COURSES SCHEME

&

SYLLABUS

FOR

M.E.

WIRELESS COMMUNICATIONS

2015

COURSES SCHEME & SYLLABUS FOR M.E. (WIRELESS COMMUNICATIONS)

SEMESTER – I

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PWC104	STOCHASTIC PROCESSES AND INFORMATION THEORY	3	1	0	3.5
2	PEC101	DISCRETE TIME SIGNAL PROCESSING	3	1	2	4.5
3	PEC104	ANTENNA SYSTEMS	3	0	2	4.0
4	PEC105	ADVANCED COMMUNICATION SYSTEMS	3	1	2	4.5
5	PEC108	EMBEDDED SYSTEM DESIGN (FOUR SELF EFFORT HOURS FOR PROJECT – 2 CREDITS)	3	0	4	6.0
TOTAL			**15**	**3**	**12**	**22.5**

SEMESTER – II

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PWC203	ADVANCED WIRELESS COMMUNICATION SYSTEMS	3	1	2	4.5
2	PWC201	SPACE TIME WIRELESS COMMUNICATION	3	0	0	3.0
3	PEC215	DETECTION AND ESTIMATION THEORY	3	0	0	3.0
4	PEC339	IMAGE PROCESSING AND COMPUTER VISION	2	0	2	3.0
5		ELECTIVE – I	3	0	0	3.0
6	PWC291	SEMINAR	-	-	-	2.0
TOTAL			**14**	**1**	**4**	**18.5**

SEMESTER – III

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1		ELECTIVE – II	3	0	0	3.0
2		ELECTIVE – III	3	0	0	3.0
3	PWC392	MINOR PROJECT 4	-	-	-	4.0
4	PWC491	DISSERTATION (STARTS)	-	-	-	-
TOTAL			**6**	**0**	**0**	**10.0**

SEMESTER – IV

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PWC491	DISSERTATION (CONTD …)	-	-	-	12.0
TOTAL			**-**	**-**	**-**	**12.0**

TOTAL CREDITS: 63.0

ELECTIVE–I

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PWC212	WIRELESS SECURITY	3	0	0	3.0
2	PWC202	ADVANCED WIRELESS NETWORKS	3	0	0	3.0
3	PEC211	PASSIVE OPTICAL NETWORKS	3	0	0	3.0
4	PEC219	MULTIMEDIA COMPRESSION TECHNIQUES	3	0	0	3.0
5	PEC218	DIGITAL SIGNAL PROCESSORS	2	0	2	3.0
6	PEC212	AUDIO AND SPEECH PROCESSING	3	0	0	3.0
7	PEC216	ADVANCED COMPUTER NETWORKS AND PROTOCOLS	3	0	0	3.0
8	PEC214	FRACTIONAL TRANSFORMS AND APPLICATIONS	3	0	0	3.0
9	PVL203	VLSI SIGNAL PROCESSING	3	0	0	3.0
10	PEC326	OPTOELECTRONICS	3	0	0	3.0
11	PVL213	NANOELECTRONICS	3	0	0	3.0
12	PEC207	RF DEVICES AND APPLICATIONS	3	0	0	3.0
13	PEC222	HDL AND SYSTEM C PROGRAMMING	2	0	2	3.0
14	PEC327	PHOTONIC INTEGRATED DEVICES & CIRCUITS	3	0	0	3.0

ELECTIVE–II

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PWC321	NEXT GENERATION WIRELESS SYSTEMS AND NETWORKS	3	0	0	3.0
2	PWC322	ADVANCED ERROR CONTROL CODING THEORY	3	0	0	3.0
3	PWC323	WIRELESS BROADBAND NETWORKS	3	0	0	3.0
4	PEC321	ADVANCED OPTICAL TECHNOLOGIES	3	0	0	3.0
5	PEC217	MICROSTRIP ANTENNAS	2	0	2	3.0
6	PEC337	ADAPTIVE SIGNAL PROCESSING	3	0	0	3.0
7	PVL332	MIXED SIGNAL CIRCUIT DESIGN	3	0	0	3.0
8	PVL334	HIGH SPEED VLSI DESIGN	3	0	0	3.0
9	PVL211	VLSI ARCHITECTURE	3	0	0	3.0
10	PEC206	MACHINE LEARNING	3	0	0	3.0
11	PEC338	ROBOTICS AND AUTOMATION	3	0	0	3.0
12	PVL343	SENSOR TECHNOLOGY AND MEMS	3	0	0	3.0

ELECTIVE–III

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PWC335	WIRELESS SENSOR NETWORKS	3	0	0	3.0
2	PWC336	WIRELESS COMMUNICATION PROTOCOL	3	0	0	3.0
3	PWC337	SPREAD SPECTRUM COMMUNICATION	3	0	0	3.0
4	PEC331	IP OVER WDM	3	0	0	3.0
5	PEC303	BIOMEDICAL SIGNAL PROCESSING	3	0	0	3.0
6	PEC304	CLOUD COMPUTING	3	0	0	3.0
7	PVL347	SOFT COMPUTING TECHNIQUES	3	0	0	3.0
8	PEC205	RF CIRCUIT DESIGN	3	0	0	3.0
9	PVL333	SYSTEM ON CHIP	3	0	0	3.0
10	PEC301	ARTIFICIAL INTELLIGENCE	3	0	0	3.0

PWC104: STOCHASTIC PROCESSES AND INFORMATION THEORY

L	T	P	Cr.
3	1	0	3.5

Course Objectives: To gain and understand the complete knowledge of probability theory, random variables, stochastic processes, Information theory and source coding. To familiarize the students with the applications of probabilistic and stochastic methods in communication engineering and information theory problems.

Probability and Induction: Axioms of Probability, Set Theory, Probability Space, Conditional Probability, Repeated Trials, Combined Experiments, Bernoulli Trials, Bernoulli's Theorem, and Games of Chance, Concept of a Random Variables, Distribution and Density, Function Specific Random Variables, Conditional Distributions, Binomial Random Variables, Functions of One Random Variable, its Distribution, Mean and Variance, Moments, Characteristic Functions; Bivariate Distributions, Two Functions of Two Random Variables, Joint Moments, Joint Characteristic Functions, Conditional Distributions, Conditional Expected Values, Normality, Stochastic Convergence and Center Limit Theorem

Estimation & Hypothesis Testing: Time and Ensemble Averages, Covariance and Correction Functions. Simple binary hypothesis tests, Decision Criteria, Neyman pearson tests, Bayes Criteria, Multiple Hypothesis testing, Composite hypothesis testing, Asymptotic Error rate of LRT for simple hypothesis testing

Stochastic Processes: Systems with Stochastic Inputs, Power Spectrum, Random Walks and Poisson Points, Cyclostationary Processes, Bandlimited Processes and Sampling Theory, Deterministic Signals in Noise Bispectra and System Identification, Poisson Sum Formula, Schwarz Inequality Problems, Spectral Representation of Random Processes, Factorization and Innovations, Finite-Order Systems and State Variables, Karhunen–Lo`eve Expansions, Ergodicity, Extrapolating Spectra and Youla's Parametrization, Minimum-Phase Functions, All-Pass Functions, Mean Square Estimation, Entropy, Maximum Entropy Method, Markov Chains, Higher Transition Probabilities and Chapman–Kolmogorov Equation, Stationary Distributions and Limiting Probabilities, Transient States and Absorption Probabilities, Branching Processes, Mixed Type Population of Constant Size, Structure of Periodic Chains

Queueing Systems: Characteristics of Queueing Process, birth-death process, arrival and service, steady state solution; M/G/1 and G/M/1, occupancy distribution, renewal theory, waiting time and busy period, Series Queues, Jackson Networks, Cyclic Queues. Little's theorem, modeling & analysis of M/M-/- queues, Burke's Theorem, Reversibility, Queues with vacations, Work conservation principle, Priority queues, Queues served in cyclic order, Fluid-flow and diffusion approximations

Statistical Modeling of Noise: Probability density of a Jointly-Gaussian random vector, Fourier transforms for joint densities, Wide-sense stationary (WSS) processes, Poisson process noise, sources of noise in communication systems, shot noise, resistor noise, calculation of noise in linear systems, noise bandwidth, noise temperature, noise in two-port networks, noise-figure, cascaded stages, signal in presence of AWGN, narrow band noise and colored noise

Information Theory: Unit of information, rate of information, joint entropy and conditional entropy, mutual information, Shannon-Hartley Theorem, bandwidth SNR trade off, channel capacity calculations of different channels, Source Coding- Coding efficiency, Shannon-Fano coding, Huffman coding, Lempel-Ziv adaptive coding

Text Books:

1. *Athanasios Papoulis, Probability Random Variables and Stochastic Processes, McGraw-Hill (1984)*
2. *John N. Daigle, Queueing theory with applications to packet telecommunication Springer (2005)*
3. *Bernard Sklar, "Digital Communication", Prentice Hall.*

Reference Books:

1. *P.Z. Peebles, Probability, random variables, and random signal principles, McGraw-Hill (1980).*
2. *Dimitri P. Bertsekas, Robert G. Gallager, Data networks, Prentice-Hall (1987).*
3. *A. Larson and B. O. Schubert, Stochastic Processes, vol. I and II, Holden-Day (1979).*
4. *W. Gardener, Stochastic Processes, McGraw Hill (1986).*
5. *IEEE Transactions on Information Theory*
6. *David J. C. Mackay, "Information Theory, Inference and Learning algorithms", Cambridge University Press (2003).*

Course Learning Outcomes (CLO):

At the end of the course, the students should be able to:

1. Identify and formulate fundamental probability distribution and density functions, as well as, functions of random variables.
2. Explain the concepts of expectation and conditional expectation, and describe their properties.
3. Understand and analyze continuous and discrete time random processes.
4. Explain the concepts of stationarity and wide–sense–stationarity and appreciate their physical significance.
5. Employ the theory of stochastic processes to analyze linear systems, and to have knowledge about cross– and auto–correlation of stochastic processes.
6. To have deep knowledge about power spectral analysis of stationary stochastic processes and ergodicity.
7. Understand the basic concepts of information theory, Entropy and mutual information, models of communication channels, the ultimate limits of data transmission, the process of data compression.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

PEC101: DISCRETE TIME SIGNAL PROCESSING

L	T	P	Cr
3	1	2	4.5

Course Objective: To introduce fundamentals of discrete-time linear systems and digital signal processing. Emphasizes theory but also includes design and applications.

Review of Discrete-Time (DT) signals and systems, Sampling and Reconstruction of signals, Z-transform, discrete-time Fourier transform (DTFT) and discrete Fourier transform (DFT), Divide and Conquer approach, The fast Fourier transform (FFT) algorithms: Decimation-in-Time and Decimation-in-Frequency FFT Algorithms.

Design of Digital Filters: Linear time-invariant (LTI) systems, convolution, ideal and realizable filter, liner phase filters, Design of FIR Filters, Symmetrical, Asymmetrical FIR Filters, Window Methods - Rectangular, Triangular, Hamming, Henning, Blackman, Kaiser Windows, frequency sampling techniques, Optimal filter design, IIR filters design using Bilinear transformation, impulse invariant transformation, Matched-Z transformation.

Implementation of Discrete-Time Systems: Block diagram representation, Structures for digital filtering, FIR digital filter structures: Direct form, Cascade form, Frequency sampling and lattice structures, IIR digital filter structures: Direct form, Cascade form, Parallel form, Lattice and Ladder-Lattice structures, Representation of numbers, Quantization of filter coefficients, Round-off effects.

Multi-Rate Signal Processing: Decimation and Interpolation by integer and rational factor, Aliasing error, Sample rate conversion, Poly-phase structures, Multistage implementation of Sampling rate converters, Multi-rate filter banks, Quadrature mirror filters, Applications.

Linear Prediction: Random signals, correlation function and power spectra, Forward & backward linear prediction, Solution to normal equations - Levinson-Durbin Algorithm, Schurz algorithm, Wiener filters for filtering.

Adaptive Filters: Concept of Adaptive filters, LMS algorithm, Recursive Least Square algorithm, Adaptive Ladder-Lattice filters, Applications of Adaptive filters.

Time-Frequency Analysis: Concept of time-frequency analysis, Forward and Inverse Wavelet transform, Wavelet families, Multi-resolution analysis.

Laboratory Work: Digital filter structures, Multi-rate signal processing, Prediction, Adaptive filters, Time-frequency analysis.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course Learning Outcomes (CLOs):
The student will be able to learn

1. Discrete time signal processing and filter design techniques.
2. Multi-rate signal processing and its application.
3. Theory of adaptive filter design and its applications.

4. To estimate the spectra of random signals and variety of modern and classical spectrum estimation techniques.

Text Books:

1. *Proakis, J. G. Digital Filters: Analysis, Design and Applications, McGraw Hill (1981).*
2. *Proakis, J. G. and Manolakis, D. G., Digital Signal Processing, Prentice Hall of India (2001).*

Reference Books:

1. *Antoniou, A., Digital Filters: Analysis, Design and Applications, McGraw Hill (2000).*
2. *Oppenheim, A. V., Schafer, R. W., Discrete-Time Signal Processing, Pearson (2002).*
3. *Rabinder, C. R., and Gold, B., Theory and Applications of Signal Processing, PHI (1990).*
4. *Mitra, S. K., Digital Signal Processing: A computer-based approach, Tata McGraw Hill (1996).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	24%
2.	EST	36%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40%

PEC104: ANTENNA SYSTEMS

L	T	P	Cr
3	0	2	4.0

Course Objective: The goals of this course are to develop student's analytical and intuitive understandings of antenna physics, and to introduce students to a large variety of antenna structures of practical interest related to recent developments in wireless communication and systems.

Introduction: Review of Radiation Principles: Review of vector algebra, Basic Antenna Concepts and parameters, Potential functions and the Electromagnetic field, alternating current element, Power Radiated by a current element, Applications to short antennas, Assumed current distributions, Radiation from a quarter-wave monopole or half wave dipole, Near and far fields.

Thin Linear Antennas and Arrays: Short Electric dipole, Thin linear antenna, Radiation resistance of antennas, Radiation resistance at a point which is not a current maximum, Fields of a thin linear antenna with a uniform travelling wave, Array parameters, Half-power beam-width Mathematics of linear array, Antenna element spacing without grating lobes, Linear broadside array with non-uniform distributions, Gain of regularly spaced planar arrays with $d = \lambda/2$, Tchebyscheff Array antennas, Reduction of side-lobes by tapering, Circular array, Phase and amplitude errors.

Secondary Sources and Aperture Antennas: Magnetic currents, Duality, Images of electric and magnetic currents, electric and magnetic currents as sheet sources, Impressed and induced current sources, Induction and equivalence theorems, Field of a secondary or Huygens source, Radiation from open end of a coaxial line, Radiation through an aperture in conducting screen, slot antenna.

Broadband and Frequency Independent Antennas: Broadband Antennas, the frequency-independent concept: Rum-says Principle, Frequency-independent planar log-spiral antennas, Frequency-independent conical-spiral Antennas, Log periodic antennas, Reflector antennas.

Pattern Synthesis: Approximate far field pattern of line sources, Synthesis of line sources, Fourier transform method of line sources, Antenna as a filter, Laplace transform method, Wood-wards synthesis method, Optimization methods, Synthesis of Planar rectangular source, Synthesis of planar circular source, Low side-lobe synthesis.

Effect of Mutual Coupling on Antennas: Accounting for mutual effects for dipole array-compensation using open-circuit voltages, compensation using the minimum norm formulation, Effect of mutual coupling- constant Jammers, Constant Signal, Compensation of mutual coupling- constant Jammers, Constant Signal, Result of different elevation angle.

Applications and Numerical Techniques: Different types of antennas for applications in communication systems, Antennas for space communication, Numerical techniques in antenna design.

Adaptive Array Concept: Motivation of using Adaptive Arrays, Adaptive Array problem statement, Signal Environment, Array Element Spacing considerations, Array Performance, Concept of optimum Array Processing, Recursive Methods for Adaptive Error Processing.

Laboratory Work:
Practicals related to Antenna Techniques using Software and Hardware.

Minor Project: To be assigned by concerned instructor/course-coordinator.

Course Learning Outcomes (CLOs):
Upon completion of the course the student will

1. Acquire knowledge about basic antenna concepts.
2. Have ability to understand thin linear antennas and arrays.
3. Foster ability to understand secondary sources, aperture, broadband and frequency independent antennas.
4. Acquire knowledge about effect of mutual coupling on antennas, applications and numerical techniques.
5. Have ability to understand adaptive array concept.

Text Books:

1. *Balanis, C., Antennas, John Wiley and sons (2007).*
2. *Milligan, Thomas A., Modern Antenna Design 2nd edition, IEEE press, Wiley Inter-science (2005).*

Reference Books

1. *Neelakanta, Perambur S., and Chatterjee, Rajeswari, Antennas for Information Super Skyways: An Exposition on Outdoor and Indoor Wireless Antennas, Research Studies Press Ltd. (2004).*
2. *Godara, Lal Chand, Smart Antennas, CRC Press (2004).*
3. *Munk, Ben A., Finite Antenna Arrays and FSS, John Wiley and Sons (2003).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	24%
2.	EST	36%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40%

PEC105: ADVANCED COMMUNICATION SYSTEMS

L	T	P	Cr
3	1	2	4.5

Course Objective: To introduce to analog and digital communication systems, Study of analog communication receivers, Study of signal designing for band limited channels, to introduce satellite communication and selected areas in communication.

Introduction: Introduction to analog and digital communication systems, Baseband, Band-pass and equivalent low pass signal representations, Concept of pre-envelop and Hilbert transform, Representation of band pass stochastic processes, Mathematics model of communication system.

Digital Pass Band Transmission and Optimum Receiver Design: Pass band transmission model, Gram Schmidt orthogonalization procedure, Geometric interpretation of signals, Response of bank of correlators to noisy input, Correlation demodulator, Matched filter demodulator, Optimum detector, Maximum likelihood sequence detector, A symbol by symbol MAP detector for signals, Probability of error calculations for band limited signal (ASK, PSK, QAM), Probability of error calculations for power limited signal (ASK, PSK, QAM), Probability of error calculations for binary modulation, M-ary orthogonal signals, bi-orthogonal signals, simplex signals.

Carrier and Symbol Synchronization: Likelihood function, carrier recovery and symbol synchronization in signal demodulation, ML carrier phase estimation, PLL, decision directed loops and non-decision directed loops, ML timing estimation, non-decision directed timing estimation, joint estimation of carrier phase and symbol timing.

