DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

SCHEME OF COURSES FOR

M.E. (Electronics and Communication), Batch – 2019-2021

THAPAR INSTITUTE
OF ENGINERING & TECHNOLOGY
(Deemed to be University)

SCHEME OF COURSES FOR

M.E. (Electronics and Communication), Batch – 2019-2021

First Semester

S. No.	**Course No.**	**Course Name**	**L**	**T**	**P**	**Cr**
1.	PEC ***	Advanced Wireless Communication Systems	3	0	2	4.0
2.	PEC***	Advanced Digital Signal Processing	3	0	2	4.0
3.	PEC ***	Random Processes: Detection, and Estimation	3	1	0	3.5
4.	PEC ***	Machine Intelligence and Learning	3	0	2	4.0
5.	PEC***	Advanced Antenna System	3	0	2	4.0
6.	PVL103	Digital VLSI Design	3	1	2	4.5
		Total	**18**	**2**	**10**	**24.0**

Second Semester

S. No.	**Course No.**	**Course Name**	**L**	**T**	**P**	**Cr**
1.	PEC***	MIMO Communication System	3	0	2	4.0
2.	PEC 106	Optical Communication Networks	3	0	2	4.0
3.	PEC 339	Image Processing and Computer Vision	3	0	2	4.0
5.		Elective – I	-	-	-	3.0
4.		Elective – II	-	-	-	3.0
6.		Elective – III	3	0	0	3.0
		Total	**-**	**0**	**-**	**21.0**

Third Semester

S. No.	**Course No.**	**Course Name**	**L**	**T**	**P**	**Cr**
1.	**PEC391**	Seminar	**-**	**-**	**-**	**4.0**
2.	**PEC*****	Design Project	**-**	**-**	**-**	**4.0**
3.		Non-credit Self study online course (Swayam, MOOC, Coursera, NPTEL etc.)				Student must register the course with the consent of respective supervisor and also submit the passing certificate.
		Dissertation (Starts)				
		Total				**8.0**

Fourth Semester

S. No.	**Course No.**	**Course Name**	**L**	**T**	**P**	**Cr**
1.	**PEC492**	Dissertation (Continued…)				**16.0**

Total Credits: 69.0

List of Electives

Elective–I

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PWC201	Space-Time Wireless Communication	3	0	0	3.0
2.	PEC***	Embedded Systems	2	0	2	3.0
3.	PEC217	Micro Strip Antenna	3	0	0	3.0
4.	PVL 203	VLSI Signal Processing	3	0	0	3.0
5.	PWC202	Advance Wireless Networks	3	0	0	3.0
6.	PEC 211	Passive Optical Networks	3	0	0	3.0
7.	PEC 212	Audio and Speech Processing	3	0	0	3.0
8.	PEC ***	Advanced Engineering Electromagnetics	3	0	0	3.0
9.	PEC 216	Advanced Computer Networks and Protocols	3	0	0	3.0
10.	PEC214	Fractional Transforms and Applications	3	0	0	3.0
11.	PEC ***	Optoelectronics Devices and Circuits	3	0	0	3.0

Elective-II

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PEC301	Artificial Intelligence	3	0	0	3.0
2.	PVL343	Sensor Technology and MEMS	3	0	0	3.0
3.	PEC***	Design for IOT	3	0	0	3.0
4.	PWC321	Next Generation Wireless Systems and Networks	3	0	0	3.0
5.	PWC106	Advanced Error Control Coding Theory	3	0	0	3.0
6.	PEC***	Compressed Sensing and Sparse Signal Processing	3	0	0	3.0
7.	PEC***	Digital Array Signal Processing	3	0	0	3.0
8.	PEC***	Computational Electromagnetics	3	0	0	3.0
9.	PEC ***	Deep Learning for Computer Vision	2	0	2	3.0
10.	PEC ***	Smart Antennas	3	0	0	3.0
11.	PVL***	Analog & Mixed Signal Circuit Design	3	0	0	3.0

Elective-III

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PEC***	Wavelet Transforms and Applications	3	0	0	3.0
2.	PEC***	Quantum Informatics	3	0	0	3.0
3.	PEC***	Digital Video: Perception and Algorithms	3	0	0	3.0
4.	PEC***	Integrated Circuits for Wireless Communication	3	0	0	3.0
5.	PWC212	Wireless Security	3	0	0	3.0
6.	PEC303	Biomedical Signal Processing	3	0	0	3.0
7.	PEC304	Cloud Computing	3	0	0	3.0
8.	PEC205	RF Circuit Design	3	0	0	3.0
9.	PEC ***	Microwave Measurements and Design	3	0	0	3.0
10.	PEC ***	Optical Computing Technology	3	0	0	3.0
11.	PEC ***	Adaptive Signal Processing	3	0	0	3.0

PEC *** ADVANCED WIRELESS COMMUNICATION SYSTEMS

L	T	P	Cr
3	0	2	4

Prerequisite(s): None

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.

Course Content Details:

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, Outage probability.

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

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

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.

Equalization: Equalizer Types, Folded Spectrum and ISI-Free Transmission, Linear Equalizers, Zero Forcing (ZF) Equalizers, MMSE Equalizer, Maximum Likelihood Sequence Estimation, Decision-Feedback Equalization, Equalizer Training and Tracking.

Multicarrier Modulation: Data Transmission using Multiple Carriers, Overlapping Subchannels, Mitigation of Sub carrier Fading, Discrete Implementation of Multi-carrier, Cyclic Prefix, OFDM, PAPR, 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:

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

1. Understand the fundamentals and advancement in wireless communication systems.
2. Analyze 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 2nd ed (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	25%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PEC *** ADVANCED DIGITAL SIGNAL PROCESSING

L	T	P	Cr
3	0	2	4.0

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

Course Content Details:

Review of Discrete Time Signals: 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, Finite word length effects in filter design.

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-offeffects. Spectrum Estimation, Parametric and non-Parametric methods

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: Various experiments related to Digital filter structures, Multi-rate signal processing, Prediction, Adaptive filters, Time-frequency analysis using MATLAB platform

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

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

1. Recognize the concept of discrete time signal processing and filter design techniques.
2. Interpret multi-rate signal processing and its application.
3. Analyze the theory of adaptive filter design and its applications.
4. Evaluate 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) 2nd Ed.***
2. ***Proakis, J. G. and Manolakis, D. G., Digital Signal Processing, Prentice Hall of India (2001) 3rd Ed.***

Reference Books:

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

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25%
2.	EST	45%
3.	Sessional (May include Assignments/Projects/Quizzes)	30%

PEC***: RANDOM PROCESSES: DETECTION AND ESTIMATION

L	T	P	Cr
3	1	0	3.5

Course objective: The subject of signal detection and estimation is concerned with the processing of information-bearing signals for the purpose of making inferences about the information that they contain. The purpose of this course is to provide an introduction to the fundamental theoretical principles underlying the development and analysis of techniques for such processing. At the end of the course the student should be able to understand the use of classical and Bayesian approaches for parameter estimation, hypothesis testing, Bayesian approaches for signal detection and linear filtering for parameter estimation.

Course Content Details:

Background: Review of Random process, Gaussian variables and processes; problem formulation and objective of signal detection and signal parameter estimation in discrete-time domain.

Statistical Decision Theory: Bayesian, minimax, and Neyman-Pearson decision rules, likelihood ratio, receiver operating characteristics, composite hypothesis testing, locally optimum tests, detector comparison techniques, asymptotic relative efficiency.

Detection of Deterministic Signals: Matched filter detector and its performance; generalized matched filter; detection of sinusoid with unknown amplitude, phase, frequency and arrival time, linear model.

Detection of Random Signals: Estimator-correlator, linear model, general Gaussian detection, detection of Gaussian random signal with unknown parameters, weak signal detection.

Nonparametric Detection: Detection in the absence of complete statistical description of observations, sign detector, Wilcoxon detector, detectors based on quantized observations, robustness of detectors.

Estimation of Signal Parameters: Minimum variance unbiased estimation, Fisher information matrix, Cramer-Rao bound, sufficient statistics, minimum statistics, complete statistics; linear models; best linear unbiased estimation; maximum likelihood estimation, invariance principle; estimation efficiency; Bayesian estimation: philosophy, nuisance parameters, risk functions, minimum mean square error estimation, maximum a posteriori estimation.

Signal Estimation in Discrete-Time: Linear Bayesian estimation, Weiner filtering, dynamical signal model, discrete Kalman filtering.

Laboratory Work: N.A.

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

Course learning outcomes (CLOs):
The students will be able to

1. Use classical and Bayesian approaches to formulate and solve problems for parameter estimation from noisy signals.
2. Apply hypothesis testing and Bayesian approaches to formulate and solve problems for signal detection from noisy signals.
3. Differentiate linear filtering methods for parameter estimation and signal smoothing.
4. Analyze discrete-time approaches for signal estimation.

Text Books:

1. H. Van Trees, Detection, Estimation and Modulation Theory, John Wiley & Sons, 2001.

Reference Books:

1. H. V. Poor, "An Introduction to Signal Detection and Estimation", Springer, 2/e, 1998.
2. L. Scharf, Statistical Signal Processing - Detection, Estimation and Time Series Analysis, Addison-Wesley, 1991.
3. A. Papoulis, Probability, Random Variables, and Stochastic Processes, McGrawHill, 1965.
4. S. M. Kay, "Fundamentals of Statistical Signal Processing: Estimation Theory", Prentice Hall PTR, 1993.
5. S. M. Kay, "Fundamentals of Statistical Signal Processing: Detection Theory", Prentice Hall PTR, 1998.

Evaluation Scheme:

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

PEC***: MACHINE INTELLIGENCE AND LEARNING

L	T	P	Cr
3	0	2	4.0

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.

Course Content Details:

Introduction to Machine Intelligence and 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, perceptron and Bayes classifier for a Gaussian environment, The Least Mean Square (LMS) algorithm, 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, 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, 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.

Regression: Linear regression, polynomial regression, Logistic regression, decision tress, random forest .

Advanced learning methods: Stochastic gradient, CNN, RNN

Laboratory Work: Supervised learning, batch learning, perceptron learning, Least Mean Square (LMS) algorithm, Least Square (RLS) algorithm, Bayesian classification, Principal Component Analysis, Back-Propagation Algorithm, RBF Networks, Support Vector Machines, K-Nearest Neighbor Algorithm, CNN, RNN

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

Course learning outcomes (CLOs):
The students will be able to

1. Recognize data in the pattern space.
2. Design a trainer and test classifiers using supervised learning.
3. Apply clustering algorithms to process big data real time.
4. Differentiate the parametric and non parametric estimations.
5. Apply Bayesian parameter estimation to real world problems.

Text Books:

1. ***Simon Hykin, Neural Networks and Learning Machines, 3rd edition Prentice Hall of India, 2010.***
2. ***Martin T. Hagan, H. B. Demuth and M. Beale, Neural Network Design, 4th edition, Cengage Learning, 1996.***

Reference Books:

1. ***Bishop, Christophe, Neural Networks for Pattern Recognition. New York, NY: Oxford University Press, 1995.***
2. ***Duda, Richard, Peter Hart, and David Stork. Pattern Classification. 2nd ed. New York, NY: Wiley-Interscience, 2000.***
3. ***Mitchell, Tom. Machine Learning. New York, NY: McGraw-Hill, 1997. ISBN: 9780070428072.***
4. ***Hastie, T., R. Tibshirani, and J. H. Friedman. The Elements of Statistical Learning: Data Mining, Inference and Prediction. New York, NY: Springer, 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%

PEC***: ADVANCED ANTENNA SYSTEM

L	T	P	Cr
3	**0**	**2**	**4.0**

Course Objective: The goals of this course are to develop student's analytical understandings of antenna subject and to investigate most common antenna structures.

Course Content Details:

Fundamental Concepts:
Physical concept of radiation, Radiation pattern, near- and far-field regions, reciprocity, directivity and gain, effective aperture, polarization, input impedance, efficiency, Friis transmission equation, radiation integrals and auxiliary potential functions.

Thin Linear Antennas and Arrays:
Infinitesimal dipole, finite-length dipole, linear elements near conductors, dipoles for mobile communication, small circular loop, N-Element 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.

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.

Computational Electromagnetics: Introduction of computational EM technique, Method of Moments, Finite Difference Time Domain Method, Finite Element Method.

Broadband Antennas: Log-periodic and Yagi antennas, frequency independent antennas, broadcast antennas.

Pattern Synthesis: Approximate far field pattern of line sources, Synthesis of line sources, Fourier transform method of line sources, Antenna as a filter, 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.

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):

The students will be able to

1. Acquire the knowledge about basic antenna parameters.
2. Theoretically analyze wire antennas and arrays.
3. Identify secondary sources, aperture, broadband and frequency independent antennas.
4. Acquire the brief knowledge about computational electromagnetic and comprehend about adaptive array concept.
5. Apply the knowledge of mutual coupling on antennas, applications and numerical techniques.

Text Books:

1. ***Balanis, C., Antennas, John Wiley and sons (2007) 3rd edition.***
2. ***Milligan, Thomas A., Modern Antenna Design 2nd edition, IEEE press, Wiley Inter-science (2005).***
3. ***David B. Davidson, Computational Electromagnetics for RF and Microwave Engineering, Cambridge University Press 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).***
4.

Evaluation Scheme:

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

PVL103: DIGITAL VLSI DESIGN

L	T	P	Cr
3	1	2	4.5

Course Objectives: To understand the physics and modeling of MOSFETs, basic theory of fabrication steps and layout of CMOS Integrated Circuits, basic theory of Power Dissipation in CMOS Digital Circuits and Foster ability to work with static and dynamic logic circuits.

Physics and Modeling of MOSFETs: Basic MOSFET Characteristics – Threshold Voltage, Body Bias concept, Current-Voltage Characteristics – Square-Law Model, MOSFET Modeling – Drain-Source Resistance, MOSFET Capacitances, Geometric Scaling Theory – Full-Voltage Scaling, Constant-Voltage Scaling.

Fabrication and Layout of CMOS Integrated Circuits: Overview of Integrated Circuit Processing – Oxidation, Photolithography, Self-Aligned MOSFET, Isolation and Wells – LOCOS, Trench Isolation, CMOS Process flow, Mask design and Layout – MOSFET Dimensions, Design Rules, Latch-up.

CMOS Inverter: Basic Circuit and DC Operation – DC Characteristics, Noise Margins, Layout considerations, Inverter Switching Characteristics – Switching Intervals, High-to-Low time, Low-to- High time, Maximum Switching Frequency, Transient Effects on the VTC, RC Delay Modeling, Elmore Delay, Output Capacitance, Inverter Design – DC Design, Transient Design, Driving Large Capacitive Loads.

Switching Properties of MOSFETs: nMOSFET/ pMOSFET Pass Transistors, Transmission Gate Characteristics, MOSFET Switch Logic, TG-based Switch Logic, D-type Flip-Flop.

Static CMOS Logic Elements: Complex Logic Functions, CMOS NAND Gate, CMOS NOR Gate, Complex Logic Gates, Exclusive OR and Equivalence Gates, Adder Circuits, Pseudo nMOS Logic Gates, Schmitt Trigger Circuits, SR and D-type Latch, CMOS SRAM Cell, Tri-state Output Circuits.

Power Dissipation in CMOS Digital Circuits: Dynamic Power Dissipation – Switching Power Dissipation, Short Circuit Power Dissipation, Glitching Power Dissipation, Static Power Dissipation – Diode Leakage Current, Subthreshold Leakage Current.

Dynamic Logic Circuit Concepts and CMOS Dynamic Logic Families: Charge Leakage, charge Sharing, Dynamic RAM Cell, Bootstrapping, Clocked-CMOS, Pre-Charge/ Evaluate Logic, Domino Logic, Multiple-Output Domino Logic, NORA Logic, Single-Phase Logic.

Effects of Technology Scaling on CMOS Logic Styles: Trends and Limitations of CMOS Technology Scaling – MOSFET Scaling Trends, Challenges of MOSFET Scaling – Short-Channel Effects, Subthreshold Leakage Currents, Dielectric Breakdown, Hot Carrier effects, Soft Errors, Velocity Saturation and Mobility Degradation, DIBL, Scaling down Vdd/Vth ratio.

CMOS Differential Logic Styles: Dual-Rail Logic, CVSL, CPL, DPL, DCVS, MCML.

Issues in Chip Design: ESD Protection, On-Chip Interconnects – Line Parasitics, Modeling of the Interconnect Line, Clock Distribution, Input-Output circuits.

Laboratory work: Familiarization with schematic and layout entry using Mentor/ Cadence/ Tanner Tools, circuit simulation using SPICE; DC transfer Characteristics of Inverters, Transient response, Calculating propagation delays, rise and fall times, Circuit design of inverters, complex gates with given constraints; Circuit Simulation and Performance Estimation using SPICE; Layouts of Inverters and Complex gates, Layout Optimization, Design Rule Check (DRC), Electrical Rule Check (ERC), Comparison of Layout Vs. Schematics, Circuit Extraction.

Course Learning Outcomes:
The students are able to:
1. Understand the basic Physics and Modeling of MOSFETs.
2. Learn the basics of Fabrication and Layout of CMOS Integrated Circuits.
3. Study and analyze the performance of CMOS Inverter circuits on the basis of their operation and working.
4. Study the Static CMOS Logic Elements.
5. Study the Dynamic Logic Circuit Concepts and CMOS Dynamic Logic Families.

Recommended Books:

1. ***Kang, S. and Leblebici, Y., CMOS Digital Integrated Circuits – Analysis and Design, Tata McGraw Hill (2008) 3rd ed.***
2. ***Weste, N.H.E. and Eshraghian, K., CMOS VLSI Design: A Circuits and Systems Perspective, eddision Wesley (1998) 2nd ed.***
3. ***Rabaey, J.M., Chandrakasen, A.P. and Nikolic, B., Digital Integrated Circuits – A Design perspective, Pearson Education (2007) 2nd ed.***
4. ***Baker, R.J., Lee, H. W. and Boyce, D. E., CMOS Circuit Design, Layout and Simulation, Wiley - IEEE Press (2004) 2nd ed.***
5. ***Weste, N.H.E., Harris, D. and Banerjee, A., CMOS VLSI Design, Dorling Kindersley (2006) 3rd ed.***

Evaluation Scheme:

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

PEC***: MIMO Communication System

L	T	P	Cr
3	0	2	4

Course objective: This subject covers the fundamentals of Multiple input multiple output (MIMO) antenna based wireless communication systems. MIMO is now an essential part of modern wireless communication systems, such as 3G, 4G, WLAN / Wifi, LTE, WiMax, etc. MIMO brings to the domain of wireless communications, spectral efficiency and reliability gains. At the end of the course, students should be able to grasp the phenomenology and theory that give rise to improved reliability and the dramatic increases in data rates enabled by MIMO, analyze, design, and simulate MIMO communication systems and be familiar with practical applications of MIMO communications.

Course Content Details:

1. **Introduction** , MIMO wireless communication , Need for MIMO systems, multiple antennas in wireless communication systems, MIMO in wireless networks, Diversity-multiplexing trade-off, transmit diversity schemes, advantages and applications of MIMO systems, MIMO channel and signal model, MIMO in wireless standards, future challenges.

2. **MIMO Channel models** : Analytical MIMO channel models: Uncorrelated, fully correlated, separately correlated and keyhole MIMO fading models, parallel decomposition of MIMO channel,

3. **Capacity limits of MIMO systems,** Introduction, Mutual information and Shannon capacity, Single-user MIMO , Multi-user MIMO, MIMO Channel models, Capacity and Information rates in MIMO channels: Capacity and Information rates in AWGN and fading channels, Capacity of MIMO channels, Capacity for deterministic and random MIMO channels, Capacity of i.i.d., separately correlated and keyhole Rayleigh fading MIMO channels, Single user MIMO Capacity, Single user capacity metrics, Multi-user capacity metrics,

4. **Precoding design**: Transmit channel side information, Information-theoretic foundation for exploiting CSIT, A transmitter structure, Precoding design criteria, Linear precoder designs, Precoder performance results and discussion, Applications in practical systems

5. **Space–time coding for wireless communications**: principles and applications, Introduction, Background, Space–time coding principles Code book pre-coding Applications, Discussion and future challenges, Algebraic structure: quadratic forms , Advantages, code design criteria, Alamouti space-time codes, SER analysis of Alamouti space-time code over fading channels, Space-time block codes, Space-time trellis codes, Performance analysis of Space-time codes over separately correlated MIMO channel, Space-time turbo codes.

6. **Fundamentals of receiver design** Introduction Reception of uncoded signals Factor graphs and iterative processing MIMO receivers for uncoded signals MIMO receivers for coded

signals Some iterative receivers: Linear receivers, MMSE-SIC, V-BLAST, D-BLAST, and Closed loop MIMO.

7. **Multi-user receiver design** Introduction Multiple-access MIMO systems Iterative space–time multi-user detection Multi-user detection in space–time coded systems Adaptive linear space–time multi-user detection

Laboratory Work: Practicals related to SDR based MIMO Antenna communication and performance evaluation such as Diversity, Bit error rate etc.

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

Course Learning Outcomes:

1. Introduce Multiple Input Multiple Output (MIMO) Communication Systems
2. Compare MIMO Systems with Single Input Single Output (SISO) Systems
3. Analyse the Information Theoretic advantages of MIMO Systems
4. Analyse the spatial multiplexing properties of MIMO
5. Introduce and analyse space time codes
6. Prove the existence of some space time codes

Text Books:

1. E.G. Larsson and P. Stoica, "Space-Time Block Coding for Wireless Communications", Cambridge University Press 2008
2. Ezio Biglieri , Robert Calderbank et al "MIMO Wireless Communications" Cambridge University Press 2007

Reference Books:

1. David Tse and Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press 2005
2. Hamid Jafarkhani, "Space-Time Coding: Theory and Practice", Cambridge University Press 2005
3. Paulraj, R. Nabar and D. Gore, " Introduction to Space-Time Wireless Communications", Cambridge University Press 2003

Evaluation Scheme:

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

PEC106: OPTICAL COMMUNICATION NETWORKS

L	T	P	Cr
3	0	2	4.0

Course objective: The main objective of this course is to understand the concept of optical networks in optical communication systems. In this syllabus, Introduction to optical networks and its enabling technologies such as transmitters, optical receivers, filters, optical amplifiers, WDM network elements and their designs are discussed. Free space optics and its use in making optical networks are of great concern in today's optical communication systems. Moreover, Control and management, network survivability, optical TDM and CDM networks are discussed as well.

Course Content Details:

Introduction to Optical Networks: Telecommunications Network Architecture, Services, Circuit Switching and Packet Switching, Optical Networks, The Optical Layer, Transparency and All Optical Networks, Optical Packet Switching, Transmission Basics, Network Evolution.

Enabling Technologies: Building Blocks of Optical Fiber, Optical Transmission in Fiber Optical Transmitters, Optical Receivers and Filters, Optical Amplifiers, Switching Elements, Wavelength Conversion, Designing WDM networks, Experimental WDM Lightwave Networks.

WDM Network Elements and Design: Optical Line Terminals, Optical Line Amplifiers, Optical Add/Drop Multiplexers, Optical Crossconnects, Cost Trade–offs, LTD and RWA Problems, Dimensioning Wavelength Routing Networks, Statistical Dimensioning Models, Maximum Load Dimensioning Models, Passive Optical Networks (PONs).

Free Space Optics: Introduction to Free Space Optics, Fundamentals of FSO Technology, Factors Affecting FSO, Integration of FSO in Optical Networks, The FSO Market.

Control and Management: Network Management Functions, Optical Layer Services and Interfacing, Layers within the Optical Layer, Multivendor Interoperability, Performance and Fault Management, Configuration Management, Optical Safety.

Network Survivability: Basic Concepts, Protection in SONET/SDH, Protection in IP Networks, Optical Layer Protection Schemes.

Optical TDM and CDM Networks: Optical TDM Networks, Optical CDM Networks.

Laboratory Work: Basic optical communication link experiments, DWDM experiments, Amplifier, Splicing, and OTDR experiment, System design and performance analysis using simulation tools.

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

Course learning outcome (CLOs):
The students will be able to

1. Identify, formulate and solve optical communication networks related problems using efficient technical approaches.
2. Design optical networks as well as to interpret statistical and physical data.
3. Design and implement WDM networks.
4. Apply the knowledge to control and manage the functions of optical networks.
5. Recognize the network survivability by various protection schemes.

Text Books:

a. ***Ramaswami Rajiv, Kumar N. Sivarajan, Optical Networks: A Practical Perspective, Morgan Kaufmann Publishers, Elsevier (2004).***
b. ***Willebrand Heinz, Ghuman Baksheesh. S., Free Space Optics: Enabling Optical Connectivity in Today's Networks, Sams (2001).***
c. ***Mukherjee, Biswanath, Optical WDM Networks, Springer (2006).***

Reference Books:

1. ***Murthy, C. Siva Ram, Mohan Gurusamy, WDM Optical Networks: Concepts, Design, and Algorithms, Prentice Hall of India (2001).***
2. ***Maier, Marti, Optical Switching Networks, Cambridge University Press (2008).***
3. ***Sivalingam, Krishna M., Subramaniam, Suresh, Emerging Optical Networks Technologies: Architectures, Protocols, and Performance, Springer (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 %

PEC339: IMAGE PROCESSING AND COMPUTER VISION

L	T	P	Cr
3	0	2	4.0

Course objective: To make students to understand image fundamentals and how digital images can be processed, Image enhancement techniques and its applications, Image compression, segmentation and its applicability, fundamentals of computer vision, geometrical features of images.

Course Content Details:

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.

Image Segmentation: Point, Line and Edge Detection, Thresholding, Region based segmentation, Segmentation using Morphological Watersheds.

Computer Vision: Imaging Geometry, Coordinate transformation and geometric warping for image registration, Hough transforms and other simple object recognition methods, Shape correspondence 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):
The students will be able to

1. Recognize the fundamental techniques of Image Processing and Computer Vision.
2. Interpret the basic skills of designing image enhancements.

3. Distinguish between different image compression standards.
4. Acquire the knowledge about image segmentation methods
5. Analyse different computer vision techniques

Text Books:

1. Gonzalez, R.C., and Woods, R.E., Digital Image Processing, Dorling Kingsley (2009) 3rd Ed.
2. Jain A.K., Fundamentals of Digital Image Processing, Prentice Hall (2007).
3. Sonka M., Image Processing and Machine Vision, Prentice Hall (2007) 3rd Ed.
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%

PEC *** SPACE TIME WIRELESS COMMUNICATION

L	T	P	Cr
3	0	0	3.0

Prerequisite(s): None

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, 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 of Frequency-Selective Fading MIMO System Capacity Derivation, 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: Beam forming, 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, 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, Design of Space-Time Trellis Codes on Fast Fading Channels.

Laboratory Work: N.A.

Course Learning Outcomes:

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

1. Recognize the basic concepts of space time coding techniques and their used in MIMO and MIMO-OFDM system.
2. Evaluate the performance of MIMO System in different fading scenario.
3. Evaluate the performance of various space time block codes and space time trellis codes.
4. Analyze the concept of various layered architecture in MIMO system.

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) 2nd ed.*
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	30%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25%

PEC***: EMBEDDED SYSTEMS

L	T	P	Cr
2	0	2	3.0

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.

Course Content Details:

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.

Course Learning Outcomes (CLOs):

The students will be able to

1. Recognize the Embedded system and its programming, Embedded Systems on a Chip (SoC) and the use of VLSI designed circuits.
2. Identify the internal Architecture and perform the programming of ARM processor.

3. Program the concepts of Arduino Microcontroller with various interfaces like memory & I/O devices and Raspberry Pi based embedded platform.
4. Analyze the need of Real time Operating System (RTOS) in embedded systems.
5. Recognize the 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, 2nd Edition.***

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 (%)
4.	MST	25%
5.	EST	45%
6.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30%

PEC217: MICROSTRIP ANTENNA

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.

Course Content Details:

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.

Laboratory Work: N.A.

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

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

1. Recognize the basic concept of micro-strip antennas, methods of analysis and configurations.
2. Analyze micro-strip antennas arrays.
3. Evaluate the physical significance of discontinuities and different micro-strip feed mechanism available.
4. Recognize coupled micro-strip line with multiband and broadband behavior.
5. Demonstrate the CPW feeding technique and its implementation.

Text Books:

1. ***Gupta, K.C. and Garg, Ramesh, Micro-strip lines and slot lines, Artech house (1996) 2nd ed.***
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	30%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25%

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 Convoltuion: 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 outcome (CLO):
The students will be able to

1. Apply performance optimization techniques in VLSI signal processing,
2. Practice 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. Use area reduction using folding techniques, Strategies for arithmetic implementation,
4. Demonstrate 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) 2nd ed.***

Reference Books:

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

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
7.	MST	30%
8.	EST	45%
9.	Sessionals (Assignments+Quizes)	25%

PEC***: ADVANCED WIRELESS NETWORKS

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 wireless networks focusing on protocol design, wireless network security, implementation and performance issues.

Course Content Details:
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.

Introduction to Wireless Networking: Introduction, Difference between wireless and fixed telephone networks, WLAN, Development of wireless networks, 3G and 4G Networks, Traffic routing in wireless networks. Wireless Networking, Packet Processing, Network Speed, Packet Buffering.

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

Mobile Network: IP packet delivery – Agent advertisement and solicitation – Registration – Tunneling and Encapsulation – Optimizations – Reverse Tunneling – Ipv6., Dynamic Host Configuration protocol, Traditional TCP - Congestion control – Slow start – Fast retransmit/fast recovery – Classical TCP improvements: Indirect TCP – Snooping TCP – Mobile TCP.

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. Mobile Agent-based Resource Management, Joint Data Rate and Power Management, Dynamic Spectra Sharing in Wireless Networks,

Ad Hoc and Sensor Networks: Routing Protocols, Hybrid Routing Protocol, Scalable Routing Strategies, Multipath Routing, Clustering Protocols. Distributed QoS Routing, Sensor Networks Parameters, Sensor Networks Architecture.
Wireless Network Security: IEEE 802.11i Wireless LAN Security, Wireless Application Protocol Overview, Wireless Transport Layer Security, WAP End-to-End Security.

Laboratory Work: N.A.

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

Course Learning Outcomes (CLOs):
The students will be able to
1. Acquire knowledge about Wireless Network Fundamentals.

2. Recognize the various Network Standards and their utility in real world.
3. Acquire knowledge about Routing and Application Layer Protocols.
4. Identify wireless network vulnerabilities and apply various security mechanisms to protect networks from security attacks.

Text Books:

1. ***Rappaport, T.S., Wireless Communications, Pearson Education (2007 2nd ed).***
2. ***Zheng, Jun and Jamalipour, Abbas, Wireless Sensor Networks: A Networking Perspective, Wiley-IEEE Press (2009).***

Reference Books:

1. ***Tanenbaum, A.S., Computer Networks, 4th Edition, Prentice Hall (2007).***
2. ***Stallings, W., Network Security Essentials, Prentice Hall (2017) 6th Edition.***

Evaluation Scheme:

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

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.

Course Content Details:

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 and Select 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 (colorless), 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.

Laboratory Work: N.A.

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

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

1. Recognize 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	30%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25%

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.

Course Content Details:

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.

Laboratory Work: N.A.

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

Course Learning Outcomes (CLOs):
The students will be able to
1. Acquire the knowledge about audio & speech signals.
2. Integrate human physiology and anatomy with signal processing paradigms.

3. Recognize speech generation models.
4. Analyze the audio & speech signal estimation & detection.
5. Acquire knowledge about hardware to process audio & speech signals.

Text Books:

1. ***Borden, G., and Harris, K., Speech Science Primer, Williams and Wilkins (2006) 2nd ed.***
2. ***Furui, S., Digital Speech Processing, Synthesis and Recognition, CRC (2001) 4th ed.***

Reference Books:

1. ***Rabiner, L., and Schafer, R., Digital Processing of Speech Signals. Signal Processing, Prentice-Hall (1978) 3rd ed.***
2. ***Owens, F. J, Signal Processing of Speech, McGraw-Hill (1993) 4th ed. Parsons, T., Voice and Speech Processing: Communications and Signal Processing, McGraw-Hill.***

Evaluation Scheme:

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

PEC*: ADVANCED ENGINEERING ELECTROMAGNETICS**

L	T	P	Cr
3	0	0	3.0

Course Objective: The goal of the course is to understand the concept of electrostatic and magnetostatic. Time varying fields Maxwell's equations. Plane, cylindrical, and spherical electromagnetic waves and boundary value problems. To understand electromagnetic theorems, waveguides and integral equations.

Course Content Details:

Introduction: Time varying and time harmonic electromagnetic fields: Maxwell equations, Boundary conditions, time-harmonic electromagnetic fields, Electrical properties of matter: dielectrics, polarization, permittivity, magnetic, magnetization, permittivity, current, conductor, conductivity, semiconductors, super conductors, Media: linear, homogeneous, and nondispersive.

Wave Propagation and Polarization: Transverse electromagnetic modes: Uniform plane waves in an unbounded lossless medium: principle axis and oblique angle, Uniform plane waves in an unbounded lossy medium: principle axis and oblique angle, Polarization: linear, circular, elliptical, Poincare sphere.

Electromagnetic Theorems and Principles: Duality theorem, Uniqueness theorem, Image theory, Reciprocity theorem, Reaction theorem, Volume equivalence theorem, Surface Equivalenece theorem: Huygens's Principle, Induction theorem.

Waveguides and Cavities: Rectangular waveguide, Partially filled waveguide, Dielectric waveguide, Ridged waveguide, Rectangular cavities, Circular waveguide, Radial waveguide, circular dielectric waveguide, Circular cavities, Dielectric covered conducting rod.

Integral Equations and the Moment Method: Integral equation method, Electric and magnetic field integral equations, Finite diameter wires: Pocklington integral equation, Hallen's integral equation, Green's Function: Green's identities and methods, Green's function of the scalar Helmholts equation, Dyadic Green's function.

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

Course Learning Outcomes (CLOs):

The students will be able to

1. Apply the concept of time varying and time harmonic fields
2. Realize the analogy of wave propagation and polarization
3. Differentiate various electromagnetic theorems and principle
4. Analyze the integral equations and their applications.

Text Books:

1. ***Constantine A. Balanis, "Advance Engineering Electromagnetics," John Wiley & Sons (1989).***
2. ***M. N. O. Sadiku, "Elements of Electromagnetics," Oxford University Press (2009).***
3. ***W. H. Hayt, "Engineering Electromagnetics," Tata McGraw Hill (2008).***

Reference Books:

1. ***J. D. Kraus, “Electromagnetics,” McGraw Hill (2006).***
2. ***E. C. Jordan and K. G. Balmain, “Electromagnetic Waves and Radiating Systems,” Prentice Hall of India (2008).***
3. ***A. Paramanik, “Electromagnetism: Theory and Applications,” Prentice-Hall of India (2006).***

Evaluation Scheme:

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

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.

Course Content Details:

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.

Laboratory Work: N.A.

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

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

1. Acquire knowledge about Network Fundamentals.

2. Identify Internetworking.
3. Recognize the Network Standards and Standard Organizations.
4. Interpret the 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:

3. ***Tanenbaum, A.S., Computer Networks, 4th Edition, Prentice Hall (2007).***
4. ***Hunt, C., TCP/IP Network Administration, 3rd Edition, O'Reilly Media (2002).***
5. ***Keshav, S., An Engineering Approach to Computer Networking, Addison-Wesley (1997).***

Evaluation Scheme:

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

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.

Course Content Details:
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.

Laboratory Work: N.A.

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

Course Learning Outcomes (CLOs):

The students will be able to

1. Recognize Time frequency analysis of signals.
2. Describe the concepts of Fractional Fourier Transform.
3. Identify the various applications of Fractional Transform.
4. Evaluate 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	30%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25%

PEC***-OPTOELECTRONICS DEVICES AND CIRCUITS

L	T	P	Cr
3	0	0	3

Course Objectives: The main objective of this course is to understand the physics of optoelectronics devices, different types of photon sources and detectors, different modulators-electrooptic and acoustooptic modulators, electroabsorption modulator, basic introduction of holography, fourier optics and holography and fiber optic sensors.

Course Content Details:

Review of Semiconductor Electronics: Overview, Maxwell's Equations and Boundary Conditions, Semiconductor Electronics Equations, Generation and Recombination in Semiconductors, Examples and Applications to Optoelectronic Devices, Semiconductor p-N and n-P Heterojunctions, Semiconductor n-N Heterojunctions and Metal-Semiconductor Junctions.

Photon Sources and Detectors: Semiconductor Photon Optical Sources, Light Sources and Transmitters, Light Emitting Diodes, Burrus LEDs, Edge Emitting LEDs, LED Analog Transmission, LED Digital Transmission, Introduction to Laser, Black Body Radiations, Boltzmann Statistics, Einstein Coefficient for Absorption and Emission, Semiconductor Laser Diode, Quantum Well Laser, Cleaved Coupled Cavity (C^3) Laser, Index Guide Lasers, Optoelectronics Integrated Circuits-OEICs.

Electrooptic and Acoustooptic Modulators: Electrooptic Effects and Amplitude Modulators, Phase Modulator, Kerr Effect and Kerr Modulators, Electrooptic Effects in Waveguide Devices, Scattering of Light by Sound: Raman-Nath and Bragg Diffractions, Coupled-Mode Analysis for Brag Acoustooptic Wave Coupler.

Electroabsorption Modulator: General Formulation for Optical Absorption Due to an Electron-Hole Pair, Franz-Keldysh Effect, Exiton Effect, Quantum Confined Stark Effect (QCSE), Interband Electroabsorption Modulator, Self-Electrooptic Effect Devices (SEEDs).

Fourier Optics and Holography: Introduction to Fourier Transform, Image Forming Properties of Lenses, Holographic Optical Element (HOE), HOE Fabrication Materials, Vibration and Motion Anlaysis by Holographic Techniques, Hologram Interferometery, Stroboscopic Holography, Modulated Beam Holography.

Fiber Optic Sensors: Introduction to Sensors, Fiber Optic Sensor in Healthcare, Fiber Optic Sensor Basic, Angiology, Gastroenterology, Oncology, Neurology, Neurology, Fiber Bragg Grating for Strain and Temperature Sensors, High Temperature Borehole, Seismometer with Fiber Optic Displacement Sensors.

Course Learning Outcome (CLOs):

The students will be able to

1. Identify, formulate and solve different optoelectronics devices related problems using efficient technical approaches.

2. Familiarization with the basic physics of optoelectronics devices and interpret various optical parameters of the photonic sources and detectors.
3. Perform the coupled-mode analysis for wave coupler and and learn about the different types of effects in electrooptic, electroabsorption and acoustooptic modulators.
4. Realize the concept of new optical technique i.e. fourier optics and identify the most suitable materials for holographic optical element fabrication.
5. Learn the basics of optical sensors and their applications in medical diagnostics for the benefit of public health.

Text Books:

1. S. C. Gupta, "Optoelectronic Devices and Systems," Second Edition, PHI Learning Private Limited, New Delhi, 2015.
2. Pallab Bhattacharya, "Semiconductor Optoelectronics Devices," Prentice Hall of India Pvt. Ltd., New Delhi, 2006.

Reference Books:

1. Shun Lien Chuang, "Physics of Optoelectronic Devices," Wiley Series in Pure and Applied Optics, John Wiley & Sons. Inc., 1995.
2. J. Singh, "Opto Electronics-As Introduction to materials and Devices," Mc Graw-Hill International Edition, 1998.
3. B.E.A. Saleh and M.C. Teich, "Fundamental of Photonics, John Wiley and Sons Inc, 2^{nd} Edition, 2007.

Evaluation Scheme:

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

PEC301: ARTIFICIAL INTELLIGENCE

L	T	P	Cr
3	0	0	3.0

Course Objective:
The objective of this subject is to be familiar with the applicability, strengths, and weaknesses of the basic knowledge representation, problem analyzing, and learning methods in solving particular engineering problems.

Course Content Details:

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.

Laboratory Work: N.A.

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

Course learning outcomes (CLOs):
The students will be able to

1. Analyse the applications of artificial intelligence and categorize various problem domains, uninformed and informed search methods.
2. Identify advanced search techniques and algorithms like minimax for game playing.
3. Recognize the importance of probability in knowledge representation for reasoning under uncertainty.
4. Describe Bayesian networks and drawing Hidden Markov Models.
5. Interpret the architecture for intelligent agents and implement an intelligent agent.

Text Books:

1. ***Rich E., Artificial Intelligence, Tata McGraw Hills (2009) 3rd ed.***
2. ***George F. Luger, Artificial Intelligence: Structures and Strategies for Complex Problem Solving, Pearson Education Asia (2009) 6th ed.***

Reference Books:

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

Evaluation Scheme:

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

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, modeling and characterization tools and calibration techniques.

Course Content Details:

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 Modeling: Numerical modeling 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.

Laboratory Work: N.A.

Course Learning Outcomes:
The student will be able to
- Acquire knowledge about MEMS & Micro Sensors.
- Differentiate various micro fabrication technologies.
- Gather knowledge of characterization tools.
- Acquire knowledge about Device Applications

Recommended Books:

1. ***Franssila, Sami, Introduction to Microfabrication, John Wiley & Sons, (2010) 2nd ed.***
2. ***Gad-el-Hak, Mohamed, MEMS: Introduction and Fundamentals, CRC Press (2005) 2nd ed.***
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	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25%

PEC-* DESIGN FOR IoT**

L	T	P	Cr
3	0	0	3.0

Learning Objectives:
Students will be able to understand the concepts of Internet of Things (IoT) and can able to build IoT based applications.

Course Content Details:

Introduction to IoT: Defining IoT, Characteristics of IoT, Physical design of IoT, Logical design of IoT, Functional blocks of IoT, Communication models & APIs

IoT & M2M: Machine to Machine, Difference between IoT and M2M, Software define Network

Sensors and Actuators modules: Concept, layout, working and applications of different sensors and actuators: temperature sensor, motion sensor LDR sensors, IR sensor, Ultrasonic sensor, Relay etc.

Embedded Systems for IoT
Introduction to Arduino Programming, Arduino interfacing with sensors and actuators, IoT based actuator operation using Arduino, Introduction to R-pi and its Programming, R-pi hardware interfacing and applications, Smartphone interfacing with R-pi, Wi-Fi module interfacing with R-pi and associated applications.

Network and Communication Protocol: Wireless medium access issues, MAC protocol survey, Constrained Application Protocol (CoAP), Message Queue Telemetry Transport Protocol (MQTT), Sensor deployment & Node discovery, Data handling and analytics, Cloud platform for IoTs, .

Developing IoT based Systems: Experiments with Arduino Hardware and sensor interfacing procedures. Automatic lighting control using IoT, home automation, connected health, smart farming, industry applications, connected vehicles, smart city, developing sensor based application through embedded system platform. Introduction to Python, Implementing IoT concepts with python

Challenges in IoT: Design challenges, Development challenges, Security challenges, other challenges

Laboratory Work: N.A.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

1. Recognize the concepts of Internet of Things
2. Demonstrate the interfacing of different sensors and actuators modules with embedded systems.
3. Analyze basic protocols in wireless sensor network.
4. Design IoT applications in different domain and be able to analyze their performance.
5. Develop and implement IoT applications using Python.

Text Books:

1. *Vijay Madisetti, Arshdeep Bahga, "Internet of Things: A Hands-On Approach"*
2. *Adrian McEwen, Hakim Cassimally, "Designing the Internet of Things" John Wiley (2014) 1st ed.*

Reference Books:

1. *Hanes David , Salgueiro Gonzalo, Grossetete Patrick, Barton Rob, Henry Jerome," IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things", Pearson (2016).*
2. *Waltenegus Dargie,Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice", John Wiley & Sons, Ltd (2011).*

Evaluation Scheme:

Sr. No.	**Evaluation Elements**	**Weightage (%)**
1	MST	30%
2	EST	45%
3	Sessional (May include Assignments/Projects/Quiz(es))	25%

PWC321 NEXT GENERATION WIRELESS SYSTEMS AND NETWORKS

L	T	P	Cr
3	0	0	3.0

Prerequisite(s): None

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: N.A.

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

1. Recognize the fundamentals and operation of next generation wireless communication systems like 3G, OFDM, MIMO systems, cognitive radio and 3GPP (4G),

2. Evaluate the performance of 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, 2nd Edition, 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	30%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25%

PWC106 ADVANCED ERROR CONTROL CODING THEORY

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

Prerequisite(s): None

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 parttioning, Multi level codes.

Laboratory Work: N.A.

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

1. Recognize 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. Design the channel encoder and decoder using different coding schemes.
3. 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, 2nd ed., 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	30%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25%

PEC 217: COMPRESSED SENSING AND SPARSE SIGNAL PROCESSING

L	T	P	Cr
3	0	0	3.0

Course Objective: To provide students with the ability to capture attributes of a signal using very few measurements in order to apply the concepts of convex optimization and statistical signal processing for estimation and recovery of real time sparse signals in noisless and noisy environments of different kind.

Course Content Details:

Sparse Signal Analysis and Estimation : Definition of sparsity, Bayesian estimation of sparse signals,Weighted estimation, Recursive Least Squares estimation, Adaptive algorithms for sparse signal Estimation, Norm minimization with emphasis on L_1 minimization, Restricted Isometric Property (RIP).

Deterministic Approaches to Compressed Sensing: A brief overview of group theory, Construction of deterministic RIP sensing matrices, Group testing, Smooth convex optimization: optimal first-order methods (Nesterov's algorithm), complexity analysis, Nonsmooth convex optimization, smooth approximations of nonsmooth functions, prox-functions, Nesterov's algorithm, Mirror-descent algorithms.

Probabilistic Approaches to Compressed Sensing: Probalilistic compressed sensing, sparse approximation, sparse approximation in the presense of noise, Regularization methods, Sampling framework for compressed sensing, Approximation of images by sparse signals, Measurement design for compressed sensing, Signal reconstruction techniques, Probbilistic estimators, MMSE, MAP and MAP estimator with Gaussian prior, Reconstruction error as a function of SNR.

Compressed sensing in noisy environment: Compressed sensing in the presence of Gaussian noise, Compressed sensing in the presense of Poisson noise, Expander based compressed sensing in the presense of poisson noise, L_1 error and its bound in the presense of Poisson noise, Low rank matrix recovery, Empirical performance analysis of compressed sensing in noisy environment.

Applications and current trends: Application to JPEG lossy image compression, Estimating packet arrival rate, Sparse array and direction of arrival (DOA) estimation, Speaker identification and speech recognition using machine learning and compressive sensing. Face classification using machine learning and compressive sensing.

Laboratory Work: N.A.

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

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

1. reconstruct sparse or nearly sparse signals from undersampled data.
2. solve convex optimization problrms for allowing rapid signal recovery and parameter estimation.
3. apply and compare probabilistic and deterministic approach to compressed sensing.
4. design adaptive/nonadaptive sampling techniques that condense the information in a compressible signal into a small amount of data.
5. recover large data matrices from incomplete sets of entries.

Text Books:

1. ***Probability and Random Processes by G. Grimmett and D. Stirzaker, 3rd. ed., Oxford University Press***
2. ***Random Matrices by M. Mehta, 3rd ed., New York: Academic Press***
3. ***Numerical Linear Algebra by LLoyd N. Trefethen and David Bau, III, SIAM***
4. ***Introductory Lectures on Convex Optimization: A Basic Course by Y. Nesterov, Kluwer Academic Publisher***
5. ***Discrete Time Signal Processing by A. Oppenheim and R. Schafer, Prentice Hall***

Reference Books:

1. ***Convex Optimization by S. Boyd and L. Vandenberghe, Cambridge University Press***
2. ***All of Statistics by L. Wasserman, Springer***

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
4.	MST	30%
5.	EST	45%
6.	Sessionals (May include Assignments/Projects/Quizzes)	25%

PEC***: DIGITAL ARRAY SIGNAL PROCESSING

L	T	P	Cr
3	0	0	3.0

Course Objective: The focus of the course is to introduce the student to the various aspect of digital array signal processing. To introduce the concept of Spatial Frequency along with the Spatial Sampling Theorem. To introduce various array design methods and direction of arrival estimation techniques.

Course Content Details:

Introduction: Spatial Signals: Signals in space and time, Spatial Frequency Vs Temporal Frequency, Slowness vector, Far field and Near field signals, Wavenumber: Frequency space spatial sampling, Spatial sampling theorem- Nyquist criteria, Aliasing in spatial frequency domain, Spatial sampling of multidimensional signals, Spatial Frequency Transform, Spatial spectrum

Sensor Arrays: Uniform linear arrays: Beam pattern in θ, u and ψ -space, Uniformly Weighted Linear Arrays. Beam Pattern Parameters : Half Power Beam Width, Distance to First Null, Location of side lobes and Rate of Decrease, Grating Lobes, Array Steering, Planar and random arrays, Array transfer (steering) vector, Array steering vector for ULA, Broadband arrays, Frequency: Wavenumber response and beam pattern, Array manifold vector, Conventional beam former, Narrowband beam former.

Array Design Methods: Visible region, Duality between Time -Domain and Space -Domain Signal Processing, Schelkunoff's Zero Placement Method, Fourier series method with windowing, Woodward -Lawson frequency-sampling design.

Direction of Arrival Estimation: Non parametric methods–Beam forming, Delay and sum Method, capon methods. Resolution of Beam forming method, Subspace methods–MUSIC, Minimum norm and ESPRIT techniques, Spatial Smoothing.

Laboratory Work: N.A.

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

Course Learning Outcomes (CLOs):

The students will be able to

1. Demonstrate the important concepts of digital array signal processing.
2. Practice the various array design techniques.
3. Analyze the basic principle of direction of arrival estimation techniques.

Text Books:

4. ***Harry L. Van Trees, "Optimum Array Processing," Wiley-Interscience.***
5. ***Sophocles J Orfandis, "Electromagnetic Waves and Antennas,"***

Reference Books:

1. ***E. D. Dugeon and D. H. Johnson, "Array Signal Processing: Concepts and Techniques," Prentice Hall, 1993.***
2. ***P. Stoica and R. L. Moses, "Spectral Analysis of Signals," 2nd Edition, Prentice Hall, 2005.***
3. ***J. Bass, C. McPheeters, J. Finnigan, E. Rodriguez "Array Signal Processing," [Connexions Web site], 2005.***

Evaluation Scheme:

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

PEC-: COMPUTATIONAL ELECTROMGNETICS

L	T	P	Cr
3	0	0	3.0

Course Objective: The objective of course is to develop the skills required to solve problems related to electrostatics, magnetostatics, microwaves and optical waves using computational methods.

Course Content Details:

Review of Basic Electromagnetics. Electrostatics, Magnetostatics, Wave equations, TE, TM and Hybrid modes, Guided wave structures, Metallic waveguides, Dielectric waveguides, Radiating structures Applications of electromagnetics, Historical development of Computational.

Numerical Methods: ODE solvers, Euler, Runge-Kutta, Boundary conditions, Propagation of errors, Survey of numerical packages.

Finite difference time domain method:
An overview of finite differences time domain method, the 1D, 2D & 3D FDTD algorithm, Obtaining wideband data using the FDTD, Numerical dispersion in FDTD simulations, The PML absorbing boundary condition, Commercial implementations.

Method of moments (MoM)
An overview of Method of Moment (MoM), Thin-wire electrodynamics and the MoM more on basis functions, the method of weighted residuals, application of

Finite Element method (FEM): Introduction of Finite element method, Variational and Galerkin weighted residual formulations: the Laplace equation, Simplex coordinates, high-frequency variational functional, Spurious modes, Vector (edge) elements, Application to waveguide eigenvalue analysis, The three-dimensional Whitney element, The time domain FEM

Application: Deterministic 3D application: waveguide obstacle analysis, Application to two-waveguide discontinuity problems, Hybrid finite element/method of moments formulations, An application of the FEM/MoM hybrid – GSM base stations

Laboratory Work: N.A.

Course Learning Outcomes (CLOs):
The students will be able to
1. Acquire knowledge about history and application computational electromagnetic
2. Acquire knowledge about different computational electromagnetic techniques
3. Solve the electromagnetic problem using computational techniques

Text Books:

4. ***Balanis, C., Antennas, John Wiley and sons (2007) 3rd edition.***
5. ***David B. Davidson, Computational Electromagnetics for RF and Microwave Engineering, Cambridge University Press 2005.***
6. ***Dennis M. Sullivan, Electromagnetic simulation using the FDTD method***

Evaluation Scheme:

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

PEC-XXX: DEEPLEARNING FOR COMPUTER VISION

L	T	P	Cr
2	0	2	3.0

Course Objective: To introduce students to fundamentals of computer vision for deep learning; and the applications of deep learning in the field of computer vision.

Course Content Details:
Introduction: Image fundamentals, Histogram processing, Image Transforms, enhancement in frequency and spatial domain, low pass filtering, high pass filtering, Image Classification.

Computer Vision: Imaging Geometry; Coordinate transformation and geometric warping for image registration, Hough transforms and other simple object recognition methods, Shape correspondence and shape matching, Principal Component Analysis, Shape priors for recognition.

Datasets for Image Classification: MNIST, Animals: Dogs, Cats, and Pandas, CIFAR-10, SMILES, Kaggle: Dogs vs. Cats, Flowers-17, CALTECH-101, Tiny ImageNet, Adience, ImageNet

Deep Learning Fundamentals: Optimization Methods and Regularization: Gradient Descent, Stochastic Gradient Descent (SGD), Regularization; Neural Network Fundamentals, Convolutional Neural Networks.

Applications: LeNet: Recognizing Handwritten Digits, MiniVGGNet: Going Deeper with CNNs.

Laboratory Work: Introduction to Python, Development of a neural network, Apply gradient descent algorithm,Explore LeNet, Use pertained models for recognition of MINST/CIFAR-10.

Course Learning Outcomes (CLOs):
The students will be able to
1. Identify fundamentals of Computer Vision and Deep learning.
2. Apply computer vision techniques on images.
3. Apply Convolution Neural Networks.
4. Apply optimisation and regularisation techniques on neural networks.
5. Program in Python for deep learning applications.

Text Books

1. ***Adrian Rosebrock, Deep Learning for Computer Vision with Python, PYIMAGESEARCH (2017).***

2. ***Gonzalez, R.C., and Woods, R.E., Digital Image Processing, Dorling Kingsley (2009).***

Reference Books

1. ***Jain A.K., Fundamentals of Digital Image Processing, Prentice Hall (2007).***
2. ***Sonka M., Image Processing and Machine Vision, Prentice Hall (2007).***
3. ***D. Forsyth and J. Ponce, Computer Vision - A modern approach, Prentice Hall.***

Evaluation Scheme:

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

PEC***: SMART ANTENNA

L	T	P	Cr
3	0	0	3

Course Objective:

The comprehensive idea of this course is to make students familiar with different smart antenna system and different algorithm to antenna smart.

Course Content Details:

Introduction

Smart Antennas: Introduction, Need for Smart Antennas, Overview, Smart Antenna Configurations, Space Division Multiple Access (SDMA), Architecture of a Smart Antenna System, Benefits and Drawbacks, Basic Principles, Mutual Coupling Effects Smart antenna, Benefits of smart antenna, Types of smart antennas. Phased array antenna, optimal antenna, adaptive antennas,

Fixed Beam Smart antenna systems

Beamforming Fundamentals: Classical Beamformer, Broad side End fire arrays, impact of number of elements. Planar arrays, Beam forming, Butler matrix, Spatial filtering, Switched beam systems, multiple fixed beam systems, adaptive cell sectorization Beam forming networks, Statistically Optimum Beamforming Weight Vectors- Maximum SNR Beamformer, Multiple Sidelobe Canceller and the Maximum SINR Beamformer, Minimum Mean Square Error (MMSE), Direct Matrix Inversion (DMI), Linearly Constrained Minimum Variance (LCMV).

Adaptive array systems

Spatial processing for wireless systems. Adaptive antennas Array Concept: Motivation of using Adaptive Arrays, Adaptive Array problem statement, Signal Environment, Array Element Spacing considerations, Array Performance, Nulling Limitations due to miscellaneous array effects. Broadband Processing.

Adaptive Algorithms

Adaptive Algorithms for Beamforming- Least Mean-Square (LMS) Algorithm, Recursive Least-Squares (RLS) Algorithm, Constant-Modulus (CM) Algorithm, Affine-Projection (AP) Algorithm, QuasiNewton (QN) Algorithm. Sectorization, Digital radio receiver techniques and software radios. Optimal spatial filtering – adaptive algorithms for CDMA. Multitarget decision – directed algorithm. Simulation studies. Neural Network Approach,

DOA Estimation

DOA Estimation Fundamentals: Introduction, Array Response Vector, Received Signal Model, Subspace-Based Data Model, Signal Autocovariance Matrices, Conventional DOA Estimation Methods, Subspace Approach to DOA Estimation: MUSIC Algorithm, ESPRIT Algorithm. Uniqueness of DOA Estimates, Source localization problem. Joint angle and delay estimation

Smart antenna receivers, MIMO systems

Applications of Smart Antennas in Wireless Communications Applications, Smart Antenna Techniques for CDMA (including current applications), Smart antenna array configurations. Mobile communication systems with smart antennas. Space–Time Processing: Introduction, Discrete Space–Time Channel and Signal Models, Space–TimeBeamforming, Intersymbol and Co-Channel Suppression, Space–Time Processing for DS-CDMA, Capacity and Data Rates in MIMO Systems.

Laboratory Work: N.A.

Course Learning Outcomes (CLOs):

The students will be able to

1. Discuss the basics of smart antenna.
2. Practice the operation of adaptive antenna array system and algorithms.
3. Analyze the DOA estimation
4. Evaluate the requirements for the design and implementation of smart antenna systems

TEXT BOOKS

1. L. C. Godara, Smart Antennas, CRC Press.
2. T.S.Rappaport & J.C.Liberti, Smart antennas for wireless Communication, Printice Hall,1999.
3. R.Janaswamy, Radiowave propagation and Smart antennas for wireless communication, Kluwer,2001.

REFERENCE BOOKS

1. T. K. Sarkar, M. C. Wicks, M. Salazar Palma, and R. Bonneau, Smart Antennas, John Wiley & Sons and IEEE Press, 2003.

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

ANALOG AND MIXED SIGNAL CIRCUIT DESIGN

L T P Cr
3 0 0 3.0

Course Objectives: The objective of this course is to provide the basic knowledge of analog and mixed signal circuitsand their performance parameters.

Course Content Details:

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

Analog MOS Process: Analog CMOS Process (Double Poly Process), Digital CMOS Process tailored to Analog IC fabrication, Fabrication of active devices, passive devices and interconnects, Analog Layout Techniques, Symmetry, Multi-finger transistors, Passive devices: Capacitors and Resistors, Substrate Coupling, Ground Bounce.

Amplifiers and Current sources: Large Signal and Small-Signal analysis of common source stage, Source Follower, Common Gate Stage, Cascode, Folded Cascode, differential amplifier, current Sources, Basic Current Mirrors, Cascode Current Mirrors and current mirror based differential amplifier, op-Amp.

Comparators: Circuit Modeling, 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, piplelined

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

Laboratory Work: N.A.

Course Learning Outcomes:

On completion of this course, the students will be able to:

1. Acquire a basic knowledge of analog and mixed signal circuit design
2. Design of single stage and differential stage amplifiers with and without current mirror circuits, respectively.
3. Use the techniques and skills for design and analysis of CMOS based switched capacitor circuits and comparator
4. Analyze the performance of A/D and D/A converter architectures.

Recommended Books:

1. ***Razavi, B., Design of Analog CMOS Integrated Circuits, Tata McGraw Hill (2008).***
2. ***Gray, P.R., Hurst, P.J., Lewis, S.H., and Meyer, R.G., Analysis and Design of Analog Integrated Circuits, John Wiley (2001) 5th ed.***
3. ***Allen, P.E. and Holberg, D.R., CMOS Analog Circuit Design, OxfordUniversity Press (2002) 2nd ed.***

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

PEC ***: WAVELET TRANSFORMS AND APPLICATIONS

L	T	P	Cr
3	0	0	3.0

Course objective: The goals of this course is to develop analytical understanding of waves and wavelets in the real-time applications, to introduce basic wavelets with their importance. Detailed analytical study of continuous and discrete wavelet transform along with the concept of wavelet decomposition, multi-resolution analysis and filter banks. To introduce bi-orthogonal and non-separable multi-dimensional wavelets along with some signal and image processing applications.

Course Content Details:
Introduction to Wavelets: Origin of wavelets and its history, different communities of wavelet, classification: continuous and discrete wavelet transforms, development in wavelet theory applications.

Continuous Wavelet Transform: Introduction, CT wavelets, definition of CWT, the CWT as a correlation, constant Q factor filtering interpretation and time-frequency resolution, the CWT as an operator, inverse CWT.

Discrete Wavelet Transform and Orthogonal Wavelet Decomposition: Introduction, approximation of vectors in nested linear vector subspaces, multi-resolution analysis of $L^2(R)$, Haar scaling function, Haar wavelet, Haar wavelet decomposition, Haar wavelet packets and application.

MRA Ortho-normal wavelets and their relationships to filterbanks: Introduction, definition of MRA, construction of a general ortho-normal MRA, wavelet basis for the MRA, digital filtering interpretation, examples of orthogonal basis generating wavelets, interpreting ortho-normal MRA for discrete-time signals, generating scaling functions and wavelets from filter coefficients.

Bi-orthogonal Wavelets: Introduction to bi-orthogonal wavelet bases, filtering relationship for bi-orthogonal filters, bi-orthogonal scaling functions and wavelets, two-dimensional wavelets,.

Non-separable multi-dimensional wavelets: non-separable multi-dimensional wavelets, wavelet packets, wavelets transform and data compression, transform coding, DTWT for image compression, audio compression, wavelet denoising, speckle removal, edge detection and object isolation.

Beyond Wavelets: Ridge-lets and Curve-lets: ridge-let transform and digital curve-let transform, curve-let construction, properties and applications,

Laboratory Work: N.A.

Minor project and Scientific literature study: To be assigned by concerned instructor/course-coordinator

Course learning outcomes (CLOs):
The students will be able to

1. Distinguish between various wavelets analytically and explain their importance.
2. Describe continuous and discrete wavelet transform along with their properties and applications.
3. Comprehend the concept of wavelet decomposition, multi-resolution analysis and filter banks.
4. Develop and realize computationally efficient wavelet based algorithms for signal and image processing.

Text Books:

1. ***R.M. Rao and A.S. Bopardikar,"Wavelet Transforms – Introduction and Applications," Pearson Education, 2008.***
2. ***K.P. Soman and K.I. Ramachadran, "Insights into Wavelets from Theory to Practice," Prentice-Hall, 2006.***
3. ***L. Debnath, "Wavelet Transforms and Their Applications," Birkhauser, 2001.***
4. ***G. Strang and K. Amaratunga, "Wavelets, Filter Banks and Applications," Spinger, 2003.***

Reference Books:

1. ***S. Mallat, "A Wavelet Tour of Signal Processing," Academic Press, 1999.***
2. ***C.K. Chui, "An Introduction to Wavelets," Academic Press, 2014, vol. 1.***
3. ***P.P. Vaidyanathan, "Multirate Systems and Filter Banks," Pearson Education, India, 1993.***
4. ***A. Teolis, "Computational Signal Processing with Wavelets," Birkhauser, 1998.***

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
4.	MST	30%
5.	EST	45%
6.	Sessional (May include Assignments/Projects/Tutorials/Quizzes/Lab Evaluations)	25%

PEC***: QUANTUM INFORMATICS

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

Course Objective: The main objective of this course is to provide an introduction to the main ideas and techniques of the field of quantum computation and quantum information theory(qubits, quantum gates, and qubit systems). To understand the various applications of quantum algorithms in different areas. One of the main motivations for working in quantum information science is the prospect of fast quantum algorithms to solve important computational problems. Most striking is to study quantum entanglement.

Course Content Details:

Introduction to Quantum Mechanics: Linear algebra, Vector spaces, Inner product Vector spaces, Definition of Hilbert space, Dimension and basis of a vector space, Linear operators, Inverse and Unitary operators, Hermitian operators, Eigenvalues and Eigenvectors, Tensor products, Commutators, Spectral decomposition theorem, Quantum states, Definition of qubits, Matrix Representation of Kets, Bras, and Operators, Wave function.

Elements of Quantum Mechanics: The postulates of quantum mechanics: (State space, State Evolution, Quantum measurement, Distinguishing quantum states, Projective measurements, POVM measurements, Phase), Time Evolution Operator, Stationary States: Time-Independent Potentials, Time independent and Time dependent Schrödinger Equation and Wave Packets, The Conservation of Probability, Time Evolution of ExpectationValues, The density operator, Ensembles of quantum states. Uncertainty principle, minimum uncertainty, Ehrenfest's theorem, E.P.R. paradox.

Quantum Computation: Multiple qubit unitary quantum gates: (CNOT, Swap, Toffoli, Fradkin, Hadamard Pauli gates), Concept of Bloch sphere, Quantum algorithms: (Deutsch–Jozsa algorithm, Shor's fast algorithms), Quantum search algorithm: Grover's algorithm, Concept of Quantum Fourier Transform. One dimensional Harmonic Oscillator quantum computer, Ion trap models.

Quantum Information theory: Overview of Coherent States, Quantum Binary Communications Systems, The Holevo bound, Quantum Entropy, Classical information over noisy quantum channels, Entropy exchange and the quantum Fano inequality, The quantum data processing inequality,Quantum Systems with OOK Modulation, Quantum Systems with BPSK Modulation . Quantum Systems with QAM Modulation, Quantum Systems with PSK Modulation, Quantum Systems with PPM Modulation, Overview of Squeezed States, Transforming bi-partite pure state entanglement, Entanglement distillation and dilution, Entanglement distillation and quantum error-correction, Quantum key distribution, Privacy and coherent information, The security of quantum key distribution.

Minor Project: Figure out how quantum algorithms work, may be compute the complexity of quantum search algorithm and how quantum Fourier transform works. Students can do the simulations on MATLAB or in C or C++ and other tools may be used.

Laboratory Work: N.A.

Course Learning Outcomes (CLOs):

The students will be able to

1. Acquire knowledge about mathematical background of quantum mechanics.
2. Identify the quantum states after taking the measurements along with unitary time evolution operator.
3. Analyze the need of quantum gates and quantum circuits in current scenario. Also doing the analysis about complexity and fast conversion rate of quantum algorithms.
4. Setup the general foundations of telecommunications systems using quantum mechanics and recognize the difference between Classical and Quantum Communication systems.
5. Apply the knowledge of quantum entanglement states and quantum cryptography for designing a secure quantum communication system.

Text Books

5. ***Michael A. Nielsen & Isaac L. Chuang. Quantum Computation and Quantum Information. Cambridge university press, (2010)***
6. ***Gianfranco Cariolaro. Quantum Communications. Springer (2015)***
7. ***Griffiths, David J. Introduction to Quantum Mechanics. Upper Saddle River, Pearson Prentice Hall, (2005)***

Reference Books

4. ***Dirac, Paul Adrien Maurice. The Principles of Quantum Mechanics. Clarendon Press, (2011)***
5. ***NouredineZettili. Quantum Mechanics (concepts and applications). Second edition, Willey, (2009)***

Evaluation Scheme:

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

PEC***: DIGITAL VIDEO: PERCEPTION AND ALGORITHMS

L	T	P	Cr
3	0	0	3.0

Course Objective: Toenhance capabilities of students towardsanalytical treatment of video signals with an aim to achieve better overall video quality in back drop of limited computational/bandwidth resources.

Course Content Details:

Video fundamentals: Video sampling, frequency response of human visual systems, color perception,motion perception, affective property of video, metrics of visual experience, video compression.

Transform based analysis: Video transforms (DFT, DCT, DWT), retinal and cortical filters, difference of Gaussians, Laplacian of Gaussians, center-surround responses, 3D Gabor filterbanks, steerable pyramids.

Motion estimation and detection: Motion detection, Reichardt detector, optical flow algorithms (Horn-Schunck, Black-Anandan, Fleet-Jepson, non-linear methods, optical flow in the brain) block motion, Machine Learning for motion detection**.**

Statistical video models: Spectrum power law, principal components, sparse coding, Generalized Gaussian models, divisive normalization, Gaussian scale mixtures, optical flow statistics, spatial and temporal masking, Weber-Fechner law), video quality assessment (MOVIE, ST-RRED, BLIINDSdenoising, and saliency.

Laboratory Work: N.A.

Course Learning Outcomes (CLOs):

The students will be able to

1. interpret video processing algorithms from the point of view of their perceptual relevance
2. analyse signal processing models suited to the human visual pathway
3. incorporate transform based models into existing video processing algorithms
4. Automate testbenches for automatic pass/fail algorithms
5. perform video processing tasks viz. compression, quality assessment, denoising, saliency, and so on for an enhanced visual.

Text Books:

1. A. C. Bovik, Al Bovikâ€™s Lecture Notes on Digital Video, The University of Texas at Austin, 2017

2. M. Tekalp, Digital Video Processing, Prentice Hall, 1995 3. A. C. Bovik, The Essential Guide to Video Processing, Academic Press, 2009

Reference Books:
Books:
1. *Fundamentals of Statistical Signal Processing, Volume III: Practical Algorithm Development (Prentice-Hall Signal Processing Series) 1st Editionby Steven M. Kay (Author)*

2. Neural Networks and learning machines, Simon Hykin, *Prentice-Hall-2014*

S.No.	Evaluation Elements	Weightage (%)
1	MST	30%
2	EST	45%
3	Sessional (/Projects/Tutorials/Quizes)	25%

PEC-XXX: INTEGRATED CIRCUITS FOR WIRELESS COMMUNICATION

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

Course Objectives: Design and analysis of electronic circuits with an emphasis on integrated circuits for wireless communication systems. Analysis of distortion and noise in amplifiers with application to transceiver design. Design considerations of Radio-frequency mixers and phase-locked loops.

Course Content Details:
Introduction of RF Design and Wireless Communication: General considerations in RF design, Effects of Non-linearity and Noise, Sensitivity and dynamic range, Passive Impedance transformation, Scattering, General considerations in wireless communication; Analog communication, Digital Modulation, Mobile RF communication, Multiple access techniques, Wireless standards.

Receiver and Transmitter Design: Basic and modern heterodyne receiver, Direct conversion receivers, Low-IF receivers, Basic and modern direct conversion transmitter, Heterodyne transmitter, transceiver design examples using CAD tools.

Low-Noise Amplifier (LNA): Parameters related to performance and design of LNA, LNA topologies, Gain switching, Band switching, Differential LNA, Non-linearity calculations for degenerated and un-degenerated CS stage, for Differential and Quasi-differential pairs.

Mixers: Performance Parameters, Mixer Noise Figures, Balanced and Double-Balanced Mixers, Passive and Active Down-conversion Mixers, Advanced Mixer Topologies, Up-conversion Mixers.

Phase-Locked Loop (PLLs): Type-I and Type-II PLLs, PFD/Cp non-idealities, Phase noise in PLLS, Loop bandwidth,

Laboratory Work: N.A.

Course Learning Outcomes:
The students are able to:

1. Understand the performance parameters of communication system in context with integrated circuit
2. Design and analysis of RF transmitters and Receivers
3. Design and analysis of parameters related to performance of Low noise amplifiers
4. Understand and analyse the performance parameters of mixers and PLL

References:

1. ***B. Razavi: "RF Microelectronics" , Prentice Hall, New Jersey, 2nd edition, 2004.***
2. ***T. Lee: "The design of CMOS Radio-Frequency Integrated Circuits", 2nd edition, Cambridge University Press, 2004.***

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

PWC212 WIRELESS SECURITY

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

Prerequisite(s): None

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.

Course Content Details:

Wireless Network Overview: RF Overview, Wireless Signal Propagation (Reflection, Refraction Diffraction, Scattering Absorption), Signal-to-Noise Ratio, Modulation, Amplitude Modulation, Frequency Modulation, Phase Modulation,

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 data security techniques Passwords, stenography, Cryptography, Introduction to encryption algorithms-DES, TDES and AES, Encryption and authentication, Security in group communication, Trust establishment and key management.

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, Router, 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

Laboratory Work: N.A.

Course Learning Outcomes:

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

1. Recognize the basic concepts of wireless security and methods to achieve it.
2. Analyze the process of data hiding and its utility in wireless communication.
3. Differentiate Encryption and decryption of data using optimal tools/techniques.
4. Evaluate 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	30%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25%

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.

Course Content Details:

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 – Non linear 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.

Laboratory Work: N.A.

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

Course learning outcomes (CLOs):
The students will be able to

1. Recognize the basics of various biomedical signals.
2. Comprehend the fundamentals of processes related to biomedical signals.
3. Analyze various parameters related to biomedical signals.
4. Evaluate data compression and its application in biomedical field.
5. Recognize neurological models of ECG, etc.

Text Books:

5. ***D. C. Reddy ,"Biomedical Signal Processing: Principles and techniques" ,Tata McGraw Hill, New Delhi, 2005.***
6. ***Willis J Tompkins, Biomedical Signal Processing -, ED, Prentice – Hall, 1993.***
7. ***R. Rangayan, "Biomedical Signal Analysis", Wiley 2002.***
8. ***Bruce, "Biomedical Signal Processing & Signal Modeling," Wiley, 2001.***

Reference Books:

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

Evaluation Scheme:

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

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.

Course Content Details:

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.

Laboratory Work: N.A.

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

Course learning outcomes (CLOs):
The students will be able to
1. Recognize different cloud architectures.

2. Apply the knowledge of data processing in cloud.
3. Apply clustering algorithms to process big data real time.
4. Identify the security issues in cloud environment.
5. Comprehend 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, Second Edition.***
2. ***Gerard Blokdijk, Ivanka Menken,The Complete Cornerstone Guide to Cloud Computing Best Practices, Emereo Pvt Ltd, 2009, Second Edition.***

Reference Books:

1. ***Anthony Velte, Toby Velte and Robert Elsenpeter, Cloud Computing: A practical Approach Tata McGraw-Hill, 2010, Second Edition.***
2. ***Judith Hurwitz, Robin Bllor, Marcia Kaufmann, Fern Halper, Cloud cOmputing for Dummies, 2009, Third Edition.***

Evaluation Scheme:

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

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**.**

Course Content Details:

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.

Laboratory Work: N.A.

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

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

1. Describe the knowledge about Basic Principles in RF Design.
2. Identify Distributed Systems.
3. Analyse high frequency Amplifier Design.
4. Design Low Noise Amplifier (LNA)
5. Apply the knowledge about Mixers and RF Power Amplifiers.

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	30%
2.	EST	45%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25%

PEC***: MICROWAVE MEASUREMENTS AND DESIGN

L	T	P	Cr
3	0	0	3.0

Course Objective: To introduce fundamentals of microwave measuring instruments. Emphasizes theory and application of microwave measuring instrument. To develop student's analytical and intuitive understandings about various microwave measurement.

Course Content Details:
Introduction: Importance of RF and Microwave Concepts and Applications- and Units Frequency Spectrum, RF and Microwave Circuit Design, Dimensions - RF Behavior of Passive Components: High Frequency Resistors, High Frequency Capacitors, High Frequency Inductors, Characteristics of microwave signals, Duplexing tube characteristics.

Microwave Measuring Instruments: Passive Devices and matching, Attenuators, Phase shifters, Directional couplers, Hybrid Junctions, Power dividers, Circulator, Isolator, Impedance matching devices: Tuning screw, Stub and quarter wave transformers, Crystal and Schottkey diode detector and mixers, Gunn diode oscillator, IMPATT diode oscillator and amplifier, Principle of operation and applications: VSWR meter, Power meter, Spectrum analyzer, Network analyzer, TDR, DC volt meter, Temperature sensor, and Coaxial probes.

Microwave Measurements: Power (Low, medium, and high), Frequency and impedance measurement at microwave frequency, Measurement of noise figure, Measurement of microwave antenna parameters (Gain, radiation patterns, Efficiency, *S*-parameters, impedance), Dielectric constant and permeability measurement, Swept frequency measurement, Measurement of Q of cavity resonator, VSWR measurement, Attenuation measurement, EMI/EMC testing, SAR (specific absorption rate) measurement, Measurement of phase shift, Nonrecirpocal structure: The measurement of their equivalent circuit parameters.

Laboratory Work: N.A.

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

Course Learning Outcomes (CLOs):
The students will be able to
1. Recognize the concept of microwave measurements.
2. Analyze the theory and application of microwave measuring instruments.
3. Acquire knowledge about various microwave measurement concept.
4. Apply the concept of microwave measurement in various applications

Text Books:

1. ***Max Sucher and Jerome Fox, "Handbook of Microwave Measurements" 3rd Edition, Polytechnic Press of the Polytechnic Institute of Brooklyn, John Wiley and Sons.***
2. ***Reinhold Ludwig and Powel Bretchko, "RF Circuit Design – Theory and Applications", Pearson Education Asia, First Edition.***

Reference Books:

1. ***Joseph . J. Carr, "Secrets of RF Circuit Design", McGraw Hill Publishers, Third Edition. 2.Ulrich L. Rohde and David P. New Kirk, "RF / Microwave Circuit Design", John Wiley & Sons USA, 2000.***
2. ***Jon B. Hagen, "Radio Frequency Electronics", Cambridge university press, Cambridge, 1996.***
3. ***James Hardy, "High Frequency Circuit Design", Resto Publishing Co., NewYork, 1979.***
4. ***Ian Hickman, "RF Hand Book", Butter Worth Heinemann Ltd., Oxford, 1993.***

Evaluation Scheme:

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

PEC- OPTICAL COMPUTING TECHNOLOGY

L T P Cr
3 0 0 3

Course Objectives: The main objective of this course is to understand the concept of optical computing technology and to provide the principle and technology of hardware and functional materials applied to the future optical computing systems, covering the optical computing unit, the optical mini-type light sources and optical interconnection, the optical storage, the optical buffer and synchronization.

Course Contents Details:

Optical Computing Technology: Phylogeny and Trend of Computing, Concept of Optical Computing, Background in Optical Operation.

Semiconductor MQWs Photo-Electronic Logic Devices: Basic Principle of Semiconductor MQWs, Principle and Properties of SEEDs, Optimization and Characteristics of MQW's Modulator, Flat Integration of SEEDs.

Mini-type Light Source for Optical Computing: Introduction, wedge-Emitting Photoelectric Elements, Structure and Principle of LED and LD Mode Vertical-to-Surface Transmission Light Source, VCSELs, Applications of Mini-type-Laser.

Micro and Diffractive Optical Elements: Introduction, Design of Micro-Optical Elements, Fabrication Technology for Micro-Optical Elements, Planar Micro-lens Array, Theory Foundation of Diffractive Optical Elements, Binary Optical Elements.

Optical Storage: Introduction, Principle and Application of Two-Photon Interaction, Photorefractive Effect and Spatial Light Modulator, Optical Holographic Storage, Near-Field Optical Storage.

Parallel Optical Interconnections: Introduction, Optical Switch and Interconnection, Fundamental of Perfect Shuffle Switch Network, Implement Perfect Shuffle Switch with Micro-Optics Elements, Optical Interconnections Based on Micro-Optical Elements.

Optical Buffer and Full-Optical Synchronization: Introduction, Optical Buffer and Full-Optically Synchronization Based on Slow Light, EIT and Atomic Vapour Systems, Scattering and Fiber Systems, Coherent Population Oscillations and Semiconductor Materials, Silicon-Based Waveguide Slow Light Device.

Laboratory Work: N.A.

Course Learning Outcome (CLOs):

The students will be able to

1. Familiarization with the basic concepts of optical computing and trend of optical computing.

2. Learn about number of photo-electronic logic devices including self-electro-optical effect devices based on multiple quantum wells and light sources used for future optical computing.
3. Design the micro-optic element and learn about fabrication technology for micro-optic element.
4. Perform the implementation of optical shuffle switch with micro-optics elements and understands the basic concepts of optical holographic storage.
5. Realize the different ways like electromagnetically induced transparency, to achieve slow light for optical computing technology.

Text Books:

1. Xiujian Li, Zhengzheng Shao, Mengjun Zhu, Junbo Yang, "Fundamentals of Optical Computing Technology," Springer, 2018.

2. Mohammad A. Karim, Abdul A. S. Awwal, "Optical Computing: An Introduction," Volume 3, Wiley series in microwave and optical engineering, Wiley, 1992.

Reference Books:

1. Dror G. Feitelson, "Optical Computing: A Survey for Computer Scientists, The MIT Press, 1992.
2. Jürgen Jahns, Sing H. Lee, "Optical Computing Hardware: Optical Computing," Academic Press, 2014.

Evaluation Scheme:

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

PEC XXX: ADAPTIVE SIGNAL PROCESSING

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

Course Objective: The subject of adaptive filters constitutes an important part of statistical signal processing. Whenever there is a requirement to process signals that result from operation in an environment of unknown statistics or one that is inherently nonstationary, the usage of an adaptive filter offers highly attractive solution to the problem, as it provides a significant improvement in performance over the use of a fixed filter designed by conventional methods. Therefore, students will be able to apply adaptive filtering techniques in the diverse fields as communications, control engineering, neural networks and machine learning etc.

Course Content Details:

Unit 1: Introduction to Stochastic Processes and Models, Details about Wiener Filters and Analysis, LCMV Filtering , Linear Prediction Details and Analysis

Unit 2: Method of Steepest-Descent and Analysis, Least-Mean-Square Adaptive Filters and Analysis, Normalized-Least-Mean-Square Adaptive Filters and Analysis

Unit 3: Method of Least-Squares, Recursive-Least-Squares Adaptive Filter, its Types and Analysis, Kalman-Filter, its Types and Analysis, Square-Root Adaptive Filters

Unit 4: Adaptive Filters using Infinite-Duration Impulse Response Structures, Blind-Deconvolution and Algorithms, Frequency-Domain and Subband Adaptive Filters with Analysis

Unit 5: Zero-Forcing and Minimum-Mean-Square-Error Criterion Based Equalization, Types of Adaptive Equalizers, Fractionally-Spaced-Equalizers, Bussgang Equalizers, Adaptive Decision-Feedback Equalization, Blind Equalization Algorithms

Unit 6: Current State of Art in Adaptive Signal Processing and its Applications in the Field of Electronics and Communication Engineering, Nonstationary Systems, Adaptive Lattice Configurations, Finite Precision Effects, Fast Transversal Filters, Introduction to Adaptive Beamforming, Adaptive Noise Cancellation, Predictive Modeling of Speech

Laboratory Work: N.A.

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

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

1. analyze stochastic processes and system modeling
2. apply adaptive estimation and prediction algorithms for system identification
3. employ FIR and IIR filtering configurations to execute adaptive signal processing schemes

4. utilize adaptive equalizers to improve the quality of signals by suppressing distortions
5. tackle engineering system problems using adaptive signal processing approach

Text Books:

1. **S. Haykin, *Adaptive Filter Theory*. 5th ed., India: Pearson Education, 2013.**
2. **Ali H. Sayed, *Adaptive Filters*. 1st ed., New Jersey, U.S.A.: J. Wiley & Sons Inc., 2008.**
3. **J.G. Proakis, *Digital Communications*. 3rd ed., New York, U.S.A.: McGraw-Hill, 1995.**

Reference Books:

1. **Harry L. Van Trees, *Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory*. U.S.A.: J. Wiley & Sons Inc., 2002.**
2. **H.V. Poor, *An Introduction to Signal Detection and Estimation*. 2nd ed. Berlin, Germany: Springer, 1998.**
3. **A. Papoulis, *Probability Random Variables and Stochastic Processes*. 3rd ed., New York, U.S.A.: McGraw-Hill, 1991.**

Evaluation Scheme:

S.No.	**Evaluation Components**	**Weightage (%)**
1.	MST	30%
2.	EST	45%
3.	Sessionals (May include Assignments/Micro-project/Quiz)	25%

PEC291 SEMINAR Credit:04

Course Learning Outcomes:

The students will be able to:

1. Identify, formulate, and research literature for complex engineering problems.
2. Use research based methods in analyzing and interpreting data.
3. Make effective oral presentation and prepare a technical report.

PEC* DESIGN PROJECT Credit:04**

Course Learning Outcomes:

The students will be able to:

1. Formulate, and analyze complex engineering problem to reach logical conclusions.
2. Conduct or simulate experiments by utilizing latest hardware and software tools and apply appropriate techniques for modeling the engineering problem.
3. Present and write technical report with professional ethics.

PEC493 DISSERTATION Credit:16

Course Learning Outcomes:

The students will be able to:

1. Design and implementation of identified research problem or industrial projects.
2. Develop acumen for higher education and research.
3. Write technical reports and publish the research work in referred journals, national and international conferences of repute.
4. Foresee how their current and future work will influence/impact the economy, society and the environment.