DEPARTMENT OF

ELECTRONICS AND COMMUNICATION ENGINEERING

Scheme of Instruction

and

Syllabus of

M.E. (ECE)
Systems and Signal Processing

Full Time & PTPG

2025-26

UNIVERSITY COLLEGE OF ENGINEERING
(Autonomous)
Osmania University
Hyderabad – 500 007, TS,
INDIA

INSTITUTE

Vision

The Vision of the institute is to generate and disseminate knowledge through harmonious blending of science, engineering and technology. To serve the society by developing a modern technology in student's heightened intellectual, cultural, ethical and humane sensitivities, fostering a scientific temper and promoting professional and technological expertise.

Mission

- To achieve excellence in Teaching and Research
- To generate, disseminate and preserve knowledge
- To enable empowerment through knowledge and information
- Advancement of knowledge in Engineering, Science and Technology
- Promote learning in free thinking and innovative environment
- Cultivate skills, attitudes to promote knowledge creation
- Rendering socially relevant technical services to the community
- To impart new skills of technology development
- To inculcate entrepreneurial talents and technology appreciation programmes
- Technology transfer and incubation

DEPARTMENT

Vision

- To be in the forefront of advances in Electronics and Communication Engineering education and research to guide and motivate young engineers to face future technological challenges.

Mission

- To inculcate analysis and design for innovative problems in the field of Electronicsand Communication Engineering with the help of state of art curricula.
- To impart practical training to face real life case studies and interdisciplinary simplesolutions to complex problems.
- To make engineering education an enjoyable learning experience through challengingtutorials, mini-projects, assignments and laboratory exercises.
- To build project team spirit for professional working environment with high ethicalvalues
- To develop the overall character that will care for society and be concerned for thenation through extra-curricular activities.

Programme Educational Objectives (PEO):

The graduating students of the Systems and Signal Processing program will be able to:

PEO1: To educate students with analytical and design skills in Signal Prcessing applicableto Industries, R&D labs and Institutions involving Space Communications and Defense Electronics.

PEO2: To strengthen the basic knowledge in mathematical science and applied science with orientation in engineering applications.

PEO3: To develop overall personality and character with team spirit, professionalism, integrity, moral and ethical values with the support of humanities, social sciences and physical educational courses.

PEO4: To equip the students with laboratory training leading to solving real life practical Problems and project analysis of Systems and Signal Processing through case studies, seminars, Mini projects, internships and main projects.

Programme Outcomes (PO):

PO1	Ability to apply the knowledge of science, mathematics, and engineering principles for developing problems solving attitude.
PO2	Ability to identify, formulate and solve engineering problems in the signal processing areas such as developing robust and problem-specific algorithms for acquisition, processing, analysis, and synthesis of signals, to be applied in Signal Processing, Machine Vision, and Communication Networks.
PO3	Ability to understand and use different software tools in the domain of signal processing. Analysis and Verification of algorithms, Functional and timing Simulation on platforms like MATLAB, code composer studio, and assembly language.
PO4	Ability to design and conduct experiments, analyze and interpret data, imbibe programming skills for development of simulation experiments.
PO5	Ability to function as a multidisciplinary team member with a sense of ethics, integrity and social responsibility.

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING
M. E. ECE (SYSTEMS AND SIGNAL PROCESSING) Scheme and Syllabus

S.No.	Type of Course	Course Code	Course Name	Contact hours per week		Scheme of Evaluation		Credits
				L	P	CIE	SEE	
			SEMESTER-I					
1.	Core-I	EC201	Advanced Digital Signal Processing	3	-	40	60	3
2.	Core-II	EC202	Digital Image and Video Processing	3	-	40	60	3
3.	Core-III	EC203	Adaptive Signal Processing	3	-	40	60	3
4.	Programme Elective-I	EC211	Pattern Recognition	3	-	40	60	3
		EC212	IoT and Applications					
		EC213	Software Defined Radio					
5.	Programme Elective-II	EC221	Optical Communications and Networks	3	-	40	60	3
		EC222	Coding Theory and Techniques					
		EC223	Biomedical Signal Processing					
6.	Programme Elective-III	EC231	VLSI Signal Processing	3	-	40	60	3
		EC232	Optimization Techniques					
		EC233	Artificial Neural Networks					
7.	Laboratory-I	EC261	Advanced Digital Signal Processing Lab	0	2	50	-	1
8.		EC271	Seminar	0	2	50	-	1
			TOTAL	**18**	**4**	**340**	**360**	**20**
			SEMESTER-II					
1.	Core-IV	EC204	DSP Processors and Architectures	3	-	40	60	3
2.	Core-V	EC205	Detection and Estimation Theory	3	-	40	60	3
3.	Core-VI	EC206	Digital Control	3	-	40	60	3
4.	Programme Elective-IV	EC241	Artificial Intelligence and Machine Learning	3	-	40	60	3
		EC242	Speech Processing					
		EC243	Radar Signal Processing					
5.	Programme Elective-V	EC251	Hardware Acceleration of Machine Learning	3	-	40	60	3
		EC252	Wireless and Mobile Communications					
		EC253	Unmanned Aerial Vehicle Systems					

6.	Open Elective	OE941BM	Medical Assistive Devices	3	-	40	60	3
		OE942BM	Medical Imaging Techniques					
		OE941CE	Green Building Technology					
		OE942CE	Cost Management of Engineering Projects					
		OE941CS	Business Analytics					
		OE941EE	Waste To Energy					
		OE942EE	Power Plant Control and Instrumentation					
		OE941EC	Elements of Embedded Systems					
		OE941ME	Operation Research					
		OE942ME	Composite Materials					
		OE943ME	Industrial Safety					
		OE941LA	Intellectual Property Rights					
7.		E272	Mini Project	-	4	50	-	2
8.	Laboratory-II	E262	Digital Image and Video Processing Lab	-	2	50	-	1
9.	Laboratory-III	E263	DSP Processors and Architectures Lab	-	2	50	-	1
			TOTAL	**18**	**8**	**390**	**360**	**22**
			SEMESTER-III					
1.	Audit Course-I	AC030EC	Research Methodology	2	-	40	60	0
2.	Audit Course-II	AC031	English for Research Paper Writing	2	-	40	60	0
		AC032	Disaster Mitigation and Management					
		AC033	Sanskrit for technical knowledge					
		AC034	Value Education					
		AC035	Stress Management by Yoga					
		AC036	Personality Development through Life Enlightenment Skills					
		AC037	Constitution of India					
		AC038	Pedagogy Studies					
		AC039	E-Waste Management					
3.		EC181	Dissertation-I	-	20	100		10
			TOTAL	**4**	**20**	**180**	**120**	**10**
			SEMESTER - IV					
1.		EC182	Dissertation-II	-	**32**	**100**	**100**	**16**
			GRAND TOTAL	**40**	**64**	**910**	**940**	**68**

Note:

i. Dissertation-II has two parts, CIE - I and CIE – II, at the end of 8th week and 16thweek respectively for evaluation of 50 marks each.

ii. Audit Courses will be offered in ONLINE mode and SEE will be conducted inComputer Based Test Mode.

EC201	**ADVANCED DIGITAL SIGNAL PROCESSING**					
(CORE - I)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**EE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objective of enabling the student to:	
1	To make students familiar with the most important methods in DSP, including digital filter design, transform-domain processing, and the importance of Signal Processors
2	Create efficient realizations for up-sampling and down-sampling of signals using the polyphase decomposition
3	To introduce some practical aspects of signal processing and in particular adaptive systems

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Design, implementation, analysis, and comparison of digital filters for processing of Discrete-time signals
CO-2	Acquire the basics of multi-rate digital signal processing.
CO-3	Comprehend design criteria and modeling adaptive systems and theoretical Performance evaluation
CO-4	Analyze the power spectrum estimation
CO-5	Apply the algorithms for a wide area of recent applications.

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	1	1	1	2
CO-2	3	1	1	1	2
CO-3	3	2	2	2	2
CO-4	3	2	2	2	1
CO-5	3	2	2	2	1

UNIT – I
Overview of DSP, Characterization in time and frequency, FFT Algorithms, Digital filter design, and structures: Basic FIR/IIR filter design &structures, design techniques of linear phase FIR filters, IIR filters by impulse invariance, bilinear transformation, FIR/IIR Cascaded lattice structures, and parallel all pass realization of IIR.

UNIT – II
Multi-rate DSP, Decimators and Interpolators, Sampling rate conversion, multistage decimator &interpolator, polyphase filters, QMF, digital filter banks, and Applications in sub-band coding.

UNIT – III
Linear prediction & optimum linear filters, stationary random process, forward-backward linear prediction filters, solution of normal equations, AR Lattice and ARMA Lattice-Ladder Filters, Wiener Filters for Filtering and Prediction.

UNIT – IV
Estimation of Spectra from Finite-Duration Observations of Signals. Nonparametric Methods for power Spectrum Estimation, Parametric Methods for Power Spectrum Estimation, Minimum-Variance Spectral Estimation, Eigen analysis Algorithms for Spectrum Estimation.

UNIT –V
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

Suggested Reading:

1	J.G.Proakis and D.G.Manolakis, "Digital signal processing: Principles, Algorithm and Applications", 4th Edition, Prentice-Hall, 2007.
2	S.Haykin, "Adaptive Filter Theory", 4th Edition, Prentice-Hall, 2001.

EC 202	**DIGITAL IMAGE AND VIDEO PROCESSING**					
(CORE –II)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	70 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objective of enabling the student to:	
1	This course offers fundamentals of digital image and video processing and algorithms for most of the work currently underway in this field.
2	Beyond the obvious applications in entertainment and scientific visualization, digital images, and video have become a central component of human/computer interfaces and databases.
3	Through this course, students will get a clear impression of the breadth and practical scope of digital image and video processing and develop a conceptual understanding which will enable them to undertake further study, research, and/or implementation work in this area.

Course Outcomes :	
On completion of this course, the student will be able to do :	
CO-1	Define digital image, digital image representation, the importance of image resolution, applications in image processing, and application of various image transforms.
CO-2	Select and apply appropriate enhancement and restoration techniques to real problems in image analysis
CO-3	Understand techniques for image segmentation and techniques for image compression
CO-4	Develop familiarity with video technology from analog color TV systems to digital video systems, and implement filtering operations in basic video processing.
CO-5	Understand general methodologies for 2D motion estimation, and various coding used in video processing

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	-	1	2	1
CO-2	2	-	1	2	-
CO-3	2	1	3	2	1
CO-4	1	1	3	2	1
CO-5	2	2	3	2	1

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Fundamentals of Image Processing and Image Transforms: Basic steps of Image Processing System, Image acquisition and display, Sampling and Quantization of an image, the basic relationship between pixels image **Image Transforms:** 2-D Discrete Fourier Transform, Discrete Cosine Transform (DCT), Haar transform, slant transform, KL transform, singular value decomposition, Radon

transform, Wavelet Transforms: Continuous Wavelet Transform, Discrete Wavelet Transforms comparison of different image transforms.

UNIT – II
Image Processing Techniques **Image Enhancement**: Spatial domain methods: Histogram processing, Fundamentals of Spatial filtering, smoothing spatial filters, Sharpening spatial filters. Frequency domain methods: Basics of filtering in the frequency domain, image smoothing, image sharpening, Selective filtering. Laplacian of Gaussian (LOG) filters. **Image Restoration**: Introduction to Image restoration, Image degradation, Types of image blur, Classification of image restoration techniques, Image restoration model, Linear and Nonlinear image restoration techniques, Blind deconvolution.

UNIT – III
Image Segmentation: Segmentation concepts, Point, Line, Edge Detection, Thresholding, and Region-Based segmentation. Edge detection and linking, Hough Transform, boundary detection, chain coding. **Image Compression:** Image compression fundamentals - Coding Redundancy, Spatial and Temporal redundancy, Compression models: Lossy & Lossless, Huffman coding, Arithmetic coding, LZW coding, Run-length coding, Bit plane coding, Transform coding, Predictive coding, Wavelet coding, JPEG standards.

UNIT – IV
Basic steps of Video Processing: Analog Video, Digital Video. Principles of Colour video processing, composite versus component video, Time-Varying Image Formation models Three-Dimensional Motion Models, Geometric Image Formation, Photometric Image Formation, Sampling of Video signals, and Filtering operations.

UNIT – V
2-D Motion Estimation: Optical flow, General Methodologies, Pixel Based Motion Estimation, Block- Matching Algorithm, Mesh-based Motion Estimation, Global Motion Estimation, Region-based motion Estimation, Multi-resolution motion estimation, Waveform based coding, Block based transform coding, Predictive coding, Application of motion estimation in Video coding, MPEGs and H.26x standards.

Suggested Reading:

1	Gonzalez and Woods, “Digital Image Processing”, 3rd ed., Pearson.
2	Yao Wang, Joem Ostermann and Ya–quin Zhang, “Video processing and communication”, 1 st Ed., PH Int.
3	M. Tekalp, “Digital Video Processing”, Prentice-Hall International.

EC203	**ADAPTIVE SIGNAL PROCESSING**					
(CORE-III)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To understand the basics of the adaptive system.
2	To make familiar with gradient search algorithms and functions
3	To introduce LMS & RLS algorithms

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	To understand the theory of different filters and algorithms
CO-2	To understand the theory of multi-rater DSP, solve numerical problems, and write algorithms
CO-3	To understand the theory of prediction and solution of normal equations
CO-4	To know applications of DSP at the block level.
CO-5	To understand Kalman Filter theory

Course outcome	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	2	1	1	2
CO-2	2	1	1	1	2
CO-3	2	1	2	2	2
CO-4	3	2	2	2	1
CO-5	3	2	2	2	1

UNIT – I
Approaches to the development of adaptive filter theory. Introduction to filtering, smoothing, and prediction. Wiener filter theory, introduction; Error performance surface; Normal equation; Principle of orthogonality; Minimum mean squared error; example.

UNIT – II
Gradient algorithms; Learning curves; LMS gradient algorithm; LMS stochastic gradient algorithms; convergence of LMS algorithms.

UNIT – III
Applications of the adaptive filter to adaptive noise canceling, Echo cancellation in telephone circuits, and adaptive beamforming.

UNIT – IV
Kalman Filter theory; Introduction; recursive minimum mean square estimation for scalar random variables; statement of the Kalman filtering problem: the innovations process; Estimation of state using the innovations process; Filtering examples.

UNIT – V
Vector Kalman filter formulation. Examples. Applications of the Kalman filter to target tracking.

Suggested Reading:

1	Sophocles, J. Orphanidies, "Optimum signal processing an introduction", McMillan,1985
2	Simon Haykins, "Adaptive signal processing", PHI, 1986.
3	Bernard Widrow, "Adaptive signal processing", PHI, 1986.
4	Bozic. SM., "Digital and Kalman Filtering"

EC 211	**PATTERN RECOGNITION**					
	(PROGRAM-SPECIFIC ELECTIVE – I**)**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Understand basic concepts in pattern recognition
2	Gain knowledge about state-of-the-art algorithms used in pattern recognition research.
3	Understand pattern recognition theories, such as Bayes classifier, and linear discriminant analysis.
4	Apply pattern recognition techniques to practical problems.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Explain and compare a variety of pattern classification, structural pattern recognition, and pattern classifier combination techniques.
CO-2	Understand machine learning concepts and the range of problems that can be handled by machine learning. Know the various fracture mechanics aspects and failure aspects of systems in a structure.
CO-3	Design neural network and SVM for classification Understand stress intensity factor and implement to notched members.
CO-4	Describe and model data to solve problems in regression and classification Understand the concepts of LEFM and compute fracture parameters for various sections.
CO-5	Apply pattern recognition techniques to real-world problems such as document analysis and recognition.