Signal Design for Band Limited Channels: Characterization of band limited channels, design of band limited signals for no ISI, Design of band limited signals with controlled ISI, data detection for controlled ISI, signal design for channels with distortion, probability of error for detection of PAM with zero ISI and with partial response signals, modulation codes for spectrum shaping.

Communication through Band Limited Linear Filter Channels: ML receiver for channels with ISI and AWGN, discrete time model for channel with ISI, Viterbi algorithm for discrete time white noise filter model, Performance of MLSE for channels with ISI, linear equalization : peak distortion criterion, MSE criterion and its performance, fractionally spaced equalizers, decision feedback equalization : coefficient optimization, performance characteristics.

Laboratory Work:

Signal generation, modulation techniques, Equalizers carrier recovery methods using MATLAB.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course Learning Outcomes (CLOs):

1. To understand Optimum Receivers for AWGN Channels.
2. To understand the pass band communication and modulation techniques to understand the small scale fading models.
3. To understand the concept of Carrier and Symbol Synchronization.
4. To understand the concept of ISI and its removal.
5. To understand the concept of communication in band limited channels.

Text Books:

1. *Haykin, Simon, Communication Systems, Wiley (2009).*
2. *Proakis, John G. and Masoud, Salehi, Communication Systems Engineering, Prentice Hall (2001).*

Reference Books:

1. *Goldsmith, Andrea, Wireless Communications, Cambridge University Press (2005).*
2. *Tse, David and Viswanath, Pramod, Fundamentals of Wireless Communication, Cambridge University Press (2006).*
3. *Rappaport, T.S., Wireless Communications, Pearson Education (2007).*
4. *Paulraj, Arogyaswami, Gore, Dhananjay and Nabar, Rohit, Introduction to Space-Time Wireless Communications, Cambridge University.*
5. *Proakis, John G., Digital Communications, McGraw-Hill (2000).*
6. *Haykin, Simon, Digital Communications, Wiley (2007).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	24%
2.	EST	36%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40%

PEC108: EMBEDDED SYSTEMS DESIGN

L	T	P	Cr
3	0	6	6.0

Course Objective: To understand the basic concepts of embedded system, understanding of different types of programming languages used for embedded systems. Study of ARM based processors: architecture, programming and interfacing of ARM processor with memory & I/O devices. To discuss the features, Architecture and programming of Arduino Microcontroller, Architecture of Arduino. To study of RTOS.

Introduction to Embedded Systems: Background and History of embedded systems, Definition and Classification, Programming languages for embedded systems: Desirable characteristics of programming languages for embedded systems, Low-level versus high-level languages, Main language implementation issues: control, typing. Major programming languages for embedded systems. Embedded Systems on a Chip (SoC) and the use of VLSI designed circuits.

ARM Processor Fundamentals: ARM core data flow model, Architecture, ARM General Purpose Register set and GPIO's, CPSR, Pipeline, Exceptions, Interrupts, Vector Table, ARM processors family, ARM instruction set and Thumb Instruction set. ARM programming in Assembly, in C and C++ Instruction Scheduling, Conditional Execution, Looping Constructs, Bit Manipulation, Exception and Interrupt Handling.

Advanced Embedded Systems Architectures: Features of Arduino Microcontroller, Architecture of Arduino, Different boards of Arduino. Fundamental of Arduino Programming, in built functions and libraries. Serial Communication between Arduino hardware and PC and Arduino Interrupt Programming. Experimental embedded platform like Raspberry Pi.

Real Time Operating Systems (RTOS): Architecture of an RTOS, Important features of Linux, Locks and Semaphores, Operating System Timers and Interrupts, Exceptions, Tasks: Introduction, Defining a task, Task states and scheduling, Task structures, Synchronization, Communication and concurrency, Kernel objects: Semaphores, Queues.

Laboratory Work:
Introduction to ARM processor kit, Programming examples of ARM processor. Interfacing of LED, seven segment display, ADC and DAC with ARM processor. Raspberry Pi based projects.

Minor Project: ARM processor/Arduino Microcontroller/Raspberry Pi based project to be allocated to each student by the course instructor. (Four Self Effort Hours for Project – 2 Credits)

Course Learning Outcomes(CLOs):

1. Understanding of Embedded system, programming, Embedded Systems on a Chip (SoC) and the use of VLSI designed circuits.
2. Understanding of internal Architecture and programming of ARM processor.
3. Programming concepts of Arduino Microcontroller with various interfaces like memory & I/O devices and Raspberry Pi based embedded platform.
4. Need of Real Time Operating System (RTOS) in embedded systems.
5. Study of Real Time Operating system with Task scheduling and Kernel Objectives.

Text Books:

1. *Raj Kamal, Embedded System Architecture, Programming and Design, Tata McGraw Hill, (2004).*
2. *Heath, S., Embedded Systems Design, Elsevier Science (2003).*
3. *Andrew N. Sloss, ARM System Developer's Guide Designing and Optimizing System Software, Morgan Kaufman Publication (2010).*
4. *Michael McRoberts, Beginning Arduino, Technology in action publications,*

Reference Books:

1. *Simon, D.E., An Embedded Software Primer, Dorling Kindersley (2005).*
2. *Alan G. Smith, Introduction to Arduino: A piece of cake, CreateSpace Independent Publishing Platform (2011).*
3. *User manual of Raspberry pi and Red Pitaya embedded board.*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1	MST	24%
2	EST	36%
3	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40%

PWC203: ADVANCED WIRELESS COMMUNICATION SYSTEMS

L	T	P	Cr
3	1	2	4.5

Course Objective: To understand the fundamentals of wireless communication, wireless channel modeling (large scale and small scale). Calculate the capacity of wireless channels along with performance of digital modulation techniques over wireless fading channels.

Overview of Wireless Communications: Cellular Telephone Systems, Wireless LANs, Broadband Wireless access, Paging Systems, Satellite Networks, Bluetooth, Ultra-wideband, Spectrum Allocations for Systems, Cellular System Fundamentals, Channel Reuse, SIR and User Capacity, Orthogonal Systems Non-Orthogonal Systems Interference Reduction Techniques, Dynamic Channel Assignment, Shannon Capacity of Cellular Systems, Area Spectral Efficiency.

Large Scale Fading Model: Radio Wave Propagation, Free-Space Path Loss, Ray Tracing, Two-Ray Model, Ten-Ray Model (Dielectric Canyon), General Ray Tracing, Empirical Path Loss Models, Okumura Model, Hata Model, COST231 Piecewise Linear Model, Indoor Attenuation, Combined Path Loss and Shadowing, Outage Probability, Cell Coverage Area.

Small Scale Fading Model: Time-Varying Channel Impulse Response, Autocorrelation, Cross Correlation, and Power Spectral Density Level Crossing Rate and Average Fade Duration, Finite State Markov Channels, Wide band Fading Models, Power Delay Profile, Coherence Bandwidth, Doppler and Channel Coherence Time, Transforms for Autocorrelation and Scattering Functions, Discrete-Time Model, Space- Time Channel Models

Capacity of Wireless Channels: Capacity in AWGN, Capacity of Flat-Fading Channels, Channel and System Model, Channel Distribution Information (CDI) Known, Channel Side Information at Receiver, Channel Side Information at Transmitter and Receiver, Capacity with Receiver Diversity, Capacity Comparisons, Capacity of Frequency- Selective Fading Channels.

Diversity: Diversity techniques for binary signals, multiphase signals, M-ary orthogonal signals on multipath channel, Receiver Diversity, System Model, Combining techniques, Moment Generating Functions in Diversity Analysis for MRC, EGC, SC of Non-coherent and Differentially Coherent Modulation.

Multicarrier Modulation: Data Transmission using Multiple Carriers, Overlapping Sub channels, Mitigation of Sub Carrier Fading, Discrete Implementation of Multi-carrier, Cyclic Prefix, OFDM, Matrix Representation of OFDM, Vector Coding, PAR, Frequency and Timing Offset, Multi-user Channels, Multiple Access, Downlink Channel Capacity, Uplink Channel Capacity, Capacity in AWGN, Fading, and with Multiple Antennas.

Course Learning Outcomes (CLO):
At the end of this course, the students should be able to:
1. Understand the fundamentals and advancement in wireless communication systems.
2. Understand the modeling (large scale and small scale) of wireless Channel.

3. Evaluate the performance of digital modulation techniques in wireless environment.

Recommended Books:

1. *Goldsmith Andrea, Wireless Communications, Cambridge University Press (2005).*
2. *Tse, David and Viswanath, Pramod, Fundamentals of Wireless Communication, Cambridge University Press (2006).*
3. *Rappaport, T.S., Wireless Communications, Pearson Education (2007).*
4. *Paulraj, Arogyaswami, Gore, Dhananjay and Nabar, Rohit, Introduction to Space-Time Wireless Communications, Cambridge University Press (2008).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	24
2.	EST	36
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PWC201: SPACE-TIME WIRELESS COMMUNICATION

L	T	P	Cr
3	0	0	3.0

Course Objective: To understand the performance of MIMO system, MIMO-OFDM system, space time block codes (STBC), Alamouti schemes of channel estimation, space time Tresllis codes, and other various space time coding schemes and their performances analysis.

Introduction: MIMO wireless communication, MIMO channel and signal model, A fundamental trade-off, MIMO transceiver design, MIMO in wireless networks, MIMO in wireless standards. Equalizer Noise Enhancement, Equalizer Types, Folded Spectrum and ISI-Free Transmission, Linear Equalizers, Zero Forcing (ZF) Equalizers, Minimum Mean Square Error (MMSE) Equalizer, Maximum Likelihood Sequence Estimation., Decision-Feedback Equalization

Performance Limits of Multiple-Input Multiple-Output Wire Less Communication Systems: MIMO System Model, Capacity in AWGN, Channel Side Information at Receiver, Channel Side Information at Transmitter and Receiver, Capacity of Frequency-Selective Fading MIMO System Capacity Derivation, Capacity of MIMO Systems with Random Channel Coefficients Channels, Capacity of MIMO Systems with Static, Capacity of MIMO Systems with Fading Channels

Multiple Antennas and Space-Time Communications: Narrowband MIMO Model, Parallel Decomposition of the MIMO Channel MIMO Diversity Gain: Beamforming, Diversity/Multiplexing Tradeoffs, Space-Time Modulation and Coding. ML Detection and Pair Wise Error Probability

Space-Time Block Codes: Alamouti Space-Time Code with Multiple Receive Antennas, Space-Time Block Codes (STBC), STBC for Real Signal Constellations, STBC for Complex Signal Constellations, Decoding of STBC, Performance of STBC, Effect of Imperfect Channel Estimation and Antenna Correlation on Performance

Layered Space-Time Codes: LST Transmitters, LST Receivers, QR Decomposition, Interference Minimum Mean Square Error (MMSE) Suppression Combined with Interference Cancellation, Iterative LST Receivers, An Iterative Receiver with PIC, An Iterative MMSE Receiver, Comparison of the Iterative MMSE and the Iterative PIC-DSC Receiver, VBLAST architecture, DBLAST Architecture.

Space-Time Trellis Codes: Encoder Structure for STTC, Generator Description, Optimal STTC Based on the Rank, Determinant and Trace Criterion, Performance Comparison for Codes Based on Different Design Criteria, The Effect of Imperfect Channel Estimation on Code Performance, Design of Space-Time Trellis Codes on Fast Fading Channels, Construction of Recursive STTC,

Course Learning Outcomes (CLO):

At the end of the course, the students should be able to:

1. Understand the basic concepts of space time coding techniques and their used in MIMO and MIMO-OFDM system.
2. Evaluate the performance of various space time coding schemes in different fading channel scenario.

3. Solve the engineering problems related to space time coding using in MIMO-OFDM system in different fading channels.

Recommended Books:

1. *Larsson, Erik G. and Petre Stoica, Space-Time Block Coding for Wireless Communications, Cambridge University Press (2008).*
2. *David, Tse and Viswanath, Pramod, Fundamentals of Wireless Communication, Cambridge University Press (2006).*
3. *Fitzek, Frank H.P., Katz and Marcos D., Cooperation in Wireless Networks: Principles and Applications, Springer (2007).*
4. *Arogyaswami., Paulraj, Gore, Dhananjay and Nabar, Rohit., Introduction to Space-Time Wireless Communications, Cambridge University Press (2008).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30

PEC215: DETECTION AND ESTIMATION THEORY

L	T	P	CR
3	0	0	3.0

Course Objective: Comprehensive understanding of the detection, parameter estimation, and signal estimation (filtering) theory based on the observations of the continuous-time and discrete-time signals. This will acquaint the students to apply this theory in varied applications spanning from radar/sonar processing, speech processing to signal/image analysis and more. In depth detailed analytical aspects of designing and analysing various optimum detection and estimation schemes with real life examples. To familiarize the understanding of white noise and colored noise and understand the concept of suboptimum and adaptive receivers. To get familiarize with the doppler-spread targets and channels and examine the performance of the optimum receiver and the communication over doppler-spread channels.

Representations of Random Processes: Orthogonal Representations, Random Process Characterization, Homogeneous Integral Equations and Eigenfunctions, Rational Spectra, Bandlimited Spectra, Nonstationary Processes, White Noise Processes, Optimum Linear Filter, Properties of Eigenfunctions and Eigenvalues.

Detection and Estimation of Signal: Linear Estimation, Nonlinear Estimation, Known Signals in White Gaussian Noise, Detection and Estimation in Nonwhite Gaussian Noise, Whitening Approach, Karhunen-Loeve Expansion, Sufficient Statistics, Integral Equations, Sensitivity, Random Phase Angles, Random Amplitude and Phase, Multiple Channels, Multiple Parameter Estimation in AWGN Channel, No-Memory Modulation Systems, Modulation Systems with Memory, Lower Bound on Mean-Square Estimation Error, Multidimensional Waveform Estimation, Bound on the Error Matrix, Nonrandom Waveform Estimation, Solution of Wiener-Hopf Equation, Unrealizable Filters, Optimum Feedback Systems, Kalman-Bucy Filters, Differential Equation Representation of Linear Systems.

Detection of Gaussian Signals in White Gaussian Noise: Optimum Receivers, Canonical Realization: Estimator-Correlator, Filter-Correlator Receiver, Filter-Squarer-Integrator (FSI) Receiver, Long Observation Time, Simple General Binary Problem, Separable Kernel Model, Time Diversity, Frequency Diversity, Low-Energy-Coherence (LEC) Case, Suboptimum Receivers, Adaptive Receivers, Parameter Estimation Model, Estimator Structure, Derivation of the Likelihood Functions, Maximum Likelihood and Maximum A-Posteriori Probability Equations, Composite-Hypothesis Tests.

Detection of Slowly Fluctuating Point Targets: Model of a Slowly Fluctuating Point Target, White Bandpass Noise, Colored Bandpass Noise, Colored Noise with a Finite State Representation, Performance of the Optimum Estimator, Local Accuracy, Global Accuracy, Properties of Time-Frequency Autocorrelation Functions and Ambiguity Functions.

Doppler-Spread Targets and Channels: Model for Doppler-Spread Target (or Channel), Detection of Doppler-Spread Targets, Likelihood Ratio Test, Canonical Receiver Realizations, Performance of the Optimum Receiver, Communication Over Doppler-Spread Channels, Performance Bounds for Optimized Binary Systems, Doppler-Spread Target, Detection of Range-Spread Targets, Time-Frequency Duality, Dual Targets and Channels, Model for a Doubly-Spread Target, Differential-Equation Model for a Doubly-Spread Target (or Channel), Detection in the Presence of Reverberation or Clutter (Resolution in a Dense

Environment), Detection of Doubly-Spread Targets and Communication over Doubly-Spread Channels, Approximate Models for Doubly-Spread Targets and Doubly-Spread Channels, Binary Communication over Doubly-Spread Channels, Detection under LEC Conditions, Parameter Estimation for Doubly-Spread Targets, Estimation under LEC Conditions, Amplitude Estimation, Estimation of Mean Range and Doppler.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course Learning Outcomes (CLOs):

1. Introduce the fundamental concepts of detection and estimation theory involving signal and system models in which there is some inherent randomness and to investigate how to use tools of probability and signal processing to estimate signals and parameters.
2. To identify the optimal estimator/detector or at least bound the performance of any estimator/detector and to study various linear and nonlinear estimation techniques for the detection and estimation of signals with and without noise.
3. To investigate the analytical aspects of various optimum filters/receivers with their system realization and also study various adaptive filters and their mathematical models for detection of Gaussian signals.
4. To focus on the concept of white and colored noise with their finite state representation. Also, study is to be done on the time-frequency signal analysis and processing with their various mathematical distribution tools.
5. To investigate the detection of Doppler-spread targets and the canonical receiver realizations, alongwith the performance of the optimum receiver. Also, study about the models for doubly-spread targets and channels.

Text Books:

1. *H. L. Van Trees, K. L. Bell, and Z. Tian, Detection, Estimation and Modulation Theory, Part I, John Wiley & Sons, (2013), Second Edition.*
2. *H. L. Van Trees, Detection, Estimation and Modulation Theory, Part III, John Wiley & Sons, (2001), Second Edition.*
3. *S. Haykin, Adaptive Filter Theory, Prentice Hall, (2008), Fourth Edition.*

Reference Books:

1. *R. D. Hippenstiel, Detection Theory: Applications and Digital Signal Processing, CRC Press, (2001), Second Edition.*
2. *S. M. Kay, Fundamentals of Statistical Signal Processing: Practical Algorithm Development, Prentice-Hall, (2013), Second Edition.*
3. *H. V. Poor, an Introduction to Signal Detection and Estimation, Springer-Verlag, (1988), Second Edition.*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PEC339: IMAGE PROCESSING AND COMPUTER VISION

L	T	P	Cr
2	0	2	3.0

Course Objective: To make students to understand image fundamentals and how digital images can be processed, Image enhancement techniques and its application, Image compression and its applicability, fundamentals of computer vision, geometrical features of images, object recognition and application of real time image processing.

Introduction: Digital image representation, fundamental steps in image processing, elements of digital image processing systems digitization.

Digital Image Fundamentals: A Simple Image Model, Sampling and Quantization, Relationship between Pixel, Image Formats and Image Transforms.

Image Enhancement: Histogram processing, image subtraction, image averaging, smoothing filters, sharpening filters, enhancement in frequency and spatial domain, low pass filtering, high pass filtering.

Image Compression: Fundamentals, Image Compression Models, Elements of Information Theory, Error-Free Compression, Lossy Compression, Recent Image Compression Standards.

Real Time Image Processing: Introduction to Digital Signal Processor (TMS320CXX), Introduction to Texas Instruments Image Library, Development of a real time image processing algorithms.

