School of Engineering and Technology

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

M.TECH – ELECTRONICS AND COMMUNICATION ENGINEERING

SEMESTER I & II

COURSE STRUCTURE & SYLLABUS

AY 2023-24

Semester I

Theory/ Practical	Sl. No	Course Type	Course Code	Course Name	Hours per week			Credit	Mark	
					L	T	P	C	IA	EA
T	1.	PCC		RTL Simulation and Synthesis with PLDs	3	0	0	3	40	60
T	2.	PCC		Wireless and Mobile Communication	3	0	0	3	40	60
T	3.	PCC		Digital Signal and Image Processing	3	0	0	3	40	60
T	4.	PE-I		Program Specific Elective-I	3	0	0	3	40	60
T	5.	OE-1		Open Elective I	3	0	0	3	40	60
P	6.	LAB I		RTL Simulation and Synthesis with PLDs Lab	0	0	4	2	40	60
T	7.	MC		Research Methodology	2	0	0	2	40	60
T	8.	AC		Audit Course – I	2	0	0	0	00	100
				Total	**19**	**0**	**0**	**4**	**280**	**520**

Semester II

Theory/ Practical	Sl. No	Course Type	Course Code	Course Name	Hours per week			Credit	Mark	
					L	T	P	C	IA	EA
T	1.	PCC		Pattern Recognition and Machine Learning	3	0	0	3	40	60
T	2.	PCC		Advanced Digital Signal Processing	3	0	0	3	40	60
T	3.	PCC		Analog and Digital CMOS VLSI Design	3	0	0	3	40	60
T	4.	PE-II		Program Specific Elective-II	3	0	0	3	40	60
T	5.	PE-III		Program Specific Elective-III	3	0	0	3	40	60
P	6.	LAB II		Analog and Digital CMOS VLSI Design Lab	0	0	4	2	40	60
P.	7.			Mini Project	0	0	4	2	40	60
T	8.	AC		Audit Course – II	2	0	0	0	00	100
				Total	**17**	**0**	**8**	**19**	**280**	**520**

Program Elective – I

Sl.No.	Course Type	Code	Course
1.	PEC		DSP Architecture
2.	PEC		Computer Vision
3.	PEC		Optical Networks
4.	PEC		Statistical Information Processing
5.	PEC		Programming Languages for Embedded Software
6.	PEC		VLSI signal processing

Open Elective-I

Sl.No.	Course Type	Code	Course
1.	OE		VLSI Design Verification and Testing
2.	OE		Low power VLSI Design
3.	OE		Satellite Communication
4.	OE		IOT and Applications
5.	OE		Digital Design and Verification
6.	OE		Memory Technologies

Professional Elective – III

Sl.No.	Course Type	Code	Course
1.	PEC		Biomedical Signal Processing
2.	PEC		Artificial Intelligence
3.	PEC		Modelling and Simulation Techniques
4.	PEC		Remote Sensing
5.	PEC		Physical design automation
6.	PEC		Nano materials and Nanotechnology

Open Elective-I

Sl.No.	Course Type	Code	Course
1.	OEC		Audio Video Coding & Compression
2.	OEC		Voice and Data Networks
3.	OEC		Cognitive Radio
4.	OEC		RF and Microwave Circuit Design
5.	OEC		System Design with Embedded Linux
6.	OEC		CAD of Digital System

Audit Course – I

Sl.No.	Course Type	Code	Course
1.	AU		English for Research paper writing
2.	AU		Disaster Management
3.	AU		Value Education

Audit Course – II

Sl.No.	Course Type	Code	Course
1.	AU		Personality Development through Life Enlightenment Skills.
2.	AU		Constitution of India
3.	AU		Pedagogy Studies
4.	AU		Stress Management by Yoga

Internal Members/ BOS **External Members/ BOS**

SEMESTER - I

DETAIL SYLLABUS

PC	RTL SIMULATION AND SYNTHESIS WITH PLDS	L	T	P	C
		3	0	0	3

Prerequisite: Digital system design

Course Objectives:

1. To make the student familiar with Finite State Machines, RTL systems using reconfigurable logic.
2. To design and develop IP cores and Prototypes
3. To use EDA tools like Cadence, Mentor Graphics and Xilinx

Course Outcome:

Upon completion of this course, the student will be able to

1. Design Finite State Machines and also to analyse those designs
2. Do programs in Verilog
3. Analyse the performance of designed systems using various tools like Cadence, Xilinx etc
4. Do various prototyping

Module:1 Introduction to FSM	**10 hours**
Top down approach to design, Design of FSMs (Synchronous and asynchronous), Static timing analysis, Meta-stability, Clock issues, Need and design strategies for multi-clock domain designs.	
Module:2 Programming using Verilog	**10 hours**
Introduction to Verilog, Design entry by Verilog ,Verilog AMS.	
Module:3 PLDs and ASIC design	**8 hours**
Programmable Logic Devices, Introduction to ASIC Design Flow, FPGA, SoC, Floor planning, Placement, Clock tree synthesis, Routing, Physical verification, Power analysis, ESD protection	
Module:4 Low power VLSI	**10 hours**
Design for performance, Low power VLSI design techniques. Design for testability.	
Module:5 IP and Prototyping	**5 hours**
IP in various forms: RTL Source code, Encrypted Source code, Soft IP, Netlist, Physical IP, Use of external hard IP during prototyping	
Module:6 Case Studies and Speed issues	**2 hours**
Total hours	**45 hours**

Text Book

1. Richard S. Sandige, “Modern Digital Design”, MGH, International Editions.
2. Donald D Givone, “Digital principles and Design”, TMH
3. Charles Roth, Jr. and Lizy K John, “Digital System Design using VHDL”, Cengage Learning.

Reference Books

1. Samir Palnitkar, “Verilog HDL, a guide to digital design and synthesis”, Prentice Hall.
2. Doug Amos, Austin Lesea, Rene Richter, “FPGA based prototyping methodology manual”, Xilinx
3. Bob Zeidman, “Designing with FPGAs & CPLDs”, CMP Books.

Internal Members/ BOS **External Members/ BOS**

PC	WIRELESS AND MOBILE COMMUNICATION	L	T	P	C
		3	0	0	3

Prerequisite: Concepts of digital communication systems, basics of linear algebra and probability

Course Objectives:

To enable the student to understand the emerging technologies of wireless and mobile communications and simulate them.

Course Outcome:

Upon completion of this course, the student will be able to:

1. Apply cellular concepts to evaluate the signal reception performance in a cellular network and traffic analysis to design cellular network with given quality of service constraints.
2. Determine the type and appropriate model of wireless fading channel based on the system parameters and the property of the wireless medium.
3. Analyze and design receiver and transmitter diversity techniques.
4. Design wireless communication systems with key 3G (e.g., CDMA) and OFDM technologies.
5. Describe and differentiate four generations of wireless standard for cellular networks.

Module:1 Cellular Communication Fundamentals — **10 hours**

Cellular system design, Frequency reuse, cell splitting, handover concepts, Co-channel and adjacent channel interference, interference reduction techniques and methods to improve cell coverage, Frequency management and channel assignment. GSM architecture and interfaces, GSM architecture details, GSM subsystems, GSM Logical Channels, Data Encryption in GSM, Mobility Management, Call Flows in GSM.2.5 G Standards: High speed Circuit Switched Data (HSCSD), General Packet Radio Service (GPRS), 2.75 G Standards: EDGE.

Module:2 Spectral efficiency analysis based on calculations for Multiple access technologies — **10 hours**

TDMA, FDMA and CDMA, Comparison of these technologies based on their signal separation techniques, advantages, disadvantages, and application areas. Wireless network planning (Link budget and power spectrum calculations).

Module:3 Mobile Radio Propagation — **10 hours**

Large Scale Path Loss, Free Space Propagation Model, Reflection, Ground Reflection (Two-Ray) Model, Diffraction, Scattering, Practical Link Budget Design using Path Loss Models, Outdoor Propagation Models, Indoor Propagation Models, and Signal Penetration into Buildings. Small Scale Fading and Multipath Propagation, Impulse Response Model, Multipath Measurements, Parameters of Multipath channels, Types of Small-Scale Fading: Time Delay Spread; Flat, Frequency selective, Doppler Spread; Fast and Slow fading.

Module:4 Equalization, Diversity — **6 hours**

Equalizers in a communications receiver, Algorithms for adaptive equalization, diversity techniques, space, polarization, frequency diversity, Interleaving.

Module:5 OFDM — **4 hours**

Introduction to OFDM.

Module:6 Higher Generation Cellular Standards — **5 hours**

3G Standards: evolved EDGE, enhancements in 4G standard, Architecture and representative protocols, call flow for LTE, VoLTE, UMTS, introduction to 5G

Total hours — **45 hours**

Text Book

1. V.K.Garg, J.E.Wilkes, “Principle and Application of GSM”, Pearson Education, 5th edition, 2008.

2. V.K.Garg, "IS-95 CDMA & CDMA 2000", Pearson Education, 4th edition, 2009.
3. T.S.Rappaport, "Wireless Communications Principles and Practice", 2nd edition, PHI,2002.

Reference Books

1. .William C.Y.Lee, "Mobile Cellular Telecommunications Analog and Digital Systems", 2nd edition, TMH, 1995.
2. Asha Mehrotra, "A GSM system Engineering" Artech House Publishers Bosten, London,1997

C	DIGITAL SIGNAL AND IMAGE PROCESSING	L	T	P	C
		3	0	0	3

Prerequisite: Signals and Systems, Digital Signal Processing

Course Objectives:

1. To introduce the concepts of signal and image processing and basic analytical methods to be used in image processing.
2. To familiarize students with image transforms, image enhancement and restoration techniques
3. To explain different image compression techniques.
4. To introduce segmentation and morphological processing techniques.

Course Outcome:

Upon completion of this course, the student will be able to:

1. Interpret image storage, sampling, and frequency domain processing operations.
2. Evaluate current technologies and issues that are specific to image processing systems.
3. Analyze different image compression techniques.
4. Integrate concepts of various image processing algorithms.