Course outcome	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	1	2	2	2	2
CO-2	2	3	3	2	2
CO-3	2	3	3	3	2
CO-4	3	3	3	3	2
CO-5	2	2	3	3	1

UNIT – I
Overview of Pattern classification and regression: Pattern recognition: Definition, Applications and Examples. Overview of Pattern Classifiers Clustering vs. Classification; Supervised Vs Unsupervised. The Bayes' Classifier for minimizing Risk Estimating Bayes' Error; Minimax and Neymann-Pearson classifiers
UNIT – II
Parametric and Nonparametric Estimation of Densities: Implementing Bayes' Classifier; Estimation of Class Conditional Densities Maximum Likelihood estimation of different densities Bayesian estimation of parameters of density

functions, MAP estimates Bayesian Estimation examples; the exponential family of densities and ML estimates Sufficient Statistics; Recursive formulation of ML and Bayesian estimates. Mixture Densities and EM Algorithm Mixture Densities, ML estimation and EM algorithm Convergence of EM algorithm; Convergence of EM algorithm; overview of Nonparametric density estimation Nonparametric estimation, Parzen nearest neighbor methods

UNIT – III

Linear models for classification and regression:
Linear Discriminant Functions; Perceptron --Learning Algorithm and convergence proof Linear Least Squares Regression; LMS algorithm Adaline and LMS algorithm; General non-linear least-squares regression Logistic Regression; Statistics of least squares method; Regularized Least Squares Fisher Linear Discriminant functions for multi-class case; multi-class logistic regression

UNIT – IV

Artificial Neural Networks for Classification and regression
Overview of Artificial Neural Networks Multilayer Feedforward Neural networks with Sigmoidal activation functions; Backpropagation Algorithm; Representational abilities of feedforward networks for Classification and Regression; Back propagation in Practice Radial Basis Function Networks; Gaussian RBF networks Learning Weights in RBF networks; K-means clustering algorithm

UNIT – V

Support Vector Machines and Kernel-based methods
Support Vector Machines: Introduction, obtaining the optimal hyperplane SVM formulation with slack variables; nonlinear SVM classifiers Kernel Functions for nonlinear SVMs; Mercer and positive definite Kernels Support Vector Regression and ε-insensitive Loss function, examples of SVM learning Overview of SMO and other algorithms for SVM; ν-SVM and ν-SVR; SVM as a risk minimizer Positive Definite Kernels; RKHS; Representer Theorem Bagging and Boosting; Classifier Ensembles; AdaBoost

Suggested Reading:

1	R.O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, John Wiley, 2001
2	T. Hastie, et al.,The Elements of Statistical Learning, Spinger, 2009
3	C.M.Bishop, Pattern Recognition and Machine Learning, Springer, 2006

EC 212	**IOT AND APPLICATIONS**					
(PROGRAM ELECTIVE – I)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To understand the concepts of the Internet of Things and be able to build IoT applications
2	To learn the programming and use of Arduino and Raspberry Pi boards Design and detail the deep beams.
3	To know about data handling and analytics in SDN

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Known basic protocols in sensor networks.
CO-2	Program and configure Arduino boards for various designs
CO-3	Python programming and interfacing for Raspberry Pi.
CO-4	Design IoT applications in different domains.
CO-5	Study the basics of Cloud Computing and different applications

Course outcome	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	1	2	2	2	2
CO-2	2	3	3	2	1
CO-3	1	3	3	3	2
CO-4	3	3	3	3	3
CO-5	2	3	3	3	3

UNIT – I
Introduction to the Internet of Things, Characteristics of IoT, Physical design of IoT, Functional blocks of IoT, Sensing, Actuation, Basics of Networking, Communication Protocols, Sensor Networks.

UNIT – II
Machine-to-Machine Communications, Difference between IoT and M2M, Interoperability in IoT, Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino.

UNIT – III
Introduction to Python programming, Introduction to Raspberry Pi, Interfacing Raspberry Pi with basic peripherals, Implementation of IoT with Raspberry Pi .

UNIT – IV
Implementation of IoT with Raspberry Pi, Introduction to Software-defined Network (SDN), SDN for IoT, Data Handling and Analytics

UNIT – V
Cloud Computing, Sensor-Cloud, Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring.

Suggested Reading:

1	"The Internet 'of Things: Enabling Technologies, Platforms, and Use Cases", by PethuruRaj and Anupama C. Raman (CRC Press).
2	“Make sensors”: Terokarvinen, kemo, karvinen and villeyvaltokari, 1st edition, maker media, 2014.
3	"Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti Vijay Madisetti
4	Arshdeep Bahga, “Internet of Things: A Hands-On Approach”
5	Waltenegus Dargie,Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice
6	Beginning Sensor networks with Arduino and Raspberry Pi – Charles Bell, Apress, 2013

EC213	**SOFTWARE DEFINED RADIO**					
(PROGRAM-SPECIFIC ELECTIVE – I)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To provide fundamental concepts in SDR.
2	To explore the reconfigurable features of modern radio communication systems.
3	To explore the digital hardware and software architectures of SDR

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the basic architecture and design principles of SDR.
CO-2	Analyze the parameters of analog RF components as front end blocks in the implementation of SDR.
CO-3	Understand the concepts of analog & digital converters for SDR architectures.
CO-4	Understand the various frequency converters, digital mixers and digital filters of SDR
CO-5	Understand the digital hardware & software components of SDR

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	3	3	2	-
CO-2	3	3	3	2	-
CO-3	3	3	3	2	-
CO-4	3	3	3	2	-
CO-5	2	1	1	1	-

UNIT – I
Introduction to Software Defined Radio: A Traditional Hardware Radio Architecture, Signal Processing Hardware History, Software Defined Radio Project Complexity. **A Basic Software Defined Radio Architecture**: 2G Radio Architectures, Hybrid Radio Architecture, Basic Software Defined Radio Block Diagram, System Level Functioning Partitioning, Digital Frequency Conversion Partitioning.

UNIT – II
RF System Design: Introduction- Noise and Channel Capacity, Link Budget, Receiver Requirements, Multicarrier Power Amplifiers, Signal Processing Capacity Tradeoff.

UNIT – III
Analog-to-Digital and Digital-to-Analog Conversion: Digital Conversion Fundamentals, Sample Rate, Band pass Sampling, Oversampling- Antialias Filtering, Quantization, ADC Techniques-Successive Approximation, Figure of Merit-DACs, DAC Noise Budget, ADC Noise Budget.

UNIT – IV
Digital Frequency Up- and Down Converters: Introduction- Frequency Converter Fundamentals, Digital NCO, Digital Mixers, Digital Filters, Halfband Filters, CIC Filters, Decimation, Interpolation, and Multirate Processing, DUCs, Cascading Digital Converters and Digital Frequency Converters.

UNIT –V
Hardware and Software Components: SDR Requirements for Processing Power- DSPs-DSP Devices- DSP Compilers Reconfigurable Processors-Adaptive Computing Machine-FPGAs, Major Software Architecture Choices, Hardware – Specific Software Architecture, Software Standards for Software Radio, Software Design Patterns, Component Choices, Real Time Operating Systems, High Level Software Languages, Hardware Languages.

Suggested Reading:

1	Paul Burns, “Software Defined Radio for 3G”, Artech House, 2002
2	Tony J Rouphael, “RF and DSP for SDR”, Elsevier Newnes Press, 2008
3	Jouko Vanakka, “Digital Synthesizers and Transmitter for Software Radio”, Springer, 2005
4	Sofie Pollin, Michael Timmers, Liesbet Van der Perre, “Software Defined Radios”, Springer Publications, 2011
5	Walter Tuttlebee, “Software Defined Radio: Enabling Technologies”, Wiley Series in Software radio, June 2002.

EC 221	**OPTICAL COMMUNICATIONS AND NETWORKS**					
(PROGRAM ELECTIVE – II)						
Pre-requisites	-		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives: This course aims	
1.	To know the basic geometric structures of Optical fibers, Light laws, modes of operation and losses in fibers.
2.	To know the physical principles of optical sources and optical detectors and develop the design models.
3.	To understand and design the analog and digital optical links, the noise effects and error control techniques.
4.	To understand the working of various optical components and WDM concepts.
5.	To know the design aspects of various Optical networks and their applications.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand and analyze the design principles of Optical fibers and their losses.
CO-2	Analyze the design aspects of various types of Optical sources and detectors.
CO-3	Analyze and design the optical links for different applications.
CO-4	Know the working of WDM systems and various optical components for different applications.
CO-5	Choose the Optical networks for various applications.

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	1	-	1	-
CO-2	2	1	-	-	-
CO-3	1	1	-	2	-
CO-4	1	-	-	-	-
CO-5	1	-	-	1	-

UNIT – I

Introduction to Matrix Methods of Analysis: Static indeterminacy and kinematic indeterminacy, Coordinate systems, displacement and force transformation matrices, element and structure stiffness matrices, equivalent joint loads and fixed end forces

Stiffness Method: Stiffness of prismatic member, Analysis of bar element, plane truss, continuous beams, plane frames and grid frames, also dealing with the effect of settlements, internal hinges and guided fixed end supports.

UNIT – II
Flexibility Method: Flexibility of prismatic member, Analysis of bar element, plane truss, continuous beams, plane frames and grid frames, also dealing with effect of settlements, internal hinges and guided fixed end supports.

UNIT – III
Direct Stiffness Method: Assemblage of global stiffness matrix, Analysis of plane truss, continuous beams, plane frame and grid frames, also dealing with effect of settlements, internal hinges and guided fixed end supports - bank matrix-semi bandwidth-computer algorithm for assembly by direct stiffness matrix method Exposure to software's

UNIT – IV
Introduction to Nonlinear Analysis: Geometric and material nonlinearity
P- effect, Effects of axial force on flexural stiffness – buckling of ideal columns, buckling behavior of real columns
Flexural behavior of beam columns, flexural stiffness measures for braced prismatic beam columns, effect of axial tension, flexural stiffness measures for unbraced prismatic beam columns

UNIT –V
Beams on Elastic Foundations: Introduction-Modulus of foundation & Basic equation. Beams of infinite length under concentrated & uniformly distributed loads, Analysis of semi-infinite beams making use of functions for infinite beams
Topics to be taught by Industry Subject Expert:
Case Study on beams on Elastic Foundation and Analyzing different structural elements using software

Suggested Reading:

1	Devdas Menon (2009), Advanced Structural Analysis by. Narosa Publishing House.
2	Amin Ghali, Adam M Neville and Tom G Brown (2007), "Structural Analysis: A Unified Classical andMatrix Approach", Sixth Edition, Chapman & Hall
3	Structural Analysis: A unified classical and matrix approach 6th editionA Ghali, AM Neville, TG Brown - 2017 - taylorfrancis.com
4	William Weaver, Jr & James M. Gere, Matrix Analysis of Framed Structures, 3rd edition Van Nostrand Reinhold New York 1990
5	Structural Analysis by Thandavamoorthy1st edition published by Oxford University 2011

EC222	**CODING THEORY AND TECHNIQUES**					
	(PROGRAM ELECTIVE – II)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Learn about the Importance of Information and Error Control
2	Describe Linear Block Codes and Applications and learn Cyclic Coding and BCH codes
3	Design Convolutional Encoders and explore the latest trends in Coding Theory

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Analyse the source of errors present in communication systems
CO-2	Perform Error detection and correction using Linear Block Codes
CO-3	Differentiate between Linear Block Codes and Cyclic Codes
CO-4	Analyse behavior of convolution encoders
CO-5	Design Turbo Encoders/Decoders and LDPC Encoders/Decoders

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	3	2	1	-
CO-2	2	3	2	2	-
CO-3	2	3	1	2	-
CO-4	2	2	1	1	-
CO-5	2	3	3	1	-

UNIT – I
Coding for Reliable Digital Transmission and Storage: Mathematical model of Information, A Logarithmic Measure of Information, Average and Mutual Information and Entropy, Types of Errors, Error Control Strategies.

UNIT - II
Linear Block Codes: Introduction to Linear Block Codes, Syndrome and Error Detection, Minimum Distance of a Block code, Error-Detecting and Error-correcting Capabilities of a Block code, Standard array and Syndrome Decoding, Applications of Block codes.

UNIT – III
Cyclic Codes: Generator and parity-check matrices of cyclic codes, Syndrome computation, and error detection. Binary BCH codes, Decoding of BCH codes, and Reed Solomon codes.

UNIT – IV
Convolutional Codes: Polynomial description of convolution code, Generator matrix of convolution code, State diagram, Tree diagram, Trellis diagram, Sequential decoding, and Viterbi decoding.

UNIT – V
Turbo Coding: Introduction to turbo coding, Performance analysis of Turbo codes, Designof Turbo codes, decoding of Turbo codes, Introduction to LDPC Codes, Tanner graph for Linear Block Codes.

Suggested Reading:

1	Shu Lin, Daniel J., Costello, Jr., "Error Control Coding", 2nd edition, Pearson, 2011.
2	Simon Haykin, "Communication Systems", 4th Edition, John Wiley & Sons, 2007.
3	Proakis J.G. & M. Salehi, "Digital Communications", Mc Graw-Hill, 2008.
4	Biglieri E., "Coding for Wireless Channels", Springer, 2007.

EC223	**BIOMEDICAL SIGNAL PROCESSING**					
	(PROGRAM-SPECIFIC ELECTIVE – II)					
Pre-requisites	-		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objective of enabling the student to:	
1	To understand the basic signals in the field of biomedical. And study t h e origins and characteristics of some of the most commonly used biomedical signals, including ECG,EEG, evoked potentials, and EMG
2	To understand the Sources and characteristics of noise and artifacts in biosignals. To understand the use of biosignals in diagnosis, patient monitoring, and physiological investigation
3	To explore the research domain in biomedical signal processing. To explore the application of established engineering methods to complex biomedical signal problems..

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand different types of biomedical signals.
CO-2	Identify and analyze different biomedical signals.
CO-3	Find applications related to biomedical signal processing
CO-4	Model a biomedical system
CO-5	Analyze ECG and EEG signal with characteristic feature points

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	1	1	1	1
CO-2	3	1	1	2	1
CO-3	2	1	2	2	1
CO-4	2	2	2	1	2
CO-5	3	2	2	1	2

UNIT - I
Acquisition, Generation of Bio-signals, Origin of bio-signals, Types of bio-signals, Study Of diagnostically significant bio-signal parameters

UNIT - II
Electrodes for bio-physiological sensing and conditioning, Electrode-electrolyte interface, polarization, electrode skin interface and motion artifact, biomaterial used for electrode,

Types of electrodes (body surface, internal, array of electrodes, microelectrodes), Practical aspects of using electrodes, Acquisition of bio-signals (signal conditioning) and Signal conversion (ADC‟s DAC‟s) Processing, Digital filtering

UNIT - III
Biomedical signal processing by Fourier analysis, Biomedical signal processing by wavelet (time-frequency) analysis, and Analysis (Computation diagnostically significant signal parameters can).

UNIT - IV
Classification of signals and noise, Spectral analysis of deterministic, stationary randomsignals and non-stationary signals, Coherent treatment of various biomedical signal processing methods and applications.

UNIT - V
Principal component analysis, Correlation, and regression, Analysis of chaotic signals Application areas of Bio–Signals analysis Multiresolution analysis (MRA) and wavelets, Principal component analysis (PCA), Independent component analysis (ICA)Pattern classification–supervised and unsupervised classification, Neural networks, Support vector Machines, Hidden Markov models. Examples of biomedical signal classification examples.

