Pearson Education/PHI, 4th Ed.
2. Data and Computer Communications, *W. Stallings*, PHI/Pearson Education, 5th Ed.
3. Network for Computer Scientists & Engineers, *Zheng & Akhtar*, Oxford University Press
4. Data Communications and Networking, *B.A. Forouzan*, TMH, 3rd Ed.

Reference Books:

1. Computer Networking: A top down approach featuring the Internet, *Kurose and Rose,* Pearson Education
2. Communication Networks, *Leon and Garica,* TMH
3. Communication Networks, *Walrand,* TMH

EC-309	**VLSI Design**	**L**	**T**	**P**	**C**
	Sixth Semester ECE	3	1	0	4
	Pre-requisite- EC-201, EC-205				

Issues and challenges in Digital IC Design*:* Overview of VLSI Design methodologies, VLSI Design flow, design hierarchy, concepts of regularity, modularity and locality, VLSI design styles, design quality, packaging technology, computer-aided design technology.

MOSFET fabrication*:* Basic steps of fabrication, CMOS p-well and n-well processes, layout design rules, Bi-CMOS fabrication process, Full-custom mask layout design.

CMOS Inverter-Static Characteristics*:* MOS device model with sub-micron effects, critical voltage analysis of resistive load inverter, inverters with n-type MOSFET load, CMOS Inverter design, supply voltage scaling and its layouts.

CMOS Inverter- switching Characteristics and Interconnect Effects*:* Delay time definitions, calculation of delay times, inverter design with delay constraints, estimation of interconnect parasitics, calculation of interconnect delay, switching power dissipation of CMOS inverters.

Combinational MOS logic Circuits Design*:* MOS logic circuits with depletion NMOS loads, CMOS logic circuits, complex logic circuits, CMOS transmission gates (Pass gates).

Sequential MOS Logic Circuits*:* Behaviour of bistable elements, SR latch circuit, clocked latch and flip-flop circuits, CMOS D-Latch and edge-triggered Flip-flop.

Dynamic Logic Circuits*:* Basic principles of pass transistor circuits, voltage bootstrapping, synchronous dynamic circuit techniques, dynamic CMOS circuit techniques, high performance dynamic CMOS circuits.

Semiconductor Memories*:* Non-volatile and volatile memory devices, DRAM design, SRAM cell design, Flash memories, Ferroelectric RAM.

VLSI Testing*:* Fault types and models, Ad Hoc Testable Design Techniques, Scan based techniques, Built-in-self Test (BIST), I_{DDQ} Test

Text/References:

1. CMOS Digital Integrated Circuits-*Analysis and Design*, Sung-Mo (Steve) Kang Yusuf Leblebici, TMH, 3rd Ed

2. Digital Integrated Circuits- A Design Perspective, J.M. Rabaey, A. Chandrakasan and B. Nikolic, PHI,2003, 2/e
3. CMOS VLSI Design: A Circuits and Systems Perspective, N. Weste and D. Harris, Pearson,2010,4/e
4. Analysis and Design of Digital Integrated Circuits in Deep submicron Technology, D. A. Hodges, H. G. Jackson, and R. Saleh, TMH, 2003,3/e
5. Introduction to VLSI Circuits and Systems, J. P. Uyemura, Wiley, 2001, 1/e
6. Modern VLSI Design - System on Chip design, W. Wolf, PHI, 2002, 3/e

EC-310	Power Electronics	L	T	P	C
	Sixth Semester ECE	3	1	0	4
	Pre-requisite- EC-201, EC-205				

Introduction: need for power conversion with efficient, high frequency, light weight converters; Power electronic converters classifications and scope;

Power semiconductor switches: Power/fast diodes, BJT, MOSFET, SCR, Triacs, GTOs, IGBT and MCT, Ratings, static and dynamic characteristics, principle of operation, drive and switching aid circuits and cooling; isolation; protection.

AC-DC converters (Rectifiers): Diode rectifier, phase control rectifiers; effect of source inductance, single/three phase rectifiers, semi/full rectifiers, power factor, harmonics.

DC-AC converters (inverters): Concept of switched mode inverters, PWM switching, voltage and frequency control of single/three phase inverters, harmonics reduction, other switching schemes-square wave pulse switching, programmed harmonic elimination switching, current regulated modulation switching- tolerance band control, fixed frequency control, voltage source inverter (VSI),current source inverter(CSI).

DC-DC Converter (Chopper): Principle, buck, boost and buck-boost converters, analysis with continuous and discontinuous loads, flyback converters

AC voltage controllers: Principle of ON-OFF control and phase control, single/three phase controllers, PWM AC voltage controller. ;Single phase AC static switches; transient-free switching of inductive loads; cycloconverter

Basic concepts of adjustable speed dc and ac drives and industrial application, Switched mode power supply

Text/Reference books:

1. Power Electronics-Converters, Application and Design, N. Mohan, John Wiley& Sons
2. Fundamentals of Electrical Drives, G.K Dubey, Narosa Publishing House

EC-321	Microprocessors Laboratory	L	T	P	C
	Seventh Semester ECE	3	1	0	4
	Pre-requisite- Nil				

List of Experiments

1. Programs for 16 bit arithmetic operations using 8086.
2. Programs for Sorting and Searching (Using 8086).
3. Programs for String manipulation operations (Using 8086).
4. Programs for Digital clock and Stop watch (Using 8086).
5. Interfacing ADC and DAC.
6. Parallel Communication between two MP Kits using Mode 1 and Mode 2 of 8255.
7. Interfacing and Programming 8279, 8259, and 8253.
8. Serial Communication between two MP Kits using 8251.
9. Interfacing and Programming of Stepper Motor and DC Motor Speed control.
10. Programming using Arithmetic, Logical and Bit Manipulation instructions of
1. 8051microcontroller.
11. Programming and verifying Timer, Interrupts and UART operations in 8051

12. Communication between 8051 Microcontroller kit and PC.
13. A design problem using 8051 (A problem like multi-parameter data acquisition system, voltmeter, power meter, frequency counter, traffic simulation, digital clock, etc)

		L	T	P	C
EC-322	**Digital Signal Processing Laboratory**				
	Fifth semester ECE	0	0	3	2
	Pre-requisite-				

		L	T	P	C
EC-323	**Digital Communication Laboratory**				
	Fifth semester ECE	0	0	3	2
	Pre-requisite-				

		L	T	P	C
EC-324	**Design Laboratory**				
	Sixth semester ECE	0	0	3	2
	Pre-requisite-				

		L	T	P	C
EC-325	**Data & Optical Communication Laboratory**				
	Sixth semester ECE	0	0	3	2
	Pre-requisite-				

		L	T	P	C
EC-326	**VLSI Design Laboratory**				
	Sixth semester ECE	0	0	3	2
	Pre-requisite-				

		L	T	P	C
EC-401	**Wireless Communication**				
	Seventh Semester ECE	3	1	0	4
	Pre-requisite- Analog Communications, Digital Communications				

Wireless Channels: Large scale path-loss, path-loss models: free space and two-ray models; small scale fading, parameters of multipath channels, time dispersion parameters, coherence bandwidth, Doppler spread, coherence time, fading due to multi path time delay spread, flat fading, frequency selective fading, fading due to Doppler spread: fast fading and slow fading; outdoor and indoor channel models: Okumara and Hata models

Introduction to Cellular Communication: Multiple access techniques: FDMA, TDMA, CDMA; cellular concept, hexagonal cell design and its SNR calculation, splitting and sectoring cells, microcell systems, microcell system design, capacity analysis traffic analysis in terms of Erlang

Digital Signaling for Fading Channels: Structure of a wireless communication link, principle of offset QPSK, $\pi/4$ QPSK, minimum shift keying, Gaussian minimum shift keying, error performance in fading channels, OFDM principle, cyclic prefix, PAPR, windowing

GSM Technology and Evolution: GSM models and its frequency plan, overview of modulation schemes suitable for cellular communications, spectral efficiency, GPRS, EDGE, CDMA-2000, WCDMA, WiMAX, LTE, emerging techniques for 5G and beyond

TEXT/REFERENCE BOOKS

1. Fundamentals of Wireless Communications, *D. Tse and P. Viswanath*, Cambridge University Press
2. Wireless Communications, *T. S. Rappaport*, Prentice-Hall
3. Wireless Communications, *Andrea Goldsmith*, Cambridge University Press
4. A First Course in Digital Communications, *Ha H. Nguyen and Ed Shwedyk*, Cambridge University Press
5. Mobile Radio Communications, *R. Steele and L. Manzo*, John Wiley
6. Mobile Cellular Telecommunications, *W. C. Y. Lee*, McGraw Hill

EC-461	Applied Optimizations in Wireless Communications	L	T	P	C
	Professional Elective-III	3	0	0	3

Course Prerequisite: *EC-208*

Introduction: Properties of vectors-Positive semi definite matrices-Gaussian random vectors-Convex set-Hyper planes.

Convex Optimizations: Beamforming-Multi User-Cognitive Radio-Convex Optimization-Linear Program-Application: Power allocations in cooperative OFDM-QCQP, SOCP problems-Application: channel shortening for wireless equalization, robust beamforming in wireless systems

Practical Applications: Duality principle and KKT framework for optimization-Application: water-filling power allocation-Optimization for MIMO systems-OFDM systems and MIMO OFDM systems. Optimization for signal estimation-LS-WLS Regularization-Application: wireless channel estimation-image reconstruction-deburring-representation of convex optimization problems-Convex optimization for machine learning-principle component analysis-support vector machine-cooperative communication-optimal power allocation-Geometrical program-Compressive sensing-Sparse signal processing-OMP-LASSO for signal estimation

Text/Reference Books:

1. Convex Optimization, Stephen Boyd, Cambridge University Press
2. Convex Optimization in Signal Processing and Communications, Daniel P. Palomar and Yonina C. Eldar, Cambridge University Press
3. QoS-Based Resource Allocation and Transceiver Optimization, Martin Schubert and Holger Boche, Now Publishers

EC-462	ADVANCED COMMUNICATION ENGINEERING	L	T	P	C
	Professional Elective-III	3	0	0	3

Course Prerequisite: *EC-206, EC-301,EC-208*

Review of Digital Modulation Techniques: Elements of digital communication systems, review of digital modulation schemes and their comparison in terms of bandwidth, SNR, BER, bit-rates in context to wireless communication.