Module:1 Fundamentals of Digital Signal Processing	**10 hours**
Review of Signals and Systems, Characterization of signal in time and Z and Fourierdomain, DFT, Direct Form-I & II Realization structures, Digital Filter design.	
Module:2 Digital Image Fundamentals	**6 hours**
Digital Image fundamentals, Components of Digital Image Processing, Sampling andQuantization, Relationship between pixels.	
Module:3 Image Transforms	**4 hours**
2D-DFT, 2D-DCT, 2D-DWT	
Module:4 Image Enhancement	**8 hours**
Introduction, Image Enhancement in Spatial domain, Enhancement through point operation,Types of point operation, Histogram manipulation, Linear and nonlinear gray level, Transformation, Local or neighborhood operation, Median filter, Spatial domain High-passfiltering.Filtering in Frequency domain, obtaining frequency domain filters from spatial filters,Generating filters directly in the frequency domain, Low pass (Smoothing) and High pass(Sharpening) filters in frequency domain.	
Module:5 Image Restoration	**6 hours**
Degradation model, Algebraic approach to restoration, Inverse filtering	
Module:6 Image Segmentation and Morphological Image Processing	**6 hours**
Detection of discontinuities, Edge linking and boundary detection, Thresholding, Region orientedsegmentation.Dilation and Erosion, Opening and Closing.	
Module:7 Image Compression	**5 hours**
Redundancies and their removal methods, Fidelity criteria, Image compression models,Huffman and Arithmetic Coding, Error free compression, Lossy compression, Lossy andLossless Predictive Coding, Transform based Compression, JPEG 2000 Standards.	
Total hours	**45 hours**

Text Book(s)

1. Digital Image Processing – Rafael C. Gonzalez, Rechard E. Woods, 3rd edition. Pearson, 2008
2. Digital Image Processing – S. Jayaraman, S Esakkirajan, T Veerakumar- TMH, 2010

Reference Books

1. Digital Image Processing using MATLAB – Rafael C. Gonzalez, Richard E woods and Steven L. Eddings, 2nd Edition, TMH, 2010.
2. Fundamentals of Digital Image Processing – A. K. Jain, PHI, 1989.Wiley India

Lab	RTL SIMULATION AND SYNTHESIS WITH PLDs LAB	L	T	P	C
		0	0	4	2

Prerequisite: Digital system design

Course Objectives:

4. To identify, formulate, solve and implement problems in signal processing,communication systems etc using RTL design tools.
5. To use EDA tools like Cadence, Mentor Graphics and Xilinx

Course Outcome:

At the end of this course, students will be able to

1. Identify, formulate, solve and implement problems in signal processing,communication systems etc using RTL design tools.
2. Use EDA tools like Cadence, Mentor Graphics and Xilinx

List of experiments:

1. Verilog implementation of 8:1 Mux/Demux, Full Adder, 8-bit Magnitudecomparator, Encoder/decoder, Priority encoder, D-FF, 4-bit Shift registers (SISO,SIPO, PISO, bidirectional), 3-bit Synchronous Counters, Binary to Gray converter,Parity generator.
2. Sequence generator/detectors, Synchronous FSM – Mealy and Moore machines.
3. Vending machines - Traffic Light controller, ATM, elevator control.
4. PCI Bus & arbiter and downloading on FPGA.
5. UART/ USART implementation in Verilog.
6. Realization of single port SRAM in Verilog.
7. Verilog implementation of Arithmetic circuits like serial adder/ subtractor, paralleladder/subtractor, serial/parallel multiplier.
8. Discrete Fourier transform/Fast Fourier Transform algorithm in Verilog

MC	RESEARCH METHODOLOGY	L	T	P	C
		2	0	0	2

Prerequisite: Professional Ethics

Course Outcome:

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

1. Understand research problem formulation
2. Analyze research related information
3. Follow research ethics
4. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Module:1 **6 Hours**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Module:2 **6 Hours**

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. Effective literature studies approaches, analysis. Plagiarism, Research ethics.

Module:3 **6 Hours**

Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

Module:4 **4 Hours**

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Module:5 **4 Hours**

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Module:6 **4 Hours**

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Total hours **30 hours**

Text Book

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"

Reference Books

1. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.

Internal Members/ BOS **External Members/ BOS**

PROGRAM ELECTIVE – I

PEC I	DSP ARCHITECTURE	L	T	P	C
		3	0	0	3

Prerequisite: Digital signal Processing, Embedded System

Course Objectives:

At the end of this course, students will be able to

1. Identify and formalize architectural level characterization of P-DSP hardware
2. Able to design, programming (assembly and C), and testing code using Code Composer
3. applications Understanding of major areas and challenges in DSP based embedded

Course Outcomes:

1. Knowledge P-DSP hardware and architecture
2. Ability to design and programming (assembly and C), and testing code using Code Composer
3. Ability for DSP hardware control, Audio and Video Signal processing

Module:1 Programmable DSP Hardware:	**6 Hours**
Processing Architectures (von Neumann, Harvard), DSP core algorithms (FIR, IIR, Convolution, Correlation, FFT), IEEE standard for Fixed and Floating Point Computations, Special Architectures Modules used in Digital Signal Processors (like MAC unit, Barrel shifters), On-Chip peripherals, DSP benchmarking.	
Module:2 Structural and Architectural Considerations	**10 Hours**
Parallelism in DSP processing, Texas Instruments TMS320 Digital Signal Processor Families, Fixed Point TI DSP Processors: TMS320C1X and TMS320C2X Family,TMS320C25 – Internal Architecture, Arithmetic and Logic Unit, Auxiliary Registers, Addressing Modes (Immediate, Direct and Indirect, Bit-reverse Addressing), Basics of TMS320C54x and C55x Families in respect of Architecture improvements and new applications fields, TMS320C5416 DSP Architecture, Memory Map, Interrupt System, Peripheral Devices, Illustrative Examples for assembly coding.	
Module:3 VLIW Architecture:	**10 Hours**
Current DSP Architectures, GPUs as an alternative to DSP Processors, TMS320C6X Family, Addressing Modes, Replacement of MAC unit by ILP, Detailed study of ISA, Assembly Language Programming, Code Composer Studio, Mixed Cand Assembly Language programming, On-chip peripherals, Simple applications developments as an embedded environment.	
Module:4 Multi-core DSPs	**10 Hours**
Introduction to Multi-core computing and applicability for DSP hardware, Concept of threads, introduction to P-thread, mutex and similar concepts, heterogeneous and homogenous multi-core systems, Shared Memory parallel programming –OpenMP approach of parallel programming, PRAGMA directives, OpenMP Constructs for work sharing like for loop, sections, TI TMS320C6678 (Eight Core subsystem).	
Module:5 FPGA based DSP Systems:	**6 Hours**
Limitations of P-DSPs, Requirements of Signal processing for Cognitive Radio (SDR), FPGA based signal processing design-case study of a complete design of DSP processor	
Module:6 High Performance Computing using P-DSP	**3 Hours**
Preliminaries of HPC, MPI, OpenMP, multicore DSP as HPC infrastructure.	
Total hours	**45 hours**

Text Book

1. M. Sasikumar, D. Shikhare, Ravi Prakash, "Introduction to Parallel Processing", 1st Edition, PHI, 2006.
2. Fayez Gebali, "Algorithms and Parallel Computing",1st Edition John Wiley & Sons, 2011
3. Rohit Chandra, Ramesh Menon, Leo Dagum, David Kohr, DrorMaydan, Jeff McDonald,"Parallel Programming in OpenMP", 1st Edition, Morgan Kaufman,2000

Reference Books

1. Ann Melnichuk,Long Talk, "Multicore Embedded systems", 1st Edition, CRC Press,2010.
2. Wayne Wolf, "High Performance Embedded Computing: Architectures, Applications and Methodologies", 1st Edition, Morgan Kaufman, 2006.
3. E.S.Gopi, "Algorithmic Collections for Digital Signal Processing Applications Using MATLAB", 1st Edition, Springer Netherlands,2007.

Internal Members/ BOS **External Members/ BOS**

PEC-II	COMPUTER VISION	L	T	P	C
		3	0	0	3

Prerequisite: Digital Image Processing

Course Objectives:

1. Introduce various techniques used in computer vision
2. To apply computer vision in various real time applications

Course Outcome:

Upon completion of this course, the student will be able to

1. Study the image formation models and feature extraction for computer vision
2. Identify the segmentation and motion detection and estimation techniques
3. Develop small applications and detect the objects in various applications

Module:1 Image Formation Models	**10 hours**

Monocular imaging system ,orthographic & Perspective Projection ,camera model andCamera calibration , binocular imaging systems, Perspective, Binocular Stereopsis: Camera andepipolar Geometry; homography, rectification, DLT, RANSAC, 3-D reconstructionframework; Auto-calibration. Apparel, Binocular Stereopsis: Camera and epipolarGeometry; homography, rectification, DLT, RANSAC, 3-D reconstruction framework;Auto-calibration. Apparel, Stereo vision

Module:2 Feature Extraction	**10 hours**

Image representations (continuous and discrete) ,edge detection, Edge linking, cornerdetection, texture, binary shape analysis, boundary pattern analysis, circle and ellipsedetection, Light at Surfaces; Phong Model; Reflectance Map; Albedo estimation;Photometric Stereo; Use of Surface Smoothness Constraint; Shape from Texture, color,motion and edges.

Module:3 Shape Representation and Segmentation	**8 hours**

Deformable curves and surfaces, snakes and active contours,level set representations,Fourier and wavelet descriptors, Medial representations,Multi-resolution analysis, RegionGrowing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, TextureSegmentation

Module:4 Motion Detection and Estimation	**8 hours**

Regularization theory , Optical computation,Stereo Vision ,Motion estimation,Background Subtraction and Modelling, Optical Flow, KLT, Spatio-Temporal Analysis,Dynamic Stereo; Motion parameter estimation , Structure from motion, Motion Tracking inVideo

Module:5 Object recognition	**4 hours**

Hough transforms and other simple object recognition methods, shape correspondence andshape matching,principal component analysis ,shape priors for recognition

Module:6 Applications of Computer Vision	**5 hours**

Automated Visual Inspection, Inspection of Cereal Grains, Surveillance, In-Vehicle VisionSystems, CBIR, CBVR, Activity Recognition, computational photography, Biometrics,stitching and document processing

Total hours	**45 hours**

Text Book

1. D. Forsyth and J. Ponce,"Computer Vision - A modern approach", 2nd Edition, PearsonPrentice Hall, 2012
2. Szeliski, Richard, "Computer Vision: Algorithms and Applications", 1st Edition,
3.Richard Hartley and Andrew Zisserman, "Multiple View Geometry in ComputerVision", 2nd Edition, Cambridge University Press, 2004..

Reference Books

1. K. Fukunaga,"Introduction to Statistical Pattern Recognition",2ndEdition, MorganKaufmann, 1990.

2. Rafael C. Gonzalez and Richard E. Woods," Digital Image Processing", 3rd Edition,Prentice Hall, 2008.
3. B. K. P. Horn, "Robot Vision", 1st Edition, McGraw-Hill, 1986.
4. E. R. Davies, "Computer and Machine Vision: Theory, Algorithms, Practicalities", 4th Edition, Elsevier Inc,2012.

Internal Members/ BOS **External Members/ BOS**

PEC I	OPTICAL NETWORKS	L	T	P	C
		3	0	0	3

Prerequisite: Optical Communication, Electronic devices, Networking

Course Objectives:

1. Introduce the area of optical network and WDM network design.
2. Introduce the techniques to implement optical network

Course Outcome:

Upon completion of this course, the student will be able to

1. Study the image formation models and feature extraction for computer vision
2. Identify the segmentation and motion detection and estimation techniques
3. Develop small applications and detect the objects in various applications

Module:1 SONET/ SDH	**8 Hours**
optical transport network, IP, routing and forwarding, multiprotocol label switching.	
Module:2 WDM network elements	**8 Hours**
optical line terminals and amplifiers, optical add/drop multiplexers, OADM architectures, reconfigurable OADM, optical cross connects.	
Module:3 Control and management:	**8 Hours**
network management functions, optical layer services and interfacing, performance and fault management, configuration management, optical safety.	
Module:4 Network Survivability	**6 Hours**
protection in SONET/SDH & client layer, optical layer protection schemes	
Module:5 WDM network design:	**8 Hours**
LTD and RWA problems, dimensioning wavelength routing networks, statistical dimensioning models	
Module:6 Access networks:	**7 Hours**
Optical time division multiplexing, synchronization, header processing, buffering, burst switching, test beds, Introduction to PON, GPON, AON.	
Total hours	**45 hours**

Text Book

1. Rajiv Ramaswami, Sivarajan, Sasaki, “Optical Networks: A Practical Perspective”, MK, Elsevier, 3 rd edition, 2010.
2. C. Siva Ram Murthy and Mohan Gurusamy, “WDM Optical Networks: Concepts Design, and Algorithms”, PHI, EEE, 2001.