Suggested Reading:

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.

EC231	**VLSI SIGNAL PROCESSING**					
(PROGRAM-SPECIFIC ELECTIVE – III)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To enable the students to learn about the concept of pipelining and parallel processing in VLSI and the students to identify applications for unfolding algorithm
2	To make the students understand the analysis of the VLSI system with high speed and low power and equip the students with knowledge of Systolic Design for Space Representations containing Delays
3	To make the students understand the concept of Power Reduction and Estimation Techniques VLSI signal processing

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Explain parallel and pipelining processing techniques.
CO-2	Identify applications for unfolding algorithm
CO-3	Analyse Systolic Design for Space Representations containing Delays
CO-4	Explain Cook-Toom Algorithm, the Fast Convolution algorithm by the Inspection method.
CO-5	Analyze Power Reduction techniques and Power Estimation techniques

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	2	-	-	-
CO-2	3	2	-	2	-
CO-3	3	2	1	2	-
CO-4	3	3	1	2	-
CO-5	2	1	1	1	-

UNIT – I

Introduction to DSP: Typical DSP algorithms, DSP algorithms benefits, Representation of DSP algorithms. Pipelining and Parallel Processing: Introduction, Pipelining of FIR Digital filters, Parallel Processing, Pipelining and Parallel Processing for Low Power, Retiming: Introduction–Definitions and Properties – Solving System of Inequalities – Retiming Techniques

UNIT - II

Folding and Unfolding, Folding: Introduction -Folding Transform - Register minimization Techniques – Register minimization in folded architectures – folding of multi-rate systems, Unfolding: Introduction – An Algorithm for Unfolding – Properties of Unfolding – critical Path, Unfolding and Retiming – Applications of Unfolding

UNIT – III
Systolic Architecture Design: Introduction – Systolic Array Design Methodology – FIR Systolic Arrays – Selection of Scheduling Vector – Matrix Multiplication and 2D Systolic Array Design– Systolic Design for Space Representations contains

UNIT – IV
Fast Convolution: Introduction – Cook-Toom Algorithm – Winogard algorithm – Iterated Convolution – Cyclic Convolution – Design of Fast Convolution algorithm by Inspection

UNIT – V
Low Power Design: Scaling Vs Power Consumption–Power Analysis, Power Reduction techniques – Power Estimation Approaches, Programmable DSP: Evaluation of Programmable Digital Signal Processors, DSP Processors for Mobile and Wireless Communications, Processors for Multimedia Signal Processing

Suggested Reading:

1	Keshab K. Parthi, "VLSI Digital Signal Processing-System Design and Implementation", 1998, Wiley Inter Science.
2	Kung S. Y, H. J. While House, T. Kailath, "VLSI and Modern Signal processing", 1985,Prentice Hall.
3	Jose E. France, Yannis Tsividis, "Design of Analog – Digital VLSI Circuits for Telecommunications and Signal Processing", 1994, Prentice Hall.
4	Medisetti V. K, "VLSI Digital Signal Processing", IEEE Press (NY), USA, 1995.

EC232	**OPTIMIZATION TECHNIQUES**					
	(PROGRAM-SPECIFIC ELECTIVE – III)					
Pre-requisites	-		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To introduce various optimization techniques i.e, classical, linear programming, transportation problem, simplex algorithm, dynamic programming
2	Constrained and unconstrained optimization techniques for solving and optimizing an electrical and electronic engineering circuits design problems in real-world situations
3	To explain the concept of Dynamic programming and its applications to project Implementation

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Explain the need for optimization of engineering systems
CO-2	Understand the optimization of electrical and electronics engineering problems
CO-3	Apply classical optimization techniques, linear programming, simplex algorithm, transportation problem
CO-4	Apply unconstrained optimization and constrained non-linear programming and dynamic programming
CO-5	Formulate optimization problems.

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	1	1	1	-
CO-2	1	2	1	2	-
CO-3	2	2	2	2	-
CO-4	2	2	2	1	-
CO-5	3	2	2	1	-

UNIT – I
Use of optimization methods. Introduction to classical optimization techniques, motivation to the simplex method, simplex algorithm, sensitivity analysis.

UNIT – II
Search methods - Unrestricted search, exhaustive search, Fibonacci method, Golden section method, Direct search method, Random search methods, Univariate method, simplex method, Pattern search method.

UNIT – III
Descent methods, Gradient of function, steepest descent method, conjugate gradient method. Characteristics of constrained problem, Direct methods, the complex method, cutting plane method.

UNIT – IV
Review of a global optimization techniques such as Monte Carlo method, Simulated annealing and Tunneling algorithm.

UNIT – V
Genetic algorithm-Selection process, Crossover, Mutation, Schema theorem, Comparison between binary and floating-point implementation.

Suggested Reading:

1	SS Rao, "Optimization techniques", PHI, 1989
2	Zhigmiew Michelewicz, "Genetic algorithms + data structures = Evaluation programs", Springer Verlog - 1992.
3	Merrium C. W., "Optimization theory and the design of feedback control systems", McGraw Hill, 1964.
4	Weldo D.J., "Optimum seeking method", PHI, 1964.

EC233	**ARTIFICIAL NEURAL NETWORKS**					
	(PROGRAM SPECIFIC ELECTIVE – III)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objective of enabling the student to:	
1	To understand the biological neural network and to model equivalent neuron models.
2	To understand the architecture, learning algorithm, and issues of various feed-forward and feedback neural networks
3	To gain knowledge on applications of ANN

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	learn the ideological basics of artificial neural networks
CO-2	Create different neural networks of various architectures.
CO-3	Learn supervised learning and unsupervised learning.
CO-4	Learn SOM in ANN
CO-5	To know some applications of artificial neural networks

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	1	1	1	-
CO-2	1	3	3	2	-
CO-3	2	3	2	2	-
CO-4	2	2	2	1	-
CO-5	3	2	2	1	-

UNIT – I
Introduction: A Neural Network, Human Brain, Models of a Neuron, Neural Networks viewed as Directed Graphs, Network Architectures, Knowledge Representation, Artificial Intelligence and Neural Networks Learning Process: Error Correction Learning, Memory-Based Learning, Hebbian Learning, Competitive, Boltzmann Learning, Credit Assignment Problem, Memory, Adaption, Statistical Nature of the Learning Process.

UNIT – II
Single Layer Perceptrons: Adaptive Filtering Problem, Unconstrained Organization Techniques, Linear Least Square Filters, Least Mean Square Algorithm, Learning Curves, Learning Rate Annealing Techniques, Perceptron –Convergence Theorem, Relation Between Perceptron and Bayes Classifier for a Gaussian Environment Multilayer

Perceptron: Back Propagation Algorithm XOR Problem, Heuristics, Output Representation and Decision Rule, Computer Experiment, Feature Detection

UNIT – III
Back Propagation: Back Propagation and Differentiation, Hessian Matrix, Generalization, Cross Validation, Network Pruning Techniques, Virtues and Limitations of Back Propagation Learning, Accelerated Convergence, Supervised Learning.

UNIT – IV
Self-Organization Maps (SOM): Two Basic Feature Mapping Models, Self OrganizationMap, SOM Algorithm, Properties of Feature Map, Computer Simulations, Learning Vector Quantization, Adaptive Pattern Classification.

UNIT – V
Neuro Dynamics: Dynamical Systems, Stability of Equilibrium States, Attractors, NeuroDynamical Models, Manipulation of Attractors as a Recurrent Network Paradigm Hopfield Models – Hopfield Models, Computer Experiment

Suggested Reading:

1	Simon Haykin, “Neural Networks a Comprehensive Foundations”, PHI edition.
2	B. Vegnanarayana, “Artificial Neural Networks”,Prentice Hall of India P Ltd 2005
3	Li Min Fu, “Neural Networks in Computer Inteligance”, MCGRAWHILL EDUCATION 2003
4	James A Freeman David M S Kapura, “Neural Networks”,Pearson Education 2004.
5	Jacek M. Zurada, “Introduction to Artificial Neural Systems”, JAICO Publishing House Ed. 2006.

EC261	**ADVANCED DIGITAL SIGNAL PROCESSING LAB**					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	2	1
Evaluation	**SEE**	-	**CIE**	50 Marks		

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Design and implement a DSP system using tools like MATLAB
2	Analyse and describe the functionality of a real-world DSP system and work in teams to plan and execute the creation of a complex DSP system
3	Apply DSP system design to real-world applications and implement signal processing algorithms on DSP processors

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Understand the handling of discrete/digital signals using MATLAB
CO-2	Understand the basic operations of Signal processing
CO-3	Analyze the spectral parameter of window functions
CO-4	Design IIR, and FIR filters for band pass, band stop, low pass, and high pass filters.
CO-5	Design the signal processing algorithm using MATLAB & and implementation on DSP processor

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	1	1	2	1	-
CO-2	1	3	2	2	-
CO-3	1	3	2	2	-
CO-4	1	3	2	1	-
CO-5	1	3	2	1	-

Experiment – I
Basic Signal Representation

Experiment – II
Correlation between Auto and Cross

Experiment – III
Stability Using Hurwitz Routh Criteria

Experiment – IV
Sampling FFT Of Input Sequence

Experiment – V
Butterworth Low pass And High pass Filter Design

Experiment - VI
Chebyshev Type I, II Filter

Experiment - VII
State Space Matrix from Differential Equation

Experiment - VIII
Normal Equation Using Levinson Durbin

Experiment - IX
Decimation and Interpolation Using Rationale Factors

Experiment - X
Maximally Decimated Analysis DFT Filter

Experiment - XI
Cascade Digital IIR Filter Realization

Experiment - XII
Convolution and M Fold Decimation &PSD Estimator

Experiment - XIII
Estimation Of PSD

Experiment - XIV
Inverse Z Transform

Experiment - XV
Group Delay Calculation

Experiment - XVI
Separation Of T/F

Experiment - XVII
Parallel Realization of IIR filter.

EC271	**SEMINAR**					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	2	1
Evaluation	**SEE**	-	**CIE**	50 Marks		

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Identify appropriate topic of relevance.
2	Update literature on technical articles of selected topic and develop comprehension.
3	Prepare a technical report.
4	Deliver presentation on specified technical topic.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Develop the habit of referring the journals for literature review.
CO-2	Understand the gist of the research paper.
CO-3	Identify the potential for further scope.
CO-4	Present the work in an efficient manner.
CO-5	Write the documentation in the standard format.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	5	-	5	-	-
CO2	5	-	5	-	-
CO3	-	3	2	-	-
CO4	5	-	3	-	-
CO5	-	-	4	-	-

Seminar topics may be chosen by the students with advice from the faculty members and the student shall read further relevant articles in the domain.

The seminar must be structured and the PowerPoint presentation shall include following aspects:

1. Introduction to the field
2. Literature survey
3. Consolidation of available information
4. Summary and Conclusions
5. References

Each student is required to:

1. Deliver the seminar for a maximum duration of 30 minutes, where the presentation should be for 20 minutes in PowerPoint, followed by Question and Answers session for 10 minutes.
2. Submit the detailed report of the seminar in spiral bound in a précised format as suggested by the Department.

Guidelines for awarding marks		
S. No.	**Description**	**Max. Marks**
1	Contents and relevance	10
2	Presentation skills	10
3	Preparation of PPT slides	05
4	Questions and answers	05
5	The report in a prescribed format	20

Note:

1. The seminar presentation should be a gist of at least five research papers from **Peer-reviewed journals.**
2. The seminar report should be in the following order: Background of work, literature review, techniques used, prospective deliverables, and discussion on results, conclusions, critical appraisal, and reference.
3. At least two faculty members will be associated with the seminar presentation to evaluate and award marks.
4. Attendance of all the students for weekly seminar presentations is compulsory. If the student fails to secure minimum attendance as per O.U. rules, the marks awarded in the seminar presentation shall remain void.

SEMESTER - II

EC 204	**DSP PROCESSORS AND ARCHITECHTURE**					
	(CORE- IV)					
Pre-requisites	Advanced Structural Analysis		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To introduce architectural features of programmable DSP processors of TI and Analog devices.
2	To give practical examples of DSP processor architectures for better understanding.
3	To develop the programming Knowledge using the Instruction set of DSP Processors.
4	To understand Interfacing Techniques to Memory and I/O devices.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Comprehends the knowledge & amp; concepts of digital signal processing techniques.
CO-2	Acquire knowledge of DSP computational building blocks and knows how to Achieve speed in DSP processors.
CO-3	Develop basic DSP algorithms using DSP processors.
CO-4	Acquire knowledge about various addressing modes of DSP TMS320C54XX, Blackfin processor and are able to program DSP processor.
CO-5	Discuss interfacing of serial and parallel communication devices.

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	1	2	1	2	-
CO-2	2	3	2	1	-
CO-3	1	3	3	3	-
CO-4	1	3	2	2	-
CO-5	1	2	1	1	-

UNIT – I
Introduction to Digital Signal Processing: Introduction, A Digital signal-processing system, The sampling process, Discrete-time sequences. Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT), Linear time-invariant systems, Digital filters, Decimation, and interpolation. Computational Accuracy in DSP Implementations: Number formats for signals and coefficients in DSP systems, Dynamic Range and Precision, Sources

of error in DSP implementations, A/D Conversion errors, DSP Computational errors, D/A Conversion Errors, Compensating filter.

UNIT – II
Architectures for programmable DSP devices: Basic Architectural features, DSP Computational Building Blocks, Bus Architecture and Memory, Data Addressing Capabilities, Address Generation UNIT, Programmability and Program Execution, Speed Issues, Features for External interfacing.

UNIT – III
Architectures for programmable DSP Devices: Commercial Digital signal-processing Devices, Data Addressing modes of TMS320C54XX DSPs, Data Addressing modes of TMS320C54XX Processors, Memory space of TMS320C54XX Processors, Program Control, TMS320C54XX instructions and Programming, On-Chip Peripherals, Interrupts of TMS320C54XX processors, Pipeline operation of TMS320C54XX Processors.

UNIT – IV
Analog Devices Family of DSP Devices: Analog Devices Family of DSP Devices – ALU and MAC block diagram, Shifter Instruction, Base Architecture of ADSP 2100, ADSP2181 high-performance Processor. Introduction to Blackfin Processor - The Blackfin Processor, Introduction to Micro Signal Architecture, Overview of Hardware Processing Units and Register files, Address Arithmetic Unit, Control Unit, Bus Architecture and Memory, Basic Peripherals.

UNIT – V
Interfacing Memory and I/O Peripherals to Programmable DSP Devices: Memory space organization, External bus interfacing signals, Memory interface, Parallel I/O interface, Programmed I/O, Interrupts and I/O, Direct memory access (DMA).

Suggested Reading:

1	A Practical Approach to Digital Signal Processing - K Padmanabhan, R. Vijayarajeswaran, Ananthi. S, New Age International, 2006/2009
2	Embedded Signal Processing with the Micro Signal Architecture Publisher: Woon-Seng Gan, Sen M. Kuo, Wiley-IEEE Press, 2007.
3	Digital Signal Processors, Architecture, Programming and Applications – B. Venkataramani and M. Bhaskar, 2002, TMH.
4	DSP Processor Fundamentals, Architectures & Features – Lapsley et al. 2000, S. Chand & Co.
5	Digital Signal Processing Applications Using the ADSP-2100 Family by The Applications Engineering Staff of Analog Devices, DSP Division, Edited by Amy Mar, PHI .