Computer Vision: Imaging Geometry, Coordinate transformation and geometric warping for image registration, Hough transforms and other simple object recognition methods, Shape correspondance and shape matching, Principal Component Analysis, Shape priors for recognition, Implementation of computer vision algorithms using Raspberry Pi.

Laboratory Work:
1. Introduction to Image Processing Toolbox of Python and MATLAB®.
2. Sampling and Quantizing Images.
3. Histogram of Images, Contrast Enhancement.
4. Filtering of Images.
5. Geometrical transformations on Images.

Minor Project: Image Compression and Facial Feature Detection with FPGA/ASIC/ARM/DSP Processors.

Course Learning Outcomes (CLOs):
1. Understanding of fundamental techniques of Image Processing and Computer Vision.
2. Understanding and acquiring the basic skills of designing image compression.
3. Familiarizing himself/herself with image compression standards.
4. Familiarizing himself/herself with computer vision.
5. Familiarizing himself/herself with real time image processing.

Text Books:

1. *Gonzalez, R.C., and Woods, R.E., Digital Image Processing, Dorling Kingsley (2009).*
2. *Jain A.K., Fundamentals of Digital Image Processing, Prentice Hall (2007).*
3. *Sonka M., Image Processing and Machine Vision, Prentice Hall (2007).*
4. *D. Forsyth and J. Ponce, Computer Vision - A modern approach, Prentice Hall.*
5. *B. K. P. Horn, Robot Vision, McGraw-Hill.*
6. *E. Trucco and A. Verri, Introductory Techniques for 3D Computer Vision, Prentice Hall.*

Reference Books:

1. *Tekalp A.M., Digital Video Processing, Prentice Hall (1995).*
2. *Ghanbari M., Standard Codecs: Image Compression to Advanced Video Coding, IET Press (2003).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PWC212: WIRELESS SECURITY

L	T	P	Cr
3	**0**	**0**	**3.0**

Course Objectives: To gain and understand the complete knowledge of threats within wireless environments. To recognize typical vulnerabilities and safeguards for wireless communication to include; Cellular and Personal Communications Services (PCS) network security, secure wireless encrypted e-mail solution, Wireless handheld device security, PAN and LAN security.

Wireless Network Overview: RF Overview, Wireless Signal Propagation (Reflection, Refraction Diffraction, Scattering Absorption), Signal-to-Noise Ratio, Modulation, Amplitude Modulation, Frequency Modulation, Phase Modulation, Complementary Code Keying (CCK), Quadrature Amplitude Modulation (QAM).

Risks and Threats of Wireless Goals of Information Security, Analysis, Spoofing, Denial-of-Service, Malicious Code, Social Engineering, Rogue Access Points, Cell Phone Security, Wireless Hacking and Hackers, Cordless Phone Driving, War Dialing, Tracking War Drivers, RFID.

Wireless Physical Layer Technologies ISM Spectrum**,** Frequency Hopping Spread Spectrum (FHSS), Direct Sequence Spread Spectrum (DSSS), Orthogonal Frequency Division Multiplexing (OFDM).

Wireless Local and Personal Area Networks Ad Hoc Mode, Infrastructure Mode, Bridging, Repeater, Mesh Wireless Networks, Local Area Networking Standards, IEEE 802.11, Real-World Wireless Data Rates, Personal Area Network (PAN) 802.15, Bluetooth 802.15.1, Infrared (IR), Ultra wide Band 802.15.3, ZIGBEE 802.15.4

Wide Area Wireless Technologies: Cell Phone Technologies, Analog, TDMA, CDMA, CDMA2000, GSM, GPS, 802.16 Air Interface Standards, 802.20 Standards.

The Wireless Deployment Process: Gather Requirements, Estimation. Make the Business Case, Site Survey

Course Learning Outcomes (CLO):
At the end of the course, the students should be able to:

1. Understand the basic concepts of wireless security and methods to achieve it.
2. Understand the process of data hiding and its utility in wireless communication.
3. Encryption and decryption of data using optimal tools/techniques.
4. Understand the various model and their parameters on which performance of network depends in communication.

Recommended Books:

1. *Randall K.Nichols, Panos C. Lekkas Wireless Security Models, Threat And Solution, Tata Mc-Greaw HILL Edition (2006).*
2. *Aaron E.Earle , Wireless Security Handbook, Aurebeach Publication (2006).*
3. *Tara M, Swaminatha, Charles R. Elden, "Wireless Security and Privacy: Best Practice and Design Technique", Pearson Edition (2003).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30

PWC202: ADVANCED WIRELESS NETWORKS

L	T	P	Cr
3	0	0	3.0

Course Objectives: Build an understanding of the fundamental concepts of wireless networking. Familiarize the student with the basic taxonomy and terminology of the various channel modeling and layers of the network. Introduce the student to resource management and security issues in wireless networks. Allow the student to gain expertise in some specific areas of networking such as Ad Hoc networks, sensors networks, and active networks.

Fundamentals: 4G Networks and Composite Radio Environment, Protocol Boosters, Hybrid 4G Wireless Network Protocols, Green Wireless Networks, Physical Layer and Multiple Access, Multicarrier CDMA, Ultrawide Band Signal, MIMO Channels and Space Time Coding

Channel Modeling for 4G: Macrocellular Environments, Urban Spatial Radio Channels in Macro/MicroCell Environment, MIMO Channels in Micro- and PicoCell Environment, Outdoor Mobile Channel, Microcell Channel, Wireless MIMO LAN Environments

Adaptive and Reconfigurable Link Layer: Link Layer Capacity of Adaptive Air Interfaces, Adaptive Transmission in *Ad Hoc* Networks, Adaptive Hybrid ARQ Schemes for Wireless Links, Stochastic Learning Link Layer Protocol, Adaptive Medium Access Control

Adaptive Network and TCP Layer: Graphs and Routing Protocols, Graph Theory, Routing with Topology Aggregation, Network and Aggregation Models, Effective Capacity, TCP Operation and Performance, TCP for Mobile Cellular Networks, Random Early Detection Gateways for Congestion Avoidance TCP for Mobile *Ad Hoc* Networks.

Mobility and Resource Management: Prioritized Handoff, Cell Residing Time Distribution, Mobility Prediction in Pico- and Micro-Cellular Networks, Channel Assignment Schemes, Resource Management in 4G.

Security: Authentication, Security Architecture, Security Management in GSM Networks, Security Management in UMTS, Security Architecture for UMTS/WLAN Interworking, Security in *Ad Hoc* Networks, Security in Sensor Networks.

Network Deployment and Management: Cellular Systems with Overlapping Coverage, Multitier Wireless Cellular Networks, Local Multipoint Distribution Service., Self-organization in 4G Networks, Simple Network Management Protocol, Distributed Network Management.

***Ad Hoc* and Sensor Networks:** Routing Protocols, Hybrid Routing Protocol, Scalable Routing Strategies, Multipath Routing, Clustering Protocols. Cashing Schemes for Routing, Distributed QoS Routing, Sensor Networks Parameters, Sensor Networks Architecture. Mobile Sensor Networks Deployment, Directed Diffusion

Active Networks: Programmable Networks Reference Models, Programmable 4G Mobile Network Architecture, Cognitive Packet Networks, Game Theory Models in Cognitive Radio Networks, Biologically Inspired Networks. Energy-efficient Wireless Networks: Energy Cost Function, Minimum Energy Routing, Maximizing Network Lifetime, Energy-efficient MAC in Sensor Networks.

Network Information Theory: Effective Capacity of Advanced Cellular Networks, Capacity of *Ad Hoc* Networks. Information Theory and Network Architectures, Cooperative Transmission in Wireless Multihop *Ad Hoc* Networks, Network Coding,

Course Learning Outcomes (CLO):

Having successfully completed this course, the students will:

1. Demonstrate their ability to perform channel modeling for 4G wireless systems
2. Demonstrate advanced knowledge of networking and wireless networking in particular
3. Demonstrate knowledge of protocols and programming used in wireless communications

Recommended Books:

1. Lewis, Barry D., Davis, Peter T., Wireless Networks for Dummies, John Wiley and sons (2004).

2. Chen, Hsiao-Hwa and Guizani, Mohsen, Next Generation Wireless Systems and Networks, John Wiley and Sons (2006).

3. Glisic, Savo G., Advanced Wireless Networks, John Wiley and Sons (2006).

4. Rappaport, T.S., Wireless Communications

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30

PEC211: PASSIVE OPTICAL NETWORKS

L	T	P	Cr
3	0	0	3.0

Course Objective: In this course the students will learn the basic optical networks design using point-to-point fiber links, star, bus and ring topologies, multiple access techniques such as WDM, SONET, PON widely used with FTTH schemes and emerging ROF networks that bridge the optical and wireless networks.

Architecture Of Future Access Networks: Multiplexing Level, WDM – Passive Optical Network, Wavelength Allocation Strategies, Dynamic Network Reconfiguration Using Flexible WDM, Static WDM PONs, Wavelength Routed PON, Reconfigurable WDM PONs, Wavelength Broadcast andSelect Access Network, Wavelength Routing Access Network, Geographical, Optical and Virtual Topologies: Star, Tree, Bus, Ring and Combined, Compatibility with Radio Applications UWB, UMTS, Wi-Fi, Radio-Over-Fibre, Next Generation G/E-PON Standards Development Process.

Components for Future Access Networks: Tuneable Optical Network Unit, Fast-Tunable Laser at the Optical Line Terminal, Arrayed Waveguide Gratings, Reflective Receivers and Modulators, Colourless ONT.

Enhanced Transmission Techniques: Advanced Functionalities in PONs, Bidirectional Single Fibre Transmission (colourless), Optical Network Unit, Re-modulation by Using Reflective Semiconductor Optical Amplifiers, Fabry Perot Injection Locking with High Bandwidth and Low Optical Power for Locking, Characterization of Rayleigh Backscattering, Strategies to Mitigate Rayleigh Backscattering, ASK-ASK Configuration Using Time Division Multiplexing, FSK-ASK Configuration Using Modulation Format Multiplexing, Subcarrier Multiplexing by Electrical Frequency Multiplexing. Rayleigh Scattering Reduction by Means of Optical Frequency Dithering, Spectral Slicing, Alternative Modulation Formats to NRZ ASK, Bidirectional Very High Rate DSL Transmission Over PON, Active and Remotely-Pumped Optical Amplification, Variable Splitter, Variable Multiplexer.

Network Protection: Protection Schemes, Reliability Performance Evaluation.

Traffic Studies: Dynamic Bandwidth Allocation, QoS and Prioritization in TDMA PONs, WDMA/TDMA Medium Access Control, Access Protocols for WDM Rings with QoS Support, Efficient Support for Multicast and Peer-to-Peer Traffic.

Metro-Access Convergence: Core-Metro-Access Efficient Interfacing, Optical Burst Switching in Access, Sardana Network: An Example of Metro-Access Convergence.

Economic Models: WDM/TDM PON, Long Reach PONs, Long Term Dynamic WDM/TDM-PON Cost Comparison.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course Learning Outcomes (CLOs):
After completing this course student will be able to

1. Understand and evaluate the performance of various enabling technologies used in modern optical networks.
2. Evaluate different WDM network topologies including broadcast-and-select and wavelength routing networks.
3. Design virtual WDM network topologies.
4. Analyze Photonic packet switching networks and time domain optical networking approaches.

Text Books:

1. *Josep, Prat, Next-Generation FTTH Passive Optical Networks, Spinger (2008).*
2. *Dhaini, Ahmad R., Next-Generation Passive Optical Networks, VDM Verlag (2008).*

Reference Books:

1. *Kramer, Glen and Kramer, Glen, Ethernet Passive Optical Networks, McGraw-Hill (2005).*
2. *Lam, Cedric F. (Editor), Passive Optical Networks: Principles and Practice, Academic Press (2007).*

Evaluation Scheme:

S.No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PEC219: MULTIMEDIA COMPRESSION TECHNIQUES

L	T	P	Cr
3	0	0	3.0

Course Objective: To provide the foundation knowledge of multimedia computing, e.g. media characteristics, compression standards, multimedia representation, Data formats, multimedia technology development and to provide programming training in multimedia computing, Multimedia system design and implementations.

Human's Visual and Audio system: Characteristics of human visual system, Light and visible light, human retina structure and functions, Non-perceptual uniform color models and perceptual uniform color models, Characteristics of human's audio system, Frequency response and magnitude range.

Multimedia Data Representation and Analysis: Representation of sound/audio, Image and video,speech generation, Analysis and software, Image analysis, Display, and printing.

Text Coding: Lossless JPEG, UNIX compress, and the GIF format, Burrows-Wheeler compression, Gunzip, Winzip etc.

Speech Compression: Speech Production model, Objectives and requirements of speech coding, Quantizers for speech signal, Differential PCM and adaptive prediction, Linear predictive coding(LPC) of speech, Computational aspects of LPC parameters, Cholesky decomposition, Lattice formulation of LPC parameters, Linear predictive synthesizers, LPC Vocoder, Code excited linear predictive coding, Voice excited linear predictive coding.

Image Compression: Introduction, Lossless and Lossy image compression, Discrete Cosine Transform (DCT), DCT Quantization and limitations, Theory of wavelets, Discrete wavelet transforms (DWT), DWT on images and its encoding, Embedded Zero Tree wavelet encoding, Digital watermarking, Introduction to Curve-lets.

Video Coding: Video coding and various building blocks, Motion estimation techniques, Fast motion estimation techniques, Video coding standards, Advanced coding aspects, Introduction to VoIP, VoIP signaling, H.323 Protocol, H.323 multiplexing, Header compression and bandwidth, ISDN Video conferencing, Features and design issues of H.264 video standards, Video Conferencing, SIP protocol.

Multimedia Technology Development: Multimedia history, technology development, challenging problem, research difficulty, multimedia industry.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course Learning Outcomes (CLOs):
At the end of the course, the students should be able to:
1. Understand and develop human speech mode,understand characteristics of human's visual system, understand the characteristics of human's audio system.
2. Understand different compression principles, understand different compression techniques, understand different multimedia compression standards, be able to design

and develop multimedia systems according to the requirements of multimedia applications.
3. Understand the various signal processing aspects of achieving high compression ratios.
4. Understand and develop new paradigm technologies in audio and video coding.
5. Understand the application of modern multimedia compression techniques in the development of new wireless communication protocols.

Text Books:

1. *Deller, J., Proakis, J. and Hansen, J., Discrete-Time Processing of Speech Signals, IEEE (1993).*
2. *Rabiner, L. and Schafer, R., Digital Processing of Speech Signals. Signal Processing, Prentice-Hall (1978).*

Reference Books:

1. *Gonzalez, R.C., and Woods, R.E., Digital Image Processing, Dorling Kingsley, (2009).*
2. *Jain A.K., Fundamentals of Digital Image Processing, Prentice Hall (2007).*
3. *Tekalp A.M., Digital Video Processing, Prentice Hall (1995).*
4. *Z.N. Li and M.S. Drew, Fundamentals of Multimedia. Prentice Hall, (2003).*
5. *K. Jeffay and H. Zhang, Readings in Multimedia Computing and Networking. Morgan Kaufmann, (2002).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PEC218: DIGITAL SIGNAL PROCESSORS

L	T	P	Cr
2	0	2	3.0

Course Objective: To familiarize students with the fundamentals of operating, architecture, interfacing and analyzing real time digital signal processing systems, including the required theory, the hardware used to sample and process the signals, and real time software development environments.

An Introduction to DSP Processors: Advantages of DSP, characteristics of DSP systems, classes of DSP applications, DSP processor embodiment and alternatives, Fixed Vs Floating point processors, fixed point and Floating Point Data Paths.

DSP Architecture: An introduction to Harvard Architecture, Differentiation between Von-Neumann and Harvard Architecture, Quantization and finite word length effects, Bus Structure, Central Processing Unit, ALU, Accumulators, Barrel Shifters, MAC unit, Compare, Select, and store unit (CSSU), Data addressing and program memory addressing.

Memory Architecture: Memory structures, features for reducing memory access required, wait states, external memory interfaces, memory mapping, data memory, program memory and I/O memory, memory mapped registers.

Addressing: Various addressing modes: implied addressing, immediate data addressing, memory direct addressing, register direct and indirect addressing, and short addressing modes.

Instruction Set: Instruction types, various types registers, orthogonality, assembly language and application development.

Execution Control and Pipelining: Hardware looping, interrupts, stacks, pipelining and performance, pipelining depth, interlocking, branching effects, interrupt effects, instruction pipelining.

Peripherals: Serial ports, timers, parallel ports, bit I/O ports, host ports, communication ports, on-chip A/D and D/A converters, external interrupts, on chip debugging facilities, power consumption and management.

Processors: Architecture and instruction set of TMS320C3X, TMS320C5X, TMS320C6X, ADSP 21XX DSP Chips, some example programs.

Recent Trends in DSP System Design: FPGA-Based DSP System Design, advanced development tools for FPGA, Development tools for Programmable DSPs, An introduction to Code Composer Studio.

Laboratory Work:
Introduction to code composer studio, Using CCS write program to compute factorial, dot product of two arrays, Generate Sine, Square and Ramp wave of varying frequency and

amplitude, Design various FIR and IIR filters, Interfacing of LED, LCD, Audio and Video Devices with the DSP processor.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course Learning Outcomes (CLOs):

1. Acquired knowledge about Fixed and floating point number systems.
2. Ability to understand the internal Structures of DSP Processors and memory accesses.
3. Ability to understand addressing instructions of a DSP processors.
4. Foster ability to understand the internal architecture, instructions set, programming and interfacing of different peripheral devices with TMS320C3X, TMS320C5X, TMS320C6X, ADSP 21XX DSP Chips.

Text Books:

1. *Lapsley, P., Bier, J., Shoham, A. and Lee, E.A., DSP Processor Fundamentals: Architecture and Features, IEEE Press Series on Signal Processing, IEEE (2000).*
2. *Venkataramani, B. and Bhaskar, M., Digital Signal Processor: Architecture, Programming and Applications, Tata McGraw Hill (2003).*

Reference Books:

1. *Padmanabhan, K., Ananthi, S. and Vijayarajeswaran, R., A practical Approach to Digital Signal Processing, New Age International Pvt. Ltd (2001).*
2. *TI DSP reference set (www.ti.com).*
3. *Babast, J., Digital Signal Processing Applications using the ADSP-2100 family, PHI (1992).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PEC212: AUDIO AND SPEECH PROCESSING

L	T	P	Cr
3	0	0	3.0

Course Objective: This course will give students a foundation in current audio and recognition technologies, familiarity with the perceptually-salient aspects of the speech signal, its processing, speech pattern recognition and speech and audio recognition systems.