PEC-I	STATISTICAL INFORMATION PROCESSING	L	T	P	C
		3	0	0	3

Prerequisites: Basics of probability and statistics, random variables, and information theory.

Course Objectives:

To enable the student to understand the statistical models to interpret information to solve problems.

Course Outcome:

Upon completion of this course, the student will be able to:

1. Characterize and apply probabilistic techniques in modern decision systems, such as information systems, receivers, filtering, and statistical operations.
2. Demonstrate mathematical modelling and problem solving using such models.
3. Comparatively evolve key results developed in this course for applications to signal processing, communications systems.
4. Develop frameworks based in probabilistic and stochastic themes for modelling and analysis of various systems involving functionalities in decision making, statistical inference, estimation, and detection.

Module:1 Review of random variables and Random process	**10 hours**

Review of random variables: Probability Concepts, distribution and density functions, moments, independent, uncorrelated, and orthogonal random variables; Vector-space representation of Random variables, Vector quantization, Chebyshev inequality theorem, Central Limit theorem, Discrete &Continuous Random Variables.Expectations, Moments, Ergodicity, Discrete-Time Random Processes Stationary process, autocorrelation and auto covariance functions, Spectral representation of random signals, Properties of power spectral density, Gaussian Process and White noise process.

Module:2 Random signal modeling	**7 hours**

MA(q), AR(p), ARMA (p, q) models, Hidden Markov Model & its applications, Linear System with random input, Forward and Backward Predictions, Levinson Durbin Algorithm

Module:3 Statistical Decision Theory	**10 hours**

Bayes' Criterion, Binary Hypothesis Testing, M-ary Hypothesis Testing, Minimax Criterion, Neyman-Pearson Criterion, Composite Hypothesis Testing. Parameter Estimation Theory: Maximum Likelihood Estimation, Generalized Likelihood Ratio Test, Some Criteria for Good Estimators, Bayes' Estimation Minimum Mean-Square Error Estimate, Minimum, Mean Absolute Value of Error Estimate Maximum A Posteriori Estimate, Multiple Parameter Estimation Best Linear Unbiased Estimator, Least-Square Estimation Recursive Least-Square Estimator.

Module:4 Spectral analysis	**6 hours**

Estimated autocorrelation function, Periodogram, Averaging the periodogram (Bartlett Method), Welch modification, Parametric method, AR(p) spectral estimation and detection of Harmonic signals.

Module:5 Information Theory and Source Coding	**6 hours**

Introduction, Uncertainty, Information and Entropy, Source coding theorem, Huffman, Shannon Fano, Arithmetic, Adaptive coding, RLE, LZW Data compaction, LZ-77, LZ-78. Discrete Memory less channels, Mutual information, channel capacity, Channel coding theorem, Differential entropy, and mutual information for continuous ensembles.

Module:6 Application of Information Theory	**6 hours**

Group, Ring & Field, Vector, GF addition, multiplication rules. Introduction to BCH codes, Primitive elements, Minimal polynomials, Generator polynomials in terms of Minimal polynomials, Some examples of BCH codes & Decoder, Reed- Solomon codes & Decoder, Implementation of Reed Solomon encoders and decoders.

Total hours	**45 hours**

Text Book

3. Papoulis and S.U. Pillai, "Probability, Random Variables and Stochastic Processes",4th Edition, McGraw-Hill, 2002.
4. R G. Gallager, "Information theory and reliable communication", Wiley, 1st edition, 1968.

Reference Books

3. D.G. Manolakis, V.K. Ingle and S.M. Kogon, "Statistical and Adaptive Signal Processing", McGraw Hill, 2000.
4. Mourad Barkat, "Signal Detection and Estimation", Artech House, 2nd Edition, 2005.
5. F. J. MacWilliams and N. J. A. Sloane, "The Theory of Error-Correcting Codes", New York, North-Holland, 1977.
6. Rosen K.H, "Elementary Number Theory", Addison-Wesley, 6th edition, 2010.

PEC-I	PROGRAMMING LANGUAGES FOR EMBEDDED SOFTWARE	L	T	P	C
		3	0	0	3

Prerequisites: Basic programming knowledge.

Course Objectives:

To develop the programming skill for embedded applications.

Course Outcome:

At the end of this course, students will be able to

1. Write an embedded C application of moderate complexity.
2. Develop and analyze algorithms in C++.
3. Differentiate interpreted languages from compiled languages.

Module:1 Embedded 'C' Programming	**10 hours**
- Bitwise operations, Dynamic memory allocation, OS services - Linked stack and queue, Sparse matrices, Binary tree - Interrupt handling in C, Code optimization issues - Writing LCD drives, LED drivers, Drivers for serial port communication - Embedded Software Development Cycle and Methods (Waterfall, Agile)	
Module:2 Object Oriented Programming	**7 hours**
- Introduction to procedural, modular, object-oriented and generic programming techniques, Limitations of procedural programming, objects, classes, data members, methods, data encapsulation, data abstraction and information hiding, inheritance, polymorphism	
Module:3 CPP Programming:	**10 hours**
'cin', 'cout', formatting and I/O manipulators, new and delete operators, Defining a class, data members and methods, 'this' pointer, constructors, destructors, friend function, dynamic memory allocation	
Module:4 Overloading and Inheritance	**8 hours**
Need of operator overloading, overloading the assignment, overloading using friends, type conversions, single inheritance, base and derived classes, friend classes, types of inheritance, hybrid inheritance, multiple inheritance, virtual base class, polymorphism, virtual functions	
Module:5 Templates:	**5 hours**
Function template and class template, member function templates and template arguments,Exception Handling: syntax for exception handling code: try-catch throw, Multiple Exceptions	
Module:6 Scripting Languages	**5 hours**
Overview of Scripting Languages – PERL, CGI, VB Script, Java Script. PERL: Operators, Statements Pattern Matching etc. Data Structures, Modules, Objects, Tied Variables, Inter process Communication Threads, Compilation & Line Interfacing.	
Total hours	**45 hours**

Text Book

1. Michael J. Pont , "Embedded C", Pearson Education, 2nd Edition, 2008
2. Randal L. Schwartz, "Learning Perl", O'Reilly Publications, 6th Edition 2011

Reference Books

1. A. Michael Berman, "Data structures via C++", Oxford University Press, 2002
2. Robert Sedgewick, "Algorithms in C++", Addison Wesley Publishing Company, 1999
3. Abraham Silberschatz, Peter B, Greg Gagne, "Operating System Concepts", John Willey & Sons, 2005

PEC I	**VLSI SIGNAL PROCESSING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Prerequisite: VLSI , DSP

Course Objectives:

To make familiar with the various techniques for doing VLSI signal analysis.

Course Outcomes:

Students will be able to:

At the end of this course students will be able to

- Acquired knowledge about DSP algorithms, its DFG representation, pipelining and parallel processing approaches.
- Ability to acquire knowledge about retiming techniques, folding and register minimization path problems.
- Ability to have knowledge about algorithmic strength reduction techniques and parallel processing of FIR and IIR digital filters.
- Acquired knowledge about finite word-length effects and round off noise computation in DSP systems

Module:1 Introduction **8 Hours**

DSP systems, Pipelined and parallel processing.

Module:2 **10 Hours**

Iteration Bound, Retiming, unfolding, algorithmic strength reduction in filters and Transforms.

Module:3 **8 Hours**

Systolic architecture design, fast convolution, pipelined and parallel recursive and adaptive filters, Scaling and round off noise.

Module:4 **8 Hours**

Digital lattice filter structures, bit level arithmetic, architecture, redundant Arithmetic.

Module:5 **6 Hours**

Numerical strength reduction, synchronous, wave and asynchronous pipe lines, low power design.

Module:6 **5 Hours**

Useful phrases, how to ensure paper is as good as it could possibly be the first-time submission

Total hours **45 hours**

Text Book

1. KeshabK.Parthi[A1],VLSI Digital signal processing systems, design and implementation [A2], Wiley, Inter Science, 1999.
2. Mohammad Isamail and Terri Fiez, Analog VLSI signal and information processing, McGraw Hill, 1994
3. S.Y.Kung, H.J.White House, T.Kailath, VLSIand Modern Signal Processing, Prentice Hall, 1985..

OPEN ELECTIVE-I

OE I	VLSI DESIGN VERIFICATION AND TESTING	L	T	P	C
		3	0	0	3

Prerequisite: VLSI

Course Objectives:

To understand the guidelines and methods for VLSI system verification and testing

Course Outcome

Students will be able to:

At the end of this course students will be able to

- Familiarity of Frontend design and verification techniques and create reusable test environments.
- Verify increasingly complex designs more efficiently and effectively.
- Use EDA tools like Cadence, Mentor Graphics.

Module:1 Introduction	**6 Hours**

Verification guidelines: Verification Process, Basic Test bench functionality, directed testing, Methodology basics, Constrained-Random stimulus, Functional coverage, Test bench components, Layered test bench, Building layered test bench, Simulation environment phases, Maximum code reuse, Test bench performance

Module:2 Data types	**10 Hours**

Built-in data types, Fixed-size arrays, Dynamic arrays, Queues, Associative arrays, Linked lists, Array methods, Choosing a storage type, Creating new types with typedef , Creating user-defined structures, Type conversion, Enumerated types, Constants strings, Expression width.

Module:3 Procedural statements and routines	**10 Hours**

Procedural statements, tasks, functions and void functions, Routine arguments, Returning from a routine, Local data storage, Time values Connecting the testbench and design: Separating the testbench and design, Interface constructs, Stimulus timing, Interface driving and sampling, Connecting it all together, Top-level scope Program – Module interactions.

Module:4 SystemVerilog Assertions:	**6 Hours**

Basic OOP: Introduction, think of nouns, Not verbs, your first class, where to define a class, OOP terminology, Creating new objects, Object de-allocation, Using objects, Static variables vs. Global variables, Class methods, Defining methods outside of the class, Scoping rules, Using one class inside another, Understanding dynamic objects, Copying objects, Public vs. Local, Straying off course building a testbench.

Module:5 Randomization:	**8 Hours**

Introduction, What to randomize, Randomization in SystemVerilog, Constraint details solution probabilities, Controlling multiple constraint blocks, Valid constraints, In-line constraints, The pre_randomize and post_randomize functions,

Module Random number functions	**5 Hours**

Constraints tips and techniques, Common randomization problems, Iterative and array constraints, Atomic stimulus generation vs. Scenario generation, Random control, Random number generators, Random device configuration

Total hours	**45 hours**

Text Book

1. Chris Spears, " System Verilog for Verification", Springer, 2nd Edition•
2. M. Bushnell and V. D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers
3. IEEE 1800-2009 standard (IEEE Standard for SystemVerilog— Unified Hardware• Design,Specification, and Verification Language).
4. System Verilog website – www.systemverilog.org ttp://www. sunburstdesign.com/

papers/Cummings_SNUG2006 Boston_ System Verilog• Events.pdf

OE I	LOW POWER VLSI DESIGN	L	T	P	C
		3	0	0	3

Prerequisite: VLSI

Course Objectives

To introduce the VLSI design with Low power consumption

Course Outcome:

At the end of the course, students will be able to:
CO1: Identify the sources of power dissipation in digital IC systems & understand the impact of power on system performance and reliability.
CO2: Characterize and model power consumption & understand the basic analysis methods.
CO3: Understand leakage sources and reduction techniques.