EC 205	**DETECTION AND ESTIMATION THEORY**					
(CORE-V)						
Pre-requisites	Advanced Structural Analysis		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Use classical and Bayesian approaches to formulate and solve problems for parameterestimation from noisy signals.
2	Use hypothesis testing and Bayesian approaches to formulate and solve problems forsignal detection from noisy signals.
3	Derive and apply linear filtering methods for parameter estimation and signal smoothing.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Understand the mathematical background of signal detection and estimation.
CO-2	Use classical and Bayesian approaches to formulate and solve problems for Signal detection and parameter estimation from noisy signals.
CO-3	Derive and apply filtering methods for parameter estimation.
CO-4	Understand the mathematical background of signal detection and estimation.
CO-5	Use classical and Bayesian approaches to formulate and solve problems for signal detection and parameter estimation from noisy signals.

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	1	2	-	1	-
CO-2	2	2	1	-	-
CO-3	1	2	-	1	-
CO-4	1	2	2	2	-
CO-5	1	2	1	1	-

UNIT – I
Random Processes: Discrete Linear Models, Markov Sequences and Processes, Point Processes, and Gaussian Processes.

UNIT – II
Detection Theory: Basic Detection Problem, Maximum A posteriori Decision Rule, Minimum Probability of Error Classifier, Bayes Decision Rule, Multiple-Class Problem (Bayes)- minimum probability error with and without equal a priori probabilities, Neyman-

Pearson Classifier, General Calculation of Probability of Error, General Gaussian Problem, Composite Hypotheses.

UNIT – III
Linear minimum Mean-square Error Filtering: Linear Minimum Mean Squared Error Estimators, Nonlinear Minimum Mean Squared Error Estimators. Innovations, Digital Wiener Filters with Stored Data, Real-time Digital Wiener Filters, Kalman Filters.

UNIT – IV
Statistics: Measurements, Nonparametric Estimators of Probability Distribution and DensityFunctions, Point Estimators of Parameters, Measures of the Quality of Estimators, Introduction to Interval Estimates, Distribution of Estimators, Tests of Hypotheses, Simple Linear Regression, Multiple Linear Regression.

UNIT –V
Estimating the Parameters of Random Processes from Data:Tests for Stationarity and Ergodicity, Model-free Estimation, Model-based Estimation of Autocorrelation Functions,Power Special Density Functions.

Suggested Reading:

1	K. Sam Shanmugam & A.M. Breipohl, “Random Signals: Detection, Estimation and Data Analysis”, Wiley India Pvt. Ltd, 2011.
2	Lonnie C. Ludeman, “Random Processes: Filtering, Estimation, and Detection”,Wiley India Pvt. Ltd., 2010.
3	Steven.M.Kay, “Fundamentals of Statistical Signal Processing: Volume I EstimationTheory”, Prentice-Hall, USA, 1998.
4	Steven.M.Kay, “Fundamentals of Statistical Signal Processing: Volume I DetectionTheory Prentice”, Hall, USA, 1998.

EC 206	**DIGITAL CONTROL**					
	(CORE-VI)					
Pre-requisites	-		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objective of enabling the student:	
1	To understand the concepts of digital control systems and assemble various components associated with them. Advantages compared to the analog type.
2	To understand basics of the theory of z–transformations and its application for the mathematical analysis of digital control systems.
3	To represent the discrete-time systems in state–space model and evaluation of the state transition matrix, the design of state feedback control by "the pole placement method.", design of state observers.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	learn the advantages of discrete time control systems and the "know-how" of various associated accessories.
CO-2	understand z–transformations and their role in the mathematical analysis of different systems (like Laplace transforms in analog systems).
CO-3	learn the stability criterion for digital systems and methods adopted for testing the same are explained.
CO-4	Understand the conventional and state space methods of design that are also introduced.
CO-5	Examine the stability of the system using different tests.

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	1	2	1	1
CO-2	2	2	2	1	1
CO-3	2	2	2	2	1
CO-4	2	1	2	1	-
CO-5	3	2	2	2	-

UNIT – I
TRANSFER FUNCTIONS, BLOCK DIAGRAMS, AND SIGNAL FLOW GRAPHS: Review of Z-Transform, Applications of Z-Transform, Signals between sampling instants-Submultiple sampling method & Delayed Z-Transform and the modified Z-Transform. Introduction to Pulse Transfer Function and Z-Transfer function, Relation between G(s) and G(z), Closed-loop systems, Sampled Signal Flow Graph, Modified Z-Transfer function,

Multi-rate Discrete Data Systems (Slow-Fast, Fast-Slow, Multi-rate Systems with All Digital systems, Closed-loop multi-sampled systems, and Cyclic Rate sampled systems, Zero-order hold, first-order hold, and Polygonal hold.

UNIT – II
STATE VARIABLE TECHNIQUE: State Equations of Discrete Data systems with Sample and Hold Devices, State equations of Digital Systems with All-Digital Elements, The State Transition Equations(the recursive method and the z transform method), Relationship between State Equations and Transfer Functions, Characteristic Equation, Eigen Values, and Eigen Vectors, Methods of Computing the Transition Matrix(The Cay-ley Hamilton Theorem, The Z-Transform Method), State Diagrams of Digital Systems, Decomposition of Discrete- Data Transfer Functions.

UNIT – III
TIME DOMAIN AND Z-DOMAIN ANALYSIS: Introduction, Prototype Second-Order system, Comparison of Time Responses of Continuous Data and Discrete Data systems, Steady State Error analysis of Digital Control systems, Correlation between time response and root locations in S-plane and Z-plane, Dominant Characteristic Equation, Root loci of Digital Control systems, Effects of adding poles and Zeroes to Open loop transfer function.
FREQUENCY DOMAIN ANALYSIS: Introduction, Polar plot of GH (z), Nyquist Stability criterion, Bode plot, Gain Margin, and Phase Margin, Bandwidth considerations, and Sensitivity analysis.

UNIT – IV
DESIGN OF DISCRETE DATA CONTROL SYSTEMS: Introduction, Cascade Compensation by continuous data Controllers, Design of Continuous Data Controllers with Equivalent Digital Controllers, Digital controllers, Design of Digital Control systems with Digital controllers through Bilinear transformation, Design in the Z-plane using Root Locus Diagram.

UNIT –V
DESIGN OF DIGITAL CONTROL SYSTEMS: Control System parameters, Conventional design tools- Root locus and Bode plots, compensation-Phase lead, phase lag, and PID controllers. Applications of DSPs in control systems-PID controllers, Motor control and Robotics.

Suggested Reading:

1	BC Kuo, “Digital Control Systems”, Second Edition, Saunders College Publishing, 1992.
2	Nekoogar F and Moriarty G, “Digital Control Using Digital Signal Processing”, Prentice HallInc, 1999.
3	M. Gopal, “Digital Control and State Variable Methods (conventional and intelligent Control) Systems, Third Edition, TMH.

EC 241	**ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING**					
(PROGRAM ELECTIVE – IV)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Study the concepts of Artificial Intelligence.
2	Learn the methods of solving problems using Artificial Intelligence.
3	Introduce the concepts of Expert Systems and machine learning.
Course Outcomes :	
On completion of this course, the student will be able to do :	
CO-1	To identify problems that are amenable to solutions by AI methods.
CO-2	To identify appropriate AI methods to solve a given problem & implement basic AI algorithms.
CO-3	To formalize a given problem in the language/framework of different AI methods.
CO-4	To study the basics of Machine learning. Usage of Python packages for Machine Learning.
CO-5	To evaluate the performance of various Machine Learning algorithms on a dataset.

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	1	1	2	1	-
CO-2	1	3	2	3	-
CO-3	2	2	2	2	-
CO-4	2	3	3	2	-
CO-5	3	2	2	2	-

UNIT – I
Introduction: Machine learning, Terminologies in machine learning, Types of machine learning: supervised, unsupervised, semi-supervised learning.

UNIT – II
Discriminate Models: Least Square Regression, Gradient Descent Algorithm, Univariate and Multivariate Linear Regression, Prediction Model, probabilistic interpretation, Regularization, Logistic regression, multi-class classification, Support Vector Machines-Large margin classifiers, Nonlinear SVM, kernel functions, SMO algorithm. Model evaluation and improvement, Regularization, Bias Variance, Hyperparameter Tuning. Computational Learning theory- Sample complexity, exhausted version space, PAC Learning, agnostic learner, VC dimensions, Sample complexity - Mistake bounds.

UNIT – III
Gaussian Models: Multivariate Gaussian distributions, Maximum Likelihood Estimate, inferring parameters, Mixture models, EM algorithm for clustering and learning with latent variables.

UNIT – IV
Generative Models: Linear Discriminative Analysis, Nave Bayes classifier, Decision trees, Ensemble models – Bagging and Boosting. Unsupervised Learning .

UNIT – V
Algorithms: Dimensionality Reduction Principal Component Analysis (PCA), Singular Value Decomposition (SVD). Clustering – Hierarchical, Partitioned clustering: K-means, PAM, explainable AI (XAI), Approaching an ML problem.

Suggested Reading:

1	Tom Mitchell, “Machine Learning”, McGraw Hill, 1997.
2	E. Alpaydin, “Introduction to Machine Learning”, PHI, 2005.
3	Andrew Ng, Machine learning yearning, https://www.deeplearning.ai/machine-learningyearning/ .
4	Aurolien Geron , “Hands-On Machine Learning with Scikit-Learn and TensorFlow, Shroff/O’Reilly”,2017.
5	Andreas Muller and Sarah Guido, “Introduction to Machine Learning with Python: A Guide for Data Scientists”, Shroff/O’Reilly, 2016 .

EC242	**SPEECH PROCESSING**					
	(PROGRAM ELECTIVE – IV)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To introduce the models of speech production and acoustic phonetics.
2	To teach time and frequency domain techniques for estimating speech parameters and teach predictive techniques for speech coding.
3	To introduce speech recognition and speech synthesis applications Course Outcomes.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand different characteristics of Speech.
CO-2	Identify and analyze different speech analysis systems.
CO-3	Write algorithms for Recognition of speech.
CO-4	Demonstrate basic knowledge in speech production mechanism phoneme classification, digital models for speech production, Homomorphic speech processing and LPC analysis.
CO-5	Demonstrate applications of signal processing theory for estimation of speech parameters in the time and frequency domain including pitch and formants.

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	1	2	2	1	-
CO-2	1	3	1	3	-
CO-3	2	2	3	2	-
CO-4	2	3	3	2	-
CO-5	3	2	2	2	-

UNIT – I
The process of speech production: Production Mechanism and acoustic phonetics. Digital models for speech signals: Vocal Tract, Radiation, Excitation, and complete model speech perception: Loudness, Bark Scale, masking, perception, and Psychoacoustics.

UNIT – II
Short-time Period analysis: Short-time energy, Average magnitude, zero crossing, Speech vs Silence discrimination and zero-crossing rate, Pitch period estimation using parallel processing approach. Autocorrelation function, Pitch period estimation using Auto correlation function, The average magnitude function, median smoothing. Short-time Fourier Analysis: Fourier transform interpretation, linear filtering interpretation, sampling

rates in time and frequency, Filter banks, Spectrograms, pitch detection. Cepstral analysis, Complex and real cepstrum, pitch detection, and Formant estimation.

UNIT – III
Digital speech representation and coding: Review of PCM, adaptive PCM, differential PCM, delta modulation. Linear Predictive coding (LPC) analysis: Basic principles, autocorrelation and covariance methods, Computation of LP coefficients, Cholesky decomposition, Durbin's recursive solution, Frequency domain interpretation of LPC, CELP.

UNIT – IV
Analysis by synthesis: Phase vocoder, sub-band coding, Formant/homomorphic vocoder,Cepstral vocoder, vector Quantizer coder, Speech Enhancement techniques: Spectralsubtraction, enhancement by resynthesis.

UNIT – V
Automatic speech recognition: Basic pattern recognition approaches, Evaluating the similarity of speech patterns, Dynamic Time Warping (DTW), HMM‟s for speech recognition, forward, backward algorithms and parameter estimation. Speaker recognitionFeatures that distinguish speakers.

Suggested Reading:

1	Rabiner and Schafer, "Digital Processing of Speech Signals", Pearson Education,2004.
2	Deller, Hansen, Proakis, "Discrete-Time Processing of Speech Signals", IEEE presses, 2000.
3	R & J Rabiner and Juang, "Fundamentals of speech recognition", Prentice-Hall,1993.
4	Douglas O‟Shaughnessy, "Speech Communication: Human and Machine", 2nd ed.,University Press, Hyderabad, 2001.

EC 243	**RADAR SIGNAL PROCESSING**					
	(PROGRAM ELECTIVE – IV)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To review the Radar fundamentals.
2	To know the sampling criteria of Pulsed radar signals and learn various radars like MTI, Doppler and tracking radars and their comparison.
3	To analysis the radar signals using ambiguity function and understand various technologies involved in the design of radar transmitters and receivers.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Know how a radar is built and understand the principles of behavior.
CO-2	Understand the basic principles of signal processing done in a radar.
CO-3	Be able to estimate the performance of a radar-based on parameters provided.
CO-4	Be able to assess what type of radar is suitable for which task (choice of waveforms, frequency bands, etc.
CO-5	Be able to use numerical tools to calculate radar performance and to simulate the signal processing in a radar.

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	1	1	1	1
CO-2	3	1	1	1	1
CO-3	3	-	1	1	-
CO-4	3	1	1	1	1
CO-5	3	1	1	1	1

UNIT – I
A Preview of Basic Radar Signal Processing, Radar Literature, Signal Models, components of a Radar Signal, Amplitude Models, clutter, Noise Model and Signal -to -Noise Ratio, Jamming, Frequency Models-The Doppler Shift, Spatial Models, Spectral Model.

UNIT – II
Sampling and Quantization of Pulsed Radar Signals, Domains and Criteria for Sampling Radar Signals, Sampling in the Fast Time Dimension, Sampling in Slow Time – Selecting
Pulse Repetition Interval, Sampling the Doppler Spectrum, Sampling in the Spatial and Angle Dimensions, Quantization, I/Q Imbalance and Digital I/Q.

UNIT – III
Radar waveforms: The waveform Matched filter, Matched filter for Moving Targets, Radar Ambiguity Function and Ambiguity Diagram-Principles and Properties; Specific Cases – Ideal Case, Single Pulse of Sine Wave, Periodic Pulse Train, Single Linear FM Pulse.

UNIT – IV
Doppler Processing, Alternate Forms of the Doppler Spectrum, Moving Target Indication (MTI), Pulse Doppler Processing, Pulse Pair Processing, Additional Doppler Processing Issues, Clutter Mapping and the Moving Target Detector, MTI for moving platforms.

UNIT – V
Pulse Compression in Radar Signals: Introduction, Significance, Types, Frequency Modulated Pulse compression waveforms, Range side lobe control for FM waveforms, Phase modulated pulse compression waveforms Costas Frequency codes.

Suggested Reading:

1	Mark A. Richards, “Fundamentals of Radar Signal Processing”,McGraw Hill .
2	M.I. Skolnik, “Introduction to Radar Systems”, 3rd Edition, 2001, TMH.
3	R. Nitzberg, “Radar Signal Processing and Adaptive Systems”, 1999, Artech House.
4	F.E. Nathanson, “Radar Design Principles”, 1st Edition, 1969, McGraw Hill.

