SCHEME OF COURSES FOR

ME (Electronics and Communication Engineering), Batch – 2016-2018

First Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PEC108/109	Embedded System Design (Four Self Effort Hours for Project - 2 Credits)	3	0	2+4	6.0
2.	PWC104	Stochastic Processes and Information Theory	3	1	0	3.5
3.	PEC 101	Discrete Time Signal Processing	3	1	2	4.5
4.	PEC 104	Antenna Systems	3	0	2	4.0
5.	PEC 105	Advanced Communication Systems	3	1	2	4.5
		Total	**15**	**3**	**12**	**22.5**

Second Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PWC203	Advanced Wireless Communication Systems	3	1	2	4.5
2.	PEC106	Optical Communication Networks	3	0	2	4.0
3.	PEC291	Seminar	-	-	-	**4.0**
5.	PEC207	RF Devices and Applications	3	1	0	3.5
4.	PEC 339	Image Processing and Computer Vision	3	0	2	4.0
6.		Elective – I (2/0/2)	3	0	0	3.0
		Total	**12**	**1**	**6**	**23.0**

Third Semester

S. No.	Course No.	Course Name	L	T	P	Cr
	PEC392	**Project**				**12.0**
2.	PEC 491	Dissertation (Starts)	-	-	-	-
3.		Elective – II	3	0	0	3.0
4.		Elective – III	3	0	0	3.0
		Total	**9**	**0**	**6**	**18.0**

Fourth Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PEC 491	Dissertation (Contd …)				**16.0**

Total Credits: 79.5

List of Electives

Elective–I

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PVL 203	VLSI Signal Processing	3	0	0	3.0
2.	PVL	Nanoelectronics	3	0	0	3.0
3.	PVL	Photonic Integrated Devices & Circuits	3	0	0	3.0
4.	PWC 201	Space-Time Wireless Communication	3	0	0	3.0
5.	PWC 212	Wireless Security	3	0	0	3.0
6.	PWC	Advance Wireless Networks	3	0	0	3.0
7.	PEC 211	Passive Optical Networks	3	0	0	3.0
8.	PEC 212	Audio and Speech Processing	3	0	0	3.0
9.	PEC 215	Detection and Estimation Theory	3	0	0	3.0
10.	PEC 216	Advanced Computer Networks and Protocols	3	0	0	3.0
11.	PEC 218	Digital Signal Processors	2	0	2	3.0
12.	PEC	Multimedia Compression Techniques	3	0	0	3.0
13.	PEC	Fractional Transforms and Applications	3	0	0	3.0
14.	PEC	Optoelectronics	3	0	0	3.0
15.	PEC	HDL and System C Programming	2	0	2	3.0

Elective-II

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PVL-334	High Speed VLSI design	3	0	0	3.0
2.	PVL-332	Mixed Signal Circuit Design	3	0	0	3.0
3.	PVL	Sensor Technology and MEMS	3	0	0	3.0
4.	PVL-110	VLSI Achitecture	3	0	0	3.0
5.	PWC-321	Next Generation Wireless Systems and Networks	3	0	0	3.0
6.	PWC	Advanced Error Control Coding Theory	3	0	0	3.0
7.	PWC	Wireless Broadband Networks	3	0	0	3.0
8.	PEC-217	Microstrip Antennas	3	0	0	3.0
9.	PEC	Machine Learning	3	0	0	3.0
10.	PEC-337	Adaptive Signal Processing	3	0	0	3.0
11.	PEC	Robotics and Automation	3	0	0	3.0
12.	PEC	Advanced Optical Technologies	3	0	0	3.0