Module:1 Technology & Circuit Design Levels — **6 Hours**

Sources of power dissipation in digital ICs, degree of freedom, recurring themes in low-power, emerging low power approaches, dynamic dissipation in CMOS, effects of Vdd & Vt on speed, constraints on Vt reduction, transistor sizing & optimal gate oxide thickness, impact of technology scaling, technology innovations.

Module:2 :Low Power Circuit Techniques: — **10 Hours**

Power consumption in circuits, flip-flops & latches, high capacitance nodes, energy recovery, reversible pipelines, high performance approaches.

Module:3 Low Power Clock Distribution: — **8 Hours**

Power dissipation in clock distribution, single driver versus distributed buffers, buffers & device sizing under process variations, zero skew Vs. tolerable skew, chip & package co-design of clock network

Module:4 :Logic Synthesis for Low Power estimation techniques: — **8 Hours**

Power minimization techniques, low power arithmetic components- circuit design styles, adders, multipliers.

Module:5 Low Power Memory Design: — **8 Hours**

Sources & reduction of power dissipation in memory subsystem, sources of power dissipation in DRAM & SRAM, low power DRAM circuits, low power SRAM circuits.

Module :Low Power Microprocessor Design System: — **5 Hours**

power management support, architectural trade offs for power, choosing the supply voltage, low-power clocking, implementation problem for low power, comparison of microprocessors for power & performance

Total hours — **45 hours**

Text Book

1. P. Rashinkar, Paterson and L. Singh, "Low Power Design Methodologies", Kluwer Academic, 2002
2. Kaushik Roy, Sharat Prasad, "Low power CMOS VLSI circuit design", John Wiley sons• Inc.,2000.
3. J.B.Kulo and J.H Lou, "Low voltage CMOS VLSI Circuits", Wiley, 1999.•
4. A.P.Chandrasekaran and R.W.Broadersen, "Low power digital CMOS design",• Kluwer,1995
5. Gary Yeap, "Practical low power digital VLSI design", Kluwer, 1998.•

OE-I	SATELLITE COMMUNICATION	L	T	P	C

		3	0	0	3

Prerequisite: Digital Communication, Mobile Communication

Course Objectives:

1. To study and understand the architecture of satellite systems as a means of high speed, high rangecommunication system.
2. Implement and state various aspects related to satellite systems such as orbital equations, sub-systems ina satellite, link budget, modulation and multiple access schemes.
3. To study and solve numerical problems related to orbital motion and design of link budget for the givenparameters and conditions.

Course Outcome:

Upon completion of this course, the student will be able to

1. Visualize the architecture of satellite systems as a means of high speed, high range communication system.
2. State various aspects related to satellite systems such as orbital equations, sub-systems in

a satellite, link budget, modulation and multiple access schemes.

3. Solve numerical problems related to orbital motion
4. Design of link budget for the givenparameters and conditions.

Module:1	**8 hours**
Architecture of Satellite Communication System: Principles and architecture ofsatellite Communication, Brief history of Satellite systems, advantages, disadvantages,applications, and frequency bands used for satellite communication and theiradvantages/drawbacks	
Module:2	**8 hours**
Orbital Analysis: Orbital equations, Kepler's laws of planetary motion, Apogee andPerigee for an elliptical orbit, evaluation of velocity, orbital period, angular velocity etc of asatellite, concepts of Solar day and Sidereal day.	
Module:3	**8 hours**
Satellite sub-systems: Architecture and Roles of various sub-systems of a satellite system such as Telemetry, tracking, command and monitoring (TTC & M), Attitude and orbit control system(AOCS), Communication sub-system, power sub-systems, antenna subsystem.	
Module:4	**7 hours**
Typical Phenomena in Satellite Communication: Solar Eclipse on satellite, itseffects, remedies for Eclipse, Sun Transit Outage phenomena, its effects and remedies,Doppler frequency shiftphenomena and expression for Doppler shift.	
Module:5	**10 hours**
Satellite link budget: Flux density and received signal power equations, Calculationof System noise temperature for satellite receiver, noise power calculation, Drafting ofsatellite link budget and C/N ratio calculations in clear air and rainy conditions, Case studyof Personal Communication system (satellite telephony) using LEO.	
Module:6	**4 hours**
Modulation and Multiple Access Schemes used in satellite communication. Typicalcase studies of VSAT, DBS-TV satellites and few recent communication satellites launchedby NASA/ISRO. GPS.	
Total hours	**45 hours**

Text Book

1. Timothy Pratt and Others, "Satellite Communications", Wiley India, 2nd edition,2010.
2. S. K. Raman, "Fundamentals of Satellite Communication", PearsonEducation

India,2011.
Reference Books
1. Tri T. Ha, "Digital Satellite Communications", Tata McGraw Hill, 2009. 2. Dennis Roddy, "Satellite Communication", McGraw Hill, 4th Edition, 2008.

OE-I	**IOT and Applications**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Prerequisite: Computer networking					
Course Objectives:					
To make understand the concept of IoT and also to implement it in various design.					
Course Outcome:					
At the end of this course, students will be able to 1. Understand the concept of IOT and M2M 2. Study IOT architecture and applications in various fields 3. Study the security and privacy issues in IOT.					
Module:1 IoT& Web Technology					**10 hours**
The Internet of Things Today, Time for Convergence, Towards theIoT Universe, Internet of Things Vision, IoT Strategic Research and Innovation Directions,IoT Applications, Future Internet Technologies, Infrastructure, Networks andCommunication, Processes, Data Management, Security, Privacy & Trust, Device LevelEnergy Issues, IoT Related standardization, Recommendations on Research Topics					
Module:2M2M to IoT					**10 hours**
A Basic Perspective– Introduction, Some Definitions, M2M Value Chains,IoT Value Chains, An emerging industrial structure for IoT, The international driven globalvalue chain and global information monopolies. M2M to IoT-An Architectural Overview–Building an architecture, Main design principles and needed capabilities, An IoT architectureoutline, standards considerations.					
Module:3 IoT Architecture					**8 hours**
State of the Art – Introduction, State of the art, Architecture Reference Model-Introduction, Reference Model and architecture, IoT reference Model, IoT Reference Architecture- Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views.					
Module:4 IoT Applications for Value Creations					**8 hours**
Introduction, IoT applications for industry: FutureFactory Concepts, Brownfield IoT, Smart Objects, Smart Applications, Four Aspects in yourBusiness to Master IoT, Value Creation from Big Data and Serialization, IoT for RetailingIndustry, IoT For Oil and Gas Industry, Opinions on IoT Application and Value for Industry,Home Management, eHealth.					
Module:5 Internet of Things Privacy					**5 hours**
Security and Governance Introduction, Overview of Governance,Privacy and Security Issues.					
Module:6 Contribution from FP7 Projects					**4 hours**
Security, Privacy and Trust in IoT-Data-Platforms for SmartCities, First Steps Towards a Secure Platform, Smartie Approach. Data Aggregation for theIoT in Smart Cities, Security					
Total hours					**45 hours**
Reference Books					
1. Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on-Approach)", 1st Edition, VPT, 2014.					

2. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to connectingEverything", 1stEdition, Apress Publications, 2013.
3. CunoPfister, "Getting Started with the Internet of Things", O_ReillyMedia, 2011.

OE –I	**Digital Design and Verification**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Prerequisite: Digital System Design

Course Objectives:

To design various digital systems and also to analyse them

Course Outcome:

At the end of this course, students will be able to

1. Familiarity of Front-end design and verification techniques and create reusable test environments.
2. Verify increasingly complex designs more efficiently and effectively.
3. Use EDA tools like Cadence, Mentor Graphics.

Module:1 Revision of basic Digital systems	**8 hours**

Combinational Circuits, Sequential Circuits, Logicfamilies. Synchronous FSM and asynchronous design, Metastability, Clock distribution andissues, basic building blocks like PWM module, pre-fetch unit, programmable counter,FIFO, Booth's multiplier, ALU, Barrel shifter etc.

Module:2 Verilog	**10 hours**

Verilog/VHDL Comparisons and Guidelines, Verilog: HDL fundamentals, simulation, and testbench design, Examples of Verilog codes for combinational and sequential logic, Verilog AMS

Module:3 System Verilog and Verification	**8 hours**

Verification guidelines, Data types, procedural statementsand routines, connecting the test bench and design, Assertions, Basic OOP concepts,Randomization, Introduction to basic scripting language: Perl, Tcl/Tk

Module:4 Current challenges in physical design	**8 hours**

Roots of challenges, Delays: Wire load modelsGeneric PD flow, Challenges in PD flow at different steps, SI Challenge - Noise & Crosstalk,IR Drop, Process effects: Process Antenna Effect &Electromigration

Module:5 Programmable Logic Devices	**6 hours**

Introduction, Evolution: PROM, PLA, PAL, Architecture ofPAL's, Applications, Programming PLD's, FPGA with technology: Antifuse, SRAM,EPROM, MUX, FPGA structures, and ASIC Design Flows, ProgrammableInterconnections, Coarse grained reconfigurable devices

Module:6 IP and Prototyping	**5 hours**

IP in various forms: RTL Source code, Encrypted Source code, Soft IP,Netlist, Physical IP, and Use of external hard IP during prototyping, Case studies, and Speedissues. Testing of logic circuits: Fault models, BIST, JTAG interface

Total hours	**45 hours**

Text Book

1. Douglas Smith, "HDL Chip Design: A Practical Guide for Designing, Synthesizing &Simulating ASICs & FPGAs Using VHDL or Verilog", Doone publications, 1998.
2. Samir Palnitkar, "Verilog HDL: A guide to Digital Design and Synthesis", Prentice

Hall,2nd Edition, 2003.

Reference Books

1. Doug Amos, Austin Lesea, Rene Richter, "FPGA based Prototyping MethodologyManual", Synopsys Press, 2011.
2. Christophe Bobda, "Introduction to Reconfigurable Computing, Architectures, Algorithmsand Applications", Springer, 2007.
3. Janick Bergeron, "Writing Testbenches: Functional Verification of HDL Models", SecondEdition, Springer, 2003.

OE –I	**MEMORY TECHNOLOGIES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Prerequisite: Digital System

Course Objectives:

To make familiar with various types memories.

Course Outcome:

At the end of the course, students will be able to:
1. Select architecture and design semiconductor memory circuits and subsystems.
2. Identify various fault models, modes and mechanisms in semiconductor memories and their testing procedures.
3. Knowhow of the state-of-the-art memory chip design•.