Subject	**Hardware Acceleration of Machine Learning**					
Pre-requisites	Computer Organization, Micro Processors		**L**	**T**	**P**	**C**
			3	**-**	**-**	**3**
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To introduce the fundamentals of parallel computing and explore different parallel architectures
2	To impart practical knowledge of MPI and CUDA programming
3	To develop an understanding of deep learning models
4	To analyze and compare accelerator architectures
5	To provide hands-on experience with optimization techniques

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	plain key concepts in parallel computing including speedup, efficiency, scalability, and memory models
CO-2	velop parallel programs using MPI for message-passing systems, utilizing point-to-point and collective communication effectively.
CO-3	rite CUDA programs that use thread hierarchies and memory management techniques to accelerate image-processing tasks.
CO-4	mpare and evaluate different accelerator architectures (CPU, GPU, TPU, FPGA) for deploying and training deep neural networks.
CO-5	derstand optimization techniques such as pruning, and batching to improve the performance of CNNs on various platforms.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1	1	1	1	1
CO2	4	1	1	4	4
CO3	4	1	1	4	4
CO4	4	1	4	4	4
CO5	4	1	1	4	3

Correlation rating: Low / Medium / High: 1 / 2 / 3 respectively.

UNIT–I
Introduction to Parallel Computing: Motivation and Concepts, Types of Parallel Architectures: SIMD, MIMD, Shared vs. Distributed Memory, Speedup, Efficiency, Scalability, Introduction to MPI & Cluster Setup (local or cloud-based), MPI Basics: MPI_Init, MPI_Comm_rank, MPI_Comm_size, MPI_Finalize, Point-to-Point Communication: MPI_Send, MPI_Recv, Collective Communication: MPI_Bcast, MPI_Reduce, MPI_Scatter, MPI_Gather, Synchronization and Barriers, Problem Decomposition: Domain vs. Functional, Load Balancing Techniques, Introduction to Parallel Matrix Multiplication using MPI, Debugging and Profiling MPI Programs

UNIT–II
Overview of CUDA Architecture: CUDA cores and the GPU structure, SIMD (SingleInstruction, Multiple Data) concept,**Efficient Memory Management,** Managing device memory, memory allocation strategies, Memory coalescing and data alignment, **Optimizing Performance with Shared Memory,** Shared memory usage for fast data access, Optimizing computational kernels using shared memory, **Reducing Latency,** Asynchronous memory copy, Overlapping computation and communication **CUDA Programming Basics:** Threads, blocks, and grids, Memory hierarchy (Global, Shared, Local, Constant, Texture memory), CUDA execution model (kernels and thread synchronization), Writing simple CUDA programs, Case Study: CUDA Program for Processing for Image Processing

UNIT–III
Overview of Machine and Deep Learning: Basics of Deep Neural Network (DNN), Training and Inference of DNNs, Forward and Backward propagation Different types, **Networks:** Fully Connected Networks, Convolutional Neural Networks, Matrix Multiplication, Applications in different domains: Computer Vision, Image Classification.

UNIT-IV
Accelerator architectures for DNNs: Introduction to Systolic Array for Matrix-Multiplication, Distinct Characteristics Of Training And Inference, Architectures of TPU v1, v2, v3 and v4; comparison between their architectures, Comparison of CPU, TPU and GPU, Deep Learning techniques on FPGA; efficacy of FPGAs for binarized neural networks (BNNs), Deep Learning on CPU, Deep Learning on GPU

UNIT – V
Case Study: Computer Vision problem example on CPU, GPU, CUDA & FPGA Optimizations techniques: Memory and Compute Optimizations to CNNs such as tiling, loop optimizations, batching, quantization, pruning, Catch Blocking

SUGGESTED READING:

1	Parallel Programming in C with MPI and Open MP", by Quinn, Michael J.
2	NVDIA- CUDA C Programming Guide – Design Guide
3	Hardware Architectures for Deep Learning: Masoud Daneshtalab, Mehdi Modarressi

EC252	**WIRELESS AND MOBILE COMMUNICATIONS**					
	(PROGRAM SPECIFIC ELECTIVE – V)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	An overview of key wireless technologies: Various generations of mobile communications for voice and data, 5G networks.
2	Wireless system design fundamentals: channel assignment, handoffs, interference, frequency reuse, capacity planning, large-scale fading, and Outdoor, Indoor propagation models.
3	Path loss, small-scale fading, multipath, reflection, diffraction, scattering and Various statistical models for small-scale fading study.
4	Various Diversity techniques, Equalizers used in communication receivers.
5	Multiple Access techniques and their applications in wireless networks.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Develop design models for cellular systems.
CO-2	Analyze the various Large-scale fading effects in designing propagation models for Mobile communications in Outdoor environments.
CO-3	Analyze the various types of Small-scale fading, measurement techniques, Parameters of multi-path radio and Statistical models.
CO-4	Understand Various Diversity techniques and Equalizers used in communication receivers.
CO-5	Develop the design models for various Multiple access techniques and understand their spectral efficiencies.

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	2	1	-	1	-
CO-2	2	1	1	1	-
CO-3	2	1	1	1	-
CO-4	1	-	-	1	-
CO-5	2	1	-	2	-

UNIT– I

Evolution of Mobile Radio Communications: Examples of Wireless Communication Systems, Overview of 1G,2G, 2.5G, 3G, 4G and 5G Cellular networks.

The Cellular Concept: Introduction, Frequency Reuse, Channel Assignment Strategies, Handoff Strategies, Interference and System Capacity, Improving Coverage and Capacity in cellular systems.

UNIT – II
Introduction to Radio wave propagation: Free-space propagation model, Relating Power to Electric Field, The three basic propagation mechanisms- Reflection, Ground Reflection (Two Ray) model, Diffraction, Scattering. **Outdoor propagation models**: Longley-Rice model, Okumura model, Hata model, PCS Extension to Hata model, Walfisch and Bertoni Model, Wideband PCS Microcell model. **Indoor propagation models**: Partition losses (same floor), Partition losses between floors, Log-distance path loss model, Ericsson multiple breakpoint model, Attenuation factor model, Signal penetration into buildings.

UNIT – III
Small scale multipath propagation: Factors influencing small scale fading, Doppler shift, Small scale multipath Measurements-Direct RF Pulse System, Spread Spectrum Sliding correlator Channel Sounding, Frequency Domain Channels Sounding, Parameters of Mobile multipath channels, Types of Small Scale Fading, Statistical models for multipath Fading Channels-Clarke's model for flat fading, spectral shape due to Doppler, Level Crossings and Fading Statistics, Two-ray Rayleigh Fading model..

UNIT – IV
Equalization: Introduction, Fundamentals of Equalization, Training a Generic Adaptive Equalizer, Equalizers in a communication Receiver, Linear Equalizers, Non linear Equalization-Decision Feedback Equalization (DFE), Maximum Likelihood Sequence Estimation (MLSE) Equalizer, Algorithms for adaptive equalization. **Diversity Techniques**: Practical Space Diversity Considerations, Selection Diversity, Scanning Diversity, Maximal Ratio Combining, Equal Gain Combining, Polarization Diversity, Frequency Diversity, Time Diversity, RAKE Receiver.

UNIT – V
Multiple Access techniques: FDMA, TDMA, Spread Spectrum Multiple Access- FHMA and CDMA, SDMA, Spectral efficiency analysis for Multiple Access Technologies: FDMA, TDMA and CDMA Comparison of these technologies based on their signal separation techniques, advantages, disadvantages and application areas.

Suggested Reading:

1	Theodore, S.Rappaport , Wireless Communications, Principles and Practice, 2nd Ed.,2002,PHI.
2	Andrea Goldsmith, Wireless Communications, 2005, Cambridge University Press
3	Kaveh pah Laven and P.Krishna Murthy, Principles of Wireless networks, 2002,PE.
4	P.Nicopolitidis, M.S.Obaidat, G.I.Papadimitriou, A.S.Pomportsis, Wireless Networks, 2003,John Wiley & Sons Pte Ltd.
5	Ashok Raj, Wireless Communication, First Edition, 2014, Khanna Publishers

EC 253	**UNMANNED AERIAL VEHICLE SYSTEMS**					
(PROGRAM ELECTIVE – VI)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	70 Marks	**CIE**		30 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To explain and make the students to understand the basic concepts of UAV/DRONE systems and its applications.
2	To understand the different hardware configurations for UAV.
3	To understand the designing, integration and testing of UAV.
4	To understand the GCS Software & applications.
5	To demonstrate the flight configurations and Practical implementation.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Able to identify different hardware for UAV.
CO-2	Prepare preliminary design requirements for an unmanned aerial vehicle.
CO-3	Perform system testing for unmanned aerial vehicles.
CO-4	Integrate various systems of unmanned aerial vehicle.
CO-5	Design micro aerial vehicle systems by considering practical limitations. Understanding of GCS Software & Practical implementation.

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	3	3	2	1	3
CO-2	3	3	3	2	2	3
CO-3	3	3	3	2	2	3
CO-4	3	3	3	2	1	3
CO-5	3	3	3	2	2	3

UNIT – I
Introduction to Unmanned Aerial Vehicle Systems -- evolution of UAV – classification – models and prototypes – System Composition-applications.

UNIT – II
Introduction to Design and Selection of the System- Aerodynamics and Airframe Configurations- Characteristics of Aircraft Types- Regulations of DGCA- Fixed Wing Operations and Aerodynamics - Drone Piloting-Weather and Meteorology- ATC Procedures & Radio Telephony.

UNIT – III
Basic Components of Drone - Different Types of Drones- Assembling of Drone, Artificial Intelligence in Drone -Drone Mapping.

UNIT – IV
Theory of Flight-Three Axes of Fight-Take –Off - Landing – Hover- Turning- Forwards and Sideway-Aerodynamic of Drone.

UNIT – V
Waypoints Navigation-Introduction to Ground Control software (GCS) - System Ground Testing- System In-flight Testing of Mini and Micro UAVs- Case study on the usage of UAV/DRONE.

Suggested Reading:

1	Paul G Fahlstrom, Thomas J Gleason, “Introduction to UAV Systems”, UAV Systems, Inc, 1998.
2	Reg Austin “Unmanned Aircraft Systems UAV design, development and deployment”, Wiley, 2010.
3	Dr. Armand J. Chaput, “Design of Unmanned Air Vehicle Systems”, Lockheed Martin Aeronautics Company, 2001.
4	Kimon P. Valavanis, “Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy”, Springer, 2007.
5	Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.

OE 941 BM	**MEDICAL ASSISTIVE DEVICES**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To extend knowledge of the amputee, of lost and remaining functions affecting locomotion, and to collect information on the best possible medical treatment.
2	To improve fitting techniques and practices, including training, so that existing devices might be used with greater comfort and function.
3	To develop improved lower-extremity devices

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Apply fundamental knowledge of engineering in rehabilitation
CO-2	Apply analytical skills to assess and evaluate the need of the end-user
CO-3	Develop self-learning initiatives and integrate learned knowledge for problem solving
CO-4	Understand the basics of robotics and apply their principles in developing prosthetics
CO-5	Apply the knowledge of computers in solving rehabilitation problems

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

UNIT – I
Introduction to Rehabilitation Engineering, Measurement and analysis of human movement, Disability associated with aging in the workplace and their solutions, clinical practice of rehabilitation engineering.

UNIT – II
Assistive Technology, Seating Biomechanics and systems. Wheeled Mobility: Categories of Wheelchairs. Wheelchair Structure and Component Design. Ergonomics of Wheel chair propulsion. Power Wheelchair Electrical Systems. Control. Personal Transportation. Auxiliary devices and systems.

UNIT – III
Sensory augmentation and substitution: Visual system: Visual augmentation. Tactual vision substitution, Auditory vision substitution; Auditory system: Auditory augmentation. Cochlear implantation, Visual auditory substitution, Tactual auditory substitution, Tactual system: Tactual augmentation. Tactual substitution. Measurement tools and processes: fundamental principles, structure, function; performance and behavior. Subjective and objective measurement methods.

UNIT – IV
Rehabilitation Robotics, Major Limb Prosthetic Devices, Orthotic Devices, Types of orthotics and prosthetics, Intelligent prosthetic Knee, Prosthetic Hand, Controlled orthotics and prosthetics FES system, Restoration of Hand function, Restoration of standing and walking, Myo-electric Hand.

UNIT – V
Augmentative and Alternative communication technology, Computer applications in Rehabilitation Engineering, telecommunications, and Web Accessibility.

Suggested Reading:

1	Robinson C.J., *Rehabilitation Engineering*, CRC Press, 1995.
2	Ballabio E., et al., *Rehabilitation Technology*, IOS Press, 1993.
3	Rory A Cooper, Hisaichi Ohnabe, Douglas A. Hobson, *Series in medical physis and biomedical engineering: An introduction to rehabilitation engineering*, Taylor and Francis Group, London, 2007.
4	Joseph D. Bronzino *The biomedical engineering handbook -biomedical engineering fundamentals*, 3rdEd., CRC Press, Taylor & Francis Group, London, 2006.

OE 942 BM	**MEDICAL IMAGING TECHNIQUES**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To familiarize the students with various medical imaging modalities.
2	To make learners understand the principles, detectors and operating procedures of X-ray, CT, MRI, ultrasound, PET and SPECT.
3	To make the students learn the advantages, disadvantages and hazards of various medical imaging equipment.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Interpret the working principle and operating procedure and applications of X-ray equipment.
CO-2	Understand the image reconstruction techniques and applications of CT.
CO-3	Summarize the image acquisition and reconstruction techniques in MRI.
CO-4	Comprehend the working principle, modes and medical applications of ultrasound imaging.
CO-5	Examine the operation and applications of PET, SPECT and radio nuclide instrumentation.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

UNIT – I

X ray Imaging: Electromagnetic spectrum, Production of X-rays, X-ray tubes- Stationary and Rotating Anode types, Block diagram of an X-Ray Machine, Collimators and Grids, Timing and Exposure controls. X-Ray Image visualization-Films, Fluorescent screens, Image Intensifiers. Dental X-Ray machines, Portable and mobile X-Ray units, Mammographic X-Ray equipment, Digital Radiography and flat panel detectors.

Radiation safety, ALARA principle, Dose units and dose limits, Radiation dosimeters and detectors.

UNIT – II
Computed Tomography: Basic principles, CT number scale, CT Generations. Major sub systems- Scanning system, processing unit, viewing unit, storage unit. Need and Principle of sectional imaging, 2D image reconstruction techniques - Iteration and Fourier methods. Applications of CT - Angio, Osteo, Dental, Perfusion (Body & Neuro), Virtual Endoscopy, Coronary Angiography.

UNIT – III
Magnetic Resonance Imaging: Principles of NMR imaging systems, Image reconstruction techniques-Relaxation processes, imaging/ pulse sequences. Sub systems of an NMR imaging system, NMR detection system, types of coils, biological effects and advantages of NMR imaging. Functional MRI - The BOLD effect, intra and extra vascular field offsets, source of T2* effects, Creating BOLD contrast sequence optimization sources and dependences of physiological noise in fMRI.

UNIT – IV
Ultrasound Imaging: - Principles of image formation -Imaging principles and instrumentation of A-mode, B-Mode, Gating Mode, Transmission mode and M-mode. Basics of multi-element linear array scanners, Digital scan conversion. Doppler Ultrasound and Colour Doppler imaging, Image artifacts, Biological effects, Ultrasound applications in diagnosis, therapy and surgery.

UNIT – V
Nuclear Medicine–Radioisotopes in medical diagnosis, Basic instrumentation- Radiation detectors, Pulse height analyzer, Rectilinear scanner, Gamma camera. Emission Computed Tomography (ECT), Principle and instrumentation of Single Photon Emission Computed Tomography(SPECT) and Positron Emission Tomography (PET). Comparison of SPECT, PET and combined PET/ X-ray CT.

Suggested Reading:

1	Khandpur R.S., *Handbook of Biomedical Instrumentation*, Tata McGraw Hill, 2016.
2	S Webb, "*The Physics of Medical Imaging*", Adam Highler, Bristol Published by CRC Press, 1988.
3	A C Kak, "*Principle of Computed Tomography*", IEEE Press New York, 1988.
4	Hykes, Heorick, Starchman, *Ultrasound physics and Instrumentation* MOSBY year book, 2nd Ed. 1992.
5	Stewart C. Bushong, *Magnetic Resonance Imaging- physical and biological principles*, MOSBY, 2nd Ed., 1995.

OE 941 CE	**GREEN BUILDING TECHNOLOGY**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Exposure to the green building technologies and their significance.
2	Understand the judicial use of energy and its management.
3	Educate about the Sun-earth relationship and its effect on climate.
4	Enhance awareness of end-use energy requirements in the society.
5	Develop suitable technologies for energy management

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the fundamentals of energy use and energy processes in building.
CO-2	Identify the energy requirement and its management.
CO-3	Know the Sun-earth relationship vis-a-vis its effect on climate.
CO-4	Be acquainted with the end-use energy requirements.
CO-5	Be familiar with the audit procedures of energy

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	3	3	2	1	2
CO-2	3	2	3	2	1	1
CO-3	3	2	3	2	1	2
CO-4	3	2	3	2	1	2
CO-5	3	2	3	2	1	1

UNIT – I
Overview of the significance of energy use and energy processes in building - Indoor activities and environmental control - Internal and external factors on energy use and the attributes of the factors - Characteristics of energy use and its management - Macro aspect of energy use in dwellings and its implications.

UNIT – II
Indoor environmental requirement and management - Thermal comfort - Ventilation and air quality – Air-conditioning requirement - Visual perception - Illumination requirement - Auditory requirement.

UNIT – III
Climate, solar radiation and their influences - Sun-earth relationship and the energy balance on the earth's surface - Climate, wind, solar radiation, and temperature - Sun shading and solar radiation on surfaces - Energy impact on the shape and orientation of buildings.

UNIT – IV
End-use, energy utilization and requirements - Lighting and day lighting - End-use energy requirements - Status of energy use in buildings Estimation of energy use in a building. Heat gain and thermal performance of building envelope - Steady and non-steady heat transfer through the glazed window and the wall - Standards for thermal performance of building envelope - Evaluation of the overall thermal transfer.

UNIT – V
Nuclear Medicine–Radioisotopes in medical diagnosis, Basic instrumentation- Radiation Energy management options - Energy audit and energy targeting - Technological options for energy management.

Suggested Reading:

1	Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.
2	Carter, W. Nick, (1991): Disaster Management, Asian Development Bank, Manila.
3	Sahni, Pardeep et.al. (eds.) (2002), Disaster Mitigation Experiences and Reflections, Prentice Hall of India, New Delhi.
4	Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.

OE 942 CE	**COST MANAGEMENT OF ENGINEERING PROJECTS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Introduce the concepts of cost management
2	Fundamentals of cost overruns
3	Introduce the concepts of Quantitative techniques for cost management Linear Programming, PERT/CPM.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understanding of strategic cost management process, control of cost and decision making based on the cost of the project.
CO-2	Ability to appreciative detailed engineering activities of the project and execution of projects
CO-3	Preparation of project report and network diagram
CO-4	Able to plan Cost Behavior , Profit Planning , Enterprise Resource Planning, Total Quality Management.
CO-5	Applications of various quantitative techniques for cost management

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

UNIT – I
Introduction and Overview of the Strategic Cost Management Process-Cost concepts in decision-making; relevant cost, Differential cost, Incremental cost and OpportUNITy cost. Objectives of a Costing System- Inventory valuation- Creation of a Database for operational control; Provision of data for Decision-Making.

UNIT – II
Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning- Project execution as conglomeration of technical and non- technical activities- Detailed Engineering activities.

UNIT – III
Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

UNIT – IV
Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems- Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector- Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints- Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets- Performance budgets- Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

UNIT – V
Quantitative techniques for cost management, Linear Programming, PERT/CPM,- Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Suggested Reading:

1	Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2	Charles T. Horngren and George Foster, Advanced Management Accounting
3	Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4	Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5	N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

OE 941 CS	**BUSINESS ANALYTICS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Understanding the basic concepts of business analytics and applications
2	Study various business analytics methods including predictive, prescriptive and prescriptive analytics
3	Prepare the students to model business data using various data mining, decision making methods

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	To understand the basic concepts of business analytics
CO-2	Identify the application of business analytics and use tools to analyze business data
CO-3	Become familiar with various metrics, measures used in business analytics
CO-4	Illustrate various descriptive, predictive and prescriptive methods and techniques
CO-5	Model the business data using various business analytical methods and techniques

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

UNIT – I

Introduction to Business Analytics: Introduction to Business Analytics, need and science of data driven (DD) decision making, Descriptive, predictive, prescriptive analytics and techniques, Big data analytics, Web and Social media analytics, Machine Learning algorithms, framework for decision making, challenges in DD decision making and future.

UNIT – II
Descriptive Analytics: Introduction, data types and scales, types of measurement scales, population and samples, measures of central tendency, percentile, decile and quadrille, measures of variation, measures of shape-skewness, data visualization.

UNIT – III
Forecasting Techniques: Introduction, time-series data and components, forecasting accuracy, moving average method, single exponential smoothing, Holt's method, Holt-Winter model, Croston's forecasting method, regression model for forecasting, Auto regression models, auto-regressive moving process, ARIMA, Theil's coefficient

UNIT – IV
Decision Trees: CHAID, Classification and Regression tree, splitting criteria, Ensemble and method and random forest. **Clustering**: Distance and similarity measures used in clustering, Clustering algorithms, K-Means and Hierarchical algorithms, **Prescriptive Analytics**- Linear Programming(LP) and LP model building.

UNIT – V
Six Sigma: Introduction, introduction, origin, 3-Sigma Vs Six-Sigma process, cost of poor quality, sigma score, industry applications, six sigma measures, DPMO, yield, sigma score, DMAIC methodology, Six Sigma toolbox.

Suggested Reading:

1	U Dinesh Kumar, "Data Analytics", Wiley Publications, 1st Edition, 2017
2	Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, "Business analytics Principles, Concepts, and Applications with SAS", Associate Publishers, 2015
3	S. Christian Albright, Wayne L. Winston, "Business Analytics - Data Analysis and Decision Making", 5th Edition, Cengage, 2015

Web Resources:

1	https://onlinecourses.nptel.ac.in/noc18-mg11/preview
2	https://nptel.ac.in/courses/110105089/

OE 941 EE	**WASTE TO ENERGY**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To know the various forms of waste
2	To understand the processes of Biomass Pyrolysis.
3	To learn the technique of Biomass Combustion.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the concept of conservation of waste
CO-2	Identify the different forms of wastage.
CO-3	Chose the best way for conservation to produce energy from waste.
CO-4	Explore the ways and means of combustion of biomass.
CO-5	Develop a healthy environment for the mankind.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	-	3	2	3	1
CO-2	3	-	3	2	3	1
CO-3	3	-	3	2	3	1
CO-4	3	-	3	2	3	1
CO-5	3	-	3	2	3	1

UNIT – I
Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNIT – II
Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT – III
Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT – IV
Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNIT – V
Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Suggested Reading:

1	Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2	Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3	Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4	Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

OE 942 EE	**POWER PLANT CONTROL AND INSTRUMENTATION**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	The operation of different types of power plants.
2	The basic working principle of instruments for measurement of electrical and non-electrical quantities like Temperature Pressure flow level measurements.
3	The instrumentation and protection systems applied in thermal power plant.
4	The control techniques employed for the operation of modern power generation plant

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Explain the different methods of power generation. Along with Piping and Instrumentation diagram of boiler.
CO-2	Select various measurements involved in power generation for measuring electrical and non-electrical parameters.
CO-3	Identify the different types of analyzers used for scrutinizing boiler steam and water.
CO-4	Model different types of controls and control loops in boilers.
CO-5	Illustrate the methods of monitoring and control of different parameters like speed, vibration of turbines

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	1	-	-	-	2
CO-2	3	1	-	-	-	2
CO-3	3	1	-	-	-	2
CO-4	3	1	-	-	-	2
CO-5	3	1	-	-	-	2

UNIT – I
Brief survey of methods of power generation, hydro, thermal, nuclear, solar and wind power, importance of instrumentation in power generation, thermal power plants, block diagram, details of boiler processes, Piping and Instrumentation diagram of boiler, cogeneration.

UNIT – II
Electrical measurements, current, voltage, power, frequency, power factor etc, non-electrical parameters, flow of feed water, fuel, air and steam with correction factor for temperature, steam pressure and steam temperature, drum level measurement, radiation detector, smoke density measurement, dust monitor.

UNIT – III
Flue gas oxygen analyzer: Analysis of impurities in feed water and steam, dissolved oxygen analyzer. Chromatography, pH meter, fuel analyzer, pollution monitoring instruments.

UNIT – IV
Combustion control, air / fuel ratio control, furnace draft control, drum level control, main steam and reheat steam temperature control, super heater control, air temperature, distributed control system in power plants, interlocks in boiler operation.

UNIT – V
Speed, vibration, shell temperature monitoring and control, steam pressure control, lubricant oil temperature control, cooling system.

Suggested Reading:

1	Sam G. Dukelow, The Control of Boilers, Instrument Society of America, 2nd Edition, 2010.
2	P.K. Nag, „Power Plant Engineering“, Tata McGraw-Hill, 1st Edition, 2001.
3	S.M. Elonka and A.L. Kohal, “Standard Boiler Operations”, Tata McGraw-Hill, 1st Edition, 1994.
4	R K Jain, “Mechanical and Industrial Measurements”, Khanna Publishers, 1st Edition, 1995.
5	E Al Wakil, “Power Plant Engineering”, Tata McGraw-Hill, 1st Edition, 1984.

OE 941 EC	**ELEMENTS OF EMBEDDED SYSTEMS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Understanding various Embedded Design strategies
2	Designing Micro controller based Embedded Systems
3	Designing FPGA Based Embedded Systems

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand Embedded Design Strategies and architecture of Arduino Board
CO-2	Program using various onboard components of Arduino
CO-3	Design real time interfacing with Arduino
CO-4	Understand Design Flow of FPGA, programming FPGA using Verilog HDL
CO-5	Implement combinational and sequential circuits using verilog HDL

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

UNIT – I
Embedded Systems Design Strategies: Micro Controller, DSP, FPGA, Introduction to Arduino (Micro controller Board), Components of Arduino, Architecture and Pin Configuration of ATMega328, Ports of ATMega328.

UNIT – II
Interfacing: Interfacing Switches, LEDs, Analog to Digital Converter, Digital to Analog Converter, Interfacing and Programming I2C, SPI

UNIT – III
Real Time Programming: Interfacing Key Pad, 7-segment display, LCD, Interfacing Sensors, Interfacing Stepper Motor**,** USB programming

UNIT – IV
FPGA Based Embedded Design: FPGA Design flow, Introduction to Verilog HDL**,** Basic building blocks, Data types of Verolog HDL, Behavioral Modelling, Data Flow Modelling, Structural Modelling, Hierarchal Structural Modelling, Case Studies on Verilog HDL descriptions of Basic Circuits

UNIT – V
Modelling of Circuits: Verilog HDL Implementation of Combinational MSI Circuits, Verilog HDL Implementation of Sequential MSI Circuits, Finite Sate Machine Design, Tasks and Functions, Introduction to Test Benches

Suggested Reading:

1	Ming-Bo Lin, Digital System Designs and Practices Using Verilog HDL and FPGAs, Wiley India, 2008
2	Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Pearson Education, 2005
3	Simon Monk, Programming Arduino: Getting Started with sketches, Mc.Hill, 2016

Web Resources:

1	www.arduino.cc
2	www.learn.sparkfun.com/tutorials/arduino

OE 941 ME	**OPERATION RESEARCH**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Introduce the concepts of optimization techniques
2	Formulation of LPP models
3	Basic concepts of Non-linear programming, Dynamic programming, Game theory are introduced.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
CO-2	Students should able to apply the concept of non-linear programming
CO-3	Students should able to carry out sensitivity analysis
CO-4	Student should able to model the real world problem and simulate it.
CO-5	Student should able to apply graph theory, competitive models, and game theory simulations.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

UNIT – I
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models.

UNIT – II
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming.

UNIT – III
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT.

UNIT – IV
Scheduling and sequencing - single server and multiple server models deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

UNIT – V
Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

Suggested Reading:

1	H.A. Taha, Operations Research, An Introduction, PHI, 2008
2	H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3	J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008.
4	Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5	Pannerselvam, Operations Research: Prentice Hall of India 2010.
6	Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010.

OE 942 ME	**COMPOSITE MATERIALS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*Study the concepts of composite construction.*
2	*Learn analysis and designs of composite beams, floors, columns and trusses as per the recommendations of IS codes of practice.*
3	*Apply the concepts for design of multi-storey composite buildings.*
4	*Scope of analysis is restricted to skeletal structures subjected to prescribed dynamic loads.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Understand the fundamentals of composite construction, and analysis and designs of composite beams.*
CO-2	*Analyse and design the composite floors*
CO-3	*Select suitable materials for composite columns,*
CO-4	*Analyse composite trusses and understand connection details.*
CO-5	*Analyse and design the multi-storey composite buildings*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

UNIT – I

Introduction of composite constructions: Benefits of composite construction - Introduction to IS - BS and Euro codal provisions.

Composite beams: Elastic behaviour of composite beams - No and full interaction cases - Shear connectors - Ultimate load behaviour - Serviceability limits - Effective breadth of flange - Interaction between shear and moment - Basic design consideration and design of composite beams.

UNIT – II
Composite floors: Structural elements - Profiled sheet decking - Bending resistance - Shear resistance - Serviceability criterion - Analysis for internal forces and moments - Design of composite floors.

UNIT – III
Composite columns: Materials - Concrete filled circular tubular sections - Non-dimensional slenderness - Local buckling of steel sections - Effective elastic flexural stiffness - Resistance of members to axial compressions - Composite column design - Fire resistance.

UNIT – IV
Composite trusses: Design of truss - Configuration - Truss members - Analysis and design of composite trusses and connection details.

UNIT – V
Design of multi-storey composite buildings: Design basis - Load calculations - Design of composite slabs with profile decks - Composite beam design - Design for compression members - Vertical cross bracings - Design of foundation.

Suggested Reading:

1	R.P. Johnson, “Composite Structures of Steel and Concrete - Beams, Slabs, Columns and Frames in Buildings”, Blackwell Publishing, Malden, USA, 2004.
2	“INSDAG Teaching Resources for Structural Steel Design”, Vol-2, Institute for Steel Development and Growth Publishers, Calcutta, India.
3	“INSDAG Handbook on Composite Construction – Multi-Storey Buildings”, Institute for Steel Development and Growth Publishers, Calcutta, India.
4	“INSDAG Design of Composite Truss for Building”, Institute for Steel Development and Growth Publishers, Calcutta, India.
5	“INSDAG Handbook on Composite Construction – Bridges and Flyovers”, Institute for Steel Development and Growth Publishers, Calcutta, India.
6	IS: 11384-1985, “Code of Practice for Composite Construction in Structural Steel and Concrete”, Bureau of Indian Standards, New Delhi, 1985.

OE 943 ME	**INDUSTRIAL SAFETY**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Causes for industrial accidents and preventive steps to be taken.
2	Fundamental concepts of Maintenance Engineering.
3	About wear and corrosion along with preventive steps to be taken
4	The basic concepts and importance of fault tracing.
5	The steps involved in carrying out periodic and preventive maintenance of various equipments used in industry

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Identify the causes for industrial accidents and suggest preventive measures.
CO-2	Identify the basic tools and requirements of different maintenance procedures.
CO-3	Apply different techniques to reduce and prevent Wear and corrosion in Industry.
CO-4	Identify different types of faults present in various equipments like machine tools, IC Engines, boilers etc.
CO-5	Apply periodic and preventive maintenance techniques as required for industrial equipments like motors, pumps and air compressors and machine tools etc

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

UNIT – I
Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes, Fire prevention and firefighting, equipment and methods.

UNIT – II
Fundamentals of Maintenance Engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT – III
Wear and Corrosion and their Prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications of Screw down grease cup, Pressure grease gun, Splash lubrication, Gravity lubrication, Wick feed lubrication, Side feed lubrication, Ring lubrication, Definition of corrosion, principle and factors affecting the corrosion, Types of corrosion, corrosion prevention methods.

UNIT – IV
Fault Tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, any one machine tool, Pump, Air compressor, Internal combustion engine, Boiler, Electrical motors, Types of faults in machine tools and their general causes.

UNIT – V
Periodic and Preventive Maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of Machine tools, Pumps, Air compressors, Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

Suggested Reading:

1	H. P. Garg, "Maintenance Engineering", S. Chand and Company
2	Audels, "Pump-hydraulic Compressors", Mcgraw Hill Publication
3	Higgins & Morrow, "Maintenance Engineering Handbook", Da Information Services.
4	Winterkorn, Hans, "Foundation Engineering Handbook", Chapman & Hall London

OE 941 LA	**INTELLECTUAL PROPERTY RIGHTS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Acquaint the students with basics of intellectual property rights with special reference to Indian Laws and its practices.
2	Compare and contrast the different forms of intellectual property protection in terms of their key differences and similarities.
3	Provide an overview of the statutory, procedural, and case law underlining these processes and their interplay with litigation.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the concept of intellectual property rights.
CO-2	Develop proficiency in trademarks and acquisition of trade mark rights.
CO-3	Understand the skill of acquiring the copy rights, ownership rights and transfer.
CO-4	Able to protect trade secrets, liability for misappropriations of trade secrets.
CO-5	Apply the patents and demonstration of case studies.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

UNIT – I
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.

UNIT – II
Trade Marks: Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting, and evaluating trade mark, trade mark registration processes.

UNIT – III
Law of copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law. Law of patents: Foundation of patent law, patent searching process, ownership rights and transfer**.**

UNIT – IV
Trade Secrets: Trade secrete law, determination of trade secrete status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation. Unfair competition: Misappropriation right of publicity, false advertising.

UNIT – V
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.

Suggested Reading:

1	Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd, 2007.
2	“Mayall, “Industrial Design”, McGraw Hill,1992
3	“Niebel, “Product Design”, McGraw Hill,1974.
4	“Asimov, “Introduction to Design”, Prentice Hall,1962.
5	“Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”,2016.
6	T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand,2008

EC 272	**MINI PROJECT**					
Pre-requisites	-		**L**	**T**	**P**	**C**
				-	-	2
Evaluation	**SEE**		**CIE**		50 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To review available literature and formulate structural engineering problems*
2	*To learn the technique of writing reports and prepare presentation*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Identify structural engineering problems reviewing available literature*
CO-2	*Study different techniques used to analyse complex structural systems.*
CO-3	*Able to work on the solutions given problem*
CO-4	*Present solution by using his/her technique applying engineering principles.*
CO-5	*Prepare technical report and presentation*

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	5	5	5	5	5
CO2	5	5	5	5	5
CO3	5	5	5	5	5
CO4	5	5	5	5	5
CO5	5	5	5	5	5

Syllabus Contents:

Mini Project will have mid semester presentation and end semester presentation. Mid semester Presentation will include identification of the problem based on the literature review on the topic referring to latest literature available.

End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals' contribution. Continuous assessment of Mini Project at Mid Semester and End Semester will be monitored by the departmental committee

EC262	**DIGITAL IMAGE AND VIDEO PROCESSING LAB**					
Pre-requisites			**L**	**T**	**P**	**C**
				-	-	1
Evaluation	**SEE**		**CIE**		25 Marks	

Course Objectives :	
The course is taught with the objective of enabling the student to:	
1	Understand the basics of the image processing system and the concepts of image transforms.
2	Gain knowledge in applying image and video processing algorithms to enhance images.
3	Gain complete knowledge about image compression and segmentation

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Analyze the relationship between pixels in images and able to apply proper image transformation on digital images for the intended application.
CO-2	Apply filtering operations to remove noise in images and segment the digital images.
CO-3	Apply proper compression techniques on images to save storage space.
CO-4	Analyze the features of the image
CO-5	Use MATLAB to perform video processing applications

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	1	2	2	1	-
CO-2	1	3	1	3	-
CO-3	2	2	3	2	-
CO-4	2	3	3	2	-
CO-5	3	2	2	2	-

LIST OF EXPERIMENTS

1. Perform basic operations on images like addition, subtraction etc.
2. Plot the histogram of an image and perform histogram equalization
3. Implement segmentation algorithms
4. Perform video enhancement
5. Perform video segmentation
6. Perform image compression using a lossy technique
7. Perform image compression using a lossless technique
8. Perform image restoration
9. Convert a color model into another
10. Calculate boundary features of an image
11. Calculate regional features of an image
12. Detect an object in an image/video using template matching/Bayes classifier

EC263	**DSP PROCESSORS AND ARCHITECTURES LAB**					
Pre-requisites	-		**L**	**T**	**P**	**C**
				-	-	1
Evaluation	**SEE**		**CIE**		50 Marks	

Course Objectives :	
The course is taught with the objective of enabling the student to:	
1	Understand the architecture of DSP processors
2	Implement DSP algorithms on DSP hardware
3	Explore the programming and debugging environment for DSP processors.
4	Design and implement real-time signal processing systems
5	Develop proficiency in DSP hardware interfacing

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Implement and optimize DSP algorithms
CO-2	Analyze and evaluate DSP processor architectures
CO-3	Interface DSP processors with real-world hardware
CO-4	Demonstrate proficiency in DSP development tools and debugging
CO-5	Document and present DSP-based solutions

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	1	2	2	1	-
CO-2	1	3	3	3	-
CO-3	2	3	3	2	-
CO-4	2	3	3	3	-
CO-5	3	2	2	2	-

LIST OF EXPERIMENTS

1. Write a program to split each element of an array (containing five 32-bit numbers) into16-bit LSBs and 16-bit MSBs and store them in two different arrays (each containing five 16-bit numbers)
2. Write an ASM program to take two 32 bytes of data from the input array and add themwith and without saturation and store the result in the array of size 2(each element 32- bits wide).
3. Write the program to transfer the data from input array input [6] = {1,2,3,4,5,6}; to buffer array buffer [12]; by repeating the array i.e., after data transfer the buffer shouldhave buffer [12] = {1,2,3,4,5,6,1,2,3,4,5,6}.
4. write the program in C to multiply two arrays element-by-element and give the outputalso into an output array.
5. write the program in C to perform FIR filtering. Take a wave file and reads 80 samplesevery time from the wave file and pass these samples through a 512 tap FIR filter and then writes to another wave file.
6. Write the program in C to do the bit reversal for index values of the supplied inputarray.
7. Write the program in C to compute 512-point FFT using radix-2 algorithm
8. Write the program in C to Compute Power Spectrum of array of elements.
9. Write the program in C for the Computation of Audio Spectrum without logarithm.
10. Write the program in C to find the Mel Cepstrum.

SEMESTER –III

AC030EC	**RESEARCH METHODOLOGY**					
AUDIT COURSE-I						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1. Learn to focus on research related activities.
2. Learn methods to devise and develop the various research designs
3.Learn basic principles of data collection and analysis techniques
4.Learn the style and format of writing a report for technical papers

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

1. Motivate the orientation towards research related activities
2. Formulate the research problem, analyze research related information
3. Identify various sources for literature review and design an experimentation set- up
4. Apply the basic principles of data collection and analysis techniques
5. Improve the style and format of writing a report for technical / Journal articles

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

UNIT – I
Research Methodology: Objectives and Motivation of Research, Types of Research, Research Approaches, Significance of Research, Research Methods verses Methodology, Research and Scientific Method, Important of Research Methodology, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India, Benefits to the society in general. **Defining the Research Problem:** Definition of Research Problem, Problem Formulation, Necessity of Defining the Problem, Technique involved in Defining a Problem.
UNIT – II
Literature Survey: Importance of Literature Survey, Sources of Information, Assessment of Quality of Journals and Articles, Information through Internet. **Literature Review**: Need of Review, Guidelines for Review, Record of Research Review.
UNIT – III
Research Design: Meaning of Research Design, Need of Research Design, Feature of a Good Design Important Concepts Related to Research Design, Different Research Designs, Basic Principles of Experimental Design, Developing a Research Plan, Design of Experimental Set-up, Use of Standards and Codes.

UNIT – IV
Data Collection: Collection of primary data, Secondary data, Data organization, Methods of data grouping, Diagrammatic representation of data, Graphic representation of data. Sample Design, Need for sampling, some important sampling definitions, Estimation of population, Role of Statistics for Data Analysis, Parametric V/s Non Parametric methods, Descriptive Statistics, Measures of central tendency and Dispersion, Hypothesis testing, Use of Statistical software. **Data Analysis:** Deterministic and random data, Uncertainty analysis, Tests for significance: Chi-square, student's t-test, Regression modeling, Direct and Interaction effects, ANOVA, F- test, Time Series analysis, Autocorrelation and Autoregressive modeling.
UNIT – V
Research Report Writing: Format of the Research report, Synopsis, Dissertation, Thesis its Differentiation, References/Bibliography/Webliography, Technical paper writing/Journal report writing, making presentation, Use of visual aids. **Research Proposal Preparation**: Writing a Research Proposal and Research Report, Writing Research Grant Proposal.

Suggested Reading:

1	C.R Kothari, Research Methodology, Methods & Technique; Revised Edition, New Age International Publishers,2004.
2	R. Ganesan, Research Methodology for Engineers, 1st Edition, MJP Publishers,2011.
3	Ratan Khananabis and SuvasisSaha, Research Methodology, 1st Edition, Universities Press, Hyderabad,2015.
4	Y.P. Agarwal, Statistical Methods: Concepts, Application and Computation, 1st Edition, Sterling Publs., Pvt., Ltd., New Delhi,2004
5	Vijay Upagade and AravindShende, Research Methodology, 1st Edition, S. Chand & Company Ltd., New Delhi,2009
6	G. Nageswara Rao, Research Methodology and Quantitative methods, 2nd Edition, BS Publications, Hyderabad,2012.

AC031	**ENGLISH FOR RESEARCH PAPER WRITING**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1.	Understand that how to improve your writing skills and level of readability
2.	Understand the nuances of language and vocabulary in writing a Research Paper.
3.	Develop the content, structure, format of writing a research paper and produce original research papers without plagiarism

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

1.	Interpret the nuances of research paper writing.
2.	Differentiate the research paper format and citation of sources.
3.	To review the research papers and articles in a scientific manner.
4.	Avoid plagiarism and be able to develop their writing skills in presenting the research work.
5.	Create a research paper and acquire the knowledge of how and where to publish their original research papers

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I

Features of Academic Writing

Language: Clear, Correct, Concise, Inclusive; **Tone**: Formal, Objective, Cautious; **Style**: Appropriate, Accurate, Organized; **Ethics**: Honesty, Integrity, Responsibility, Accountability.

UNIT – II

Kinds of Academic Writing

Essays, Reports, Reviews, Abstracts, Proposals

UNIT – III

Academic Writing Skills

Paraphrasing; Summarizing; Quoting; Rewriting; Expansion

UNIT – IV

Research Process

Selection of Topic, Formulation of Hypothesis, Collection of Data, Analysis of Data, Interpretation of Data, Presentation of Data

UNIT – V

Structure of a Research Document

Title, Abstract, Introduction, Literature Survey, Methodology, Discussion, Findings/Results, Conclusion, Documenting Sources (IEEE style)

References:

1	Bailey, S. (2014). *Academic writing: A handbook for international students*. Routledge.
2	Gillett, A., Hammond, A., & Martala, M. (2009). *Inside track: Successful academic writing. Essex*: Pearson Education Limited.
3	Griffin, G. (2006). *Research methods for English studies*. Edinburgh: Edinburgh University Press.
4	Silyn-Roberts, Heather. (2013*). Writing for Science and Engineering: Papers, Presentations and Reports* (2nd ed.). Elsevier.
5	Lipson, Charles (2011). Cite right: *A quick guide to citation styles; MLA, APA, Chicago, the sciences, professions, and more* (2nd ed.). Chicago [u.a.]: University of Chicago Press.

AC032	**DISASTER MITIGATION AND MANAGEMENT**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1.	To impart knowledge in students about the nature, causes, consequences and mitigation measures of the various natural disasters
2.	To enable the students to understand risks, vulnerabilities and human errors associated with human induced disasters
3.	To enable the students to understand and assimilate the impacts of any disaster on the affected area depending on its position/ location, environmental conditions, demographic, etc.

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

1.	Learn to demonstrate a critical understanding of key concepts in disaster risk reduction
2.	Humanitarian response
3.	Critically evaluate disaster risk reduction and humanitarian response policy and Practice from multiple perspectives.
4.	Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
5.	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**.**

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I
Introduction: Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.
UNIT – II
Repercussions of Disasters and Hazards: 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.
UNIT – III
*Disasters Prone Areas in India:*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

UNIT – IV
Disaster 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.
UNIT – V
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. Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

References:

1	R. Nishith, Singh AK, *"Disaster Management in India: Perspectives, issues and strategies"*, New Royal Book Company.
2	Sahni, Pardeep (Eds.), *"Disaster Mitigation Experiences and Reflections"*, PHI, New Delhi.
3	Goel S. L., *"Disaster Administration and Management Text and Case Studies",* Deep & Deep Publication Pvt. Ltd., New Delhi.