Receiver Design: Receivers in additive white Gaussian noise channels, CPM, MSK, CPFSK; Inter symbol interference; Adaptive receivers and channel equalization.

Multipath Mitigation Techniques:

MIMO system, linear and non-linear equalization, zero-forcing and LMS algorithms, MMSE, spatial multiplexing and diversity, error probability in fading channel, Rake receiver

Channel Coding Scheme: Block codes, convolutional codes and their performance evaluation, coded modulation schemes: TCM; Turbo codes.

Channel Modeling Techniques: Digital transmission over fading channels and performance analysis.

TEXT/REFERENCE BOOKS

1. Principles of Digital Transmission with Wireless Applications, S Benedetto and E Biglieri , Kluwer Academic
2. Fundamentals of Wireless Communications, D. Tse and P. Viswanath, Cambridge University Press
3. Digital Communications, J G Proakis , McGraw Hill
4. A First Course in Digital Communications, Ha H. Nguyen and Ed Shwedyk, Cambridge University Press
5. Information theory, Coding and Cryptography, Ranjan Bose, TMH

EC-451	RADAR Systems	L	T	P	C
	Professional Elective-II	3	0	0	3

Course Prerequisite: EC-206, EC-307

Introduction to RADAR: Radar Block Diagram and Operation, Radar Frequencies and Applications, Radar Equation, Radar Cross Section of Targets, Detection Of Signal In Noise; Receiver Noise And S/N Ratio, Transmitter Power, Pulse Repetition Frequency and Range Ambiguities. ***CW and Frequency Modulated Radar:*** Doppler Effect, CW Radar – Block Diagram, Applications; FM-CW Radar – Range and Doppler Measurement, Block Diagram and Characteristics, FM-CW altimeter, Measurement Errors, Multiple Frequency CW Radar.

MTI and Pulse Doppler Radar: Introduction, Principle, Delay Line Cancellers – Filter Characteristics, Blind Speeds, Staggered PRFs, Range Gated Doppler Filters, MTI Radar Parameters, Limitations to MTI Performance, Non-coherent MTI, MTI versus Pulse Doppler Radar.

Tracking RADAR: Tracking with Radar, Sequential Lobing, Conical Scan, Monopulse Tracking Radar – Amplitude Comparison Monopulse (one- and two- coordinates), Phase Comparison Monopulse, Target Reflection Characteristics and Angular Accuracy, Tracking in Range, Acquisition and Scanning Patterns. Comparison of Trackers.

RADAR Antennas: Reflector Antennas, Electronically Steered Phased Array Antennas, Phase Shifters, Frequency Scan Arrays, Mechanically Steered Planar Array Antennas, Radiators.

RADAR Receivers: Noise and Clutter, Superheterodyne Receiver, Duplexers and Receiver Protectors, Radar Displays.

Text/Reference Books:

1. Introduction to Radar Systems, Merrill I. Skolnik, Tata McGraw-Hill
2. Elements of Electronics Navigation, N. S. Nagaraja, Tata McGraw-Hill
3. Modern RADAR System Analysis, D. K. Barton, Artech House

EC-452	**RF Circuits and Design**	**L**	**T**	**P**	**C**
	Professional Elective-II	**3**	**0**	**0**	**3**

Course Prerequisite: EC-307

Parameters of interest in RF systems: Noise in RF circuits, Noise figure, 3rd order intercept points (IIP3 & OIP3), Dynamic Range (Linear & Spurious-free dynamic range).

n-port Networks: Scattering parameters of n-port networks, Various implementation of transmission lines in RF/microwave circuits, Tees, Circulators.

Microwave passive circuits: Filters, Impedance transformers, Hybrids, Isolators.

Microwave active circuits: Amplifiers (Class A, B, AB, C, D, E, F), Mixers, Phased Locked Loops (PLLS), Phase shifters.

Review of high speed RF devices: Schottky barrier gate FET, GaAs MESFET, High Electron Mobility Transistor (HEMT), Hetro-structures.

RF Circuits Design: Active RF components & modeling, Matching and Biasing Networks, Basic blocks in RF systems and their VLSI implementation, Design issues in integrated RF filters.

Text/Reference Books:

1. Microwave Engineering, D. M. Pozar, Wiley
2. RF Circuit Design, C. Bowick, Newnes
3. Microwave Transistor Amplifiers: Analysis and Design, G. Gonzalez, PHI
4. RF Microelectronics, B. Razavi, PHI

EC-453	**WIRELESS SENSOR NETWORK**	**L**	**T**	**P**	**C**
	Professional Elective-II	**3**	**0**	**0**	**3**

Course Prerequisite: *EC-308, EC-206, EC-301*

Sensor Network Concept: Introduction, Networked wireless sensor devices, Advantages of Sensor networks, Applications, Key design challenges.

Network deployment: Structured versus randomized deployment, Network topology, Connectivity, Connectivity using power control, Coverage metrics, Mobile deployment.

Localization and Tracking: Issues and approaches, Problem formulations: Sensing model, collaborative localization. Coarse-grained and Fine-grained node localization. Tracking multiple objects.

Wireless Communications: Link quality, shadowing and fading effects

Medium-access and sleep scheduling: Traditional MAC protocols, Energy efficiency in MAC protocols, Asynchronous sleep techniques, Sleep-scheduled techniques, and Contention-free protocols

Routing: Metric-based approaches, Multi-path routing, Lifetime-maximizing energy-aware routing techniques, Geographic routing

Sensor network Databases: Data-centric routing, Data-gathering with compression

State space decomposition and Synchronization: Issues and Traditional approaches, Fine-grained clock synchronization, and Coarse-grained data synchronization; Querying; Data-centric storage and retrieval; the database perspective on sensor networks; Security: Privacy issues, Attacks and countermeasures.

Text Books:

1. Wireless Sensor Networks: An Information Processing Approach, *Feng Zhao, Leonidas*
2. *Guibas*, Morgan Kaufmann Series in Networking 2004
3. Networking Wireless Sensors, *Bhaskar Krismachari,* Cambridge University Press

Reference Books:

1. Wireless Sensor Networks, *C.S Raghavendra, Krishna M, Sivalingam, TaiebZnati,* Springer
2. Wireless Sensor Networks: Technology, Protocols, and Applications, *Kazem Sohraby, Daniel Minoli, Taieb Znati,* Wiley Inter Science.

EC-481	WIRELESS COMMUNICATION SYSTEMS	L	T	P	C
	Open Elective-III	**3**	**0**	**0**	**3**

Course Prerequisite: EC-401

History of wireless communication: Concept of mobile and personal communication, wireless cellular platform, the design fundamentals of cellular networks, frequency reuse, spectrum capacity enhancement techniques, co-channel and adjacent channel interference, location management, handoff management; Concept of mobile IP for mobility management issues.

Propagation Models for Wireless Networks: Two-ray ground reflection model, a micro-cell propagation model, a macro-cell propagation model, shadowing model, large scale path loss and shadowing, multi path effects in mobile communication, linear time variant channel model; Concept of coherent bandwidth, Coherent time, Doppler Shift - Effect of velocity of the mobile, models for multi path reception, mobile communication antennas.

Multiple access techniques in wireless communications: frequency division multiple access technology (FDMA), time division multiple access (TDMA), space division multiple access (SDMA), code division multiple access (CDMA); spectral efficiency of different wireless access technologies, spectral efficiency in FDMA system, spectral efficiency in TDMA system, spectral efficiency for DSCDMA system.

Second Generation Mobile Networks-GSM: Architecture and protocols, access technology, call set up procedure, 2.5 G networks; evolution to GPRS, concept of data communication on GPRS, session management and PDP Context, data transfer through GPRS network and routing.

Evolution of modern mobile wireless communication systems: Personal area networks (PAN),
Public wide-area wireless networks, wireless Local Area Networks; Brief introduction to 3G – The universal mobile telecommunication system (UMTS) Basic idea of satellite mobile communication systems.

Text Books:

1. Wireless Communication and Networks, *Upen Dalal,* Oxford university Press
2. Wireless Communication and Networks 3G and Beyond, *Iti Saha Misra,* Tata McGraw Hill
3. Education Pvt. Ltd
4. Mobile Communication Engineering – Theory and Applications, *WC Y Lee,* TMH Publication

Reference Books:

1. Wireless Communications- Principles and Practice, *T S Rappaport,* Pearson Education India
2. Wireless Communication, *Andrea Goldsmith,* Cambridge University Press
3. Fundamentals of Wireless communication, *David Tse and Pramod Viswanath,* Cambridge
4. University Press
5. Advanced Electronic Communications Systems, *Wayne Tomasi,* Pearson New International Edition

EC-371	SOFT COMPUTING	L	T	P	C
	Open Elective-I	**3**	**0**	**0**	**3**

Course Prerequisite: CS-101

Open Elective I, B.Tech, Semester – VI

Introduction to Soft Computing: Soft Computing Constituents; "Soft" computing versus "Hard" computing, Characteristics of Soft computing, Real time applications of Soft computing techniques, Machine Learning Basics.

Evolutionary Algorithms: Genetic Algorithms (GAs): Concept of "Genetics" and "Evolution" and its application to probabilistic search techniques, Basic GA framework and different GA architectures, GA operators: Encoding, Crossover, Selection, Mutation, etc., Solving single-objective optimization problems using Gas; Differential Evolution; GA based Machine Learning

Metaheuristic and Swarm Intelligence: Ant colony optimization; Particle swarm optimization; Cuckoo Search Algorithm; Bacteria Foraging optimization, Various other optimization algorithms and their applications.

Artificial Neural Networks (ANN): Biological neurons and its working, Simulation of biolgical neurons to problem solving, Different ANNs architectures, Adaptive Networks – Feed Forward Networks – Supervised Learning Neural Networks – Radial Basis Function Networks - Reinforcement Learning – Unsupervised Learning Neural Networks, Applications of ANN.

Fuzzy logic: Introduction to Fuzzy logic, Fuzzy sets and membership functions, Operations on Fuzzy sets, Fuzzy relations, rules, reasoning, propositions, implications and inferences, Defuzzification techniques, Fuzzy logic controller design, Fuzzy Expert Systems – Fuzzy Decision Making, Applications of Fuzzy logic.

Adaptive Neuro-Fuzzy Inference Systems – Coactive Neuro-Fuzzy Modeling – Classification and Regression Trees – Data Clustering Algorithms – Rule base Structure Identification – Neuro-Fuzzy Control – Case Studies..

Text Books:

1. Neuro-Fuzzy and soft Computing, *J.-S. R. Jang, C.-T. Sun, and E. Mizutani,* PHI Learning, 2009
2. An Introduction to Genetic Algorithms, *Melanie Mitchell,* MIT Press, 2000
3. Introduction to Genetic Algorithms, *S.N. Sivanandam, S.N.Deepa,* Springer, 2008 edition
4. Foundations of Neural Networks, Fuzzy Systems, and Knowldge Engineering, *Nikola K. Kasabov,* MIT Press, 1998
5. Neural Networks, Fuzzy Logis and Genetic Algorithms : Synthesis, and Applications, *S. Rajasekaran, and G. A. Vijayalakshmi Pai,* Prentice Hall of India, 2007
6. Fuzzy Logic with Engineering Applications, *Timothy J. Ross,* Willey, 2010
7. Fuzzy Logic: A Pratical approach, *F. Martin, , Mc neill, and Ellen Thro,* AP Professional, 2000

Reference Books:

1. Practical Genetic Algorithms, *Randy L. Haupt and sue Ellen Haupt,* John Willey & Sons, 2002
2. Soft Computing, *D. K. Pratihar,* Narosa, 2008
3. Neuro-Fuzzy and soft Computing, *J.-S. R. Jang, C.-T. Sun, and E. Mizutani,* PHI Learning, 2009
4. Neural Networks and Learning Machines, *Simon Haykin,* PHI Learning, 2011
5. Genetic Algorithms In Search, Optimization And Machine Learning, *David E. Goldberg,* Pearson Education, 2002
6. Fuzzy Logic for Embedded Systems Applications, *Ahmed M. Ibrahim,* Elsevier Press, 2004

EC-463	**MATHEMATICS FOR COMMUNICATION ENGINEERS**	**L**	**T**	**P**	**C**
	Professional Elective-III	**3**	**0**	**0**	**3**

Course Prerequisite: EC-208, EC-206, EC-301

Introduction and Foundations: Mathematical Models, Models for Linear Systems and Signals, Adaptive Filtering, Gaussian Random Variables and Random Processes, Markov and Hidden Markov Models

Vector Spaces and Linear Algebra: Metric Spaces, Vector Spaces, Norms and Normed Vector Spaces, Inner Products and Inner Product Spaces, Induced Norms, The Cauchy-Schwarz Inequality, Orthogonal Subspaces, Projections and Orthogonal Projections, Projection Theorem Orthogonalization of Vectors.

Representation and Approximation in Vector Spaces: The Approximation Problem in Hilbert Space, The Orthogonality Principle, Matrix Representation of Least-Squares Problems, Linear Regression, Least-Squares Filtering, Minimum Mean-Square Estimation, Minimum Mean-Squared Error (MMSE) Filtering, Comparison of Least Squares and Minimum Mean Squares.

Some Important Matrix Factorization: The LU Factorization, The Cholesky Factorization, Unitary Matrices and the QR Factorization.

Eigenvalues and Eigenvectors: Eigen Values and Linear Systems, Linear Dependence of Eigenvectors, Diagonalization of a Matrix.

The Singular Value Decomposition: Theory of the SVD, Matrix Structure from the SVD, Pseudo-inverses and the SVD, Rank-Reducing Approximations: Effective Rank, System Identification Using the SVD.

Introduction to Detection and Estimation, and Mathematical Notation: Detection and Estimation Theory, Some Notational Conventions, Conditional Expectation, Sufficient Statistics, Exponential Families.

Detection Theory: Introduction to Hypothesis Testing, Neyman-Pearson Theory, Neyman Pearson testing with Composite Binary Hypotheses, Bayes Decision Theory, Some M-ary Problems, Maximum–Likelihood Detection.

Estimation Theory: The Maximum-Likelihood Principle, ML Estimates and Sufficiency, Applications of ML Estimation, Bayes Estimation Theory, Bayes risk

Text Books:

1. Mathematical Methods and Algorithms for Signal Processing, *Todd K. Moon and W. C. Stirling,* Pearson Education

Reference Books:

2. Probability, Random Variables and Random Process, *P. Z. Peebles,* McGraw Hill
3. Publications
4. Introduction to Linear Algebra, *Gilbert Strang,* Cambridge Press
5. Fundamentals of Statistical Signal Processing, Estimation Theory, *S. M. Kay*, Pearson Publication

EC-482	MOBILE COMPUTING	L	T	P	C
	Open Elective-III	**3**	**0**	**0**	**3**

Course Prerequisite: EC-401

Introduction to Personal Communications Services (PCS): PCS Architecture, mobility management, Networks signaling; Global System for Mobile Communication (GSM) System.

Overview: GSM Architecture, Mobility management, Network signaling; General Packet Radio Services (GPRS): GPRS Architecture, GPRS Network Nodes, Mobile Data Communication; WLANs (Wireless LANs) IEEE 802.II standard.

Wireless Application Protocol (WAP): The Mobile Internet standard, WAP Gateway and Protocols, wireless mark up Languages (WML).

Wireless Local Loop (WLL): Introduction to WLL Architecture, wireless Local Loop Technologies.

Third Generation (3G) Mobile Services: Introduction to International Mobile Telecommunications 2000 (IMT 2000) Vision.

Global Mobile Satellite Systems; case studies of the IRIDIUM, ICO and GLOBALSTAR systems.

Wireless Enterprise Networks: Introduction to Virtual Networks, Blue tooth technology, Blue tooth Protocols; Server-side programming in Java, Pervasive web application architecture, Device independent example application

Wideband Code Division Multiple Access (W-CDMA) and CDMA 2000; Mobile IP.

Text Books:

1. Mobile Communication , *J. Schiller,* Pearson Education
2. Mobile Computing, *Talukder,* TMH
3. Pervasive Computing, *Burkhardt,* Pearson Education
4. Mobile Computing, *Raj Kamal,* Oxford University Press

Reference Books:

1. Principles of Mobile Computing , *Hansmann, Merk,* Springer
2. Wireless Communication & Networking, *Garg,* Elsevier
3. The Wireless Application Protocol, Pearson Education, Pearson Education

EC-351	COMMUNICATION SYSTEM MODELING AND SIMULATION	L	T	P	C
	Professional Elective-I	**3**	**0**	**0**	**3**

Course Prerequisite: EC-206, EC-301

Simulation methodology- Introduction, Aspects of methodology, Performance Estimation, Sampling frequency, Low pass equivalent models for band pass signals, multicarrier signals, Non-linear and time varying systems, Post processing, Basic Graphical techniques and estimations

Simulation of random variables random process- Generation of random numbers and sequence, Gaussian and uniform random numbers Correlated random sequences, Testing of random numbers generators, Stationary and uncorrelated noise, Goodness of fit test.

Modelling of communication systems- Radio frequency and optical sources, Analog and Digital signals, Communication channel and models, Free space channels, Multipath channel and discrete channel noise and interference.

Quality of estimator, Estimation of SNR, Probability density function and bit error rate, Monte Carlo method, Importance sampling method, Extreme value theory.

Simulation and modeling methodology- Simulation environment, Modelling considerations, Performance evaluation techniques, error source simulation, Validation.

Text Books:

1. Simulation of Communication Systems: Modeling, Methodology and Techniques , *MC. Jeruchim, P. Balaban and Sam K Shanmugam,* Plenum Press, New York, 2001.

Reference Books:

2. Simulation Modeling and Analysis , *Averill. M. Law and W. David Kelton,* McGraw Hill Inc., 2000
3. Discrete Event System Simulation, *Jerry Banks and John S. Carson,* Prentice Hall
4. of India
5. Performance Analysis of Digital Communication Systems, *W. Turin,* Computer Science Press, New York
6. Principles of Communication Systems Simulation, *William H. Tranter, K. Sam Shanmugam, Theodore S. Rappaport, K. KurtL. Kosbar,* Pearson Education

EC-464	ADVANCED WIRELESS COMMUNICATIONS	L	T	P	C
	Professional Elective-III	**3**	**0**	**0**	**3**

Course Prerequisite: EC-206, EC-301, EC-401

Review of Propagation & Fading: Propagation path loss, Free-space propagation model, Indoor propagation models, Multipath fading, time dispersive and frequency dispersive channels, delay spread and coherence bandwidth, LCR and ADF.

Introduction to MIMO Communications: MIMO wireless communication, MIMO channel and signal model, fundamental trade-off, MIMO transceiver design, MIMO in wireless networks and standards, Spatial multiplexing, Spatial diversity, Alamouti Coding, Various space-time block codes.

Precoding and receiver design: Open-loop MIMO, Closed-loop MIMO, Transmit channel side information, A transmitter structure, Precoding design criteria, Linear precoder designs, Precoder performance analysis, Reception of uncoded signals, MIMO receivers for coded, and uncoded signals.

OFDM: Single-Carrier vs. Multi-Carrier Transmission, Basic Principle of OFDM, OFDM Modulation and Demodulation, Resource Allocation, PAPR, PAPR Reduction Techniques, Channel Estimation: Pilot Structure, Different channel estimation methods.

MIMO Channel Capacity: Deterministic MIMO Channel Capacity, Channel Capacity with CSIT and without CSIT, Channel Capacity of Random MIMO Channels, Channel Reciprocity, CSI Feedback, Antenna Selection Techniques, Optimum Antenna Selection Technique, Complexity-Reduced Antenna Selection, Antenna Selection for OSTBC, Capacity of MAC, and BC, Channel Inversion, Block Diagonalization, Dirty Paper Coding (DPC).

Text Books:

1. MIMO Wireless Communications, , *E. Biglieri, R. Calderbank, A. Constantinides, A. Goldsmith, A. Paulraj, H. V. Poor,* CAMBRIDGE
2. Fundamentals of Wireless Communication , *David Tse, Pramod Viswanath,* CAMBRIDGE UNIVERSITY PRESS
3. Principles of Mobile Communication, *G L. Stuber,* Kluwer Acdemic

Reference Books:

1. Digital Communications, *J G Proakis ,* McGraw Hill
2. MIMO-OFDM WIRELESS COMMUNICATIONS WITH MATLAB®, *Y. S. Cho, J. Kim, W. Y. Yang, C.G. Kang,* John Wiley & Sons
3. Wireless Communications, *Andrea Goldsmith,* CAMBRIDGE UNIVERSITY PRESS

4. MIMO Wireless Communications From real-world propagation to space–time code design, *Claude Oestges and Bruno Clerckx,* Academic Press

EC-454	ADVANCED COMMUNICATION TECHNIQUE	L	T	P	C
	Professional Elective-II	**3**	**0**	**0**	**3**

Pre-requisite- EC-206, EC-301, EC-208

Deterministic and Random Signal Analysis: Bandpass and Lowpass Signal Representation, Signal Space Representation of Waveforms, Limit Theorems for Sums of Random Variables, Random Processes, Series Expansion of Random Processes

Digital Modulation Schemes: Representation of Digitally Modulated Signals, Memoryless Modulation Methods, Signaling Schemes with Memory, Power Spectrum of Digitally Modulated Signals

Optimum Receivers for AWGN Channels: Waveform and Vector Channel Models, Waveform and Vector AWGN Channels, Optimal Detection and Error Probability for Band-Limited Signaling, Optimal Detection and Error Probability for Power-Limited Signaling, Optimal Detection in Presence of Uncertainty: Noncoherent Detection

Carrier and Symbol Synchronization: Signal Parameter Estimation, Carrier Phase Estimation, Symbol Timing Estimation, Joint Estimation of Carrier Phase and Symbol Timing, Performance Characteristics of ML Estimators

Digital Communication Through Band-Limited Channels: Characterization of Band-Limited Channels, Signal Design for Band-Limited Channels, Optimum Receiver for Channels with ISI and AWGN, Linear Equalization, Decision-Feedback Equalization

Adaptive Equalization: Adaptive Linear Equalizer, Adaptive Decision-Feedback Equalizer, Adaptive Equalization of Trellis-Coded Signals, Recursive Least-Squares Algorithms for Adaptive Equalization, Self-Recovering (Blind) Equalization

Multichannel and Multicarrier Systems: Multichannel Digital Communications in AWGN Channels, Multicarrier Communications

Text Books:

1. Principles of Digital Transmission with Wireless Applications, , *S Benedetto and E Biglieri ,* Kluwer Academic
2. Principles of Digital Communication , *R G Gallager ,* Cambridge University Press
3. Wireless Communications, *Andreas F. Molisch,* Wiley

Reference Books:

1. Digital Communications, , *J G Proakis ,* McGraw Hill
2. Fundamentals of Digital Communication, *U Madhow ,* Cambridge University Press

EC-471	Machine Learning	L	T	P	C
	Open Elective-II	**3**	**0**	**0**	**3**

Course Prerequisite: None

Introduction to Machine Learning:

Introduction, Learning Paradigms: Linear and nonlinear Regression and Feature Selection,
Overfitting and complexity; training, validation, test data, Decision Tree
Classifier Evaluation- Bayes Classifier, Bayesian Networks, k-Nearest Neighbor, Kernel Machines,
Support Vector Machines, Neural Networks, Perceptron, k-Nearest Neighbor
Multilayered Perceptron, Ensemble Learning, Boosting
Unsupervised Learning, Clustering
Introduction to Learning Theory

References:

1. T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, 2008.
2. Christopher Bishop. Pattern Recognition and Machine Learning. 2e 2009

EC-483	COGNITIVE RADIO	L	T	P	C
	Open Elective-III	**3**	**0**	**0**	**3**

Course Prerequisite: EC-401

INTRODUCTION TO COGNITIVE RADIOS Digital dividend, cognitive radio (CR) architecture, functions of cognitive radio, dynamic spectrum access (DSA), components of cognitive radio, spectrum sensing, spectrum analysis and decision, potential applications of cognitive radio

SPECTRUM SENSING Spectrum sensing, detection of spectrum holes (TVWS), collaborative sensing, geo-location database and spectrum sharing business models.

OPTIMIZATION TECHNIQUES OF DYNAMIC SPECTRUM ALLOCATION Linear programming, convex programming, non-linear programming, integer programming, dynamic programming and stochastic programming.

DYNAMIC SPECTRUM ACCESS AND MANAGEMENT Spectrum broker, cognitive radio architectures, centralized dynamic spectrum access, distributed dynamic spectrum access.

SPECTRUM TRADING Introduction to spectrum trading, classification to spectrum trading, radio resource pricing, brief discussion on economics theories in DSA, classification of auctions.

Text / Reference Books

1. Ekram Hossain, Dusit Niyato, Zhu Han, "Dynamic Spectrum Access and Management in Cognitive Radio Networks", Cambridge University Press, 2009.
2. Kwang-Cheng Chen, Ramjee Prasad, "Cognitive radio networks", John Wiley & Sons Ltd., 2009.
3. Bruce Fette, "Cognitive radio technology", Elsevier, 2nd edition, 2009.
4. Huseyin Arslan, "Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems", Springer, 2007
5. Francisco Rodrigo Porto Cavalcanti, Soren Andersson, "Optimizing Wireless Communication Systems" Springer, 2009
6. Linda Doyle, "Essentials of Cognitive Radio", Cambridge University Press, 2009

EC-352	Materials for Semiconductors	L	T	P	C
	Professional Elective-I	**3**	**0**	**0**	**3**

Course Prerequisite: *EC-101, EC-201*

VLSI Environment: Micro-contamination; Contamination Sources; Effects of Contamination; Contamination Control; Clean Room.

Semiconductor Materials: properties of semiconductors; Crystallography; Extraction of semiconductor grade silicon wafer and characterization; Wafer Surface Cleaning; Doping: Diffusion and Ion-Implantation.

Insulator Materials: Oxidation: Dry and Wet; Kinetics of SiO_2 growth; High-κ Dielectrics; Low-κ Dielectrics

Conductors or Metals: Role in Semiconductor Devices; Deposition methods; Alloying; Selection of conductors.

Vacuum Technology: Vacuum basics; Vacuum pumps: Rotary pump, Diffusion Pump, Turbo Molecular pump; Measurement of Vacuum: Pirani and Penning gauges; example of a vacuum system.

Thin Film Deposition: Chemical Vapor Deposition and Atomic Layer Deposition; Physical Vapor Deposition: Sputtering, Thermal Evaporator, e-beam evaporation; Epitaxy

Lithography: Photoresists: Negative and Positive; Deposition of photoresists; Photomasks; Lithography techniques: Optical, E-beam, and Soft Lithography; Etching: Wet and Dry; Lift-off.

Device Structures fabrication and electrical characteristics: Metal-Semiconductor Contacts: Ohmic and Schottky, Diode, MOS Capacitor and MOSFET, Memory Devices, Packaging.

Text/Reference books:

1. Silicon VLSI Technology, Plummer, Deal and Griffin, Prentice Hall
2. Fundamentals of Semiconductor Fabrication, S. M. Sze, John Wiley and Sons
3. Fundamentals of Microfabrication: The Science of Miniaturization, Marc Madou, CRC Press
4. Introduction to Microelectronic Fabrication, R.C. Jaeger, Prentice Hall
5. Semiconductor Physics and Devices, Donald A. Neaman, Tata McGraw Hills
6. Semiconductor Material and Device characterization, D. K. Schroder, John Wiley and Sons

EC-484	Nano structure and Quantum Devices	L	T	P	C
	Open Elective-III	3	0	0	3

Course Prerequisite: *PH-101, EC-201*

Semiconductor Heterojunctions, Nano-CMOS devices, Low-dimensional semiconductor structures, Semiconductor Superlattices and minibands, Optical properties of nanostructures, Resonant tunneling phenomena, Coulomb blockade and quantum transport. Metallic superlattices, Self-assembled nanostructures, Nanofabrication, Probing of nanostructures. Quantum devices: Single Electron Devices, Quantum cascade lasers, ultra-fast switching devices, high density memories, Giant Magneto Resistance and Josephson devices, Long wavelength IR detectors, photonic integrated circuits

Text/Reference Books

1. Nano structure and Quantum Devices, Science Direct
2. Nanoscale Materials and Devices for Electronics, Photonics and Solar Energy (Nanostructure Science and Technology), Springer