Module: Random Access Memory Technologies:	**8 hours**
Static Random Access Memories (SRAMs), SRAM Cell Structures, MOS SRAM Architecture, MOS SRAM Cell and Peripheral Circuit, Bipolar SRAM, Advanced SRAM Architectures, Application Specific SRAMs.	
Module:2 DRAMs	**8 hours**
DRAMs, MOS DRAM Cell, BiCMOS DRAM, Error Failures in DRAM, Advanced DRAM Design and Architecture, Application Specific DRAMs.SRAM and DRAM Memory controllers.	
Module:3 Non-Volatile Memories:	**8 hours**
Masked ROMs, PROMs, Bipolar & CMOS PROM, EEPROMs, Floating Gate EPROM Cell, OTP EPROM, EEPROMs, Non-volatile SRAM, Flash Memories.	
Module:4	**8 hours**
Semiconductor Memory Reliability and Radiation Effects: General Reliability Issues, RAM Failure Modes and Mechanism, Nonvolatile Memory, Radiation Effects, SEP, Radiation Hardening Techniques. Process and Design Issues, Radiation Hardened Memory Characteristics, Radiation Hardness Assurance and Testing.	
Module:5 Advanced Memory Technologies and High-density Memory Packing Technologies:	**8 hours**
Ferroelectric Random Access Memories (FRAMs), Gallium Arsenide (GaAs) FRAMs, Analog Memories, Magneto Resistive Random Access Memories (MRAMs), Experimental Memory Devices	
Module:6	**5 hours**
Memory Hybrids (2D & 3D), Memory Stacks, Memory Testing and Reliability Issues, Memory Cards, High Density Memory Packaging	
Total hours	**45 hours**

Text Book

1. Ashok K Sharma, "Advanced Semiconductor Memories: Architectures, Designs and Applications", Wiley Interscience
2. Kiyoo Itoh, "VLSI memory chip design", Springer International Edition
3. Ashok K Sharma," Semiconductor Memories: Technology, Testing and Reliability , PHI

AUDIT COURSE - I

AU	ENGLISH FOR RESEARCH PAPER WRITING	L	T	P	C
		2	0	0	0

Prerequisite: English Communication & Draft skill

Course Objectives:

Students will be able to:
1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title
4. Ensure the good quality of paper at very first-time submission

Module:1	**5 Hours**
Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	
Module:2	**5 Hours**
Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction.	
Module:3	**5 Hours**
Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	
Module:4	**5 Hours**
Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature	
Module:5	**5 Hours**
skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions	
Module:6	**5 Hours**
Useful phrases, how to ensure paper is as good as it could possibly be the first-time submission	
Total hours	**30 hours**

Text Book

1.	Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2.	Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press.

Reference Books

1.	Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
2.	Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

AU	DISASTER MANAGEMENT	L	T	P	C
		2	0	0	0

Prerequisite: Environmental Science

Course Objectives:

Students will be able to:
1. Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

3. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations. 4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in.	
Module:1 Introduction	**5 Hours**
Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.	
Module:2 Repercussions Of Disasters And Hazards	**5 Hours**
Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.	
Module:3 Disaster Prone Areas In India	**5 Hours**
Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics.	
Module:4 Disaster Preparedness And Management	**5 Hours**
Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.	
Module:5 Risk Assessment	**5 Hours**
Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.	
Module:6 Disaster Mitigation	**5 Hours**
Useful phrases, how to ensure paper is as good as it could possibly be the first-time submission	
Total hours	**30 hours**
Text Book	
1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.	
Reference Books	
1. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi. 2. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.	

AU	**VALUE EDUCATION**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**0**
Prerequisite: Universal Human Value					
Course Objectives:					
Students will be able to: 1. Understand value of education and self- development 2. Imbibe good values in students 3. Let the should know about the importance of character					
Course Outcome:					

At the end of the course, the student should be able to 1. Knowledge of self-development 2. Learn the importance of Human values 3. Developing the overall personality	
Module:1	**6 Hours**
Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles. Value judgements.	
Module:2	**8 Hours**
Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature ,Discipline	
Module:3	**8 Hours**
Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour. Universal brotherhood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature	
Module:4	**8 Hours**
Character and Competence –Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence ,Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.	
Total hours	**30 hours**
Text Book	
1.	Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University

SEMESTER - II

DETAIL SYLLABUS

PC	PATTERN RECOGNITION AND MACHINE LEARNING	L	T	P	C
		3	0	0	3

Prerequisites: Basic probability, linear algebra, calculus, and some programming experience.

Course Objectives:

1. To introduce students to the basic concepts and techniques of statistical pattern recognition and Machine Learning.
2. To develop skills of using recent machine learning software for solving practical problems.
3. To gain experience of doing independent study and research.

Course Outcome:

Upon completion of this course, the student will be able to:

5. Study the parametric and linear models for classification
6. Design neural network and SVM for classification
7. Develop machine independent and unsupervised learning techniques.

Module:1 Introduction to Pattern Recognition	**8 hours**
Problems, applications, design cycle, learning and adaptation, examples, Probability Distributions, Parametric Learning - Maximum likelihood and Bayesian Decision Theory- Bayes rule, discriminant functions, loss functions and Bayesian error analysis	
Module:2 Linear models	**8 hours**
Linear Models for Regression, linear regression, logistic regression Linear Models for Classification	
Module:3 Neural Network	**8 hours**
Perceptron, multi-layer perceptron, backpropagation algorithm, error surfaces, practical techniques for improving backpropagation, additional networks and training methods, Adaboost, Deep Learning	
Module:4 Linear discriminant functions	**8 hours**
Decision surfaces, two-category, multi-category, minimum-squared error procedures, the Ho-Kashyap procedures, linear programming algorithms, Support vector machine	
Module:5 Algorithm independent machine learning	**8 hours**
Lack of inherent superiority of any classifier, bias and variance, re-sampling for classifier design, combining classifiers	
Module:6 Unsupervised learning and clustering	**5 hours**
k-means clustering, fuzzy k-means clustering, hierarchical clustering	
Total hours	**45 hours**

Text Book

5. Richard O. Duda, Peter E. Hart, David G. Stork, “Pattern Classification,” 2nd Edition John Wiley & Sons, 2001.
6. C. Bishop, “Pattern Recognition and Machine Learning,” Springer, 2006.

Reference Books

7. Trevor Hastie, Robert Tibshirani, Jerome H. Friedman, “The Elements of StatisticalLearning,” 2nd Edition, Springer, 2009.

PC	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

Prerequisite: Signals and Systems, Digital signal Processing ,VLSI

Course Objectives:

1. At the end of this course, students will be able to Analyze, design, optimize and simulate analog and digital circuits using CMOS constrained by the design metrics.
2. Connect the individual gates to form the building blocks of a system.
3. Use EDA tools like Cadence, Mentor Graphics and other open source software tools like• Ngspice.

Module:1 Review	**10 hours**
Basic MOS structure and its static behavior, Quality metrics of a digital design: Cost, Functionality, Robustness, Power, and Delay, Stick diagram and Layout, Wire delay models. Inverter: Static CMOS inverter, Switching threshold and noise margin concepts and their evaluation, Dynamic behavior, Power consumption.	
Module:2 Physical design flow	**10 hours**
Floor planning, Placement, Routing, CTS, Power analysis and IR drop estimation-static and dynamic, ESD protection-human body model, Machine model. Combinational logic: Static CMOS design, Logic effort, Ratioed logic, Pass transistor logic, Dynamic logic, Speed and power dissipation in dynamic logic, Cascading dynamic gates, CMOS transmission gate logic	
Module:3 :Sequential logic:	**8 hours**
Static latches and registers, Bi-stability principle, MUX based latches, Static SR flip-flops, Master-slave edge-triggered register, Dynamic latches and registers, Concept of pipelining, Pulse registers, Non-bistable sequential circuit. Advanced technologies: Giga-scale dilemma, Short channel effects, High–k, Metal Gate Technology, FinFET, TFET etc.	
Module:4 :Single Stage Amplifier:	**8 hours**
CS stage with resistance load, Divide connected load, Current source load, Triode load, CS stage with source degeneration, Source follower, Common gate stage, Cascade stage, Choice of device models. Differential Amplifiers: Basic difference pair, Common mode response, Differential pair with MOS loads, Gilbert cell.	
Module:5 Passive and active current mirrors	**5 hours**
Basic current mirrors, Cascade mirrors, Active current mirrors. Frequency response of CS stage: Source follower, Common gate stage, Cascade stage and difference pair, Noise	
Module:6 :Operational amplifiers:	**4 hours**
One stage OPAMP, Two stage OPAMP, Gain boosting, Common mode feedback, Slew rate, PSRR, Compensation of 2 stage OPAMP, Other compensation techniques	
Total hours	**45 hours**

Text Book

1 J P Rabaey, A P Chandrakasan, B Nikolic, “Digital Integrated circuits: A design perspective”, Prentice Hall electronics and VLSI series, 2nd Edition.

8. Baker, Li, Boyce, “CMOS Circuit Design, Layout, and Simulation”, Wiley, 2nd Edition.• BehzadRazavi , “Design of Analog CMOS Integrated Circuits”, TMH, 2007.
9. Phillip E. Allen and Douglas R. Holberg, “CMOS Analog Circuit Design”, Oxford, 3rd• Edition.
10. R J Baker, “CMOS circuit Design, Layout and Simulation”, IEEE Inc., 2008.•

PC	ANALOG AND DIGITAL CMOS VLSI DESIGN	L	T	P	C
		3	0	0	3

Prerequisite: Signals and Systems, Digital signal Processing

Course Objectives:

4. To study theory of different filters and algorithms
5. To study theory of multirate DSP, solve numerical problems and write algorithms
6. To understand theory of prediction and solution of normal equations
7. To study applications of DSP at block level.

Course Outcome:

Upon completion of this course, the student will be able to

1. To study and implement theory of different filters and algorithms
2. To implement and analyse multirate DSP, solve numerical problems and write algorithms
3. To apply prediction and solution of normal equations
4. To study and design applications of DSP at block level.

Module:1	**8 hours**

Overview of DSP, Characterization in time and frequency, FFT Algorithms, Digitalfilter design and structures: Basic FIR/IIR filter design &structures, design techniques oflinear phase FIR filters, IIR filters by impulse invariance, bilinear transformation, FIR/IIRCascaded lattice structures, parallel realization of IIR.

Module:2	**8 hours**

Multi rate DSP, Decimators and Interpolators, Sampling rate conversion, multistagedecimator & interpolator, poly phase filters, QMF, digital filter banks, Applications insubband coding.

Module:3	**8 hours**

Linear prediction & optimum linear filters, stationary random process, forwardbackwardlinear prediction filters, solution of normal equations, AR Lattice and ARMALattice-Ladder Filters,Wiener Filters for Filtering and Prediction.

Module:4	**6 hours**

Adaptive Filters, Applications, Gradient Adaptive Lattice, Minimum mean squarecriterion, LMS algorithm, Recursive Least Square algorithm

Module:5	**8 hours**

Estimation of Spectra from Finite-Duration Observations of Signals. NonparametricMethods for Power Spectrum Estimation, Parametric Methods for Power SpectrumEstimation, MinimumVariance Spectral Estimation, Eigen analysis Algorithms forSpectrum Estimation.