AC033	**SANSKRIT FOR TECHNICAL KNOWLEDGE**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. To make the novice Learn the Sanskrit to develop the logic in mathematics, science & other subjects
3. To explore the huge knowledge from ancient Indian literature

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

1. Develop passion towards Sanskrit language
2. Decipher the latent engineering principles from Sanskrit literature
3. Correlates the technological concepts with the ancient Sanskrit history.
4. Develop knowledge for the technological progress
5. Explore the avenue for research in engineering with aid of Sanskrit

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I
Introduction to Sanskrit Language: Sanskrit Alphabets-vowels-consonants- significance of Amarakosa-parts of Speech-Morphology-creation of new words-significance of synonyms-sandhi-samasa-sutras-active and passive Voice-Past/Present/Future Tense-Syntax-Simple Sentences (elementary treatment only)
UNIT – II
Role of Sanskrit in Basic Sciences: Brahmagupthas lemmas (second degree indeterminate equations), sum of squares of n-terms of AP- sulba, sutram or baudhayana theorem (origination of Pythagoras theorem)-value of pie-Madhava's sine and cosine theory (origination of Taylor's series). The measurement system-time-mass-length-temp, Matter elasticity-optics-speed of light (origination of Michaelson and Morley theory).
UNIT – III
Role of Sanskrit in Engineering-I (Civil, Mechanical, Electrical and Electronics Engineering): Building construction-soil testing-mortar-town planning-Machine definition-crucible-furnace-air blower- Generation of electricity in a cell-magnetism-Solar system-Sun: The source of energy, the earth-Pingalachandasutram (origination of digital logic system)
UNIT – IV
*Role of Sanskrit in Engineering-II (Computer Science Engineering & Information Technology):*Computer languages and the Sanskrit languages-computer command words and the vedic command words-analogy of pramana in memamsa with operators in computer language-sanskrit analogy of physical sequence and logical sequence, programming.
UNIT – V
*Role of Sanskrit in Engineering-III (Bio-technology and Chemical Engineering):*Classification of plants- plants, the living-plants have senses-classification of living creatures, Chemical laboratory location and layout- equipment-distillation vessel-kosthiyanthram

References:

1	M Krishnamachariar, "*History of Classical Sanskrit Literature",* TTD Press, 1937.
2	M.R. Kale, "*A Higher Sanskrit Grammar: For the Use of School and College Students*", MotilalBanarsidass Publishers, 2015.
3	Kapail Kapoor, "*Language, Linguistics and Literature: The Indian Perspective",* ISBN-10: 8171880649, 1994.
4	"*Pride of India*", SamskritaBharati Publisher, ISBN: 81-87276 27-4, 2007.
5	Shri Rama Verma, "*Vedas the source of ultimate science",* Nag publishers, 2005.

AC034	**VALUE EDUCATION**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1. Understand the need and importance of Values for self-development and for National development.
2. Imbibe good human values and Morals
3. Cultivate individual and National character.

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

1. Gain necessary Knowledge for self-development
2. Learn the importance of Human values and their application in day to day professional life.
3. Appreciate the need and importance of interpersonal skills for successful career and social life
4. Emphasize the role of personal and social responsibility of an individual for all-round growth.
5. Develop a perspective based on spiritual outlook and respect women, other religious practices, equality, non-violence and universal brotherhood.

Program Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1					
CO2					
CO3					
CO4					
CO5					

UNIT – I
Human Values, Ethics and Morals: Concept of Values, Indian concept of humanism, human values; Values for self-development, Social values, individual attitudes; Work ethics, moral and non- moral behaviour, standards and principles based on religion, culture and tradition.
UNIT – II
Value Cultivation, and Self-management: Need and Importance of cultivation of values such as Sense-of Duty, Devotion to work, Self-reliance, Confidence, Concentration, Integrity & discipline, and Truthfulness.
UNIT – III
Spiritual outlook and social values: Personality and Behavior, Scientific attitude and Spiritual (soul) outlook; Cultivation of Social Values Such as Positive Thinking, Punctuality, Love & Kindness, avoiding fault finding in others, Reduction of anger, forgiveness, Dignity of labour, True friendship, Universal brotherhood and religious tolerance.
UNIT – IV
Values in Holy Books: Self-management and Good health; internal & external cleanliness, Holy books versus Blind faith, Character and Competence, Equality, Nonviolence, Humility, Role of Women.

UNIT – V
Dharma, Karma and Guna: Concept of soul; Science of Reincarnation, Character and Conduct, Concept of Dharma; Cause and Effect based Karma Theory; The qualities of Devine and Devilish; Satwic, Rajasic and Tamasicgunas.

References:

1	Chakroborty, S.K., *"Values & Ethics for organizations Theory and practice*", Oxford University Press, New Delhi, 1998.
2	2. Jaya DayalGoyandaka, "*Srimad Bhagavad Gita with Sanskrit Text*", Word Meaning and Prose Meaning‖, Gita Press, Gorakhpur, 2017.

AC035	**STRESS MANAGEMENT BY YOGA**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1. *Creating awareness about different types of stress and the role of yoga in the management of stress.*
2. *Promotion of positive health and overall wellbeing (Physical, mental, emotional, social and spiritual).*
3. *Prevention of stress related health problems by yoga practice.*

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

1. *Understand yoga and its benefits.*
2. *Enhance Physical strength and flexibility.*
3. *Learn to relax and focus.*
4. *Relieve physical and mental tension through asanas.*
5. *Improve work performance and efficiency.*

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I
Meaning and Definition of Yoga **-** Historical perspective of Yoga - Principles of Astanga Yoga by Patanjali.
UNIT – II
Meaning and Definition of Stress- Types of stress - Eustress and Distress. Anticipatory Anxiety and Intense Anxiety and depression. Meaning of Management- Stress Management.
UNIT – III
Concept of Stress According to Yoga- Stress assessment methods - Role of Asana, Pranayama and Meditation in the management of stress
UNIT – IV
Asanas- (5 Asanas in each posture) - Warm up - Standing Asanas - Sitting Asanas - Prone Asanas - Supine asanas - Surya Namaskar.
UNIT – V
*Pranayama***-** Anulom and Vilom Pranayama - Nadishudhi Pranayama - Kapalabhati Pranayama - Bhramari Pranayama - Nadanusandhana Pranayama. *Meditation Techniques:*Om Meditation - Cyclic meditation: Instant Relaxation technique (QRT), Quick Relaxation Technique (QRT), Deep Relaxation Technique (DRT)

References:

1	Janardhan Swami Yogabhyasi Mandal, "*Yogic Asanas for Group Training - Part-I*", , Nagpur.
2	AdvaitaAshrama, "*Swami Vivekananda, "Rajayoga or Conquering the Internal Nature",* (Publication Department), Kolkata.
3	Nagendra H.R and Nagaratna R, "*Yoga Perspective in Stress Management",* Swami Vivekananda Yoga Prakashan, Bangalore.

AC036	**PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

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

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

1. Develop their personality and achieve their highest goal of life.
2. Lead the nation and mankind to peace and prosperity.
3. Practice emotional self-regulation.
4. Develop a positive approach to work and duties.
5. Develop a versatile personality.

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I
Neetisatakam – Holistic Development of Personality- Verses 19, 20, 21, 22 (Wisdom) - Verses 29, 31, 32 (Pride and Heroism) - Verses 26,28,63,65 (Virtue)
UNIT – II
Neetisatakam – Holistic Development of Personality (cont'd) - Verses 52, 53, 59 (don'ts) - Verses 71,73,75 & 78 (do's) - Approach to day to day works and duties.
UNIT – III
Introduction to Bhagavadgeetha for Personality Development - Shrimad Bhagavadgeetha: 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 Chapter – 6: Verses 5, 13, 17, 23, 35; Chapter – 18: Verses 45, 46, 48
UNIT – IV
Statements of Basic Knowledge - Shrimad Bhagavadgeetha: Chapter 2- Verses 56, 62,68 - Chapter 12 – Verses 13, 14, 15, 16, 17, 18 - Personality of Role model from Shrimad BhagawatGeeta.
UNIT – V
Role of Bhagavadgeetha in the Present Scenario **-** Chapter 2 – Verses 17 - Chapter 3 – Verses 36, 37, 42 - Chapter 4 – Verses 18, 38, 39 - Chapter 18 – Verses 37, 38, 63.

References:

1	Swami SwarupanandaAdvaita Ashram "*Srimad Bhagavad Gita",* (Publication Department), Kolkata
2	P.Gopinath, *"Bhartrihari's Three Satakam (Niti-sringar-vairagya*)", Rashtriya Sanskrit Sansthanam, New Delhi

AC037	**CONSTITUTION OF INDIA**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

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
3.	Entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.

Outcomes: At the end of this course, students will 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
4.	The eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
5.	Discuss the passage of the Hindu Code Bill of 1956.

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I
History of Making of the Indian Constitution: History, Drafting Committee, (Composition & Working) Philosophy of the Indian Constitution: Preamble, Salient Features.
UNIT – II
Contours of Constitutional Rights & Duties: 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.
UNIT – III
Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications. Powers and Functions.
UNIT – IV
Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative CEO of Municipal Corporation, Panchayat raj: Introduction, PRI: Zilla Panchayat, Elected officials and their roles, CEO Zilla Panchayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT – V
Election Commission: 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.

References:

1	*"The Constitution of India",* 1950 (Bare Act), Government Publication.
2	Dr. S. N. Busi, *"Dr. B. R. Ambedkar framing of Indian Constitution",* 1st Edition, 2015.
3	M. P. Jain, "*Indian Constitution Law",* 7th Edn., Lexis Nexis, 2014.
4	D.D. Basu, *"Introduction to the Constitution of India",* Lexis Nexis, 2015.

AC038	**PEDAGOGY STUDIES**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1.	To present the basic concepts of design and policies of pedagogy studies.
2.	To provide understanding of the abilities and dispositions with regard to teaching techniques, curriculum design and assessment practices and familiarize various theories of learning and their connection to teaching practice.
3.	To create awareness about the practices followed by DFID, other agencies and other researchers and provide understanding of critical evidence gaps that guides the professional development

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

1.	Illustrate the pedagogical practices followed by teachers in developing countries both in formal and informal classrooms.
2.	Examine the effectiveness of pedagogical practices.
3.	Understand the concept, characteristics and types of educational research and perspectives of research.
4.	Describe the role of classroom practices, curriculum and barriers to learning.
5.	Understand Research gaps and learn the future directions.

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I
Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions, Overview of methodology and Searching.
UNIT – II
Thematic Overview: Pedagogical practices followed by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education
UNIT – III
*Evidence on the Effectiveness of Pedagogical Practices***:** Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and Practicum) and the school curriculum and guidance material 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.
UNIT – IV
*Professional Development: A*lignment with classroom practices and follow up support - Support from the head teacher and the community – Curriculum and assessment - Barriers to learning: Limited resources and large class sizes.

UNIT – V
Research Gaps and Future Directions: Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment – Dissemination and research impact.

References:

1	Ackers J, Hardman F, *"Classroom Interaction in Kenyan Primary Schools, Compare*", 31 (2): 245 – 261, 2001.
2	2. Agarwal M, *"Curricular Reform in Schools: The importance of evaluation*", Journal of Curriculum Studies, 36 (3): 361 – 379, 2004.
3	Akyeampong K, "*Teacher Training in Ghana – does it count? Multisite teacher education research project (MUSTER)",* Country Report 1. London: DFID, 2003.
4	Akyeampong K, Lussier K, Pryor J, Westbrook J, *"Improving teaching and learning of Basic Maths and Reading in Africa: Does teacher Preparation count?"*International Journal Educational Development, 33 (3): 272- 282, 2013.
5	Alexander R J, *"Culture and Pedagogy: International Comparisons in Primary Education",* Oxford and Boston: Blackwell, 2001.
6	Chavan M, Read India: *"A mass scale, rapid, learning to read campaign",* 2003

AC039	**E-WASTE MANAGEMENT**					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1. Introduction to E-Waste management
2. Understanding on resource efficiency and circular economy
3. E-waste Management rules 2016
4. RoHS compliances/directives to EEE

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

1. Complete understanding on E-Waste management
2. Understanding on effective recycling methodologies for e-waste management
3. Overall understanding about E-waste Management rules 2016 and strategies for e-waste management
4. Understanding on RoHS compliances for EEE products

Program Articulation Matrix

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I
Waste Electrical and Electronic Equipment (WEEE): Flows, Quantities and Management, a Global Scenario; The Importance of Waste Management; Types of Waste- Solid and Liquid; Criteria for EEE/E-Waste Classification; Multivariate Model for E-Waste Estimation; Environmental and Health Effects of Waste Management, Inventorisation of E-Waste and Emerging trends in E-waste disposal with bench marks for depollution - global scenario; Dumping, Burning and Landfill: Impact on the Environment
UNIT – II
Effective Waste Management and Disposal Strategies; Legislative Influence on Electronics Recycling; Waste Management Rules and Their Amendments; Extended Producer Responsibility (EPR) in E-Waste Management; The Role of Collective versus Individual Producer Responsibility in E-Waste Management
UNIT – III
Electronic Waste: Public Health Implications; Restriction of Hazardous Substances (RoHS) Directives in Electrical and Electronic Equipment; Materials Used in Manufacturing Electrical and Electronic Products
UNIT – IV
Recycling and Resource Management: Ecological and Economical Valuation; Life Cycle Assessment (LCA) Approach to Waste Management System; Environmental Incentives for Recycling and Life Cycle Analysis of Materials Recycling Electronic Waste: Challenges and Opportunities for Sustainable Management; Resource Recovery from E-waste: Efficiency and Circular Economy; Integrated Approach to E-Waste Recycling: Recycling and Recovery Technologies, Recycling and Recovery Technologies.
UNIT – V
Cases studies: E-waste Generation, collection and recycling

References:

1	Electronic Waste Management and Treatment Technology, Editors: Majeti Narasimha Vara Prasad Meththika Vithanage
2	Electronic Waste Management, Edited by R. E. Hester, R. M. Harrison, RSC Publishing 2009
3	Solid Waste Technology & Management, Christensen, T., Ed., Wiley and Sons., 2011
4	Electronics Waste Management: An India Perspective. Front Cover. Sandip Chatterjee. Lap Lambert Academic Publishing GmbH KG, 2010 - Electronic
5	Handbook of Electronic Waste Management, International Best Practices and Case studies, Elsevier, 2019
6	E-waste: Implications, regulations, and management in India and current global best practices. Author(s): Rakesh Johri, TERI Press

EC281	**DISSERTATION-I**					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	20	10
Evaluation	**SEE**	-	**CIE**	100 Marks		

Course Objectives :	
1	Identification of the research problem
2	Discussion of literature survey.

Course Outcomes :	
CO-1	Identification of the objectives of the Research Problem.
CO-2	Ability to update the latest literature in chosen area of research & establishment of the scope of work.
CO-3	Development of the methodology for the chosen research problem and perform basic theoretical /experiment studies.
CO-4	Identification of the objectives of the Research Problem.
CO-5	Ability to update the latest literature in chosen area of research & establishment of the scope of work.

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	5	5	5	5	5
CO-2	5	5	5	5	5
CO-3	5	5	5	5	5

Contents:

Each student will be attached to a faculty member/guide for project. The student will carry out the project which may be development of Software / Hardware / Simulation studies / Design analysis / Experimental related to his/her specialization. The work will be monitored regularly by the guide.

At the end of the semester student will write the report on the work done and submit to the guide. Student has to present his/her work before two faculty members (one guide and other to be appointed by chairman BOS) on a fixed day during last week of the semester in which project is offered. The sessional marks will be awarded jointly by these examiners based on the report, presentation and viva voice

SEMESTER – IV

EC282	**DISSERTATION-II**					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	32	16
Evaluation	**SEE**	100	**CIE**	100 Marks		

Course Objectives :	
1	*Identification of the research problem*
2	*Discussion of literature survey.*

Course Outcomes :	
CO-1	*Expand the defined Research Problem for the dissertation work.*
CO-2	*Conduct of Laboratory/analytical/ software studies*
CO-3	*Analysis of Data, development of models, offer solutions to the research problem and provide conclusions of the work.*

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	5	5	5	5	5
CO-2	5	5	5	5	5
CO-3	5	5	5	5	5

Contents:

The student will carry out the project under allotted supervisor, which may be development of Software / Hardware / Simulation studies / Design analysis / Experimental related to his/her specialization. The work will be monitored regularly by the guide. At the end of the semester student will write the report on the work done and submit to the guide. Student has to present his/her work before two faculty members (one guide and other to be appointed by chairman BOS) on a fixed day during last week of the semester in which project is offered. The final marks will be allotted based on the report, presentation and viva voce conducted by the external examiner whose name is suggested by Chairman BOS