EC-472	INFORMATION THEORY AND CODING	L	T	P	C
	Open Elective-II	3	0	0	3

Course Prerequisite: *EC-301, EC-208*

Entropy and Mutual Information: Uncertainty and information, average mutual information and entropy, joint entropy and conditional entropy, relative entropy, chain rules

Source Coding: Information measures for continuous random variables, Kraft inequality, source coding theorem, Huffman codes, Lempel-Ziv codes

Channel Capacity: Channel models, channel capacity, channel coding, information capacity theorem, The Shannon limit

Linear Block Codes: Matrix description of linear block codes, equivalent codes, parity check matrix, decoding of a linear block code, perfect codes, Hamming codes

Cyclic Codes: Polynomials, division algorithm for polynomials, a method for generating cyclic codes, matrix description of cyclic codes, Golay codes

BCH Code: Primitive elements, minimal polynomials, generator polynomials in terms of minimal polynomials, examples of BCH codes

Convolutional Codes: Tree codes, trellis codes, polynomial description of convolutional codes, distance notions for convolutional codes, the generating function, matrix representation of convolutional codes, decoding of convolutional codes (Viterbi Decoding), distance and performance bounds for convolutional codes, examples of convolutional codes

Introduction to Turbo coding: Turbo coding, turbo decoding

TEXT/REFERENCE BOOKS

1. Elements of Information Theory, T.M. Cover and J.A. Thomas, Wiley Student Edition
2. Information theory, Coding and Cryptography, Ranjan Bose, TMH
3. Error Control Coding, Shu Lin and D J Costello Jr, Prentice Hall
4. Information and Coding, N Abramson, McGraw Hill
5. Information Theory, R B Ash, Prentice Hall

EC-455	ADVANCED OPTICAL COMMUNICATION NETWORKS	L	T	P	C
	Professional Elective-II	3	0	0	3

Pre-requisite- EC-306, EC-308

Introduction to optical networks: Telecommunication network architecture, services, circuit switching, and packet switching, optical networks, the optical layer, transparency and all-optical networks, optical packet switching, transmission basics, network evolution.

I. Technology:

Propagation of signals in optical fiber: Light propagation in optical fiber, loss and bandwidth, chromatic dispersion, nonlinear effects, solitons and problems.

Passive and Active Components: Couplers, isolators and circulators, multiplexers and filters, optical amplifiers, transmitters, detectors, wavelength converters.

Modulation and Demodulation: Modulation, Subcarrier modulation and multiplexing, spectral efficiency, demodulation, error detection and corrections.

Transmission system engineering: System model, power penalty, transmitter, receiver, optical amplifier, EDFA crosstalk, dispersion, fiber nonlinearities, wavelength stabilization.

II. Networks:

Client layers of the optical layer: SONET/SDH, Multiplexing, SONET/SDH layers, SONET frame structures, SONET/SDH physical layers ATM, IP, storage area networks, ESCON, HIPPI.

WDM Network elements: Optical line terminals, optical line amplifiers, optical add/drop multiplexers, optical crossconnects.

WDM Network Design*:* Cost trade-offs: A detailed ring network example, LTD and RWA problems, Dimensioning Wavelength-Routing networks, statistical dimensioning models, maximum load dimensioning models.

Access Networks: Network architecture overview, enhanced HFC, FTTC (Fiber to the curb), Passive optical network evolution

Text Books:

1. Optical Networks , R.Ramaswami, K.N.Sivarajan, Galen H. Sasaki , Elsevier

References Books:

1. Optical Communication System , J.Gower , Prentice Hall of India
2. Optical Fiber Communication , John M. Senior , Pearson Education
3. Optical Fiber Communication , Gerd Keiser , Mc Graw Hill
4. Fiber-optic communication systems , Govind P. Agrawal , John Wiley & sons

EC-473	**Digital Image Processing**	**L**	**T**	**P**	**C**
	Open Elective-II	**3**	**0**	**0**	**3**
	Pre-requisite- Nil				

DIGITAL IMAGE FUNDAMENTALS: Elements of digital image processing systems, Vidicon and Digital Camera working principles, - Elements of visual perception, brightness, contrast, hue, saturation, mach band effect, Color image fundamentals - RGB, HSI models, Image sampling, Quantization, dither,

IMAGE TRANSFORMATION: 2D DFT, DCT, SVD, Walsh-Hadamard transform, KLT, Harr transform and discrete wavelet transform.

IMAGE ENHANCEMENT: Point processing, Histograms, Histogram equalization and specification techniques, Noise distributions, Spatial averaging, Directional Smoothing, Median, Geometric mean, Harmonic mean, Contraharmonic mean filters, Homomorphic filtering, Color image enhancement.

IMAGE RESTORATION: Image Restoration - degradation model, Unconstrained and Constrained restoration, Inverse filtering, Wiener filtering, Geometric transformations-spatial transformations.

IMAGE SEGMENTATION: Edge detection, Edge linking via Hough transform – Thresholding - Region based segmentation– Region growing – Region splitting and Merging – Segmentation by morphological watersheds – Hybrid methods

IMAGE COMPRESSION: Need for data compression, Huffman, Run Length Encoding, Shift codes, Arithmetic coding, Vector Quantization, Transform coding, JPEG standard, MPEG

TEXT BOOKS:

1. Rafael C. Gonzalez, Richard E. Woods, , Digital Image Processing', Pearson, Education, Inc., Second Edition, 2004.
2. Anil K. Jain, Fundamentals of Digital Image Processing', Pearson Education, Inc., 2002. REFERENCES: 1. Kenneth R. Castleman, —Digital Image Processing‖, Pearson, 2006. 2. Rafael C. Gonzalez, Richard E. Woods, Steven Eddins, ‖Digital Image Processing using MATLAB‖, Pearson Education, Inc., 2004.
3. D,E. Dudgeon and RM. Mersereau, —Multidimensional Digital Signal Processing‖, Prentice Hall Professional Technical Reference, 1990.
4. William K. Pratt, —Digital Image Processing‖, John Wiley, New York, 2002.
5. Milan Sonka et aI, —Image Processing, Analysis and Machine vision‖, Brookes/Cole, Vikas Publishing House, 2nd edition, 1999.
6. Alan C. Bovik, —Handbook of image and video processing‖ Elsevier Academic press, 2005.
7. S.Sridhar, — Digital Image processing‖ Oxford University press, Edition 2011.

EC-474	**Biometrics for Network Security**	**L**	**T**	**P**	**C**
	Open Elective-II	**3**	**0**	**0**	**3**
	Pre-requisite- None				

INTRODUCTION TO BIOMETRICS: Introduction and background – biometric technologies – passive biometrics – active biometrics – Biometric systems – Enrollment – templates – algorithm – verification – Biometric applications – biometric characteristics – Authentication technologies – Need for strong authentication – Protecting privacy and biometrics and policy – Biometric applications – biometric characteristics.

FINGERPRINT TECHNOLOGY: History of fingerprint pattern recognition – General description of fingerprints – Finger print feature processing techniques – fingerprint sensors and RF imaging techniques – finger point quality assessment – computer enhancement and modeling of fingerprint images – finger print enhancement – Feature extraction – fingerprint classification – fingerprint matching.

FACE RECOGNITION AND HAND GEOMETRY: Introduction to face recognition, Neural networks for face recognition – face recognition from correspondence maps – Hand geometry – scanning – Feature Extraction – Adaptive Classifiers – Visual-Based Feature Extraction and Pattern Classification – feature extraction – types of algorithm – Biometric fusion.

MULTIMODAL BIOMETRICS AND PERFORMANCE EVALUATION: Introduction to multimodal biometric system – Integration strategies – Architecture – level of fusion – combination strategy – training and adaptability – examples of multimodal biometric systems – Performance evaluation – Statistical Measures of Biometrics – FAR – FRR – FTE – EER – Memory requirement and allocation.

BIOMETRIC AUTHENTICATION: Introduction – Biometric Authentication Methods – Biometric Authentication Systems – Biometric authentication by fingerprint – Biometric Authentication by Face Recognition – Expectation – Maximization theory – Support Vector Machines. Biometric authentication by fingerprint – biometric authentication by hand geometry – Securing and trusting a biometric transaction – matching location – local host – authentication server – match on card (MOC) – Multibiometrics and Two-Factor Authentication.

REFERENCES:

1. Paul Reid, —Biometrics for Network Security‖, Pearson Education, 2004.
2. Nalini K. Ratha, Rund Bolle,—Automatic fingerprint recognition system, Springer‖, 2003.
3. L C Jain, I Hayashi, S B Lee, U Haleci, —Intelligent Biometric Techniques in Fingerprint and Face Recognition‖.
4. S.Y.Kung,S.H.Lin,M.W.,—MakBiometricAuthentication:A Machine Learning Approach‖.
5. John Chirillo, Scott Blaul, —Implementing Biometric Security‖, John Wile, 2003.
6. IEEE – T - PAMI (IEEE transaction on Pattern Analysis and Machine Intelligence) International journal of computer vision, Springer

EC-485	**Special Topics on Image Processing**	**L**	**T**	**P**	**C**
	Open Elective-III	**3**	**0**	**0**	**3**
	Pre-requisite- nil				

REGISTRATION METHODOLOGY: Introduction. Concepts and algorithms – notation and terminology, Types of transformation, Registration algorithms, Image transformation. Correcting for scanner errors in CT,

MRI, SPECT and 3D Ultrasound – geometric distortion in CT, spatial inaccuracies in MRI, SPECT and 3D US. Detecting failure, Assessing success – measure and alignment of errors, methods for estimating error, gold standards and Registration circuits, accounting for error in the standard, independent validation

TECHNIQUES AND APPLILCATIONS OF RIGID BODY REGISTRATION: Registration and subtraction of serial MRI of the Brain: Image interpretation and clinical applications - Regional and tissue-specific appearances on different images, artifacts and failed registration, physiological changes, contrast enhancement, pediatrics, adult infarction, multiple sclerosis, tumors, schizophrenia, alzheimer‘s disease, postoperative changes, bone marrow transplantation, quantization of brain change. Role of registration in fMRI- motion correction, geometric distortion. Structural registration- Registration of MRI and PET images, Registration of MR and CT images, Image registration in nuclear medicine. Guiding therapeutic procedures

TECHNIQUES AND APPLILCATIONS OF NON-RIGID BODY REGISTRATION: Non rigid registration: concepts, algorithms and applications – registration using splines, FEM and mechanical models, optical flow, elastic registration, fluid registration, intra subject and inter subject registration. Analysis of motion and deformation using non rigid registration. Registration based analysis of normal brain anatomy and metabolism in multiple sclerosis. Biomechanical modeling for image registration: Application in image guided neuro surgery. Future applications of image registration.

OPTIMIZATION METHODS FOR MEDICAL IMAGE REGISTRATION: Optimization methods – Gradient descent (GDD & GDL)method, Non linear conjugate (NCG) method , stochastic gradient descent (SGD) method, Preconditioned SGD method and Adaptive SGD method. Quasi newton (QN) method, Evolution strategy (ES) method, Preconditioned Monomodal registration method. Label image fusion in detail.

ELASTIX - TOOL

Image registration with elastix, Registration frame work, software characteristics, Registration components, Registration set up. Transformation models. Sampling strategies and Multiresolution strategies. Atificial motions. Rigid registration of fMRI series and Non rigid registration of CT chest scans. Adaptive vs Nonadaptive. Maximum voxel displacement. Evaluation measures.

REFERENCES:

1. Joseph. V. Hajnal, Derek L.G. Hill, David J. Hawkes, ―Medical image registration‖, The Biomedical engineering series, CRC Press, 2001.
2. Stefan Klein, ―Optimization Methods for Medical image registration‖, Uitgeverij BOX press, the Netherlands, 2008.
3. Isaac N. Bankman, ―Handbook of Medical Imaging processing and analysis‖, Academic Press, 2000.
4. Steve Webb, ―The Physics of Medical Imaging‖, Taylor & Francis, New York.1988.
5. Stefan Klein, Marius Staring, Keelin Murphy, Max A. Viergever and Josien P. W. Pluim,‖ elastix: A Toolbox for Intensity-Based Medical Image Registration, IEEE Transactions on Medical Imaging, VOL. 29, NO. 1, January 2010.

EC-475	**Medical Image Processing**	**L**	**T**	**P**	**C**
	Open Elective-II	**3**	**0**	**0**	**3**
	Pre-requisite- Nil				

INTRODUCTION TO MEDICAL IMAGE RETRIEVAL: Need for Intelligent Databases – Significance of Feature Space Selection – Towards Advanced Image Retrieval – Multimedia Systems and Image Retrieval Systems – Wavelet Transforms.

IMAGE RETRIEVAL SYSTEMS: Systems Using Edge Points – Colour Histograms – Textures, Fuzzy Based Image Retrieval – System Clustering Based Image Retrieval System – Texture Based and Content based Image Retrieval Systems – Meta data based image retrieval system – Web based image retrieval system – Neural based approaches for image retrieval system.

CONTENT BASED IMAGE AND VIDEO RETRIEVAL SYSTEMS: Feature Extraction and representation – Feature classification and selection – Colour based – Features – Color models – Representation of colors properties – Texture based features – Shape based features – Specialized features – Video Parsing – Shot boundary Detection – Scene boundary detection – Video abstraction and summarization Keyframe extraction – Highlight sequences – Video content representation indexing and retrieval – video browsing schemes.

ONTOLOGY BASED MEDICAL IMAGE RETRIEVAL SYSTEM: Digital Image management in biomedicine – Ontologies and models for the handling of medical images – Advances in Image Databases languages – Indexing Large collections of medical Images – Telematics in Health care – Wavelet based medical Image distribution – Understanding and using DICOM – The data interchange standard for Bio medical Imaging.

APPLICATIONS AND CURRENT TRENDS: Image retrieval in pathology – mammography – Biomedical applications – Web related applications – ADL (Alexandria Digital Library) – AMORE (Advanced Multimedia Oriented Retrieval Engine) – BDLP (Berkeley Digital Library Project) – Blobworld CANDID (Comparison Algorithm for navigating digital image databases) – CBVQ (content based visual query) – CHROMA (colour hierarchical Representation Oriented Management Architecture).

REFERENCES:

1. Gong Yihong Gong, Intelligent Image Databases: Towards Advanced Image Retrieval, Springer, USA, 1997.
2. James Z Wang, Integrated Region – Based Image Retrieval, Springer USA, 2001.
3. Remco C Veltkamp, Hans Burkhardt, Hans-Peter Kriegel, State-Of-The-Art in Content-Based Image and Video Retreval, Springer, USA, 2001.
4. Milan Petkovic, Willem Jonker, Content-Based Video Retrieval, Springer, USA, 2003.
5. C. Brodley, A. Kak, C.Shyu, J.Dy, L.Broderick, and A.M.Aisen. Content-Based Retreival from Medical Image Databases: A Synergy of Human interactions, Maching Learning and Computer Vision, In Proc. of the Sixteenth National Conference on Artificial Intelligence (AAAI'99), Orlando Florida, July 1999.
6. C.H.Wei, C-Li and R.Wilson. A General Framework for Content-Based Medical Image Retrieval with its Application to Mammograms. In Proc. SPIE Int'l Symposium on Medical Imaging, San Diego, February, 2005.
7. Tagore, D.H., Jaffe, C.C., & Duncan. J. Medical Image Databases: A Content-based retrieval approach. Journal of American Medical Informatics Association, 4(3),1997, pp.184-198.

EC-XXX	Machine Learning	L	T	P	C
	Open Elective	3	0	0	3

Pre-requisite- ~~Opto-Electronics, Computer Networks~~

INTRODUCTION: Machine Learning - Machine Learning Foundations –Overview – Design of a Learning system- Types of machine learning –Applications Mathematical foundations of machine learning - random variables and probabilities - Probability Theory – Probability distributions -Decision Theory- Bayes Decision Theory - Information Theory

SUPERVISED LEARNING: Linear Models for Regression - Linear Models for Classification – Naïve Bayes - Discriminant Functions -Probabilistic Generative Models -Probabilistic Discriminative Models - Bayesian Logistic Regression. Decision Trees - Classification Trees- egression Trees - Pruning. Neural Networks - Feed-forward Network Functions - Back- propagation. Support vector machines - Ensemble methods- Bagging- Boosting

UNSUPERVISED LEARNING: Clustering- K-means - EM Algorithm- Mixtures of Gaussians. The Curse of Dimensionality - Dimensionality Reduction - Factor analysis - Principal Component Analysis - Probabilistic PCA Independent components analysis

PROBABILISTIC GRAPHICAL MODELS: Graphical Models - Undirected graphical models - Markov Random Fields - Directed Graphical Models -Bayesian Networks - Conditional independence properties - Inference – Learning Generalization - Hidden Markov Models - Conditional random fields(CRFs)

ADVANCED LEARNING: Sampling –Basic sampling methods – Monte Carlo. Reinforcement Learning- K-Armed Bandit Elements - Model-Based Learning- Value Iteration- Policy Iteration. Temporal Difference Learning Exploration Strategies- Deterministic and Non-deterministic Rewards and Actions Computational Learning Theory - Mistake bound analysis, sample complexity analysis, VC dimension. Occam learning, accuracy and confidence boosting

REFERENCES:

1. Christopher Bishop, "Pattern Recognition and Machine Learning" Springer, 2007.

2. Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012.
3. Ethem Alpaydin, "Introduction to Machine Learning", MIT Press, Third Edition, 2014.
4. Tom Mitchell, "Machine Learning", McGraw-Hill, 1997.
5. Trevor Hastie, Robert Tibshirani, Jerome Friedman, "The Elements of Statistical Learning", Springer, Second Edition, 2011.
6. Stephen Marsland, "Machine Learning - An Algorithmic Perspective", Chapman and Hall/CRC Press, Second Edition, 2014.

EC-372	Neural Network and Fuzzy Logic	L	T	P	C
	Open Elective-I	3	0	0	3
	Pre-requisite- None				

Introduction to Neural Networks: Introduction, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models, Integrate-and-Fire Neuron Model, Spiking Neuron Model, Characteristics of ANN, McCulloch-Pitts Model, Historical Developments, Potential Applications of ANN.

Essentials of Artificial Neural Networks: Artificial Neuron Model, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN – Connectivity, Neural Dynamics (Activation and Synaptic), Learning Strategy (Supervised, Unsupervised, Reinforcement), Learning Rules, Types of Application

Single Layer Feed Forward Neural Networks: Introduction, Perceptron Models: Discrete, Continuous and Multi-Category, Training Algorithms: Discrete and Continuous Perceptron Networks, Perceptron Convergence theorem, Limitations of the Perceptron Model, Applications.

Multilayer Feed forward Neural Networks: Credit Assignment Problem, Generalized Delta Rule, Derivation of Backpropagation (BP) Training, Summary of Backpropagation Algorithm, Kolmogorov Theorem, Learning Difficulties and Improvements.

Classical & Fuzzy Sets: Introduction to classical sets – properties, Operations and relations; Fuzzy sets, Membership, Uncertainty, Operations, properties, fuzzy relations, cardinalities, membership functions.

Fuzzy Logic System Components: Fuzzification, Membership value assignment, development of rule base and decision making system, Defuzzification to crisp sets, Defuzzification methods.

Applications: Neural network applications: Process identification, control, fault diagnosis and load forecasting. Fuzzy logic applications: Fuzzy logic control and Fuzzy classification.

TEXT BOOK

1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Rai – PHI Publication
2. Introduction to Neural Networks using MATLAB 6.0 – S.N.Sivanandam, S.Sumathi, S.N.Deepa, TMH, 2006

REFERENCE BOOKS:

1. Neural Networks – James A Freeman and Davis Skapura, Pearson Education, 2002.
2. Neural Networks – Simon Hakins, Pearson Education
3. Neural Engineering by C.Eliasmith and CH.Anderson, PHI
4. Neural Networks and Fuzzy Logic System by Bart Kosko, PHI Publications

EC-456	Advanced VLSI Design	L	T	P	C
	Professional Elective-II	3	0	0	3
	Pre-requisites- EC-309				

Implementation strategies for Digital ICs: Custom, semi-custom, structured array design approaches, custom circuit design, cell based system design methodology – standard cell, compiled cell, macro-cell, mega-cell, intellectual property, array based implementation – pre-diffused array, pre-wired array.

Interconnect: Capacitive, resistive and inductive parasitic, advanced interconnect techniques – reduced swing circuits, current mode transmission techniques, Network-on-Chip.

Timing Issues: Timing Classification of digital circuits, synchronous design, self-timed circuit design, synchronizers and arbiters, clock synthesis and synchronization.

Design Verification: Data paths in digital processor architectures, multiplier, shifter, other arithmetic operators, power and speed trade-offs in data path structures.

Memory and array structures: Memory core, memory peripheral structures, power dissipation in memories, case study-PLA, SRAM etc.
Validation and test of manufactured circuits: Design for testability- Ad Hoc testing, scan based test, boundary scan test, built-in-self test (BIST), test pattern generation- fault models, automatic test pattern generation, fault simulation.

Text/Reference books:

1. Digital Integrated Circuits- A Design Perspective, J.M. Rabaey, A. Chandrakasan and B. Nikolic, PHI
2. CMOS VLSI Design: A Circuits and Systems Perspective, N. Weste and D. Harris, Pearson

EC-465	LOW POWER VLSI DESIGN	L	T	P	C
	Professional Elective-III	3	0	0	3
	Pre-requisite- EC-309				

Introduction: Introduction, Motivation for low power design, need and application low power design, Low power design space: voltage, Physical Capacitance, Switching Activity.
Sources of power consumption and Power estimation: Static power and dynamic power: switching component of power, short circuit component of power, leakage component of power and other component of power consumption. Power estimation considering node transition activity factor, glitching effect and glitching power.
Voltage Scaling approaches for low power design: Reliability driven voltage scaling, technology driven voltage scaling, energy-delay minimum based voltage scaling, voltage scaling through threshold reduction, architecture driven voltage scaling.
Adiabatic Switching for low power design: Concept of adiabatic charging, adiabatic amplification. Adiabatic logic gates, stepwise charging, pulsed power supply.
Switching Capacitance minimization for low power design: Algorithmic approaches, Architecture optimization, Logic optimization, Circuit optimization, physical design optimization.
Low power adder design: Introduction, Standard adder: half adder, full adder, CMOS adder architectures: Ripple carry adder (RCA), Carry look- Ahead adder (CLA), Carry Select Adder (CSL), Carry Save Adder (CSA), Carry Skip Adder (CSK), Conditional Sum Adder (COS), Performances of all the adders with low power design, Bi-COS adders.

Text/Reference books:

1. Low Power Digital CMOS Design, Anantha P. Chandrakasan and Robert W. Broderson, Springer
2. Low Power CMOS VLSI Circuit Design, Kaushik Roy and Sarat C. Prasad, Wiley India Pvt Ltd
3. Low– Voltage, Low– Power VLSI Subsystems, Kiat-Seng Yeo and Kaushik Roy, TMH

EC-353	SIMULATION OF DEVICES AND CIRCUITS	L	T	P	C
	Professional Elective-I	3	0	0	3
	Pre-requisite-EC-201				

Review of Semiconductor Devices: P-N Junction Diode, Schottky diodes, MOS Device operations, Poisson's equation, continuity, drift, diffusion, mobility, trap changes. BJT models – Eber's Moll, Gummel – Poon model.
MOS Models: LEVEL1, LEVEL2 and LEVEL3, MESFETs, HEMTs and HBTs.
PSPICE: Introduction – Pspice overview – DC circuit Analysis –AC circuit analysis – Transient and the time domain – Fourier Series and Harmonic components – An introduction to Pspice devices BJT, FET, MOSFET and its model, Amplifiers and Oscillators.
MATLAB simulation for the computation of device characteristics of simple devices.
SUPREM Process simulation

Text/Reference books:

1. Semiconductor Device modeling with SPICE, Massobrio, TMH
2. Computer aided analysis of power electronic systems, Rajagopalan. V, Marcel Dekker
3. Microsim Pspice and circuit analysis, John Keown, Prentice Hall College Div
4. Introduction to Device Modeling and Circuit Simulation, T or A. Fjeldly, Trond Ytterdal, and Michael Shur, Wiley-Interscience
5. Semiconductor Material and Device Characterization, Dieter K. Schroder, Wiley-Interscience
6. Computer-Aided Circuit Analysis Using P Spice, Walter Banzhaf, Prentice Hall College Div
7. Device Electronics for Integrated Circuits, Richard S. Muller, Theodore I. Kamins, and Mansun Chan, John Wiley & Sons
8. Matlab / Simulink manual, Mathworks

EC-354 **ANALOG AND DIGITAL FILTER DESIGN** **L T P C**

Professional Elective-I **3 0 0 3**

Pre-requisite- EC-204, EC-304, EC-203

Introduction, Time and Frequency response Poles and Zeros, Analog Low Pass, High pass, Band Pass and Band Stop Filter Design, Selecting Components for Filters, Filters for Phase locked Loop (PLL), Integrated Circuit Filter Design, Introduction to Digital filters, Digital FIR Filter Design, Digital IIR Filter Design, Noise Analysis in Filter.

Text/Reference books:

1. Analog Filter Design, Van Valkenberg, Oxford University Press
2. Design of Analog Filters, Roll Schaumann, Oxford University Press
3. Analog & Digital Filters Design and Realization, H Y F Lam, PHI
4. Digital Filter Design , Antonou, TMH

EC-476 **Selected Topics on VLSI** **L T P C**

Open Elective-II **3 0 0 3**

Pre-requisite – EC-101, EC-201

Introduction to Semiconductor Industry and VLSI Technology: Clean Room, Materials for semiconductor Industry, crystallography, extraction of semiconductor grade silicon wafer and identification, Doping: Diffusion and Ion-implantation.

Thin Film Technology: Vacuum basics, Conditions for formation of thin films, Physical Vapor Deposition: Sputtering, Thermal Evaporator, e-beam evaporation, Oxidation, and Chemical Vapor Deposition.

Lithography: Photoresists: Negative and Positive, Deposition of photoresists, Photomasks, Lithography Techniques: Optical, E-beam, X-Ray and Soft Lithography, Etching: Wet and Dry, Lift-off.

Device Fabrication: Salient steps for fabrication: diode, MOS Capacitor, MOSFET devices.

VLSI Design Perspectives: Data path analysis and timing analysis

Emerging Areas in VLSI: VLSI in IOT, Embedded Systems, Challenges of Nanoelectronics, and MEMS/NEMS.

Text/Reference:

1. Silicon VLSI Technology, Plummer, Deal and Griffin, Prentice Hall
2. Fundamentals of Semiconductor Fabrication, S. M. Sze, John Wiley and Sons
3. Fundamentals of Microfabrication: The Science of Miniaturization, Marc Madou, CRC Press
4. Introduction to Microelectronic Fabrication, R.C. Jaeger, Prentice Hall
5. Semiconductor Physics and Devices, Donald A. Neaman, Tata McGraw Hills

EC-373 **RECONFIGURABLE COMPUTING AND HARDWARES** **L T P C**

Open Elective-I **3 0 0 3**

Pre-requisite-EC-205, EC-301

Introduction, Field Programmable Gate Arrays, FPGA Placement, FPGA Routing, Contrasting Processors: Fixed and Reconfigurable, Coarse-grained Reconfigurable Devices, Reconfigurable Systems.
FPGA Testing Methodology, Functional and gate level testing, SDF file description and usage.
FPGA Configuration, Different types of FPGA configuration files, Generation of configuration file and its loading into FPGA.
Multi-FPGA Partitioning, Logic Emulation, Power Reduction Techniques for FPGAs, High-Level Compilation, Reconfigurable Coprocessors, Reconfigurable Memory Security, Network Virtualization, GPGPU on FPGA.
Reconfigurable Weather Radar Data Processing, Dynamically Reconfigurable Adaptive Viterbi Decoder, High Speed Data Acquisition System for Space Applications

Text/Reference books:

1. Reconfigurable Computing, Scott Hauck and Andre DeHon, Morgan Kaufmann, Elsevier India Pvt. Ltd.-New Delhi
2. FPGA Prototyping by Verilog Examples: Xilinx Spartan-3 Version, Pong P. Chu, Wiley-Interscience
3. Rapid Prototyping of Digital Systems, James O. Hamblen, Tyson S. Hall, Michael D. Furman, Springer
4. The Design Warrior's Guide to FPGAs: Devices, Tools and Flows, Clive Max Maxfield, Reed Elsevier India
5. Advanced FPGA Design: Architecture, Implementation, and Optimization., Steve Kilts, IEEE Computer Society Press

EC-355	**ANALOG IC DESIGN**	**L**	**T**	**P**	**C**
	Professional Elective-I	**3**	**0**	**0**	**3**
	Pre-requisite- EC-203				

Differential amplifiers: Single ended and Differential operation, Basic Differential Pair, Common Mode Response, Differential Pair with MOS loads.
Passive and Active Current Mirrors: Basic Current Mirrors, Cascode Current Mirrors, Active Current Mirrors.
Operational Amplifiers: General Considerations, One- Stage Op-Amp, Two- stage Op-Amp, gain Boosting, Common Mode feedback, Input Range limitations, Slew Rate, Power Supply Rejection Ratio, Noise in Op-Amp.
Noise: Statistical characteristics of Noise, Types of noise, Representation of Noise in Circuits, Noise in Single Stage Amplifiers, Noise in Differential Pairs, Noise BW.
Stability and Frequency Compensation: General considerations, Multipole Systems, Phase Margin and Gain Margin, Frequency Compensation : Compensation of Two Stage Op-Amp, Other Compensation Techniques.
Wave generators and wave shaping: Sinusoidal oscillator, Phase shift oscillator, Wein bridge oscillator, Square wave and triangular wave generator, Voltage time base generator, step generator, Modulation of square wave.
Filters: Active RC filters, Butterworth & Chebyshev filter function, switched capacitor filter.

Text/Reference:

1. Design of Analog CMOS Integrated Circuits, Behzad Razavi, TMH
2. Analysis & Design of Analog Integrated Circuits, Gray, Hurst, Lews, and Meyer, Wiley India Pvt Ltd
3. CMOS Analog Circuit Design, Allen and Holberg, Oxford University Press
4. Analog IC Design, John & Martin, Wiley

EC-457	**CAD FOR VLSI**	**L**	**T**	**P**	**C**
	Professional Elective-II	**3**	**0**	**0**	**3**
	Pre-requisite- EC-309				

Introduction: VLSI design flow, challenges.
Verilog/VHDL: Introduction and use in synthesis, modeling combinational and sequential logic, writing test benches.
Logic synthesis: Two-level and multilevel gate-level optimization tools, state assignment of finite state machines.
Basic concepts of high-level synthesis: Partitioning, scheduling, allocation and binding. Technology mapping. Testability issues: fault modeling and simulation, test generation, design for testability, built-in self-test. Testing SoC's. Basic concepts of verification. Physical design automation.
VLSI design styles: Full-custom, standard-cell, gate-array and FPGA.

Physical design automation algorithms: Floor-planning, placement, routing, compaction, design rule check, power and delay estimation, clock and power routing, etc. Special considerations for analog and mixed-signal designs.

Text/Reference Books:

1. Synthesis and Optimization of Digital Circuits, Giovanni De Micheli, TMH
2. Algorithms for VLSI Design Automation, S. H. Gerez, John Wiley & Sons
3. High Level Synthesis: Introduction to Chip and System Design, D. D Gajski et al, Springer
4. Algorithms for VLSI Physical Design Automation, N. A. Sherwani, Springer
5. An Introduction to VLSI Physical Design, M. Sarrafzadeh and C.K. Wong, Mcgraw-Hill
6. Logic Synthesis, S. Devadas, A. Ghosh, K. Keutzer, Mcgraw-Hill

EC-466	**RF and Microwave Integrated Circuits**	**L**	**T**	**P**	**C**
	Professional Elective-III	**3**	**0**	**0**	**3**

Pre-requisite- EC-201, EC-202, EC-210

Introduction: Lower Frequency Analog Design and Microwave Design Versus Radio Frequency Integrated Circuit Design, RFIC used in a Communication Transceiver, Review of Transmission Line Theory, Distributed Transmission Lines, Smith Chart, Impedance Matching, Microstrip and Coplanar Waveguide Implementations, S Parameters, Components and Interconnects at High frequencies.

Issues in RFIC Design: Noise – Thermal Noise, Noise Power, Noise Figure, Phase Noise; Linearity and Distortion in RF Circuits – Third Order Intercept Point, Second Order Intercept Point, 1-dB Compression Point, Relationships between 1-dB compression point and IP3 Points, Broadband Measures of Linearity; Modulated Signals – PM, FM, MSK, QAM, OFDM.

LNA Design: Basic Amplifiers, Feedback Techniques, Noise in Amplifiers, Linearity in Amplifiers, Stability Analysis, Differential Amplifiers, Low Voltage Topologies and Use of on-chip Transformers, DC Bias, Broadband LNA Design, CMOS LNA Example.

Mixers: Basic Mixer Operation, Transconductance Controlled Mixer, Double Balanced Mixer, Mixer Noise, Linearity, Isolation, Genera Design Comments, Image Reject and Single-Sideband Mixer, Alternative Mixer Designs, CMOS Mixer Example.

Voltage Controlled Oscillators: LC Resonator, Analysis of Oscillator as Feedback System, Negative Resistance Oscillator, Differential Topologies, Colpitts Oscillator, Phase Noise Reduction Techniques, Quadrature Oscillators and Injection Locking. CMOS Example.

Frequency Synthesis: PLL Components, Continuous Time Analysis of PLL Synthesizers, Discrete Time Analysis for PLL Synthesizers, Transient Behaviors, Fractional – N PLL Frequency Synthesizers, CMOS Example.

Power Amplifiers: Introduction, Power Capability, Efficiency, Matching Considerations, Class A,B,C,D,E,F,G amplifiers, AC Load line, Transistor Saturation, Power Combining Techniques, Effects and Implications of Nonlinearity – Cross Modulation, AM – PM Conversion, Spectral Regrowth, Linearization Techniques, Feedforward, Feedback, Predistortion, CMOS Power Amplifier Example.

Text/Reference books:

1. The Design of CMOS Radio-Frequency Integrated Circuits, Thomas H. Lee, Cambridge University Press
2. Radio Frequency Integrated Circuit Design, Rogers and Plett, Artech House Publishers
3. RF Power Amplifiers for Wireless Communications, Steve C. Cripps, Artech House Publishers
4. Analysis and Design of Analog Integrated Circuits, Gray, Hurst, Lewis & Meyer, Wiley India Pvt Ltd
5. Design of Analog CMOS Integrated Circuits, B. Razavi, TMH

EC-374	**Nanotechnology**	**L**	**T**	**P**	**C**
	Open Elective-I	**3**	**0**	**0**	**3**

Pre-requisite- PH-101

Introduction to Quantum Mechanics: Introduction, matter waves, Heisenberg's Uncertainty Principle, Schrodinger equation, Electron Confinement, Tunnelling of a particle through Potential barrier.

Structure and bonding: Arrangement of atoms, Two dimensional Crystal Structures, Three dimensional Crystal Structures, Some example of Three dimensional crystals, planes in crystal, Crystallographic Directions, Reciprocal Lattice, Quasi crystal, Bonding in solid, electronic structure of solids.
Synthesis of Nanomaterial's: Mechanical methods- Methods based on evaporation, sputter Deposition, Chemical Vapour Deposition, Ion beam technique, and Molecular beam epitaxy.
Chemical methods: Colloids and colloids in Solutions, growth of Nanoparticles,
Biological methods: Synthesis using Microorganism, Synthesis using plant extracts.
Analysis techniques: Microscopes, Electron Microscopes, Scanning Probe Microscopes, diffraction Techniques, Spectroscopies, Magnetic measurement.
Properties of Nano material: Mechanical properties, Structural properties, melting of nanoparticles, Electrical conductivity, Optical properties, Magnetic properties.
Some special Nano material: Carbon Nano tubes, Porous Silicon, Aerogels, Zeolites, self-assembled Nanomaterial's.
Applications: Electronics, Sports and toys, Textiles, Cosmetics, Biotechnology and medical field, Space and defence.

Text/References:

1. Nano- The Next Revolution, Mohan Sunder Rajan, NBTI
2. Introduction To Nano Technology, Charles P. Pode, Springer
3. Quantum Dot Heterostructures, D.Bimberg,M.Grundman, John Wiley & Sons
4. Light and Matter, Yehuda Band, John Wiley & Sons
5. NanoPhotonics, Paras N. Prasad, John Wiley & Sons
6. Quantum Dot Heterostructures, D.Bimberg, M.Grundman, N.N. Ledenstov, John Wiley & Sons
7. Advances in Nano Science and Technology, Sharma Ashutosh, Jayesh, National Institute of Science Communication and Information Resources, Council of Scientific & Industrial Research, 2004

EC-375	**Microelectromechanical Systems**	**L**	**T**	**P**	**C**
	Open Elective-I	**3**	**0**	**0**	**3**
	Pre-requisite- PH-101				

INTRODUCTION TO MEMS AND MICROFABRICATION: MEMS Roadmap - MEMS markets - MEMS foundries - Benefits of Miniaturization- Benefits of Scaling. Microfabrication: Basic Fabrication Processes – oxidation - film deposition – lithography – etching - ion implantation – diffusion.
SURFACE MICROMACHINING AND BULK MICROMACHINING: Surface Micromachining: Basic process flow – release – stiction – material choices - residual stress - Electroplating. Bulk Micromachining: wet etch-based - dissolved wafer process - SOI MEMS – Scream – MEMS – RIE – DRIE
MECHANICS OF MEMS MATERIALS: Stress – strain - material properties - measurement & characterization of mechanical parameters. Microstructural Elements: bending moment and strain - flexural rigidity - residual stress - boundary conditions - spring combinations.
MEMS DEVICES: Pressure sensors- Accelerometers - Gyroscopes- RF MEMS Switch- Temperature sensors - Humidity sensors. Microactuators: Electrostatic – piezoelectric – SMA – Thermoelectric – electromagnetic.
FLUID DYNAMICS AND MICROPUMPS: Viscosity – density - surface tension - continuity equation - Newton's second law - Navier-Stokes equation and its interpretation - flow types. Microfluidics: Electrokinetics – electroosmosis – electrophoresis - fabrication methods - Lab on a Chip – micropumps - microvalves.

Text/References:

1. Foundations of MEMS, Chang Liu
2. MEMS, N P Mahalik
3. Microsystem Design, S. D. Senturia
4. RF MEMS & Their Applications, Varadan, Vinoy, Jose
5. MEMS and Nanotechnology Based Sensors and Devices for Communications, Medical and Aerospace Applications, A R Jha