Module:6	**7 hours**

Application of DSP & Multi rate DSP, Application to Radar, introduction to wavelets,application to image processing, design of phase shifters, DSP in speech processing & other applications

Total hours	**45 hours**

Text Book

1. J.G.Proakis and D.G.Manolakis,"Digital signal processing: Principles, Algorithm andApplications", 4th Edition, Prentice Hall, 2007.

2. S.Haykin, "Adaptive Filter Theory", 4th Edition, Prentice Hall, 2001.,

3.D.G.Manolakis, V.K. Ingle and S.M.Kogon, "Statistical and Adaptive Signal Processing",McGraw Hill, 2000

Reference Books

1. N. J. Fliege, "Multirate Digital Signal Processing: Multirate Systems -Filter Banks –Wavelets", 1st

Edition, John Wiley and Sons Ltd, 1999.
2. Bruce W. Suter, "Multirate and Wavelet Signal Processing",1st Edition, Academic Press, 1997.
3. M. H. Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley & Sons Inc., 2002

PROGRAM ELECTIVE - II

PE-II	BIOMEDICAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

Prerequisite: Signals and Systems

Course Objectives:

1. To be able to understand different types of biomedical signal.
2. To study, identify and analyse different biomedical signals.
3. To find applications related to biomedical signal processing

Course Outcome:

Upon completion of this course, the student will be able to

1. Analyse different types of biomedical signal.
2. Recognise different biomedical signals for practical applications
3. Implement and specify applications related to biomedical signal processing

Module:1	**5 hours**
Acquisition, Generation of Bio-signals, Origin of bio-signals, Types of bio-signals, Study ofdiagnostically significant bio-signal parameters	
Module:2	**10 hours**
Electrodes for bio-physiological sensing and conditioning, Electrode-electrolyte interface,polarization, electrode skin interface and motion artefact, biomaterial used for electrode,Types of electrodes (body surface, internal, array of electrodes, microelectrodes), Practicalaspects of using electrodes, Acquisition of bio-signals (signal conditioning) and Signalconversion (ADC's DAC's) Processing, Digital filtering	
Module:3	**8 hours**
Biomedical signal processing by Fourier analysis, Biomedical signal processing by wavelet(time frequency) analysis, Analysis (Computation of signal parameters that arediagnosticallysignificant)	
Module:4	**8 hours**
Classification of signals and noise, Spectral analysis of deterministic, stationary randomsignals and non-stationary signals, Coherent treatment of various biomedical signalprocessing methods and applications.	
Module:5	**7 hours**
Principal component analysis, Correlation and regression, Analysis of chaotic signalsApplication areas of Bio–Signals analysis Multiresolution analysis(MRA) and wavelets,Principal component analysis(PCA), Independent component analysis(ICA)	
Module:6	**7 hours**
Pattern classification–supervised and unsupervised classification, Neural networks, Supportvector Machines, Hidden Markov models. Examples of biomedical signal classification examples.	
Total hours	**45 hours**

Text Book

1. W. J. Tompkins, "Biomedical Digital Signal Processing", Prentice Hall, 1993.

2. Eugene N Bruce, "Biomedical Signal Processing and Signal Modeling", John Wiley &Son's _publication, 2001.

Reference Books

1. Myer Kutz, "Biomedical Engineering and Design Handbook, Volume I", McGraw Hill,2009.
2. D C Reddy, "Biomedical Signal Processing", McGraw Hill, 2005.
3. Katarzyn J. Blinowska, JaroslawZygierewicz, "Practical Biomedical Signal AnalysisUsingMATLAB", 1st Edition, CRC Press, 2011.

PEC-II	ARTIFICIAL INTELLIGENCE	L	T	P	C
		3	0	0	3

Prerequisites: Strong knowledge of Mathematics, knowledge of Programming, basic knowledge of statistics and modelling.

Course Objectives:

1. To impart knowledge about Artificial Intelligence.
2. To enable the students to understand the basic principles of Artificial Intelligence in variousapplications.

Course Outcome:

Upon completion of this course, the student will be able to:

8. Understand the concept of Artificial Intelligence, search techniques and knowledgerepresentation issues.
9. Understanding reasoning and fuzzy logic for artificial intelligence.
10. Understanding game playing and natural language processing.

Module:1 What is AI (Artificial Intelligence)?	**8 hours**

The AI Problems, The Underlying Assumption,what are AI Techniques, The Level of The Model, Criteria for Success, Some General References, One Final Word-Problems, State Space Search & Heuristic Search Techniques: Defining the Problems As A State Space Search, Production Systems, Production Characteristics, Production System Characteristics, And Issues In The Design Of Search Programs, Additional Problems. Generate-And-Test, Hill Climbing, Best-First Search, Problem Reduction, Constraint Satisfaction, Means-Ends Analysis.

Module:2 Knowledge Representation Issues	**8 hours**

Representations and Mappings, Approaches to Knowledge Representation. Using Predicate Logic: Representation Simple Facts in Logic, Representing Instance and Isa Relationships, Computable Functions and Predicates, Resolution. Representing Knowledge Using Rules: Procedural Versus Declarative Knowledge, Logic Programming, Forward Versus Backward Reasoning.

Module:3 Symbolic Reasoning Under Uncertainty	**8 hours**

Introduction to No monotonic Reasoning, Logics for Non-monotonic Reasoning. Statistical Reasoning: Probability and Bays' Theorem, Certainty Factors and Rule-Base Systems, Bayesian Networks, Dempster Shafer Theory

Module:4 Fuzzy Logic	**6 hours**

Concept of Fuzzy Logic. Weak Slot-and-Filler Structures: Semantic Nets, Frames. Strong Slot-and-FillerStructures: Conceptual Dependency, Scripts, CYC

Module:5 Game Playing	**7 hours**

Overview, And Example Domain: Overview, Minimax, Alpha-Beta Cut-off, Refinements, Iterative deepening, The Blocks World, Components of A Planning System, Goal Stack Planning, Nonlinear Planning Using Constraint Posting, Hierarchical Planning, Reactive Systems, Other Planning Techniques. Understanding: What is understanding? What makes it hard? As constraint satisfaction

Module:6 Natural Language Processing	**8 hours**

Introduction, Syntactic Processing, Semantic Analysis, Semantic Analysis, Discourse and PragmaticProcessing, Spell Checking Connectionist Models: Introduction: Hopfield Network, Learning in Neural Network, Application of Neural Networks, Recurrent Networks, Distributed Representations, Connectionist AI And Symbolic AI.

Total hours	**45 hours**

Text Book

7. Artificial Intelligence by Elaine Rich, Kevin Knight and Shivashankar B Nair, Tata McGraw Hill.
8. Introduction to Artificial Intelligence and Expert Systems by Dan W. Patterson, Pearson Education.

Reference Books
11. Stuart Russel and Peter Norvig, "Artificial Intelligence: A Modern Approach," 3rd Edition, Prentice Hall, 2009.
12.

PEC-II	MODELLING AND SIMULATION TECHNIQUE	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Prerequisite: Basic programming techniques

Course Objectives:

To have the basic knowledge of various statistical methods used for dynamic system simulation

Course Outcome:

1. At the end of this course, students will be able to Identify and model discrete systems (deterministic and random)
2. Identify and model discrete signals (deterministic and random)
3. Understand modelling and simulation techniques to characterize systems/processes.

Module:1	**10 hours**
Introduction Circuits as dynamic systems, Transfer functions, poles and zeroes, State space, Deterministic Systems, Difference and Differential Equations, Solution of Linear Difference and Differential Equations, Numerical Simulation Methods for ODEs, System Identification, Stability and Sensitivity Analysis.	
Module:2	**8 hours**
Statistical methods, Description of data, Data-fitting methods, Regression analysis, Least Squares Method, Analysis of Variance, Goodness of fit.	
Module:3	**7 hours**
Probability and Random Processes, Discrete and Continuous Distribution, Central Limit theorem, Measure of Randomness, Monte-Carlo Methods.	
Module:4	**7 hours**
Stochastic Processes and Markov Chains, Time Series Models	
Module:5	**8 hours**
Modeling and simulation concepts, Discrete-event simulation, Event scheduling/Time advance algorithms, Verification and validation of simulation models.	
Module:6	**5 hours**
Continuous simulation: Modeling with differential equations, Example models, Bond Graph Modeling, Population Dynamics Modeling, System dynamics.	
Total hours	**45 hours**

Text Book

1. R. L. Woods and K. L. Lawrence, "Modeling and Simulation of Dynamic Systems", Prentice-Hall, 1997.
2. Z. Navalih, "VHDL Analysis and Modelling of Digital Systems", McGraw-Hill, 1993.
3. J. Banks, JS. Carson and B. Nelson, "Discrete-Event System Simulation", 2nd Edition, Prentice-Hall of India, 1996.

PEC-II	**Remote Sensing**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Prerequisite: Communication system

Course Objectives:

1. To understand basic concepts, principles and applications of remote sensing
2. To state applications of principles to a variety of topics in remote sensing

Course Outcome:

At the end of this course, students shall be able to

1. Understand basic concepts, principles and applications of remote sensing, particularly thegeometric and radiometric principles;
2. Provide examples of applications of principles to a variety of topics in remote sensing,particularly related to data collection, radiation, resolution, and sampling.

Module:1 Physics of Remote Sensing	**8 hours**
Electro Magnetic Spectrum, Physics of Remote Sensing-Effects of Atmosphere-Scattering–Different types–Absorption-Atmospheric window-Energy interaction with surface features –Spectral reflectance of vegetation, soil and wateratmospheric influence on spectral response patterns-multi concept in Remote sensing.	
Module:2 Data Acquisition	**8 hours**
Types of Platforms–different types of aircrafts-Manned andUnmanned spacecrafts–sun synchronous and geo synchronous satellites –Types andcharacteristics of different platforms –LANDSAT, SPOT, IRS, INSAT, IKONOS,QUICKBIRD etc	
Module:3 Photographic products and scanners	**8 hours**
B/W, color, color IR film and their characteristics –resolvingpower of lens and film -Opto mechanical electro optical sensors –across track and alongtrack, scanners-multispectral scanners and thermal scanners–geometric characteristics of scannerimagery -calibration of thermal scanners.	
Module:4 Scattering System	**8 hours**
Microwave scatterometry, types of RADAR –SLAR –resolution– range and azimuth –real aperture and synthetic aperture RADAR. Characteristics ofMicrowave images topographic effect-different types of Remote Sensing platforms –airborne and space borne sensors -ERS, JERS, RADARSAT, RISAT -Scatterometer,Altimeter-LiDAR remote sensing, principles, applications	
Module:5 Thermal and Hyper Spectral Remote Sensing	**8 hours**
Sensors characteristics-principle ofspectroscopy-imaging spectroscopy–field conditions, compound spectral curve, Spectrallibrary, radiative models, processing procedures, derivative spectrometry, thermal remotesensing – thermal sensors, principles, thermal data processing, applications.	
Module:6 Data Analysis	**5 hours**
Resolution–Spatial, Spectral, Radiometric and temporal resolutionsignalto noise ratio-data products and their characteristics-visual and digital interpretation–Basic principles of data processing –Radiometric correction–Image enhancement–Imageclassification–Principles of LiDAR, Aerial Laser Terrain Mapping	
Total hours	**45 hours**

Text Book

1. Lillesand T.M., and Kiefer,R.W. Remote Sensing and Image interpretation, John Wiley &Sons-2000, 6thEdition
2. John R. Jensen, Introductory Digital Image Processing: A Remote Sensing Perspective,2nd Edition, 1995

Reference Books

1. John A.Richards, Springer –Verlag, Remote Sensing Digital Image Analysis,1999.
2. Paul Curran P.J. Principles of Remote Sensing, ELBS; 1995.
3. Charles Elachi and Jakob J. van Zyl , Introduction To The Physics and Techniques ofRemote Sensing , Wiley Series in Remote Sensing and Image Processing, 2006.
4. Sabins, F.F.Jr, Remote Sensing Principles and Image interpretation, W.H.Freeman&

Co,1978.