Introduction: Review of digital signal and systems, Transform representation of signal and systems, Sampling Theorem, STFT, Goertzel algorithm, Chirp algorithm, Digital filters and filter banks.

Digital Models for Speech signals: Speech production and acoustic tube modeling, acoustic phonetics, anatomy and physiology of the vocal tract and ear, hearing and perception.

Digital Representation: Linear quantization, commanding, optimum quantization, PCM, effects of channel errors, vector quantization (VQ), Adaptive quantization, differential PCM, APCM , ADPCM, delta modulation, adaptive delta modulation, and CVSD.

Digital Vocoders: Linear predictive coding (LPC), hybrid coders: voice excited vocoders, voice excited linear predictor, and residual excited linear predictor (RELP).

Speech Recognition: Isolated word recognition, continuous speech recognition, speaker (in) dependent, measures and distances (articulation index, log spectral distortion, Itakura-Saito, cepstral distance), Dynamic time warping (DTW), HMM, HMM networks, Viterbi algorithm, discrete and continuous observation density HMMs.

Speaker Recognition: speaker verification/authentication *vs. s*peaker identification, closed *vs.* open set, feature vectors (e.g., line spectrum pair and cestrum), pattern matching (e.g., DTW, VQ, HMM), hypothesis testing, and errors.

Advanced Topics: Emerging speech coding standards (e.g., 2400 bps MELP), Internet phone, voice and multimedia applications, audio signal generation, speech generation and recognition algorithms and techniques using MATLAB and related DSP kits.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course Learning Outcomes (CLOs):

1. Acquired knowledge about audio & speech signals.
2. Ability to understand speech generation models.
3. Foster ability to understand speech recognition models.
4. Understanding of audio & speech signal estimation & detection.
5. Acquired knowledge about hardware to process audio & speech signals.
6. Ability to relate human physiology and anatomy with signal processing paradigms.

Text Books:

1. *Borden, G., and Harris, K., Speech Science Primer, Williams and Wilkins (2006).*
2. *Furui, S., Digital Speech Processing, Synthesis and Recognition, CRC (2001).*

Reference Books:

1. *Rabiner, L., and Schafer, R., Digital Processing of Speech Signals. Signal Processing, Prentice-Hall (1978).*
2. *Owens, F. J, Signal Processing of Speech, McGraw-Hill (1993) Parsons, T., Voice and Speech Processing: Communications and Signal Processing, McGraw-Hill.*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PEC216: ADVANCED COMPUTER NETWORKS AND PROTOCOLS

L	T	P	Cr
3	0	0	3.0

Course Objective: The objective of this course unit is to study the problematic of service integration in TCP/IP networks focusing on protocol design, implementation and performance issues; and to debate the current trends and leading research in the computer networking area.

Review of Network Fundamentals: Network Systems and the Internet, Network Systems Engineering, Packet Processing, Network Speed, A conventional computer system, Fetch-Store paradigm, Network Interface Card functionality, Onboard Address Recognition, Packet Buffering, Promiscuous Mode, IP Datagram, Fragmentation, Reassembly, Forwarding, TCP Splicing.

Internetworking: Motivation, Concept, Goals, IP addressing, Address Binding with ARP, IP Datagram, Encapsulation IP Fragmentation and Reassembly, ICMP, TCP, UDP concept and datagram protocols, Remote Login, Introduction to Protocol Specification, Validation and Testing.

Network Standards and Standard Organizations: Proprietary, Open and De-facto Standards, International Network Standard Organizations, Internet Centralization Registration Authorities, Modern hierarchy of registration authority, RFC categories, The Internet Standardization Process.

TCP/IP Network Interface Layer Protocol: TCP/IP Serial Internet Protocols, Point to Point Protocols, PPP core protocols, PPP Feature Protocols, PPP Protocol Frame Formats, ARP and RARP Protocols, IPv4 and IPv6, IP Network Address Translation Protocol, ICMP Protocols and IPv6 Neighbor Discovery Protocol.

Routing and Application Layer Protocols: Communication Protocols, Connection Oriented, Connection Less, Working with Network Layer and Transport Layer, Routing Information Protocol (RIP, RIP-2, and Ripping), Border Gateway Protocol, User Datagram protocol, SMTP and FTP protocols, TFTP Protocols, Hypertext Transfer Protocols.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course Learning Outcomes (CLOs):

Upon the completion of the course the student will

1. Acquire knowledge about Network Fundamentals.
2. Be able to identify Internetworking.
3. Foster ability to work using Network Standards and Standard Organizations.
4. Foster ability to work using TCP/IP Network Interface Layer Protocol.
5. Acquire knowledge about Routing and Application Layer Protocols.

Text Books:

1. *Farrel, A., The Internet and Its Protocols - A Comparative Approach, Morgan Kaufmann (2004).*
2. *Puzmanová, R., Routing and Switching - Time of Convergence, Addison-Wesley (2001).*

Reference Books:

1. *Tanenbaum, A.S., Computer Networks, Prentice Hall (2007).*
2. *Hunt, C., TCP/IP Network Administration, O'Reilly Media (2002).*
3. *Keshav, S., An Engineering Approach to Computer Networking, Addison-Wesley (1997).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PEC214: FRACTIONAL TRANSFORMS AND APPLICATIONS

L	T	P	Cr
3	0	0	3.0

Course Objective: To introduce time frequency analysis, Study of Discrete Fractional Fourier transforms, Applications of Fractional Fourier Transform in Optics and signal processing, to introduce various other forms of Fractional Transform.

Introduction: Fractional operations and the fractional Fourier transform, Applications of the fractional Fourier transform, Signals, Systems, Representations and transformations, Operators, The Fourier transform, Some important operators, Uncertainty relations, Time-frequency and space-frequency representations, The Wigner distribution and the ambiguity function, Linear canonical transforms.

The Fractional Fourier Transform: Fractional operations, Definitions of the fractional Fourier transform, Eigen-values and Eigen-functions, Transforms of some common functions, Properties, Rotations and projections in the time-frequency plane, Fractional Fourier domains, Chirp bases and chirp transforms, Relationships with the Wigner distribution and the ambiguity function, Two-dimensional fractional Fourier transforms, Applications of the fractional Fourier transform.

The Discrete Fractional Fourier Transform: Discrete Hermite-Gaussian functions, the discrete fractional Fourier transform, Definition in hyper difference form, Higher-order discrete analogs, Discrete computation of the fractional Fourier transform.

The Fractional Fourier Transform in Optics: General fractional Fourier transform relations in free space, Fractional Fourier transformation in quadratic graded-index media, Hermite-Gaussian expansion approach, First-order optical systems, Fourier optical systems, Locations of fractional Fourier transform planes, Wave-field reconstruction, phase retrieval, and phase-space tomography, Applications of the transform to wave and beam propagation.

Applications to Signal Processing: Optimal Wiener filtering in fractional Fourier domains, Multi-stage, multi-channel, and generalized filtering configurations, Applications of fractional Fourier domain filtering, Convolution and filtering in fractional Fourier domains, Repeated filtering in the ordinary time and frequency domains, Multiplexing in fractional Fourier domains, Fractional correlation, Controllable shift-invariance, Performance measures for fractional correlation, Fractional joint-transform correlators, Adaptive windowed fractional Fourier transforms, Applications with different orders in the two dimensions.

Other fractional Transforms: Fractional sine and Cosine transforms fractional Hartley Transforms, fractional Wavelet Transforms and their applications in one and two dimensional Signal processing.

Minor Project: To be assigned by concerned instructor/course-coordinator.
Course Learning Outcomes (CLOs):

1. To understand Time frequency analysis of signals.
2. To learn concepts of Fractional Fourier Transform.
3. To introduce various applications of Fractional Transform.
4. To learn different types of Fractional Fourier Transforms.

Text Books:

1. *Ozaktas, Haldun M., Zalevsky, Zeev, and Kutay, M. Alper, The Fractional Fourier Transform with Applications in Optics and Signal Processing, John Wiley and Sons (2001).*

Reference Books:

1. *IEEE and Elsevier Papers*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PVL203: VLSI SIGNAL PROCESSING

L	T	P	Cr
3	0	0	3.0

Course objective: To know how to design high-speed, low-area, and low-power VLSI systems for a broad range of DSP applications. Explore optimization techniques indispensable in modern VLSI signal processing. immediate access to state-of-the-art, proven techniques for designers of DSP applications-in wired, wireless, or multimedia communications.

Introduction: Concept of FIR Filters, IIR filters, Multirate Signal Processing: Sampling rate conversion by rational factors, Implementation of sampling rate conversion, Multistage Implementation, Applications of multirate signal processing, Digital filter banks, Wavelets, Concept of Adaptive filters, Basic Wiener filter Theory, LMS adaptive algorithm, Recursive Least Square algorithm, Introduction to DSP Systems, Terminating and Non-Terminating, Representation of DSP programs, Data Flow graphs (DFGs), Single rate and multi rate DFGs, Iteration bound, Loop, Loop Bound, Iteration rate, Critical loop, Critical path, Area-Speed-Power trade-offs, Precedence constraints, Acyclic Precedence graph, Longest Path Matrix (LPM) and Minimum Cycle Mean (MCM) Algorithms, Pipelining and parallel processing of DSP Systems, Low Power Consumption.

Algorithmic Transformations: Retiming, Cut-set retiming, Feed-Forward and Feed-Backward, Clock period minimization, register minimization, Unfolding, Sample period reduction, Parallel processing, Bit-serial, Digit-serial and Parallel Architectures of DSP Systems, Folding, folding order, Folding Factor, Folding Bi-quad filters, Retiming for folding, Register Minimization technique, Forward Backward Register Allocation technique.

Systolic Architecture Design and Fast Convolution: Systolic architecture design methodology, Projection vector, Processor Space vector, Scheduling vector, Hardware Utilization efficiency, Edge mapping, Design examples of systolic architectures, Cook-Toom Algorithm and Modified Cook-Toom Algorithm, Wniograd Algorithm and Modified Winograd Algorithm, Iterated Convolution, Cyclic Convolution.

Algorithm Strength Reduction: Introduction, Parallel FIR filters, Polyphase decomposition, Fast FIR filters Algorithms, Discrete Cosine Transform and Inverse Discrete Cosine Transform, Algorithm-Architecture Transformation, DIT Fast DCT, Pipelined and Parallel Recursive and Adaptive Filters, Look-Ahead Computation, Look-Ahead Pipelining, Decompositions, Clustered Look-Ahead Pipelining, Scattered Look-Ahead pipelining, Parallel processing in IIR Filters, Combining Pipelining and Parallelism.

Scaling and Round-off Noise: Introduction, State variable description of Digital Systems, Scaling and Round-off Noise Computation, Slow-Down Approach, Fixed-point digital filter implementation.

Course Learning Outcomes (CLO):

1. To learn performance optimization techniques in VLSI signal processing,
2. Transformations for high speed and power reduction using pipelining, retiming, parallel processing techniques, supply voltage reduction as well as for strength or capacitance reduction,
3. Area reduction using folding techniques, Strategies for arithmetic implementation,
4. Synchronous, wave, and asynchronous pipelining.

Text Books:

1. *Parhi, K.K., VLSI Digital Signal Processing Systems: Design and Implementation, John Wiley (2007).*
2. *Oppenheim, A.V. and Schafer, R.W., Discrete-Time Signal Processing, Prentice Hall (2009).*

Reference Books:

1. *Proakis, J.G., Digital Filters: Analysis, Design and Application, McGraw Hill (1981).*
2. *Proakis, J.G., and Manolakis, D.G., Digital Signal Processing, PHI (2001).*
3. *Mitra, S.K., Digital Signal Processing. A Computer Based Approach, McGraw Hill (2007).*
4. *Wanhammar, L., DSP Integrated Circuits, Academic Press (1999).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1	MST	25
2	EST	45
3	Sessionals (Assignments + Quizes)	30

PEC326: OPTOELECTRONICS

L	T	P	Cr
3	0	0	3.0

Course Objective: To understand the nature of light, fundamentals, advances and applications of optoelectronic materials, devices and systems; to understand fundamentals of optoelectronic properties of semiconductors, to analyze optoelectronic system based on important parameters for characterizing optical fiber, optical source, detector and amplifier, fundamentals and advances in lasers, LEDs, photodiodes, optical and optical-electronic modulators, optical- filters, displays, memory, basics of optical fiber communications, optical measurements and sensors.

Elements of Optics and Solid State Physics: Nature of light, Wave nature of light, Optical components, Light sources, Review of some quantum mechanical concepts, Energy bands in solids, Electrical conductivity, Semiconductors, junctions, and quantum- well, dot and applications.

Optical Sources and Modulation: Emission and absorption of radiation, Einstein relations, Absorption of radiation, Population inversion, Optical feedback, Threshold conditions-laser losses, Line shape function, population inversion and pumping threshold conditions, Laser modes, Classes of Laser, Single mode operation, Frequency stabilization, VCSEL, Mode locking, Q switching, Laser applications, Measurement of distance, Holography, High power applications of lasers, LEDs Electro-optic effect, electro-optic switch and modulator, Kerr modulators, Lithium Niobate devices, Electro-absorption modulator.

Photo Detectors: Principle of optical detection, Detector performance parameters, Thermal detectors, Photon devices, Solar cell.

Display Devices: Luminescence, Photoluminescence, Cathodoluminescence, Cathode ray tube, Electro luminescence, Injection luminescence and light emitting diodes, Plasma displays, Display brightness, LCD, Numeric displays.

Optical Fiber Communication: Optical Communication, Total internal reflection, Planar dielectric waveguide, Optical fiber waveguide, Losses in fibers, Optical fiber connectors, Measurement of fiber characteristics, Fiber materials and manufacturing, Fiber cables, Modulation schemes, Free space communication, Fiber optical communication systems, Integrated optics.

Optical Measurements: Optical fiber sensor, Optical CDs.

Minor Project: To be assigned by concerned instructor/course-coordinator.

Course Learning Outcomes (CLOs):

1. Able to understand fundamentals, advantages and advances in optoelectronic devices, circuits and systems.
2. To acquire a detailed understanding of types, basic properties and characteristics of optical waveguides, modulators and detectors.
3. Able to have the knowledge of design, working, Classification and analysis of Semiconductor Lasers, LEDs, and modulators.
4. Able to identify, formulate and solve engineering and technological problems related to optical sources, displays, detectors and optical measurements.

Text Books:

1. *Ajoy Kumar Ghatak and K. Thyagarajan, Optical Electronics, Cambridge University Press (2001).*
2. *Wilson, John and Hawkes, John, Optoelectronics: An Introduction, Prentice Hall (2003).*

Reference Books:

1. *Kasap, S.O., Optoelectronics and Photonics: Principles and Practices, Prentice Hall (2001).*
2. *Keiser, G, Optical Fiber Communication, Tata McGraw Hill (2007).*
3. *Senior, John M., Optical Fiber Communication, Dorling Kindersley (2008).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PVL213: NANOELECTRONICS

L	T	P	Cr
3	0	0	3.0

Course Objectives: In this course the students will learn overview of nanoelectronic and nano devices, its mechanics and technologies, nano fabrication and characterization and its future aspects.

Shrink-down approaches: Introduction to Nanoscale Systems, Length energy and time scales, Top down approach to Nanolithography, CMOS Scaling, Limits to Scaling, System Integration Limits - Interconnect issues, etc.

Overview of Nano-electronics and Devices: The Nano-scale MOSFET, FinFETs, Vertical MOSFETs, Resonant Tunnelling Transistors, Single Electron Transistors, New Storage devices, Optoelectronic and Spin Electronics Devices.

Basics of Quantum Mechanics: History of Quantum Mechanics, Schrödinger Equation, Quantum confinement of electrons in semiconductor nano structures, 2D confinement (Quantum Wells), Density of States, Ballistic Electron Transport, Coulomb Blockade, NEGF Formalism, Scattering.

Leakage in Nanometer CMOS Technologies: Taxonomy of Leakage: Introduction, Sources, Impact and Solutions. Leakage dependence on Input Vector: Introduction, Stack Effect, Leakage reduction using Natural Stacks, Leakage reduction using Forced Stacks. Power Gating and Dynamic Voltage Scaling: Introduction, Power Gating, Dynamic Voltage Scaling, Power Gating methodologies.

Nano-Fabrication and Characterization: Fabrication: Photolithography, Electron-beam Lithography, Advanced Nano-Lithography, Thin-Film Technology, MBE, CVD, PECVD

Characterization: Scanning Probe Microscopy, Electron Microscopy (TEM, SEM), Photon Spectroscopy, Nano Manipulators

Future Aspects of Nano-electronics: Molecular Electronics: Molecular Semiconductors and Metals, Electronic conduction in molecules, Molecular Logic Gates, Quantum point contacts, Quantum dots and Bottom up approach, Carbon Nano-tube and its applications, Quantum Computation and DNA Computation. Overview of Organic Electronics: OLEDs, OLETs, Organic Solar Cells

Course Learning Outcomes (CLO):
After the completion of this course, the students are able to:

1. acquire knowledge about nano-electronics and shrink down approach.
2. understand concept behind nano-mosfets and nano devices.
3. set up and solve the Schrodinger equation for different types of potentials in one dimension as well as in 2 or 3 dimensions for specific cases.
4. use the nanofabrication and characterization facilities.

Recommended Books:

1. *Lundstorm, M. and Guo, J., Nanoscale Transistors – Device Physics, Modelingand Simulation, Springer (2006).*
2. *Bhushan, B., Handbook of Nanotechnology, Springer (2007).*

3. *Beenaker, C.W.J., and Houten, V., Quantum Transport in Semiconductor Nanostructures in Solid State Physics, Ehernreich and Turnbell, Academic Press (1991).*
4. *Ferry, D., Transport in Nanostructures, Cambridge University Press (2008).*
5. *Mitin, V.V. and Kochelap, V.A., Introduction to Nanoelectronics: Science, Nanotechnology, Engineering and Application, Cambridge Press (2008).*
6. *Draoman, M. and Dragoman, D., Nanoelectronics: Principles and Devices, Artech House (2008).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PEC207: RF DEVICES AND APPLICATIONS

L	T	P	Cr
3	0	0	3.0

Course Objectives: To understand the theory, operation, device fabrication and the C-V, V-I and frequency response characteristics of RF devices and their application in latest engineering circuits. Some of these devices are SBD, Tunnel diode and advanced deices like IMPATT, TRAPATT and HEMT have been included in this course.

Schottky Barrier Diode: S.B. diode theory, thermionic theory, diffusion theory and thermionic emission diffusion theory. Current - Voltage theory based on presence of Surface states. noise-temperature ratio, white noise, tangential sensitivity and its use in detection. Structure and fabrication of SB diodes using out diffusion and photolithography. SBD structures using no oxide, oxide passivated and guard ring structures, Its use as a Mixer and Detector, mixer: single and double balanced mixer.