Elective-III

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PVL	System on Chip	3	0	0	3.0
2.	PVL	Advanced Analog Circuit Design Techniques	3	0	0	3.0
3.	PVL	Hardware Algorithms for Computer Arithmetic	3	0	0	3.0
4.	PWC	Wireless Sensor Networks	3	0	0	3.0
5.	PWC-336	Wireless Communication Protocol	3	0	0	3.0
6.	PWC	Spread Spectrum Communication	3	0	0	3.0
7.	PEC	Artificial Intelligence	3	0	0	3.0
8.	PEC	Biomedical Signal Processing	3	0	0	3.0
9.	PEC	Cloud Computing	3	0	0	3.0
10.	PEC	RF Circuit Design	3	0	0	3.0
11.	PEC	IP over WDM	3	0	0	3.0
12.	PEC	Soft Computing Techniques	3	0	0	3.0

PEC108/109: EMBEDDED SYSTEMS DESIGN

L	T	P	Cr
3	0	6	6.0

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

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. (Four Self Effort Hours for Project – 2 Credits)

Course Learning Outcomes (CLOs):

The students will be able to

- Recognize the Embedded system and its programming, Embedded Systems on a Chip (SoC) and the use of VLSI designed circuits.
- Identify the internal Architecture and perform the programming of ARM processor.
- Program the concepts of Arduino Microcontroller with various interfaces like memory & I/O devices and Raspberry Pi based embedded platform.
- Analyze the need of Real time Operating System (RTOS) in embedded systems.
- 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 (%)
1.	MST	25%
2.	EST	40%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	35%

PEC101: DISCRETE TIME SIGNAL PROCESSING

L	T	P	Cr
3	1	2	4.5

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

Course Content Details:

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

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

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

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

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

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

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

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

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

Course Learning Outcomes (CLOs):

The students will be able to

- Recognize the concept of discrete time signal processing and filter design techniques.
- Interpret multi-rate signal processing and its application.
- Analyze the theory of adaptive filter design and its applications.

- 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.***

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25%
2.	EST	35%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40%

PEC104: ANTENNA SYSTEMS

L	T	P	Cr
3	0	2	4.0

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

Course Content Details:

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

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

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

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

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

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

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

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

Laboratory Work: Practical 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

- Acquire knowledge about basic antenna concepts.
- Recognize thin linear antennas and arrays.
- Identify secondary sources, aperture, broadband and frequency independent antennas.
- Apply the knowledge of mutual coupling on antennas, applications and numerical techniques.
- Comprehend the adaptive array concept.

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).***

Reference Books

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

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25%
2.	EST	40%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	35%

PEC105: ADVANCED COMMUNICATION SYSTEMS

L	T	P	Cr
3	1	2	4.5

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

Course Content Details:

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

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

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

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

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

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

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

Course Learning Outcomes (CLOs):

The students will be able to

- Recognize Optimum Receivers for AWGN Channels.
- Analyze the pass band communication and modulation techniques to understand the small scale fading models.
- Comprehend the concept of Carrier and Symbol Synchronization.
- Analyse the concept of ISI and its removal.
- Describe the concept of communication in band limited channels.

Text Books:

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

Reference Books:

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

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25%
2.	EST	35%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40%

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

- Identify, formulate and solve optical communication networks related problems using efficient technical approaches.
- Design optical networks as well as to interpret statistical and physical data.
- Design and implement WDM networks.

- Apply the knowledge to control and manage the functions of optical networks.
- Recognize the network survivability by various protection schemes.

Text Books:

1. ***Ramaswami Rajiv, Kumar N. Sivarajan, Optical Networks: A Practical Perspective, Morgan Kaufmann Publishers, Elsevier (2004).***
2. ***Willebrand Heinz, Ghuman Baksheesh. S., Free Space Optics: Enabling Optical Connectivity in Today's Networks, Sams (2001).***
3. ***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	40 %
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	35 %

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 application, Image compression and its applicability, fundamentals of computer vision, geometrical features of images, object recognition and application of real time image processing.

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.

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

Computer Vision: Imaging Geometry, Coordinate transformation and geometric warping for image registration, Hough transforms and other simple object recognition methods, Shape 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

- Recognize the fundamental techniques of Image Processing and Computer Vision.
- Interpret the basic skills of designing image compression.
- Distinguish between different image compression standards.
- Analyse different computer vision techniques
- Analyse real time image processing system.

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	35%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40%

PEC207: RF DEVICES AND APPLICATIONS

L	T	P	Cr
3	1	0	3.5

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

Course Content Details:

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

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

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

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

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

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

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

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

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

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

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

Laboratory Work: N.A.

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

Course Learning Outcomes (CLOs):

The students will be able to

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

Text Books:

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

Reference Books:

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

Evaluation Scheme:

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

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

- Recognize and evaluate the performance of various enabling technologies used in modern optical networks.
- Evaluate different WDM network topologies including broadcast-and-select and wavelength routing networks.
- Design virtual WDM network topologies.
- 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	50%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20%

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

- Acquire the knowledge about audio & speech signals.
- Recognize speech generation models.
- Analyze the audio & speech signal estimation & detection.
- Acquire knowledge about hardware to process audio & speech signals.
- Integrate human physiology and anatomy with signal processing paradigms.

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	50%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20%

PEC215: DETECTION AND ESTIMATION THEORY

L	T	P	CR
3	0	0	3.0

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

Course Content Details:

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

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

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

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

Doppler-Spread Targets and Channels: Model for Doppler-Spread Target (or Channel), Detection of Doppler-Spread Targets, Likelihood Ratio Test, Canonical Receiver Realizations, Performance of the Optimum Receiver, Communication Over Doppler-Spread Channels, Performance Bounds for Optimized Binary Systems, Doppler-Spread Target, Detection of Range-Spread Targets, Time-Frequency Duality, Dual Targets and Channels, Model for a Doubly-Spread Target, Differential-Equation Model for a Doubly-Spread Target (or Channel), Detection in the Presence of Reverberation or Clutter (Resolution in a Dense Environment), Detection of Doubly-Spread Targets and Communication over Doubly-Spread Channels, Approximate Models for Doubly-Spread Targets and Doubly-Spread Channels, Binary Communication over Doubly-Spread Channels, Detection under LEC Conditions, Parameter Estimation for Doubly-Spread Targets, Estimation under LEC Conditions, Amplitude Estimation, Estimation of Mean Range and Doppler.

Laboratory Work: N.A.

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

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

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

Text Books:

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

Reference Books:

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

Evaluation Scheme:

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

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

- Acquire knowledge about Network Fundamentals.
- Identify Internetworking.
- Recognize the Network Standards and Standard Organizations.
- Interpret the TCP/IP Network Interface Layer Protocol .
- Acquire knowledge about Routing and Application Layer Protocols.

Text Books:

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

Reference Books:

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

Evaluation Scheme:

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

PEC218: DIGITAL SIGNAL PROCESSORS

L	T	P	Cr
2	0	2	3.0

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

Course Content Details:

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

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

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

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

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

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

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

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

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

Laboratory Work: Introduction to code composer studio, Using CCS write program to compute factorial, dot product of two arrays, Generate Sine, Square and Ramp wave of varying frequency and amplitude, Design various FIR and IIR filters, Interfacing of LED, LCD, Audio and Video Devices with the DSP processor.

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

Course Learning Outcomes (CLOs):

The students will be able to

- Acquire knowledge about Fixed and floating point number systems.
- Recognize the internal Structures of DSP Processors and memory accesses.
- Analyse addressing instructions of a DSP processors.
- Recognize the internal architecture, instructions set, programming and interfacing of different peripheral devices with TMS320C3X, TMS320C5X, TMS320C6X, ADSP 21XX DSP Chips.

Text Books:

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

Reference Books:

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

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25%
2.	EST	35%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40%

PEC: MULTIMEDIA COMPRESSION TECHNIQUES

L	T	P	Cr
3	0	0	3.0

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

Course Content Details:

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

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

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

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

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

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

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

Laboratory Work: N.A.

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

Course Learning Outcomes (CLOs):

The students will be able to

- Recognize and develop human speech mode, understand characteristics of human's visual system, understand the characteristics of human's audio system.

- Evaluate different compression principles, understand different compression techniques, understand different multimedia compression standards, be able to design and develop multimedia systems according to the requirements of multimedia applications.
- Analyze the various signal processing aspects of achieving high compression ratios.
- Recognize and develop new paradigm technologies in audio and video coding.
- Describe the application of modern multimedia compression techniques in the development of new wireless communication protocols.

Text Books:

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

Reference Books:

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

Evaluation Scheme:

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

PEC: 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

- Recognize Time frequency analysis of signals.
- Describe the concepts of Fractional Fourier Transform.

- Identify the various applications of Fractional Transform.
- 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	50%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20%

PEC: OPTOELECTRONICS

L	T	P	Cr
3	0	0	3.0

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

Course Content Details:

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

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

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

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

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

Optical Measurements: Optical fiber sensor, Optical CDs.

Laboratory Work: N.A.

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

Course Learning Outcomes (CLOs):

The students will be able to

- Recognize fundamentals, advantages and advances in optoelectronic devices, circuits and systems.
- Acquire a detailed understanding of types, basic properties and characteristics of optical waveguides, modulators and detectors.
- Dewcribe the knowledge of design, working, Classification and analysis of Semiconductor Lasers, LEDs, and modulators.
- Identify, formulate and solve engineering and technological problems related to optical sources, displays, detectors and optical measurements.

Text Books:

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

Reference Books :

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

Evaluation Scheme:

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

PEC: HDL AND SYSTEM C PROGRAMMING

L	T	P	Cr
2	0	2	3.0

Course Objective:

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

Course Content Details:

VHDL:

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

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

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

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

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

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

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

SystemC:

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

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

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

Course learning outcome (CLOs):

The students will be able to

1. Design and model digital systems in VHDL and SystemC at different levels of abstraction.
2. Analyse the partition of a digital system into different subsystems.
3. Simulate and verify a design.
4. Synthesize a model from its simulation version.
5. Apply modern software tools for digital design in VHDL.

.

Text Books:

1. ***Bhaskar, J., A VHDL Primer, Pearson Education/ Prentice Hall (2006)3rd Ed.***
2. ***Bhaskar, J., A SystemC Primer, Pearson Education/ Prentice Hall (2009)2nd Ed.***

Reference Books:

1. Ashenden, P., The Designer's Guide To VHDL, Elsevier (2008) 3rd Ed.
2. David C. Black and Jack Donovan, SystemC: From the Ground Up , Springer, (2014) 2nd Ed.

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25%
2.	EST	35%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40%

PEC: MICROSTRIP ANTENNAS

L	T	P	Cr
3	0	0	3.0

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

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

- Recognize the basic concept of micro-strip antennas, methods of analysis and configurations.
- Analyze micro-strip antennas arrays.
- Evaluate the physical significance of discontinuities.
- Evaluate the significance of different micro-strip feed mechanism available.
- Recognize coupled micro-strip line with multiband and broadband behavior.

- 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	50%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20%

PEC: MACHINE LEARNING

L	T	P	Cr
3	0	0	3.0

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

Course Content Details:

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

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

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

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

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

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

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

Laboratory Work: N.A.

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

Course learning outcomes (CLOs):

The students will be able to

- Differntiate the parametric and non parametric estimations.
- Recognize data in the pattern space.
- Design a Trainer and test classifiers using supervised learning.
- Apply clustering algorithms to process big data real time.
- Apply Bayesian parameter estimation to real world problems.

Text Books:

1. ***Duda, Richard, Peter Hart, and David Stork. Pattern Classification. 2nd ed. New York, NY: Wiley-Interscience, 2000. ISBN: 9780471056690.***
2. ***Simon Hykin, Neural Networks and Learning Machines, Prentice Hall of India, (2010) 3rd ed.***
3. ***Mitchell, Tom. Machine Learning. New York, NY: McGraw-Hill, 1997. ISBN: 9780070428072.***

Reference Books:

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

Evaluation Scheme:

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

PEC: ADAPTIVE SIGNAL PROCESSING

L	T	P	Cr
3	0	0	3.0

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

Course Content Details:

Signals and Systems: System theory, stochastic processes Gauss Markov model, Representation of stochastic processes, likelihood and sufficiency, Hypothesis testing, decision criteria, multiple measurements.

Estimation Theory: Estimation of parameters, random parameters, Bayes Estimates, estimation of non random parameters, properties of estimators, Linear Estimation of signals, prediction, filtering, smoothing, correlation cancellation, Power Spectrum Estimation-Parametric and Maximum Entropy Methods.

Estimation of Waveforms: Linear, MMSE estimation of waveforms, estimation of stationary processes: Wiener filter, Estimation of non stationary processes: Kalman filter, Non linear estimation.

Prediction: Forward and backward linear prediction, Levinson-Durben algorithm, Schurz algorithm, properties of linear prediction error filters, AR- Lattice and ARMA -Lattice Ladder filters, Wiener filters for prediction.

System Modeling and Identification: System identification based on FIR (MA), All Pole (AR), Pole Zero (ARMA) system models, Least square linear prediction filter, FIR least squares inverse filter, predictive de convolution, Matrix formulation for least squares estimation: Cholesky decomposition, LDU decomposition, QRD decomposition, Grahm - Schmidt orthogonalization, Givens rotation, Householder reflection, SVD.

Adaptive Filtering: Least square method for tapped-delay line structures, Least Mean Squares (LMS) and Recursive Least Squares (RLS) algorithms and their convergence performance, IIR adaptive filtering and Transform domain adaptive filtering, introduction of different types of LMS, RLS and Kalman filters and their relationship with each other.

Adaptive Equalization: Optimal Zero-Forcing and MMSE Equalization, Generalized Equalization Methods, Fractionally Spaced Equalizer, Transversal Filter Equalizers, ISI and ADFE and Error Propagation.

Non-stationary Signal Analysis: Time frequency analysis, Cohen class distribution, Wigner-Ville Distribution, Wavelet Analysis.

Applications: Noise and echo cancellation, Parameters estimation in Radar systems, Dynamic target tracking, Application to pattern classification and system identification, channel identification and equalization, Generalized inverses, regularization of ill-posed problems, Interpolation and approximation by least squares and minimax error criteria, Optimization techniques for linear and nonlinear problems, Model order selection, MUSIC, ESPRIT algorithms, Signal Analysis with Higher order Spectra, array processing, Beam forming, time-delay estimation, successive and parallel interference cancellers.

Laboratory Work: N.A.

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

Course Learning Outcomes (CLOs):

The students will be able to

- Acquire knowledge about Signals and Systems.
- Identify Estimation Theory.
- Describe the Estimation of Waveforms.
- Recognize system modeling and Identification.
- Acquire knowledge about Adaptive Filtering.
- Acquire knowledge about Adaptive Equalization.
- Acquire knowledge about Non-stationary Signal Analysis and its Applications.

Text Books:

1. ***Haykin, Simon S., Adaptive filter theory, Dorling Kingsley (2008).***
2. ***Honig, Michael L., David G., Messerschmitt, Adaptive Filters: Structures Algorithms and Applications, Springer (1984).***

Reference Books:

1. ***Trees, Harry L. Van, Optimum Array Processing, Detection, Estimation, and Modulation Theory, Part IV, John Wiley and Sons (2002).***
2. ***Adams, Peter F., Cowan, Colin F. N. and Grant, Peter M., Adaptive Filters, Prentice-Hall (1985).***
3. ***Sayeed, Zulfiquar, Adaptive Coding and Transmitter Diversity for Slow Fading Channels, University of Pennsylvania (1996).***

Evaluation Scheme:

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

PEC: ROBOTICS AND AUTOMATION

L	T	P	Cr
3	0	0	3.0

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

Course Content Details:

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

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

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

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

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

Laboratory Work: N.A.

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

Course learning outcomes (CLOs):

The students will be able to

- Recognize the basics of robotics and their functionality.
- Comprehend the fundamentals of sensors.
- Evaluate various driver systems for robots.
- Analyze the image processing and computer vision for robotics.
- Recognize development of algorithms for robot kinematics .

Text Books:

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

Reference Books:

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

Evaluation Scheme:

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

PEC: ADVANCED OPTICAL TECHNOLOGIES

L	T	P	Cr
3	0	0	3.0

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

Course Content Details:

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

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

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

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

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

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

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

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

Laboratory Work: N.A.

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

Course Learning Outcomes (CLOs):

The students will be able to

- Recognize the Fundamentals, advantages and advances in optical devices and circuits.
- Describe advanced optical waveguides, detectors, amplifiers, silicon photonics and MEMS applications in photonics.
- Acquire Knowledge of Design, working, Classification and analysis of Advanced Semiconductor Lasers and High speed modulators.

Text Books:

1. ***Kaminow, Ivan P., Li, Tingye, Willner, Alan E., Optical Fiber Telecommunications V.A., Components and Subsystems, Elsevier (2008).***
2. ***Kaminow, Ivan P., Li, Tingye and Willner, Alan E., Optical Fiber Telecommunications V.B., Systems and Networks, Academic Press (2008) 5th ed.***

Reference Books:

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

Evaluation Scheme:

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

PEC: ARTIFICIAL INTELLIGENCE

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

Course Objective:

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

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

- Analyse the applications of artificial intelligence and categorize various problem domains, uninformed and informed search methods.
- Identify advanced search techniques and algorithms like minimax for game playing.
- Recognize the importance of probability in knowledge representation for reasoning under uncertainty.
- Describe Bayesian networks and drawing Hidden Markov Models.
- 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	50%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizzes/Lab Evaluations)	20%

PEC: 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

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

Text Books:

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

Reference Books:

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

Evaluation Scheme:

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

PEC: 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

- Recognize different cloud architectures.
- Apply the knowledge of data processing in cloud.
- Apply clustering algorithms to process big data real time.
- Identify the security issues in cloud environment.
- 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	50%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20%

PEC: 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
- Describe the knowledge about Basic Principles in RF Design.
- Identify Distributed Systems.
- Analyse high frequency Amplifier Design.
- Design Low Noise Amplifier (LNA)
- 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	50%
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20%

PEC: IP OVER WDM

L	T	P	Cr
3	0	0	3.0

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

Course Content Details:

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

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

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

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

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

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

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

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

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

Laboratory Work: N.A.

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

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

- Describe the knowledge about protocol design concepts, electro-optic and wavelength conversion.
- Define Terabit Switching and Routing Network Elements& Optical Network Engineering.
- Analyze the performance of Traffic Management for IP-over-WDM and Wavelength-Routing Networks.
- Analyze Internetworking Optical Internet and Optical Burst Switching, Survivability in IP-over-WDM Networks.
- Differntiate Optical Internetworking Models and Standards Directions.

Text Books:

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

Reference Books:

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

Evaluation Scheme:

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

PEC: SOFT COMPUTING TECHNIQUES

L	T	P	Cr
3	0	0	3.0

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

Course Content Details:

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

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

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

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

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

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

Laboratory Work: N.A.

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

Course Learning Outcomes (CLOs):

The students will be able to

- Solve Pattern Classification & Function Approximation Problems.

- Design appropriate ANN model for a given Problem.
- Apply data pre-processing techniques.
- Design Fuzzy inference systems from linguistic models.
- Design genetic optimization to create objective functions for a given optimization problem.

Text Books:

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

Reference Books:

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

Evaluation Scheme:

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