PSE-II	PHYSICAL DESIGN AUTOMATION	L	T	P	C
		3	0	0	3

Prerequisite: VLSI

Course Objectives:

To understand and develop algorithms for physical design of VLSI systems

Course Outcome:

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

1 Study automation process for VLSI System design.
2 Understanding of fundamentals for various physical design CAD tools.
3 Develop and enhance the existing algorithms and computational techniques for physical design process of VLSI systems..

Module:1	**8 hours**
Introduction to VLSI Physical Design Automation.	
Module:2	**8 hours**
Standard cell, Performance issues in circuit layout, delay models Layout styles.	
Module:3	**8 hours**
Discrete methods in global placement	
Module:4	**7 hours**
Timing-driven placement. Global Routing Via Minimization.	
Module:5	**8 hours**
Over the Cell Routing - Single layer and two-layer routing, Clock and Power Routing	
Module:6	6 hours
Compaction, algorithms, Physical Design Automation of FPGAs..	
Total hours	**45 hours**

Text Book

1. William Stallings, "Cryptography and Network Security, Principles and Practices", Pearson Education, 3rd Edition.
2. Charlie Kaufman, Radia Perlman and Mike Speciner, "Network Security, Private• Communication in a Public World", Prentice Hall, 2nd Edition
3. Christopher M. King, ErtemOsmanoglu, Curtis Dalton, "Security Architecture, Design• Deployment and Operations", RSA Pres

Reference Books

1. Stephen Northcutt, LenyZeltser, Scott Winters, Karen Kent, and Ronald W. Ritchey, "Inside Network Perimeter Security", Pearson Education, 2nd Edition
2. Richard Bejtlich, "The Practice of Network Security Monitoring: Understanding Incident• Detection and Response", William Pollock Publisher, 2013

PSE-II	NANO MATERIALS AND NANOTECHNOLOGY	L	T	P	C
		3	0	0	3

Prerequisite: Semiconductor Physics, Chemistry

Course Objectives:

1. To understand the basic science behind the design and fabrication of nano scalesystems.
2. To understand and formulate new engineering solutions for current problems andcompeting technologies for future applications.

3. To be able make inter disciplinary projects applicable to wide areas by clearing andfixing the boundaries in system development.
4. To gather detailed knowledge of the operation of fabrication and characterisationdevices to achieve precisely designed systems.

Course Outcome:

Upon completion of this course, the student will be able to

4. Implement the basic science behind the design and fabrication of nano scale systems.
5. Analyse and formulate new engineering solutions for current problems andcompeting technologies for future applications.
6. Design inter-disciplinary projects applicable to wide areas by clearing andfixing the boundaries in system development.
7. Analyse the operation of fabrication and characterisationdevices to achieve precisely designed systems.

Module:1	**10 hours**
Nanomaterials in one and higher dimensions,	
Module:2	**9 hours**
Applications of one and higher dimension nano-materials.	
Module:3	**8 hours**
Nano-lithography, micro electro-mechanical system (MEMS) and nano-phonics. ellite sub-systems: Architecture and Roles of various sub-systems of a satellite system such as Telemetry, tracking, command and monitoring (TTC & M), Attitude and orbit control system (AOCS), Communication sub-system, power sub-systems, antenna subsystem.	
Module:4	**8 hours**
Carbon nanotubes – synthesis and applications	
Module:5& 6	**10 hours**
Interdisciplinary arena of nanotechnology.	
Total hours	**45 hours**

Text Book

4. Kenneth J. Klabunde and Ryan M. Richards,"Nanoscale Materials in Chemistry,2nd Ed, John Wiley and Sons, 2009.
5. A I Gusev and A ARempel,"Nanocrystalline Materials", Cambridge International SciencePublishing, 1st Indian edition by Viva Books Pvt. Ltd. 2008.

Reference Books

3. B. Bhushan, "Springer Handbook of Nanotechnology", Springer, 3rd Ed, 2010.
4. K. K. Kar,"Carbon Nanotubes: Synthesis, Characterization and Applications" Research Publishing Services; 1st Ed, 2011, ISBN-13: 978-9810863975.

OPEN ELECTIVE II

PC	AUDIO VIDEO CODING & COMPRESSION	L	T	P	C
		3	0	0	3

Prerequisite: Analog and Digital Circuits

Course Objectives:

6. To make the student familiar with multimedia systems
7. To design and analyze video coding and motion estimation
8. To understand multimedia synchronization

Course Outcome:

Upon completion of this course, the student will be able to

11. Familiarity to lossy and lossless compression systems.
12. Study of Video coding techniques and standards.
13. Understand audio coding and multimedia synchronization techniques

Module:1	**8 hours**

Introduction to Multimedia Systems and Processing, Lossless Image Compression Systems Image Compression Systems, Huffman Coding, Arithmetic and Lempel-Ziv Coding, Other Coding Techniques

Module:2	**8 hours**

Lossy Image Compression Systems, Theory of Quantization, Delta Modulation and DPCM, Transform Coding & K-L Transforms, Discrete Cosine Transforms, Multi-Resolution Analysis, Theory of Wavelets, Discrete Wavelet Transforms, Still Image Compression Standards: JBIG and JPEG

Module:3	**8 hours**

Video Coding and Motion Estimation: Basic Building Blocks & Temporal Redundancy, Block based motion estimation algorithms, Other fast search motion estimation algorithms

Module:4	**8 hours**

Video Coding Standards MPEG-1 standards, MPEG-2 Standard, MPEG-4 Standard, H.261, H.263 Standards, H.264 standard

Module:5	**8 hours**

Audio Coding, Basic of Audio Coding, Audio Coding, Transform and Filter banks, Polyphase filter implementation, Audio Coding, Format and encoding, Psychoacoustic Models

Module:6	**5 hours**

Multimedia Synchronization, Basic definitions and requirements, References Model and Specification, Time stamping and pack architecture, Packet architectures and audio-video interleaving, Multimedia Synchronization, Playback continuity, Video Indexing and Retrieval: Basics of content-based image

Total hours	**45 hours**

Text Book

1. Iain E.G. Richardson, “H.264 and MPEG-4 Video Compression”, Wiley, 2003.
2. Khalid Sayood, “Introduction to Data Compression”, 4th Edition, MorganKaufmann,2012.
3. Mohammed Ghanbari, “Standard Codecs: Image Compression to Advanced VideoCoding”, 3rd Edition, The Institution of Engineering and Technology, 2011.

Reference Books

1. Julius O. Smith III, “Spectral Audio Signal Processing”, W3K Publishing, 2011.
2. Nicolas Moreau, “Tools for Signal Compression: Applications to Speech and AudioCoding”, Wiley, 2011.

PC	VOICE AND DATA NETWORKS	L	T	P	C
		3	0	0	3

Prerequisite: Network design architecture

Course Objectives:

9. To make the student familiar with network design issues and layered and layer less communication
10. To design and analyze Data networks and queuing models
11. To understand inter networking and congestion

Course Outcome:

Upon completion of this course, the student will be able to

14. Protocol, algorithms, trade-offs rationale.
15. Routing, transport, DNS resolutions
16. Network extensions and next generation architectures

Module:1	**8 hours**

Network Design Issues, Network Performance Issues, Network Terminology, centralized and distributed approaches for networks design, Issues in design of voice and data networks.

Module:2	**10 hours**

Layered and Layer less Communication, Cross layer design of Networks, Voice Networks (wired and wireless) and Switching, Circuit Switching and Packet Switching, Statistical Multiplexing

Module:3	**8 hours**

Data Networks and their Design, Link layer design- Link adaptation, Link Layer Protocols, Retransmission. Mechanisms (ARQ), Hybrid ARQ (HARQ), Go Back N, Selective Repeat protocols and their analysis.

Module:4	**8 hours**

Queuing Models of Networks, Traffic Models, Little's Theorem, Markov chains, M/M/1 and other Markov systems, Multiple Access Protocols, Aloha System, Carrier Sensing, Examples of Local area networks

Module:5	**7 hours**

Inter-networking, Bridging, Global Internet, IP protocol and addressing, Sub netting, Classless Inter domain Routing (CIDR), IP address lookup, Routing in Internet. End to End Protocols, TCP and UDP. Congestion Control, Additive Increase/Multiplicative Decrease, Slow Start, Fast Retransmit / Fast Recovery

Module:6	**4 hours**

Congestion avoidance, RED TCP Throughput Analysis, Quality of Service in Packet Networks. Network Calculus, Packet Scheduling Algorithms.

Total hours	**45 hours**

Text Book

1. D. Bertsekas and R. Gallager, “Data Networks”, 2nd Edition, Prentice Hall, 1992.
2. L. Peterson and B. S. Davie, “Computer Networks: A Systems Approach”, 5th Edition, Morgan Kaufman, 2011.
3. Kumar, D. Manjunath and J. Kuri, “Communication Networking: An analytical approach”, 1st Edition, Morgan Kaufman, 2004.

Reference Books

1. Walrand,“Communications Network: A First Course”, 2nd Edition, McGraw Hill, 2002.
2. Leonard Kleinrock, “Queueing Systems,Volume I: Theory”, 1st Edition, John Wiley and Sons, 1975.
3. Aaron Kershenbaum, “Telecommunication Network Design Algorithms”, McGraw Hill, 1993.