Varactor Diode: Diode theory based on the ideality factor and its use in diode equation for generating various equations including normal, linear, abrupt and hyper abrupt junctions, their operation and frequency response, The device capacitance equations for these diodes and their applications in high frequency circuits.

The p-i-n Diode: p-i-n structure, device theory, Equation for drift region, carrier concentration n(x) as a function of x in the intrinsic region using the equation of continuity; the I-region capacitance. Equivalent circuit of a packaged p-i-n diode both in forward and reverse bias. Application of p-i-n diode as a switch using the concept of insertion loss and isolation based on the conductance and susceptance of a transmission line and its operation, and for current limiter using a strip line cross section for analysis of limiting action in microwave range.

The IMPATT Diode: IMPATT structure; theory of IMPATT diodes using the equation for junction breakdown, equivalent circuit of IMPATT diode for LC avalanche region, drift region and the parasitic resistance to derive the device impedence. Active resistance and its use for generation of negative resistance, interchange of L & C components of the avalanche region at the output frequency. Frequency – power curve of IMPATT diode, IMPATT mountings.

The TRAPATT Diode: The TRAPATT structure and the theory of operation. Concept of carrier velocities exceeding saturated drift velocity of carriers in the central region of the device. The electric field, distance and time, i.e., 3-axis plot of the diode with bias. Output voltage and current waveforms plots, power and frequency limitations of TRAPATT diode and the related duty cycle.

The Gunn Oscillator: Transferred Electron Devices or Bulk Effect Devices. E-k diagrams, velocity field profiles of semiconductors, RWH mechanism for mass variation with electric field IN-semiconductors, threshold field for negative differential resistance (NDR), dipole domain formation, Gunn Effect, Different modes of operation, Gunn, LSA and Quenched Domain mode, The output power and frequency of Gunn Oscillators.

Tunnel Diode: Degeneratively doped diode and their energy band diagrams, V-I characteristics and the generation of negative resistance in tunnel diodes, Tunnel diode as a switch and its operation as a MW generator.

Step Recovery Diode: SRD device structure and operation, Application of SRD as a harmonic generator in a MW range, SRD theory, carrier transit times in SRD, Operation of SRD multiplier using bias method and general impedance matching method.

Microwave Transistor: Structure and design of Bipolar MW Transistors, Equivalent circuit of a packaged MW transistor and associated S parameters, Device geometry, cutoff frequency and operation of MESFET and HEMT.

Semiconductor Heterojunctions: Basic device model, Energy band diagram of Semiconductor Heterojunction diodes and their V-I characteristics, Introduction to Heterojunction transistors and lasers.

Fundamentals of Power Semiconductor devices: Introduction, SiC Material properties, polytypes, comparison of electrical properties of polytypes; Transport physics of SiC power devices, Breakdown voltage, SiC Schottky Rectifiers, SiC Metal-Semiconductor Field Effect Transistors (DIMOSFET and LDMOSFET).

Minor Project: To be assigned by concerned instructor/course-coordinator

Course Learning Outcomes (CLOs):

1. Understand semiconductor device theory at an advanced level including the use of energy band diagram as applied to devices like BJT and MOSFETs.
2. Solve device equations based on equations of continuity and the derivation of C-V and I-V equations of High Frequency devices.
3. Understand and develop the equivalent circuit of High Frequency devices and simplify them for analytical work.
4. Understand the fabrication of devices like SBD, Tunnel diode, DIMOSFET and SiC power devices.

Text Books:

1. *Sze, S.M., Physics of Semiconductor Devices, John Wiley and Sons (2008).*
2. *Gupta, K.C., Microwaves, New Age International (2002).*
3. *Baliga, B. Jayant, Silicon Carbide Power Devices, World Scientific Publishing Company (2006).*

Reference Books:

1. *Liao, S.Y., Microwave Devices and Circuits, Pearson Education (2006).*
2. *Dutta, A.K., Semiconductor Devices and Circuits, Oxford University Press (2008).*
3. *Baliga, B. Jayant, Fundamentals of Power Semiconductor Devices, Springer (2008).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PEC222: HDL AND SYSTEM C PROGRAMMING

L	T	P	Cr
2	0	2	3.0

Course Objective:

1. Students must demonstrate the use and application of Boolean Algebra in the areas of digital circuit reduction, expansion, and factoring.
2. Students must learn the IEEE Standard 1076 VHDL Hardware Description Language.
3. Students must be able to simulate and debug digital systems described in VHDL
4. Students must be able to synthesize complex digital circuits at several level of abstractions.

VHDL:

Combinational Logic: Design units, entities and architectures, simulation and synthesis model, signals and ports, simple signal assignments, conditional signal assignments, selected signal assignment.

Types: standard types, standard operators, scalar types, records, arrays.

Operators: standard operators, operator precedence, Boolean operators, comparison operators, arithmetic operators, concatenation operators, mixing types in expressions, numeric packages.

Sequential VHDL: Processes, signal assignments, variables, if statements, case statements.

Hierarchy: Role of components, using components, component instances, component declaration, Configuration specifications, default binding, binding process, component packages, generate statements.

Subprograms: Functions, type conversions, procedures, declaring subprograms.

Test Benches: Test benches, verifying responses, clocks and resets, printing response values.

SystemC: Overview: Capabilities, Design Hierarchy, Data Types, Modelling combinational Logic, Modelling Sequential Logic, Writing Testbenches.

Laboratory Work:

Modeling and simulation of all VHDL and SystemC constructs using ModelSim, their testing by modeling and simulating test benches.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course learning outcome (CLOs):

1. Model digital systems in VHDL and SystemC at different levels of abstraction.
2. Partition a digital system into different subsystems.
3. Simulate and verify a design.
4. Transfer a design from a version possible to simulate to a version possible to synthesize.
5. Use modern software tools for digital design in VHDL.

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Text Books:

1. *Bhaskar, J., A VHDL Primer, Pearson Education/ Prentice Hall (2006).*
2. *Bhaskar, J., A SystemC Primer, Pearson Education/ Prentice Hall (2009).*

Reference Books:

1. *Ashenden, P., The Designer's Guide to VHDL, Elsevier (2008).*
2. *David C. Black and Jack Donovan, SystemC: From the Ground Up, Springer, (2014).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PEC327: PHOTONICS INTEGRATED DEVICES AND CIRCUITS

L	T	P	Cr
3	0	0	3.0

Course Objectives: In this course the students will learn basics of optical fiber communication, optical waveguides, light sources, amplifiers, modulators, detectors, optical MEMS & NEMS and silicon photonics.

Introduction to Optical Fiber Communication: Nature of light; optical communication; optical fibers; propagation of light in optical fibers; transmission characteristics of optical fibers; fabrication of optical fibers.

Planar Optical Waveguides and Passive Devices: Waveguide classification, step-index waveguides, graded-index waveguides, 3D waveguides, coupled mode theory, grating in waveguide structure, bent waveguides, directional coupler, Bragg reflectors, waveguide filters, AWG, Multiplexer, Demultiplexer.

Semiconductor Light Sources and Amplifiers: Spontaneous and stimulated emission, emission from semiconductors, semiconductor injection lasers, single frequency lasers, Various laser configurations, injection laser characteristics, VCSEL, LEDs - Introduction, LED power efficiency, LED structures, LED characteristics and Organic LEDs, Optical amplifiers, Semiconductor optical amplifier.**)**

Optical Modulators: Electro-optic modulator, Acousto-optic modulator, Electro-absorption modulator, Interferometric modulator, micro-electro-mechanical modulator.

Optical Detectors: Optical detection principle, quantum efficiency and responsivity, semiconductor photodiodes with/without internal gain, Solar cell.

Optical MEMS and NEMS: Micro-electro-mechanical and nano-electro-mechanical systems, MEMS integrated tunable photonic devices-filters, lasers, hollow waveguides; NEMS tunable devices

Silicon Photonics: Introduction, Silicon-on-insulator (SOI) Technology, silicon modulators, non-linear silicon photonics, lasers on silicon, CMOS-Photonic hybrid integration, Silicon-germanium detector, Nanophotonics-Photonic crystals, Slow light and its applications.

Course Learning Outcomes (CLO):
After the completion of this course, the students are able to:

1. understand the fundamentals, advantages and advances in optical communication and integrated photonic devices and circuits.
2. introduce optical waveguides, detectors, amplifiers, silicon photonics and MEMS applications in photonics.
3. design, operate, classify and analyze Semiconductor Lasers, LEDs, modulators and other Integrated photonic devices.
4. identify, formulate and solve engineering-technological problems related optoelectronic integration.

Recommended Books:

1. *B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, Wiley (2007).*
2. *H. Nishihara, M. Haruna, T. Suhara, Optical Integrated Circuits, Mc-Graw Hill (2008).*
3. *J.M. Senior, Optical Fiber Communications, Pearson Education (2009).*
4. *G. T. Reed, Silicon Photonics: The state of the art, John Wiley and Sons (2008)*
5. *H. Ukita, Micromechanical Photonics, Springer (2006).*
6. *S. V. Gaponenko, Introduction to Nanophotonics, Cambridge University Press (2010).*
7. *J. D. Joannopoulos, S. G. Johnson, J. N. Winn and R. D. Meade, Photonic Crystals: Molding the flow of light, Princeton University Press (2008)*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PWC321: NEXT GENERATION WIRELESS SYSTEMS AND NETWORKS

L	T	P	Cr
3	0	0	3.0

Course Objectives: To understand and gain complete knowledge of wireless systems and networks of next generation like IEEE 802.15, IEEE 802.16, Bluetooth technology, and 4G. To understand the basic concepts of cognitive and software defined radio, Mobile IP, IPv6 versus IPv4, Wireless Application Protocol (WAP), IP on Mobile Ad Hoc Networks.

Review: Background Knowledge, 3GMobile Cellular Standards, Wireless Networking, B3G and Emerging Wireless Technologies.

Fundamentals of Wireless Communications: Theory of Radio Communication Channels, Spread Spectrum Techniques, Multiple Access Technologies, Multiple User Signal Processing, OSI Reference Model, Switching Techniques, IP-Based Networking.

3G Mobile Cellular Technologies : CDMA2000, WCDMA, TD-SCDMA.

Wireless Data Networks: IEEE 802.11 Standards for Wireless Networks, IEEE 802.11a Supplement to 802.11 Standards, IEEE 802.11 Security, IEEE 802.15 WPAN Standards, IEEE 802.16 WMAN Standards, ETSI HIPERLAN and ETSI HIPERLAN/2 Standards, MMAC by Japan, Bluetooth Technologies.

All-IP Wireless Networking: Some Notes on 1G/2G/3G/4G Terminology, Mobile IP, IPv6 versus IPv4, Mobile IPv6, Wireless Application Protocol (WAP), IP on Mobile Ad Hoc Networks. All-IP Routing Protocols.

MIMO Systems: SIMO, MISO, and MIMO Systems, Spatial Diversity in MIMO Systems, Spacial Multiplexing in MIMO Systems, STBC-CDMA Systems, Generic STBC-CDMA System Model, Unitary Codes Based STBC-CDMA System, Complementary Coded STBC-CDMA System.

Cognitive Radio Technology: Why Cognitive Radio, History of Cognitive Radio, SDR to Cognitive Radio, Cognitive Radio for WPANs, Cognitive Radio for WLANs, Cognitive Radio for WMANs, Cognitive Radio for WWANs, Cognitive Radio for WRANs: IEEE 802.22, Challenges to Implement Cognitive Radio, Cognitive Radio Products and Applications.

Laboratory Work:
Matlab related simulation experiments.

Course Learning Outcomes (CLO):
At the end of the course, the students should be able to:

1. Understand the fundamentals and operation of next generation wireless communication systems like 3G, OFDM, MIMO systems, cognitive radio and 3GPP (4G),
2. Understand broadband wireless networks and all IP based wireless networking.
3. Analyze the performance of next generation wireless communication systems.

Recommended Books:

1. *Chen, Hsiao-Hwa and Mohsen Guizani, Next Generation Wireless Systems and Networks John Wiley and sons (2006).*
2. *Wong, David T., Kong, Peng-Yong, Ying-Chang Liang and Chua, Kee C., Wireless Broadband networks, John Wiley and sons (2009).*
3. *Kaveh, Pahlavan and Levesque, Allen H., Wireless Information Networks, John Wiley and Sons (2005).*
4. *Glisic, Savo G., Advanced Wireless Networks: 4G Technologies, John Wiley and Sons (2006).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30

PWC322: ADVANCED ERROR CONTROL CODING THEORY

L	T	P	Cr
3	0	0	3.0

Course Objectives: To provide a comprehensive introduction to error correction coding, including both classical block and trellis based codes and recent developments in iteratively decoded codes such as turbo codes and LDPC codes. To understand the coding using Factor Graph methods and message passing. To understand the methods of designing efficient channel encoder and decoder using various coding schemes like Block codes, Turbo coding, convolution coding, cyclic coding and LDPC coding.

Introduction: Codes and ensembles, MAP and ML decoding, APP processing, Channel Coding Theorem, Linear Codes and complexity, hamming codes, Gallager's parity check codes, Decoding complexity of linear codes, Convolutional codes and its complexity, Iterative coding and decoding, Extending, Puncturing and shortening of codes

Factor Graphs: Distributive law, Graphical representation of factorization, Recursive determination of marginals, Marginalization via message passing, Decoding via message passing, Limitations of cycle-free codes, Message passing on codes with cycles.

Binary Erasure Channel: Channel model, Transmission via linear codes, Tanner graphs, Low density parity check (LDPC) codes, Message passing decoder, Computation graph and tree ensemble, Convergence to tree channel, Density evolution, Monotonicity, Gallager's lower bound on density, Sparse distribution, Maxwell decoder

Turbo Codes: Structure and encoding, decoding of turbo codes, Density evolution, Stability condition, Exit charts, MAP performance, High performance turbo codes, Sliding window turbo codes, Turbo coded modulation, Set partitioning, Multi-level codes.

Course Learning Outcomes (CLO):
At the end of this course, the students should be able to:

1. Understand the basic concepts of different types of coding techniques like block codes, trellis based codes, iteratively decoded codes such as turbo codes and LDPC codes.
2. To efficiently design the channel encoder and decoder using different coding schemes.
3. To evaluate the performance of different channel encoders.

Recommended Books:

1. *Tom Richardson, Rudiger Urbanke, "Modern Coding Theory", Cambridge University Press (2008).*
2. *S. Lin and D. J. Costello, Jr., Error Control Coding, Prentice Hall, Englewood Cliffs, NJ, USA (2004).*
3. *C. Schlegel and L. C. Perez, Trellis and Turbo Coding,Wiley-IEEE Press (2004).*
4. *John G. Proakis, "Digital Communication", Mcgraw Hill (2008).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30

PWC323: WIRELESS BROADBAND NETWORKS

L	T	P	Cr
3	0	0	3.0

Course Objectives: To understand and gain the complete knowledge of wireless broadband networks which include the concepts of OFDM, OFDMA, MAC and routing protocols for broadband networks, modem design, concepts of equalizer and Convergence of Networks of various of networks.

Review Basics of Probability, Random Variables, Random Processes, and Queueing Systems: Probability, Random Variables, Poisson Random Process, Birth-Death Processes, Basic Queueing Systems.

Enabling Technologies for Wireless Broadband Networks: Orthogonal Frequency-Division Multiplexing and Other Block-Based Transmissions: Block-based Transmissions, Orthogonal Frequency-Division Multiplexing Systems, Single-Carrier Cyclic Prefix Systems, OFDMA, IFDMA, SC-FDMA, CP-based CDMA Systems, Receiver Design.

Routing Protocols for Multihop Wireless Broadband Networks: Multihop Wireless Broadband Networks: Mesh Networks, Importance of Routing Protocols, Routing Metrics, Classification of Routing Protocols, MANET Routing Protocols; Radio Resource Management for Wireless Broadband Networks: Packet Scheduling, Admission Control. Quality of Service for Multimedia Services: Traffic Models, Quality of Service in Wireless Systems, Outage Probability for Video Services in a Multirate DS-CDMA System.

Modem Design: Basic Modulation Techniques, Theoretical Limits and Practical Impairments, Traditional Modems for Wide-Area Wireless Networks, Other Aspects of Modem Implementation. Broadband Modem Technologies: Effects of Frequency-Selective Multipath Fading, Discrete Multipath Fading Channel Model, Adaptive Discrete Matched Filter, Adaptive Equalization, Sectored Antennas, Multi-carrier, OFDM, and Frequency Diversity, MIMO in Frequency-Selective Fading.

Systems for Wireless Broadband Networks: Long-Term-Evolution Cellular Networks.: Network Architecture, Physical Layer, Avoidance MAC, Polling MAC, Reservation MAC, Energy-Efficient MAC, Multi-Channel MAC, Directional-Antenna MAC, MultiHop Saturated Throughput of IEEE 802.11 MAC, Mobility Resource Management: Types of Handoffs, Handoff Strategies, Channel Assignment Schemes, Location Management, Mobile IP, Cellular IP, HAWAII, Radio Resource Management, Security, Quality of Service, Applications

Wireless Broadband Networking with WiMAX: WiMAX Overview, Competing Technologies, Overview of the Physical Layer, PMP Mode, Mesh Mode, Multihop Relay Mode.

Wireless Local Area Networks: Network Architectures, Physical Layer of IEEE 802.11n, Medium Access Control, Mobility Resource Management; Quality of Service, Applications.

Wireless Personal Area Networks: Network Architecture, Physical Layer, Medium Access Control, Mobility Resource Management, Routing, Quality of Service, Applications.

Convergence of Networks: GPP/WLAN Interworking, IEEE 802.11u Interworking with External Networks, LAN/WLAN/WiMax/3G Interworking Based on IEEE 802.21 Media-

Independent Handoff, Future Cellular/WiMax/WLAN/WPAN Interworking, Analytical Model for Cellular/WLAN Interworking.

Course Learning Outcomes (CLO):
At the end of this course, the students should be able:

1. To understand the concepts and operation of wireless broadband networks.
2. To analyze and evaluate the performance of physical layer (OFDM and OFDMA), data link layer (MAC protocols) and routing protocols for wireless broadband networks.
3. To understand different types of networks and the concepts of convergence of networks.

Recommended Books:

1. *Wong, David T., Kong, Peng-Yong, Liang, Ying-Chang and Chua, Kee C., Wireless Broadband Networks, John Wiley and sons (2009).*
2. *Pahlavan, Kaveh and Levesque, Allen H., Wireless Information Networks, John Wiley and Sons (2005).*
3. *Goldsmith, Andrea, Wireless Communications, Cambridge University Press (2007).*
4. *Geier, Jim, Wireless Networks first-step, Cisco Press (2004).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30

PEC321: ADVANCED OPTICAL TECHNOLOGIES

L	T	P	Cr
3	0	0	3.0

Course Objective: To understand advanced optical fibre systems like fibres, lasers, modulation techniques, optical amplifiers, MEMS and light wave communication.

Specialty Fibers for Optical Communication: Introduction, Dispersion Compensation Fibers, Polarization Maintaining and Single Polarization Fibers, Nonlinear fibers, Double-clad fibers for fiber Lasers and Amplifiers, Micro-structured Optical fibers, Photonic crystal fibers.

Advanced Semiconductor Lasers: Introduction, Fundamental Properties of Quantum Well and Long-Wavelength Quantum Well Lasers, High-Speed Direct Modulation of Quantum Well Strained Lasers, Quantum Dot Lasers, VCSEL, Long-Wavelength VCSEL, VCSEL applications, VCSEL-Based Slow Light Devices.

High-Speed Modulation: Introduction, principles and mechanisms of external optical modulation, high-speed modulation, modulators based on phase changes and interference, intensity modulators based on absorption changes, Introduction, basic principle of Optical Injection Locking (OIL), modulation properties of OIL VCSELS, RF link gain enhancement of OIL VCSELS, nonlinearity and dynamic range of OIL VCSELS, Traveling-wave electro-absorption modulators (EAMS), High-efficiency modulators for 100 gb/s and beyond novel types of modulators.

Optical Amplifiers: Types of optical amplifiers, Er/Yb doped fiber amplifiers, Raman amplifier, Semiconductor optical amplifier, single-mode fiber 980-NM pumps, Materials for 980-nm Pump Diodes, Optical Beam Narrow Stripe Technology, Output Power Scaling, Spectral Stability, Packaging, Failure Rate, High Power Photonics.

Advances in Photo-detectors: Introduction, Waveguide Photodiodes, Balanced Receivers, High-Power Photo-detectors, Avalanche Photodiodes, Solar Cell.

Planar Light-wave Circuits in Fiber-Optic Communication: Introduction, Basic waveguide theory, Passive Optical Filtering, Demodulating, De-multiplexing Devices, AWG, Inter-Signal Control Devices, Intra-Signal Control Devices, Photonic Crystals.

Silicon Photonics: Introduction, SOI-wafer Technology, High-index-contrast Waveguide types and performance, Input–Output Coupling, Passive Waveguide Devices and Resonators, Active Modulation, Silicon Photonic Devices, Germanium Photo-detectors and Photo-receivers, CMOS-photonic hybrid integrated devices and circuits, Nonlinear Effects and their applications.

Micro-Electro-Mechanical Systems for Light-Wave Communication: Introduction, Optical Switches and Cross-connects, Wavelength-Selective MEMS Components, Transform Spectrometers, Diffractive Spectrometers and Spectral Synthesis, Tuneable Lasers, Other Optical MEMS Devices, Emerging MEMS Technologies and Applications.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course Learning Outcomes (CLO):

1. Understanding of Fundamentals, advantages and advances in optical devices and circuits.
2. Know-how of advanced optical waveguides, detectors, amplifiers, silicon photonics and MEMS applications in photonics.
3. Knowledge of Design, working, Classification and analysis of Advanced Semiconductor Lasers and High speed modulators.

Text Books:

1. *Kaminow, Ivan P., Li, Tingye, Willner, Alan E., Optical Fiber Telecommunications V.A., Components and Subsystems, Elsevier (2008).*
2. *Kaminow, Ivan P., Li, Tingye and Willner, Alan E., Optical Fiber Telecommunications V.B., Systems and Networks, Academic Press (2008).*

Reference Books:

1. *Goleniewski, Lillian, Jarrett Kitty Wilson, Telecommunications Essentials: The Complete Global Source, Addison Wesley Professional (2006).*
2. *Lee, Chi H., Thompson and Brian J., Optical Science and Engineering, CRC (2007).*
3. *H. Nishihara, M. Haruna, T. Suhara, Optical Integrated Circuits, Mc-Graw Hill (2008).*
4. *J.M. Senior, Optical Fiber Communications, Pearson Education (2009).*
5. *G. T. Reed, Silicon Photonics: The state of the art, John Wiley and Sons (2008)*
6. *H. Ukita, Micromechanical Photonics, Springer (2006).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PEC217: MICROSTRIP ANTENNAS

L	T	P	Cr
3	0	0	3.0

Course Objective: The objectives of this course is to provide general knowledge of the fundamental principles and concepts related with micro-strip patch antennas and circuits, their analysis, design, fabrication and test are addressed.

Micro-Strip Lines: Introduction of Planar Transmission Structures, Micro-strip Field Configuration, Micro-strip Dispersion Models, Micro-strip Transitions, Micro-strip measurement, Methods of Full wave Analysis, Analysis of an Open Micro-strip, Analysis of an Enclosed Micro-strip, Design Considerations, Suspended and Inverted Micro-strip Lines, Multilayered Dielectric Micro-strip, Thin Film Micro-strip (TFM), Valley Micro-strip Lines, Micro-strip Applications.

Micro-Strip Antenna Arrays: Array theory, Array calculations and analysis, array architectures, corporate array design, Resonant series fed array design, Series fed traveling wave array design.

Micro-Strip Discontinuities: Introduction of Quasi-Static Analysis and Characterization, Discontinuity Capacitance Evaluation, Discontinuity Inductance Evaluation, Characterization of Various Discontinuities, Planar Waveguide Analysis, Full wave Analysis of Discontinuities, Discontinuity Measurements.

Slot-Line: Introduction of Slot-lines, Slot-line Analysis, Design Considerations, Slot-line Discontinuities, Slot-line Transitions, Slot-line Applications.

Coplanar Lines and Wave Guides: Introduction of Coplanar Waveguide and Coplanar Strips, Quasi-Static Analysis, Design Considerations Losses, Effect of Tolerances, Comparison with Micro-Strip Line and Slot-line, Transitions, Discontinuities in Coplanar Waveguide, Coplanar Line Circuits.

Coupled Micro-Strip Lines: Introduction of Coupled Micro-Strip Lines, General Analysis of Coupled Lines, Characteristics of Coupled Micro-Strip Lines, Measurements on Coupled Micro-Strip Lines, Design Considerations for Coupled Micro-Strip Lines, Coupled Multi conductor Micro-Strip Lines, Discontinuities in Coupled Micro-Strip Lines.

Micro-Strip Circuit Design: impedance transformers, filters, isolators and phase shifters.

Minor Project: To be assigned by concerned instructor/course-coordinator.

Course Learning Outcomes (CLOs):
1. Ability to understand the basic concept of micro-strip antennas, methods of analysis and configurations.
2. Ability to understand micro-strip antennas arrays.
3. To understand the physical significance of discontinuities.
4. To understand the significance of different micro-strip feed mechanism available.
5. Ability to understand coupled micro-strip line with multiband and broadband behavior.
6. To know about CPW feeding technique and its implementation.

Text Books:

1. *Gupta, K.C. and Garg, Ramesh, Micro-strip lines and slot lines, Artech house (1996).*
2. *Sainiti, Robert A., CAD of Micro-Strip Antenna for Wireless Applications, Artech House (1996).*

Reference Books:

1. *Lu, Wong Kim, Planar antennas for Wireless applications, John Wiley and Sons (2003).*
2. *Simons, Rainee N., Coplanar Waveguide Circuits, Components, and Systems, John Wiley and Sons (2001).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PVL332: MIXED SIGNAL CIRCUIT DESIGN

L	T	P	Cr
3	0	0	3.0

Course Objectives: In this course the students will learn basics of comparator circuits, data converters, implementation of A/D and D/A converters and their performance analysis with design challenges.

Introduction: Device Models, IC Process for Mixed Signal, Concepts of MOS Theory.

Comparators: Circuit Modelling, Auto Zeroing Comparators, Differential Comparators, Regenerative Comparators, Fully Differential Comparators, Latched Comparator.

Data Converters: Requirements, Static and Dynamic Performance, SNR and BER, DNL, INL.

High Speed A/D Converter Architectures: Flash, Folding, Interpolating, pipelined

High Speed D/A Converter Architectures: Nyquist-Rate D/A Converters, Thermometer Coded D/A Converters, Binary Weighted D/A Converters.

Design of multi-channel low level and high level data acquisition systems using ADC/DAC, SHA and Analog multiplexers, Designing of low power circuits for transducers.

Sigma-Delta Data Converter Architectures: Programmable Capacitor Arrays (PCA), Switched Capacitor converters, Noise Spectrum, Sigma-Delta Modulation Method, Sigma-Delta A/D and D/A Converters, Non Idealities.

Key Analog Circuit Design: Analog VLSI building blocks, Operational Amplifiers for converters, advanced op-amp design techniques, Voltage Comparators, Sample-and-Hold Circuits.

Implementation and Design of High Performance A/D and D/A Converters: System Design, Digital Compensation, Noise, and Mismatch, Layout and Simulation Technologies for Data Converters.

Design Challenges: Low Voltage Design, Ultra-High Speed Design, High Accuracy Design.

Advanced Topics: Multipliers, Oscillators, Mixers, Passive Filter Design, Active filter design, Switched Capacitor Filters, Frequency Scaling, Phase-Locked Loops, Device Modelling for AMS IC Design, Concept of AMS Modelling and Simulation.

Course Learning Outcomes (CLO):
After the completion of this course, the students are able to:

1. apply knowledge of mathematics, science, and engineering to design CMOS analog circuits to achieve performance specifications.
2. identify, formulates, and solves engineering problems in the area of mixed-signal design.
3. use the techniques and skills for design and analysis of CMOS based switched capacitor circuits.
4. work as a team to design, implement, and document a mixed-signal integrated circuit.

Recommended Books:

1. *Baker, R.J., Li, H.W. and Boyce, D.E., CMOS: Circuit Design, Layout and Simulation, IEEE Press (2007).*
2. *Gregorian, R. and Temes, G.C., Analog MOS Integrated Circuits for Signal Processing, Wiley (2002).*
3. *Gregorian, R., Introduction to CMOS Op-Amps and Comparators, Wiley (1999).*
4. *Jespers, P.G. A., Integrated Converters: D-A and A-D Architectures, Analysis and Simulation, Oxford University Press (2001).*
5. *Plassche, Rudy J.Van De, Integrated A-D and D-A Converters, Springer (2007).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PVL334: HIGH SPEED VLSI DESIGN

L	T	P	Cr
3	0	0	3.0

Course Objectives: In this course the students will learn the basics of VLSI design for high speed processing, methods for logical efforts, logic styles, latching strategies, interface techniques and related issues.

Introduction of High Speed VLSI Circuits Design

Back-End-Of -Line Variability Considerations: Ideal and non-ideal interconnect issues, Dielectric Thickness and Permittivity

The Method of Logical Effort: Delay in a logic gate, Multi-stage logic networks, Choosing the best number of stages.

Deriving the Method of Logical Effort: Model of a logic, Delay in a logic gate, minimizing delay along a path, Choosing the length of a path, Using the wrong number of stages, Using the wrong gate size.

Non-Clocked Logic Styles: Static CMOS, DCVS Logic, Non-Clocked Pass Gate Families. Clocked Logic Styles: Single-Rail Domino Logic Styles, Dual-Rail Domino Structures, Latched Domino Structures, Clocked Pass Gate Logic.

Circuit Design Margining: Process Induced Variations, Design Induced Variations, Application Induced Variations, Noise

Latching Strategies: Basic Latch Design, latching single-ended logic, Latching Differential Logic, Race Free Latches for Pre-Charged Logic Asynchronous Latch Techniques

Interface Techniques: Signalling Standards, Chip-to-Chip Communication Networks, ESD Protection.

Clocking Styles: Clock Jitter, Clock Skew, Clock Generation, Clock Distribution, Asynchronous Clocking Techniques.

Skew Tolerant Design.

Course Learning Outcomes (CLO):

After the completion of this course, the students are able to:

1. acquire knowledge about High Speed VLSI Circuits Design.
2. identify the basic Back-End-Of -Line Variability Considerations.
3. use the Method of Logical Effort.
4. model the Circuit Design Margining and Latching Strategies.
5. understand the Clocking Styles.

Recommended Books:

1. *Chung-Kang Cheng, John Lillis, Shen Lin and Norman H. Chang, "Interconnect Analysis and Synthesis", A wiley Interscience Publication (2000).*
2. *Sung-Mo (Steve) Kang, Yusuf Leblebigi, "CMOS Digital integrated circuits analysis and design", by Tata Mcgraw-Hill, (2007).*

3. *L.O. Chua, C.A. Desoer, and E.S. Kuh, "Linear and Non-linear circuits", McGraw-Hill (1987).*
4. *R.E. Matrick, "Transmission lines for digital and communication networks", IEEE press (1995).*
5. *Mauricio Marulanda, "Electronic properties of Carbon Nanotubes", InTech publisher (2011).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PVL211: VLSI ARCHITECTURE

L	T	P	CR.
3	0	0	3.0

Course Objective: The motive of this course is to inculcate the knowledge of the different processors; their architecture and organizational intricacies. For performance enhancement consideration is given to various instruction level and memory management techniques such as pipeling, parallelism, instruction scheduling, hierarchical memory management etc. Study of the superscaler architecture organization, design issues and Power PCs is to be carried out.

Introduction: Review of basic computer architecture, quantitative techniques in computer design, measuring and reporting performance. CISC and RISC processors. Processor organization and Architectural Overview.

Pipelining: Basic concepts, instruction and arithmetic pipeline, data hazards, control hazards, and structural hazards, techniques for handling hazards. Exception handling. Pipeline optimization techniques, dynamic instruction scheduling

Hierarchical memory technology: Inclusion, Coherence and locality properties; Cache memory organizations, Techniques for reducing cache misses; Virtual memory organization, mapping and management techniques, memory replacement policies.

Instruction-level parallelism: basic concepts, techniques for increasing ILP, superscalar, super-pipelined and VLIW processor architectures. Array and vector processors.

Multiprocessor architecture: taxonomy of parallel architectures. Centralized shared-memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory architecture Superscaler Processors: Overview, Design Issues, PowerPC, Pentium

Course Learning Outcome (CLO):
The students will able to:

1. To review the basics of different processors including architecture and organization
2. To foster ability of handling and designing different types of pipelinning techniques; exception handling corresponding instruction scheduling.
3. To understand various memory organization and management techniques
4. To Understand the various advanced architectures.
5. To achieve the understanding of parallel, shared architectures and important organizational details of superscaler architecture.

Text Books:

1. *Hennessy, J.L., Patterson, D.A, and Goldberg, D., Computer Architecture A Quantitative Approach, Pearson Education Asia (2006).*
2. *Leigh.E. and Ali, D.L., System Architecture: software and hardware concepts, South Western Publishing Co. (2000).*
3. *Stallings, W., Computer Organization and Architecture: Designing for Performance, Prentice Hall (2003).*
4. *Parhami, B., Computer Arithmetic Algorithms and Hardware Design, Oxford (2000).*

Reference Books:

1. *Mano, Morris M., Computer System Architecture, Prentice Hall (2013).*
2. *Hayes, J.P., Computer Architecture and Organization, McGraw Hill (1998).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1	MST	25
2	EST	45
3	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30

PEC206: MACHINE LEARNING

L	T	P	Cr
3	0	0	3.0

Course Objective: At the end of the course the student should be able to represent multidimensional data in the pattern space and segment the same according to standard paradigms. The student should understand Bayesian decision criteria and probabilistic inferences. The student should understand formation of decision boundaries using a neural network and unsupervised learning paradigms. He should be able to apply the concepts learnt in real world scenarios.

Introduction to Machine Perception: Historical perspective, Pattern recognition systems, Segmentation and Grouping, Feature Extraction, Classification.

Learning and Adaptation Processes: Pattern space and decision boundaries, McCulloch-Pitts model of a neuron, Learning tasks, Hebbian learning, Supervised and unsupervised learning, Batch learning and On-Line learning.

Perceptron Learning Algorithms: Rosenblatt's perceptron, The perceptron and Bayes classifier for a Gaussian environment, The Least Mean Square (LMS) algorithm, The Recursive Least Square (RLS) algorithm.

Bayesian Decision Theory: Two category Bayesian classification, Minimum Error Rate classification, Minimax criterion, Neyman-Pearson criterion, Discriminant Functions and Decision Surfaces, Error Probabilities and Integrals, Error bounds viz. Chernoff Bound and Bhattacharya Bound.

Maximum Likelihood and Bayesian Parameter Estimation: Fundamental Principles, The Gaussian case, the class conditional densities, Recursive Bayes learning, Gibb's Algorithm, Principal Component Analysis, Fisher's Linear Discriminant, Expectation Maximization, first order Hidden Markov Models.
Nonparametric Techniques: Density Estimation, Parzen Windows in classification problems, The Nearest Neighbor Rule, K-Nearest Neighbor Algorithm, Error bounds and computational complexity of KNN algorithm.

Multilayer Neural Networks: Feedforward operation and classification, The Back-Propagation Algorithm, XOR Problem, Learning Rates, Momentum constant, Weight Pruning, K-Fold cross validation.

Kernel Methods: Cover's theorem on separability of patterns, The interpolation problem, Radial Basis Function Networks, Hybrid Learning Procedure for RBF Networks, Support Vector Machines,
Preprocessing and Unsupervised Learning: Self Organizing Maps, K-means clustering algorithm, Principle Component Analysis for dimensionality reduction, Cluster Analysis for compaction.

Minor Project: To be assigned by concerned instructor/course-coordinator.

Course Learning Outcomes (CLO):

1. Familiarization with parametric and non-parametric estimations.
2. Ability to visualize data in the pattern space.
3. Ability train and test classifiers using supervised learning.
4. Ability to apply clustering algorithms to process big data real time.
5. Apply Bayesian parameter estimation to real world problems.

Text Books:

1. *Duda, Richard, Peter Hart, and David Stork. Pattern Classification. New York, NY: Wiley-Interscience (2000).*
2. *Simon Hykin, Neural Networks and Learning Machines, Prentice Hall of India (2010)*
3. *Mitchell, Tom. Machine Learning. New York, NY: McGraw-Hill (1997).*

Reference Books:

1. *Bishop, Christophe, Neural Networks for Pattern Recognition. New York, NY: Oxford University Press, 1995. ISBN: 9780198538646.*
2. *Hastie, T., R. Tibshirani, and J. H. Friedman. The Elements of Statistical Learning: Data Mining, Inference and Prediction. New York, NY: Springer, 2001. ISBN: 9780387952840.*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PEC338: ROBOTICS AND AUTOMATION

L	T	P	Cr
3	**0**	**0**	**3.0**

Course Objectives: To make students understand principles of sensors and Robotics, interaction with outer world with the help of sensors, image processing for machine learning, object recognition and kinematics for robots and its interaction with objects.

Introduction: Definition and Need for Robots, Robot Anatomy, Co-ordinate Systems, Work Envelope, types and classification, Specifications, Pitch, Yaw, Roll, Joint Notations, Speed of Motion, Pay Load, Robot Parts and Their Functions, Different Applications.

Sensors: Principles and Applications and need of a sensor, Principles, Position of sensors, Piezo-Electric Sensor, LVDT, Resolvers, Optical Encoders, Pneumatic Position Sensors, Range Sensors, Triangulation Principle, Structured, Lighting Approach, Time of Flight Range Finders, Laser Range Meters, Proximity Sensors, Inductive, Hall Effect, Capacitive, Ultrasonic and Optical Proximity Sensors, Touch Sensors, (Binary Sensors, Analog Sensors), Wrist Sensors, Compliance Sensors, Slip Sensors.

Drive Systems & Grippers for Robot: Drives systems (Mechanical, Electrical, Pneumatic Drives, Hydraulic), D.C. Servo Motors, Stepper Motor, A.C. Servo Motors, Comparison of all Drives, End Effectors, Grippers (Mechanical, Pneumatic, Hydraulic, Magnetic, Vacuum Grippers), Two Fingered and Three Fingered Grippers, Internal Grippers and External Grippers, Selection and Design Considerations.

Machine Vision: Camera, Frame Grabber, Sensing and Digitizing Image Data, Signal Conversion, Image Storage, Lighting Techniques, Image Processing and Analysis, Data Reduction, Edge detection, Segmentation Feature Extraction, Object Recognition, Other Algorithms, Applications, Inspection, Identification, Visual Serving and Navigation.

Robot Kinematics & Programming: Forward Kinematics, Inverse Kinematics and Differences; Forward Kinematics and Reverse Kinematics of Manipulators with Two, Three Degrees of Freedom (In 2 Dimensional), Four Degrees of Freedom (in 3 Dimensional), Deviations and Problems Teach Pendant Programming, Lead through programming, Robot programming Languages, VAL Programming, Motion Commands, Sensor Commands, End effecter commands.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course Learning Outcomes (CLO):

1. To understand basics of robotics and their functionality.
2. To understand fundamentals of sensors.
3. To understand various driver systems for robots.
4. To understand image processing and computer vision for robotics.
5. To understand development of algorithms for robot kinematics.

Text Books:

1. *M.P.Groover, —Industrial Robotics – Technology, Programming and Applications, McGraw-Hill (2001).*
2. *Ghosal, A., Robotics: Fundamental Concepts and Analysis, Oxford University Press, (2008).*

Reference Books:

1. *Yoram Koren, —Robotics for Engineers, McGraw-Hill Book Co. (1992).*
2. *Fu, K., Gonzalez, R. and Lee, C.S. G., Robotics: Control, Sensing, Vision and Intelligence¸ McGraw- Hill (1987).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PVL343: SENSOR TECHNOLOGY AND MEMS

L	T	P	Cr
3	**0**	**0**	**3.0**

Course Objectives: In this course the students will learn basic concept of MEMS devices, their working principles, equivalent circuits, different MEMS sensors, fabrication technologies, modelling and characterization tools and calibration techniques.

Introduction to MEMS: Introduction to MEMS and Micro sensors, MEMS system-level design methodology, Equivalent Circuit representation of MEMS, Signal Conditioning Circuits.

Principles of Physical and Chemical Sensors: Sensor classification, Sensing mechanism of Mechanical, Electrical, Thermal, Magnetic, Optical, Chemical and Biological Sensors.

Sensor Technology: Concept of clean room, Vacuum systems, Thin Film Materials and processes (Lithography, oxidation, sputtering, diffusion, CVD, micro machining, Wafer bonding, Wire bonding and Packaging.

Sensor Modelling: Numerical modelling techniques, Model equations, different effects on modelling (mechanical, electrical, thermal, magnetic, optical, chemical and biological and example of modelling.

Sensor characterization and Calibration: Basic measurement and characterization systems, study of static and dynamic Characteristics, Sensor reliability, Ageing Test, failure mechanism.

Sensor Applications: Pressure Sensor with embedded electronics, Accelerometer, RF MEMS Switch with electronics, Bio-MEMS, environmental monitoring (Gas Sensors).

Future Aspects of MEMS: NEMS, MOEMS, BIO-MEMS, RF MEMS, OPTICAL MEMS.

Course Learning Outcomes (CLO):

After the completion of this course, the students are able to:

1. Understand various micro fabrication technologies.
2. Acquire knowledge about mems & micro sensors.
3. Use characterization tools.
4. Transfer knowledge to device applications

Recommended Books:

1. *Franssila, Sami, Introduction to Microfabrication, John Wiley & Sons, (2010).*
2. *Gad-el-Hak, Mohamed, MEMS: Introduction and Fundamentals, CRC Press (2005).*
3. *Maluf, N., An Introduction to Micro-Electro-Mechanical Systems Engineering, Artech House (2000).*
4. *Ristic, L. (Editor), Sensor Technology and Devices, Artech House (1994).*
5. *Leondes, T.C., MEMS/NEMS Handbook: Techniques and Applications, Springer Press (2007).*
6. *Senturia, S. D., Microsystem Design, Springer (2004).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PWC335: WIRELESS SENSOR NETWORKS

L	T	P	Cr
3	0	0	3.0

Course Objectives: To understand and gain the complete knowledge of wireless sensor networks. To understand the fundamentals of various architectures, different layers' protocols and their applications, topology Control, routing protocols details, transport layer and quality of service. To understand the concepts of data-centric and content-based networking.

Introduction: The vision of Ambient Intelligence., Application examples, Types of applications, Challenges for WSNs, why are sensor networks different? Enabling technologies.

Single Node Architecture: Hardware components, Energy consumption of sensor nodes, Operating systems and execution environments, Some examples of sensor nodes, Conclusion.

Network Architecture: Sensor network scenarios, Optimization goals and figures of merit, Design principles for WSNs, Service interfaces of WSNs, Gateway concepts, Conclusion.

Physical Layer: Introduction, Wireless channel and communication fundamentals, Physical layer and transceiver design considerations in WSNs.

MAC Protocols: Fundamentals of (wireless) MAC protocols, Low duty cycle protocols and wakeup concepts, Contention-based protocols, Schedule-based protocols, The IEEE 802.15.4 MAC protocol, How about IEEE 802.11 and Bluetooth.

Link Layer Protocols: Fundamentals: Tasks and requirements, Error control, Framing, Link management, Summary.

Topology Control: Motivation and basic ideas, Flat network topologies, Hierarchical networks by dominating sets, Hierarchical networks by clustering, Combining hierarchical topologies and power control, Adaptive node activity.

Routing Protocols: Geometric routing, Routing with virtual coordinates, Gossiping and agent-based unicast forwarding, Energy-efficient unicast, Broadcast and multicast, Geographic routing, Mobile nodes.

Data-Centric and Content-based Networking: Introduction, Data-centric routing, Data aggregation, Data-centric storage.

Transport Layer and Quality of Service: The transport layer and QoS in wireless sensor networks, Coverage and deployment, Reliable data transport, Block delivery, Congestion control and rate control.

Advanced Application Support: Advanced in-network processing, Security, Application-specific support.

Course Learning Outcomes (CLO):

At the end of the course, the students should be able to:

1. Understand the fundamentals of various Architectures, different layers' protocols and their applications, topology Control and routing protocols details.
2. Understand the data-centric and content-based networking.
3. Understand the transport layer and quality of service.

Recommended Books:

1. Karl, Holger and Andreas, Willig, Protocols and Architectures for Wireless Sensor Networks, John Wiley and sons (2005).
2. Xiaoyan, Cheng Maggie and Li, Deying, Advances in Wireless Ad Hoc and Sensor Networks Series, Springer (2008).
3. Sohraby, Kazem, Minoli, Daniel and Taieb Znati, Wireless Sensor Networks: Technology, Protocols, and Applications, John Wiley and Sons (2007).
4. Swami, Ananthram, Qing, Zhao, Hong, Yao-Win, and Lang Tong (editors), Wireless Sensor Networks: Signal Processing and Communications, Wiley (2007).
5. Rappaport, T.S., Wireless Communications, Prentice hall of India (2003).
6. Jun, Zheng and Jamalipour, Abbas, Wireless Sensor Networks: A Networking Perspective, Wiley-IEEE Press (2009).

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30

PWC336: WIRELESS COMMUNICATION PROTOCOLS

L	T	P	Cr
3	0	0	3.0

Course Objectives: To understand wireless networking, Mobile IP and wireless access protocols, Introduction to mobile network layers and WAP protocols. Study of wireless ATM and Hyper LAN.

Introduction to Wireless Networking: Introduction, Difference between wireless and fixed telephone networks, Development of wireless networks, Traffic routing in wireless networks.

Mobile IP and Wireless Access Protocol: Mobile IP Operation of mobile IP, Co-located address, Registration, Tunneling, WAP Architecture, overview, WML scripts, WAP service, WAP session protocol, wireless transaction, Wireless datagram protocol.

Bluetooth: Overview, Radio specification, Base band specification, Links manager specification, Logical link control and adaptation protocol. Introduction to WLL Technology.

Mobile Network Layer: Mobile IP: Overview, Terminologies related to Mobile IP, IP packet delivery, Agent advertisement and solicitation, Registration, Tunneling and Encapsulation, Optimizations, Reverse Tunneling, IPv6, Dynamic Host Configuration protocol: History, Applications of DHCP, DHCP Protocol: Significance and importance of DHCP, Routing , Routing types: Least cost, Adaptive, Non Adaptive routing namely DSDV and DSR protocols, Transport Layer: Traditional TCP, Congestion control, Slow start, Fast retransmit/fast recovery, Classical TCP improvements: Indirect TCP, Snooping TCP, Mobile TCP.

Wireless Application Protocol: WAP(1.0) Introduction, Main Objectives, Integration of WAP components, Stack arrangement with WAP, WAP network, Protocol stack of WAP, WAP client architecture, WAP network architecture, WAP (2.0): Advantages, Main architectural components of WAP 2.0, WAP Programming model, Uses of WAP 2.0 additional services.

Wireless ATM & Hiper LAN: Introduction, Wireless ATM, HIPERLAN, Adhoc Networking and WPAN.

Course Learning Outcomes (CLO):

At the end of the course the student should be able to:

1. Understand the basic concepts wireless networking and methods to achieve it.
2. Understand various wireless devices and their utility in wireless communication.
3. Understand various protocols used in wireless communication
4. Able to use the protocols for data optimized performance and to achieve QoS.

Recommended Books:

1. *Wireless Communication of Networks - William Stallings PHI*
2. *BlueTooth - Demystified Nathan J.Muller Tata McGraw – Hill Publication, New Delhi.*
3. *Wireless Communication and Networking – William Stallings, PHI, (2003).*
   Mobile Communications - Jochen Schiller Pearson Education, New Delhi.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30

PWC337: SPREAD SPECTRUM COMMUNICATION

L	T	P	Cr
3	0	0	3.0

Course Objectives: To understand the basic concept of spread spectrum communication, spreading codes. To understand and gain complete knowledge of radio channel modeling, OFDM, hybrid multiple access technique like OFDMA, MC-CDMA, BLAST architecture.

Introduction: Radio channel characteristics, Channel Modeling, Channel Statics, ISI and ICI, Discrete Multipath Channel Models, Diversity, Multi Carrier Transmission OFDM, Advantages and drawbacks of OFDM, Applications and standards of OFDM, Spread Spectrum Techniques, Multicarrier Spread Spectrum, MC-CDMA, MC-DS-CDMA

Hybrid Multiple Access Schemes: Multi carrier FDMA, OFDMA, OFDMA with code division multiplexing, distributed DFT, localized DFT, multi carrier TDMA, Pseudo random PPM Ultra-Wide Band systems, Comparison of Hybrid multiple access schemes, Multi carrier modulation and demodulation, synchronization, channel estimation, channel coding and decoding, signal constellation, mapping demapping and equalization, Adaptive techniques in multi carrier transmission, RF issues

Applications: 3GPP LTE systems, Requirements on LTE, Radio Access Network Architecture, Radio protocol Architecture, Downlink and Uplink Transmission Scheme, WiMax, System Architecture, WiMax Profiles, Hyper Man and 802.16x, Future mobile communication concepts, VSF-OFCDM access schemes, Wireless LAN, interaction channel for DVB-T:DVB-RCT

Additional Techniques for Capacity and Flexibility Enhancement: MIMO, BLAST architecture, Space-time coding, diversity techniques for multi carrier transmission, spatial pre -coding for multi carrier transmission, software defined radio.

Course Learning Outcomes (CLO):
At the end of the course, the students should be able to:

1. Understand the basic concepts of Spread Spectrum Communication and spreading codes.
2. Understand the basic concepts of OFDM and various Hybrid Multiple Access Schemes
3. Realize the basic ideas of the applications related to the spread spectrum communication
4. Understand the concepts of additional techniques for capacity and flexibility enhancement related to the spread spectrum communication.
5. Understand the basic concepts of MIMO and BLAST Architecture

Recommended Books:

1. K. Fazel and S. Kaiser, Multi-Carrier and Spread Spectrum Systems, John Wiley & Sons (2008).
2. David, Tse and Viswanath, Pramod, Fundamentals of Wireless Communication, Cambridge University Press (2006).

3. Fitzek, Frank H.P., Katz and Marcos D., Cooperation in Wireless Networks: Principles and Applications, Springer (2007).
4. Arogyaswami., Paulraj, Gore, Dhananjay and Nabar, Rohit., Introduction to Space-Time Wireless Communications, Cambridge University Press (2008).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30

PEC331: IP OVER WDM

L	T	P	Cr
3	0	0	3.0

Course Objective: This is a course dealing with the principles and issues arising in the design of optical networks with WDM technology. The student will study the architecture of WDM networks and related protocols. Emphasis is placed on performance, Internetworking, And transition strategies from today's technology to a future all-optical infrastructure.

Protocol Design Concepts: Capacity, Interface Speeds, and Protocols, TCP/IP, and the Network Layer, Protocols and Layering , Internet Protocol Design: The End-to-End Principle, Transport Layer and TCP, Service Models at the Transport Layer, UDP and Connectionless Transport, TCP and Connection-Oriented Transport, Network Layer, Network Service Models, Internet Protocol and Fragmentation/Reassembly, Routing in the Internet, Asynchronous Transfer Mode, IP over ATM , IP Switching, QoS, Integrated Services, and Differentiated Services, Integrated Services and RSVP, Differentiated Services, Multiprotocol Label Switching, Labels, Route Selection.

Electro-optic and Wavelength Conversion: Enabling Technologies, Wavelength-Converter Design, Wavelength-Convertible Switch Design, Network Design, Control, and Management Issues, Network Design, Network Control, Network Management.

Terabit Switching and Routing Network Elements: Transparent Terabit Switching and Routing, Opaque Terabit Switching and Routing, Modular Structure and Greater Granularity, Scalability, Multiple Protocol Interfaces, Architectures and Functionalities, Buffering Scheme, Switching Fabric, IP-Based IPI and OPI, IP-Based Electronic Controller, Multiprotocol Label Switching.

Optical Network Engineering: Optical Network Architecture, Optical Network and Traffic Engineering, Routing and Wavelength Assignment, Optical Network Design and Capacity Planning, Physical Topology Design, Virtual Topology Design, Design of Survivable Optical Networks, Dynamic Light path Provisioning and Restoration, Route Computation, Wavelength Assignment, Performance of Dynamic RWA Algorithms, Control Plane Issues and Standardization Activities.

Traffic Management for IP-over-WDM Networks: Network Scenario, Traffic Management in IP Networks, Self-Similarity, Demand Analysis, Connection-Level Analysis, IP Traffic Management in IP-over-WDM Network, End-to-End Issues, Performance Evaluation of File Transfer (WWW), Services over WDM Networks.

IP- and Wavelength-Routing Networks: Internet Protocol and Routing, Routing in Datagram Network, Wavelength-Routing Networks, Layered Graph Approach for RWA, VWP Approach for Design of WDM Networks, MPLS/MPlS/GMPLS, IP-over-WDM Integration, Interconnection Models, Integrated Dynamic IP and Wavelength Routing, Network Model, Waveband Routing in Optical Networks, Additional Issues in Optical Routing.

Internetworking Optical Internet and Optical Burst Switching: Overview of Optical Burst Switching, QoS Provisioning with OBS, Survivability Issue in OBS Network, IP-over-WDM Control and Signaling, Network Control, Engineering Control Plane, MPlS/GMPLS Control Plane for Optical Networks, Signaling Protocol, Optical Internetworking and Signaling, Across the Network Boundary, Sample IP-Centric Control Plane for Optical Networks.

Survivability in IP-over-WDM Networks: IP-over-WDM Architecture, Survivability Strategies, Survivable Routing Algorithms, Survivability Layer Considerations, Fault Detection and Notification, Signaling Protocol Mechanism, Survivability in Future IP-over-Optical Networks.

Optical Internetworking Models and Standards Directions: Intelligent Optical Network, Internetworking Models to Support, Optical Layer Intelligence, Overlay Model, Static Overlay Model, Dynamic Overlay Model, Peer Model, Optical Internetworking and Ethernet Standards, Gigabit Ethernet.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course Learning Outcomes (CLOs):

1. To acquire knowledge about protocol design concepts, electro-optic and wavelength convertion.
2. To learn about Terabit Switching and Routing Network Elements& Optical Network Engineering.
3. To study and analyze the performance of Traffic Management for IP-over-WDM and Wavelength-Routing Networks.
4. To analyze Internetworking Optical Internet and Optical Burst Switching, Survivability in IP-over-WDM Networks.
5. To understand Optical Internetworking Models and Standards Directions.

Text Books:

1. *Liu, Kelvin H., IP Over WDM, Wiley (2002).*
2. *Dixit, Sudhir, IP over WDM: Building the Next Generation Optical Internet, Wiley Interscience (2003).*

Reference Books:

1. *Serrat, Joan and Galis, Alex, Deploying and Managing IP over WDM networks, Artech House (2003).*
2. *R. Dutta, A. E. Kamal, G, N. Rouskas (Eds,), Traffic Grooming for Optical Networks: Foundations, Techniques and Frontiers, Springer (2008).*
3. *E. Stern, G. Ellinas, K. Bala, Multi-wavelength Optical Networks: Architectures, Design and Control (2nd edition), Cambridge University Press (2008).*
4. *M. Maier, Optical Switching Networks, Cambridge University Press (2008).*
5. *R. Ramaswami, K, N, Sivarajan, Optical Networks: A Practical Perspective, Morgan Kaufmann (2002).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PEC303: BIOMEDICAL SIGNAL PROCESSING

L	T	P	Cr
3	0	0	3.0

Course Objective: To make students understand principles of Biomedical signals, biomedical signals on time-frequency axis and their analysis, interference of various signals, basics of ECG, EEG, compression of biomedical signals, modelling of biomedical signals.

Introduction to Biomedical Signals: Examples of Biomedical signals - ECG, EEG, EMG etc - Tasks in Biomedical Signal Processing - Computer Aided Diagnosis. Origin of bio potentials - Review of linear systems - Fourier Transform and Time Frequency Analysis (Wavelet) of biomedical signals- Processing of Random & Stochastic signals – spectral estimation – Properties and effects of noise in biomedical instruments - Filtering in biomedical instruments.

Concurrent, Coupled and Correlated Processes: illustration with case studies – Adaptive and optimal filtering - Modeling of Biomedical signals - Detection of biomedical signals in noise -removal of artifacts of one signal embedded in another -Maternal-Fetal ECG – Musclecontraction interference. Event detection - case studies with ECG & EEG – Independent component Analysis - Cocktail party problem applied to EEG signals - Classification of biomedical signals.

Cardio Vascular Applications: Basic ECG: Electrical Activity of the heart ECG data acquisition – ECG parameters & their estimation - Use of multiscale analysis for ECG parameters estimation - Noise & Artifacts- ECG Signal Processing: Baseline Wandering, Power line interference, Muscle noise filtering – QRS detection - Arrhythmia analysis.

Data Compression: Lossless & Lossy- Heart Rate Variability – Time Domain measures – Heart Rhythm representation - Spectral analysis of heart rate variability - interaction with other physiological signals.

Neurological Applications: The electroencephalogram - EEG rhythms & waveform - categorization of EEG activity - recording techniques - EEG applications- Epilepsy, sleep disorders, brain computer interface. Modeling EEG- linear, stochastic models – Nonlinear modeling of EEG - artifacts in EEG & their characteristics and processing – Model based spectral analysis - EEG segmentation - Joint Time-Frequency analysis – correlation analysis of EEG channels - coherence analysis of EEG channels.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course Learning Outcomes (CLO):

1. To understand basics of various biomedical signals.
2. To understand fundamentals of processes related to biomedical signals.
3. To understand and analyse various parameters related to biomedical signals.
4. To understand data compression and its application in biomedical field.
5. To understand neurological models of ECG, etc.

Text Books:

1. *D. C. Reddy, "Biomedical Signal Processing: Principles and techniques", Tata McGraw Hill, New Delhi (2005).*
2. *Willis J Tompkins, Biomedical Signal Processing -, ED, Prentice – Hall (1993).*
3. *R. Rangayan, "Biomedical Signal Analysis", Wiley (2002).*
4. *Bruce, "Biomedical Signal Processing & Signal Modeling," Wiley (2001).*

Reference Books:

1. *Sörnmo, "Bioelectrical Signal Processing in Cardiac & Neurological Applications", Elsevier.*
2. *Semmlow, "Bio-signal and Biomedical Image Processing", Marcel Dekker.*
3. *Enderle, "Introduction to Biomedical Engineering," 2/e, Elsevier, 2005.*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PEC304: CLOUD COMPUTING

L	T	P	Cr
3	0	0	3.0

Course Objective: At the end of the course the student should be able to appreciate the benefits of cloud computing and apply cloud paradigms for evolving businesses. He should be familiar with cloud architectural models and resource allocation strategies. The student should comprehensively be exposed to cloud based services.

Introduction: Basics of the emerging cloud computing paradigm, cloud computing history and evolution, cloud enabling technologies, practical applications of cloud computing for various industries, the economics and benefits of cloud computing.

Cloud Computing Architecture: Cloud Architecture model, Types of Clouds: Public Private & Hybrid Clouds, Resource management and scheduling, QoS (Quality of Service) and Resource Allocation, Clustering.

Cloud Computing Delivery Models: Cloud based services: Iaas, PaaS and SaaS Infrastructure as a Service (IaaS): Introduction to IaaS, Resource Virtualization i.e. Server, Storage and Network Virtualization Platform as a Service (PaaS): Introduction to PaaS, Cloud platform & Management of Computation and Storage, Azure, Hadoop, and Google App. Software as a Service (SaaS): Introduction to SaaS, Cloud Services, Web services, Web 2.0, Web OS Case studies related to IaaS, PaaS and SaaS.

Data Processing in Cloud: Introduction to Map Reduce for Simplified data processing on Large clusters, Design of data applications based on Map Reduce in Apache Hadoop.

Advanced Technologies: Advanced web technologies (AJAX and Mashup), distributed computing models and technologies (Hadoop and MapReduce), Introduction to Open Source clouds like Virtual Computing Lab (Apache VCL), Eucalyptus.

Cloud Issues and Challenges: Cloud computing issues and challenges like Cloud Provider Lock-in, Security etc.
Introduction to Python Runtime Environment: The Datastore, Development Workflow.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course Learning Outcomes (CLO):
1. Familiarization with cloud architectures.
2. Knowledge of data processing in cloud.
3. Ability to apply clustering algorithms to process big data real time.
4. Ability to address security issues in cloud environment.
5. Understand the nuances of cloud based services.

Text Books:

1. *Rajkumar Buyya, James Broberg and Goscinski Author Name, Cloud Computing Principles and Paradigms, John Wiley and Sons (2012).*
2. *Gerard Blokdijk, Ivanka Menken, The Complete Cornerstone Guide to Cloud Computing Best Practices, Emereo Pvt Ltd. (2009).*

Reference Books:

1. *Anthony Velte, Toby Velte and Robert Elsenpeter, Cloud Computing: A practical Approach Tata McGrawHill (2010).*
2. *Judith Hurwitz, Robin Bllor, Marcia Kaufmann, Fern Halper, Cloud Computing for Dummies (2009).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PVL347: SOFT COMPUTING TECHNIQUES

L	T	P	Cr
3	0	0	3.0

Course Objective: To provide students with the ability to apply adaptive filtering techniques to real-world problems (e.g. adaptive interference cancellation, adaptive equalization) in order to improve the performance over static, fixed filtering techniques. To provide a theoretical basis of adaptive signal processing necessary for the students to extend their area of study to additional applications, and other advanced concepts in statistical signal processing.

Introduction to Artificial Neural Networks: Historical Perspective, Overview of biological Neural System, Popular models of a Neuron, Network architectures, Single & multilayer Perceptron models, Their variants and Applications Terminology, Notations and representation of Neural Networks, Types of activation functions.

ANNs as Learning Machines: Statistical learning theory, Supervised, Unsupervised and reinforcement learning, Training using Back-propagation and Radial Basis Function algorithms, Support Vector Machines for non-linear regression, Least Means Square (LMS) algorithm, Orthogonal least squares algorithm, Hopfield networks, Principal Component Analysis (PCA), Kernel based PCA, Self-Organizing Map, Learning Vector Quantization, Stochastic Machines, Gibb's Sampling & Simulated Annealing, Sigmoidal Belief Networks.

Fuzzy Logic: Introduction to Fuzzy Logic, Crisp sets and Fuzzy sets, Membership functions, Fuzzy Arithmetic, Fuzzy Numbers, Arithmetic operations on Intervals and Numbers Lattice of Fuzzy Numbers, Fuzzy Equations, Fuzzy inference systems, Comparison of Bayesian & Fuzzy Computational models, Application of Fuzzy Logic in real world scenarios.

Operations on Fuzzy Sets: Compliment, Intersections, Unions, Aggregation operations, Combinations of operations. Advanced Fuzzy measures viz. Fuzzy Entropy, Fuzzy Subset hood, Fuzzy Similarity, Relative Fuzzy Entropy and their significance, Information-theoretic analysis of advanced Fuzzy measures.

Genetic Algorithm: An overview of GA, GA operators, GA in optimization, Selection Techniques, Single-point, Multi-point and Uniform cross-over, Mutation Scheduling, Fitness parameters of parents and offspring.

Hybrid Soft Computational Paradigms: Introduction to Neuro-Fuzzy, Neuro-Genetic and Fuzzy Genetic paradigms, Fuzzy system as a pre-processor, GA for synaptic weight optimization in ANN, Design challenges before a hybrid system, Introduction to ant colony and particle swarm optimization algorithms.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course Learning Outcomes (CLOs):

1. Solve Pattern Classification & Function Approximation Problems.
2. Design appropriate ANN model for a given Problem.
3. Apply data pre-processing techniques.
4. Build Fuzzy inference systems from linguistic models.

5. Undertake genetic optimization and ability to create objective functions for a given optimization problem.

Text Books:

1. *Vijay Laxmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms, Soft Computing Paradigms, Prentice Hall of India (2008).*
2. *Bart Kosko, Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence, Prentice Hall India (1992).*

Reference Books:

1. *Simon Hykin, Neural Networks: A Comprehensive Foundation, PHI (1999).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PEC205: RF CIRCUIT DESIGN

L	T	P	Cr
3	0	0	3

Course Objective: In this course, students will learn the basic principles of RF devices, from device level, relating to the wireless technologies**.**

Basic Principles in RF Design: Units in RF Design, Time Variance, Nonlinearity, Effects of Nonlinearity, Harmonic Distortion, Gain Compression, Cross Modulation, Intermodulation, Cascaded Nonlinear Stages, AM/PM Conversion, noise, sensitivity and dynamic range, S parameters, analysis of nonlinear dynamic systems.

Distributed Systems: Transmission lines, reflection coefficient, the wave equation, examples, Lossy transmission lines, Smith charts – plotting gamma, Micro-strip Transmission Lines.

Noise: Thermal noise, flicker, noise review, Noise figure Intrinsic MOS noise parameters, Power match versus noise match.

High Frequency Amplifier Design: Bandwidth estimation using open-circuit time constants, Bandwidth estimation using short-circuit time constants, Rise time, delay and bandwidth, Zeros to enhance bandwidth, Shunt-series amplifiers, Tuned amplifiers.

LNA Design: General Considerations, Problem of Input Matching, LNA Topologies, Gain Switching, Band Switching, High-IP2 LNAs, Differential LNAs Other Methods of IP2 Improvement, Nonlinearity Calculations, Degenerated CS Stage, Undegenerated CS Stage, Differential and Quasi-Differential Pairs, Degenerated Differential Pair. Large signal performance, design examples & Multiplier based mixers Sub-sampling mixers.

Mixers: General Considerations, Performance Parameters, Mixer Noise Figures, Single-Balanced and Double-Balanced Mixers, Passive Down-conversion Mixers, Active Down-conversion Mixers, Active Mixers with High IP2, Active Mixers with Low Flicker Noise, Upconversion Mixers, Performance Requirements, Upconversion Mixer Topologies.

RF Power Amplifiers: Class A, AB, B, C amplifiers, Class D, E, F amplifiers, RF Power amplifier design examples.

RF Filter Design: Filter types and parameters, Insertion Loss. Special Filter Realizations, Butterworth type filter, Chebyshev type filters, De-normalization of standard low pass design, Filter Implementation Kuroda's Identities, Micro-strip Filter Design. Coupled Filters, Odd and Even Mode Excitation, Band-pass Filter Design, Cascading band-pass filter elements.

Transceiver Architectures: General Considerations, Receiver Architectures, Transmitter Architectures

Active RF Components: Semiconductor Basics: Physical properties of semiconductors, PN-Junction, Schottky contact. Bipolar-Junction Transistors: Construction, Functionality, Temperature behaviour, Limiting values. RF Field Effect Transistors: Construction, Functionality, Frequency response, Limiting values. High Electron Mobility Transistors: Construction, Functionality, Frequency response.

Active RF Component Modeling: Transistor Models: Large-signal BJT Models, Small-signal BJT Models, Large-signal FET Models, Small-signal FET Models. Measurement of Active Devices: DC Characterization of Bipolar Transistors, Measurements of AC parameters of Bipolar Transistors, Measurement of Field Effect Bipolar Transistors Transistor Parameters. Scattering Parameters, Device Characterization.

Minor Project: To be assigned by concerned instructor/course-coordinator.

Course Learning Outcomes (CLO):

1. Acquired knowledge about Basic Principles in RF Design.
2. Ability to identify Distributed Systems.
3. Foster ability to work using High Frequency Amplifier Design.
4. Foster ability to work using LNA Design.
5. Acquired knowledge about Mixers and RF Power Amplifiers, Design.

Text Books:

1. *Thomas H. Lee, The Design of CMOS Radio-Frequency Integrated Circuits. Cambridge University Press (2004).*
2. *Behzad Razavi, RF Microelectronics. Prentice Hall (1997).*

Reference Books:

1. *Reinhold Ludwig, Pavel Bretchko, RF Circuit Design, Pearson Education Asia (2000).*
2. *W.Alan Davis , K K Agarwal, Radio Frequency circuit Design, Wiley (2001).*
3. *Mathew M. Radmanesh, RF & Microwave Design Essential, Engineering Design and Analysis from DC to Microwaves, KRC Books (2007).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PVL333: SYSTEM ON CHIP

L	T	P	Cr
3	0	0	3.0

Course Objectives: In this course the students will learn SOC design processes, ASIc design flow, EDA tools, architecture design and test optimization with system integration issues.

Overview of SOC Design Process: Introduction, Top-down SoC design flow, Metrics of SoC design, Techniques to improve a specific design metric, ASIC Design flow and EDA tools.

SOC Architecture Design: Introduction, Front-end chip design, Back-end chip design, Integration platforms and SoC Design, Function Architecture Co-design, Designing Communication Networks, System Level Power Estimation and Modelling, Transaction Level Modelling, Design Space Exploration, Software design in SoCs.

SOC Design and Test Optimization: Design methodologies for SoC, Noise and signal integrity analysis, System Integration issues for SoC, SoC Test Scheduling and Test Integration, SoC Test Resource partition.

Course Learning Outcomes (CLO):

After the completion of this course, the students are able to:

1. Understand the ASIC Design flow and EDA tools.
2. Acquire knowledge about Top-down soc design flow.
3. Apply knowledge about Front-end and back-end chip design.
4. Model designing communication Networks.
5. Analyse the design space exploration.
6. Interpret the design methodologies for soc

Recommended Books:

1. *Wolf, W., Modern VLSI Design: System-on-chip Design, Prentice Hall (2002).*
2. *Nekoogar, F. and Nekoogar, F., From ASICs to SOCs: A Practical Approach, Prentice Hall (2003).*
3. *Uyemura, J.P., Modern VLSI Design – SOC Design, Prentice Hall (2001).*
4. *Rajsuman, R., System-on-a-chip: Design and Test, Artech House (2000).*
5. *Asheden, P.J. and Mermet J., System-on-Chip Methodologies and Design Languages, Kluwer Academic (2002)*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PEC301: ARTIFICIAL INTELLIGENCE

L	T	P	Cr
3	0	0	3.0

Course Objective: To be familiar with the applicability, strengths, and weaknesses of the basic knowledge representation, problem solving, and learning methods in solving particular engineering problems.

Fundamental Issues: Overview of AI problems, Examples of successful recent AI applications, Intelligent behaviour, The Turing test, Rational versus non-rational reasoning, Problem characteristics: Fully versus partially observable, Single versus multi-agent, Deterministic versus stochastic, Static versus dynamic, Discrete versus continuous, Nature of agents: Autonomous versus semi-autonomous, Reflexive, Goal-based, and Utility-based, Importance of perception and environmental interactions, Philosophical and ethical issues.

Basic Search Strategies: Problem spaces (states, goals and operators), Problem solving by search, Factored representation (factoring state into variables), Uninformed search (breadth-first, depth-first, depth-first with iterative deepening), Heuristics and informed search (hill-climbing, generic best-first, A*), Space and time efficiency of search, Constraint satisfaction (backtracking and local search methods).

Advanced Search: Constructing search trees, Dynamic search space, Combinatorial explosion of search space, Stochastic search: Simulated annealing, Genetic algorithms, Monte-Carlo tree search, Implementation of A* search, Beam search, Minimax Search, Alpha-beta pruning, Expectimax search (MDP-solving) and chance nodes.

Knowledge Representation: Propositional and predicate logic, Resolution in predicate logic, Question answering, Theorem proving, Semantic networks, Frames and scripts, conceptual graphs, conceptual dependencies.

Reasoning under Uncertainty: Review of basic probability, Random variables and probability distributions: Axioms of probability, Probabilistic inference, Bayes' Rule, Conditional Independence, Knowledge representations using Bayesian Networks, Exact inference and its complexity, Randomized sampling (Monte Carlo) methods (e.g. Gibbs sampling), Markov Networks, Relational probability models, Hidden Markov Models, Decision Theory Preferences and utility functions, Maximizing expected utility.

Agents: Definitions of agents, Agent architectures (e.g., reactive, layered, cognitive), Agent theory, Rationality, Game Theory Decision-theoretic agents, Markov decision processes (MDP), Software agents, Personal assistants, and Information access Collaborative agents, Information-gathering agents, Believable agents (synthetic characters, modelling emotions in agents), Learning agents, Multi-agent systems Collaborating agents, Agent teams, Competitive agents (e.g., auctions, voting), Swarm systems and Biologically inspired models.

Expert Systems: Architecture of an expert system, existing expert systems: MYCIN, RI. Expert system shells.

Minor Project: To be assigned by concerned instructor/course-coordinator

Course learning outcomes (CLO):

1. To assess the applications of artificial intelligence and categorize various problem domains, uninformed and informed search methods.
2. To explore and understand advanced search techniques and algorithms like minimax for game playing.
3. To understand the importance of probability in knowledge representation for reasoning under uncertainty.
4. To learn to represent knowledge using Bayesian networks and drawing Hidden Markov Models.
5. To learn the architecture for intelligent agents and implement an intelligent agent.

Text Books:

1. *Rich E., Artificial Intelligence, Tata McGraw Hills (2009).*
2. *George F. Luger, Artificial Intelligence: Structures and Strategies for Complex Problem Solving, Pearson Education Asia (2009).*

Reference Books:

1. *Patterson D.W, Introduction to AI and Expert Systems, Mc GrawHill (1998).*
2. *Shivani Goel, Express Learning- Artificial Intelligence, Pearson Education Asia (2013).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%