PC	COGNITIVE RADIO	L	T	P	C
		3	0	0	3

Prerequisite: Wireless communication

Course Objectives:

12. To make the student familiar with cognitive radios and spectrum sensing
13. To design and analyze the optimization techniques
14. To estimate the research challenges in cognitive radios

Course Outcome:

Upon completion of this course, the student will be able to

17. Understand the fundamental concepts of cognitive radio networks.
18. Develop the cognitive radio, as well as techniques for spectrum holes detection that
19. Cognitive radio takes advantages in order to exploit it.
20. Understand technologies to allow an efficient use of TVWS for radio
21. Communications based on two spectrum sharing business models/policies.
22. Understand fundamental issues regarding dynamic spectrum access, the radioresource
23. Management and trading, as well as a number of optimization techniquesfor better spectrum exploitation

Module:1 Introduction to Cognitive Radios	**8 hours**
Digital dividend, cognitive radio (CR)architecture, functions of cognitive radio, dynamic spectrum access (DSA),components of cognitive radio, spectrum sensing, spectrum analysis and decision,potential applications of cognitive radio.	
Module:2 Spectrum Sensing	**10 hours**
Spectrum sensing, detection of spectrum holes (TVWS),collaborative sensing, geo-location database and spectrum sharing business models(spectrum of commons, real time secondary spectrum market).	
Module:3 Optimization Techniques of Dynamic Spectrum Allocation	**8 hours**
Linear programming,convex programming, non-linear programming, integer programming, dynamicprogramming, stochastic programming.	
Module:4 Dynamic Spectrum Access and Management	**10 hours**
Spectrum broker, cognitive radioarchitectures, centralized dynamic spectrum access, distributed dynamic spectrumaccess, learning algorithms and protocols.	
Module:5 Spectrum Trading	**5 hours**
Introduction to spectrum trading, classification to spectrumtrading, radio resource pricing, brief discussion on economics theories in DSA(utility, auction theory), classification of auctions (single auctions, double auctions,concurrent, sequential).	
Module:6 Research Challenges in Cognitive Radio	**4 hours**
Network layer and transport layer issues,crosslayer design for cognitive radio networks	
Total hours	**45 hours**

Text Book

1. Ekram Hossain, Dusit Niyato, Zhu Han, "Dynamic Spectrum Access and Management in Cognitive Radio Networks", Cambridge University Press, 2009.
2. Kwang-Cheng Chen, Ramjee Prasad, "Cognitive radio networks", John Wiley & Sons Ltd., 2009.
3. Bruce Fette, "Cognitive radio technology", Elsevier, 2nd edition, 2009.
3.Huseyin Arslan, "Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems", Springer, 2007.

Reference Books

1. Francisco Rodrigo Porto Cavalcanti, Soren Andersson, "Optimizing WirelessCommunication Systems" Springer, 2009.
2. Linda Doyle, "Essentials of Cognitive Radio", Cambridge University Press,2009.McGraw Hill, 1987

PC	RF AND MICROWAVE CIRCUIT DESIGN	L	T	P	C
		3	0	0	3

Prerequisite: Wireless Communications, EMF Theory

Course Objectives:

1. To make the student familiar with transmission line and microwave components
2. To design and analyze microwave networks
3. To understand microwave semiconductor devices and amplifiers design

Course Outcome:

Upon completion of this course, the student will be able to

1. Understand the behavior of RF passive components and model active components.
2. Perform transmission line analysis.
3. Demonstrate use of Smith Chart for high frequency circuit design.
4. Justify the choice/selection of components from the design aspects.
5. Contribute in the areas of RF circuit design.

Module:1 Transmission Line Theory	**8 hours**
Lumped element circuit model for transmission line,field analysis, Smith chart, quarter wave transformer, generator and load mismatch,impedance matching and tuning.	
Module:2 Microwave Network Analysis	**7 hours**
Impedance and equivalent voltage and current,Impedance and admittance matrix, The scattering matrix, transmission matrix, Signalflow graph.	
Module:3 Microwave Components	**6 hours**
Microwave resonators, Microwave filters, power dividersand directional couplers,Ferromagnetic devices and components.	
Module:4 Nonlinearity and Time Variance	**10 hours**
Inter-symbol interference, random process & noise,definition of sensitivity and dynamic range, conversion gain and distortion.	
Module:5 Microwave Semiconductor Devices and Modelling	**8 hours**
PIN diode, Tunnel diodes,Varactor diode, Schottky diode, IMPATT and TRAPATT devices, transferredelectron devices, Microwave BJTs, GaAs FETs, low noise and power GaAs FETs,MESFET, MOSFET, HEMT.	
Module:6 Amplifiers Design	**6 hours**
Power gain equations, stability, impedance matching, constantgain and noise figure circles, small signal, low noise, high power and broadbandamplifier, oscillators, Mixers design.	
Total hours	**45 hours**

Text Book

1. Matthew M. Radmanesh, “Advanced RF & Microwave Circuit Design: The UltimateGuide to Superior Design”, AuthorHouse, 2009.
2. D.M.Pozar, “ Microwave engineering” ,Wiley, 4th edition, 2011.
3. R.Ludwig and P.Bretchko, “R. F. Circuit Design”, Pearson Education Inc, 2009.

Reference Books

1. G.D. Vendelin, A.M. Pavoi, U. L. Rohde, “Microwave Circuit Design Using LinearAnd Non Linear Techniques”, John Wiley 1990.
2. S.Y. Liao, “Microwave circuit Analysis and Amplifier Design”, Prentice Hall 1987.
3. Radmanesh, “RF and Microwave Electronics Illustrated”, Pearson Education, 2004.

OE-II	SYSTEM DESIGN WITH EMBEDDED LINUX	L	T	P	C
		3	0	0	3

Prerequisite: Embedded system

Course Objectives:

To make familiarise Embedded Linux and to make designs with Linux

Course Outcome:

At the end of this course, students will be able to

1. Familiarity of the embedded Linux development model.
2. Write, debug, and profile applications and drivers in embedded Linux.
3. Understand and create Linux BSP for a hardware platform

Module:1	**8 hours**
:Embedded Linux Vs Desktop Linux, Embedded Linux Distributions	
Module:2 Embedded Linux	**8 hours**
Architecture, Kernel Architecture – HAL, Memory manager, Scheduler, File System, I/O and Networking subsystem, IPC, User space, Start-up sequence	
Module:3 Board Support Package	**8 hours**
Embedded Storage: MTD, Architecture, Drivers, Embedded File System Embedded Drivers: Serial, Ethernet, I2 C, USB, Timer, Kernel Modules	
Module:4 Porting Applications	**8 hours**
Real-Time Linux: Linux and Real time, Programming, Hard Real-time Linux.	
Module:5 Building and Debugging: Kernel, Root file system	**8 hours**
Embedded Graphics.	
Module:6	**5 hours**
:Case study of uClinux	
Total hours	**45 hours**

Text Book

1. Karim Yaghmour, "Building Embededd Linux Systems", O'Reilly & Associates
2. P Raghvan, Amol Lad, SriramNeelakandan, "Embedded Linux System Design and Development", Auerbach Publications
3. Christopher Hallinan, "Embedded Linux Primer: A Practical Real World Approach", Prentice Hall, 2nd Edition, 2010.
4. Derek Molloy, "Exploring BeagleBone: Tools and Techniques for Building with• Embedded Linux", Wiley, 1st Edition, 2014

OE-II	CAD OF DIGITAL SYSTEM	L	T	P	C
		3	0	0	3

Prerequisite: VLSI, Data structure, VHDL

Course Objectives:

To introduce various VLSI Methodologies and design automation tools

Course Outcome:

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

1. Fundamentals of CAD tools for modelling, design, test and verification of VLSI systems.
2. Study of various phases of CAD, including simulation, physical design, test and• verification.
3. Demonstrate knowledge of computational algorithms and tools for CAD

Module:1 VLSI Methodologies	**10 Hours**
:Introduction to VLSI Methodologies – Design and Fabrication of VLSI Devices, Fabrication Process and its impact on Design.	
Module:2 VLSI design automation tools	**10 Hours**
Data structures and basicalgorithms, graph theory and computational complexity, tractable and intractable problems	
Module:3	**10 Hours**
General purpose methods for combinational optimization – partitioning, floor planning andpin assignment, placement , routing	
Module:4	10 Hours
:Simulation – logic synthesis, verification, high level Synthesis	
Module -5	5 Hours
MCMS-VHDL-Verilog-implementation of simple circuits using VHDL	
Total hours	**45 hours**
Text Book	
1. N.A. Sherwani, “Algorithms for VLSI Physical Design Automation”.	
2. S.H. Gerez, “Algorithms for VLSI Design Automation•	

AUDIT COURSE – II

AU	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L	T	P	C
		2	0	0	0

Prerequisite: Universal Human Value

Course Objectives:

Students will be able to:
1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

Course Outcome:

At the end of the course, the student should be able to
1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

Module:1	**10 Hours**
Neetisatakam-Holistic development of personality Verses- 19,20,21,22 (wisdom) Verses- 29,31,32 (pride & heroism) Verses- 26,28,63,65 (virtue) Verses- 52,53,59 (dont's) Verses- 71,73,75,78 (do's)	
Module:2	**10 Hours**
Approach to day to day work and duties. Shrimad BhagwadGeeta: Chapter 2-Verses 41, 47,48, Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35, Chapter 18-Verses 45, 46, 48.	
Module:3	**10 Hours**
Statements of basic knowledge. Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 Personality of Role model. Shrimad BhagwadGeeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42, Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63	
Total hours	**30 hours**

Text Book

1.	"Srimad Bhagavad Gita" by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata

Reference Book

1.	Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

AU	CONSTITUTION OF INDIA	L	T	P	C
		2	0	0	0

Prerequisite: History

Course Objectives:

Students will be able to:
1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role

and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism. 3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.
Course Outcome:
At the end of the course, the student should be able to 1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics. 2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India. 3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution. 4. Discuss the passage of the Hindu Code Bill of 1956.

Module:1 History of Making of the Indian Constitution	**3 Hours**
History Drafting Committee, (Composition & Working)	
Module:2 Philosophy of the Indian Constitution	**3 Hours**
Preamble Salient Features.	
Module:3 Contours of Constitutional Rights & Duties	**6 Hours**
Fundamental Rights Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.	
Module:4 Organs of Governance	**6 Hours**
Parliament Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.	
Module:5 Local Administration	**8 Hours**
District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: ZilaPachayat. Elected officials and their roles, CEO ZilaPachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.	
Module:6 Election Commission	**4 Hours**
Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.	
Total hours	**30 hours**
Text Book	
1. The Constitution of India, 1950 (Bare Act), Government Publication.	
Reference Books	
1. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015. 2.. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.	

AU	**PEDAGOGY STUDIES**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**0**
Prerequisite: Social Science					
Course Objectives:					
Students will be able to: 1. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.					

2. Identify critical evidence gaps to guide the development.
Course Outcome:
At the end of the course, the student should be able to 1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries? 2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners? 3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?
Module:1 — **6 Hours**
Aims and rationale, Policy background, Conceptual framework and terminology Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions. Overview of methodology and Searching.
Module:2 — **6 Hours**
Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.
Module:3 — **6 Hours**
Evidence on the effectiveness of pedagogical practices Methodology for the in depth stage: quality assessment of included studies. Model Curriculum of Engineering & Technology PG Courses [Volume -II] [39] How can teacher education (curriculum and practicum) and the school, curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.
Module:4 — **6 Hours**
Professional development: alignment with classroom practices and followup support Peer support. Support from the head teacher and the community. Curriculum and assessment Barriers to learning: limited resources and large class sizes.
Module:5 — **6 Hours**
Research design Contexts, Pedagogy, Teacher education, Curriculum and assessment, Dissemination and research impact.
Total hours — **30 hours**
Text Book
1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
Reference Books
1. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379. 2. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.

AU-II	**STRESS MANAGEMENT BY YOGA**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**0**

Course Objectives:
1. To achieve overall health of body and mind 2. To overcome stress
Module:1 — **10 Hours**
Definitions of Eight parts of yog. (Ashtanga
Module:2 — **10 Hours**

Yam and Niyam. Do`s and Don't's in life. i) Ahinsa, satya, astheya, bramhacharya and aparigraha ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan	
Module:3	**10 Hours**
Asan and Pranayam i) Various yog poses and their benefits for mind & body ii) ii)Regularization of breathing techniques and its effects-Types of pranayam	
Total hours	**30 hours**
Text Book	
1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur 2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata	