Electronics & Communication Engg. Deptt.
DELHI TECHNOLOGICAL UNIVERSITY
(Formerly Delhi College of Engineering)
ShahbadDaulatpur, Bawana Road-Delhi-42

Scheme and Syllabus

II Year: ODD SEMESTER

S.No	**Course Category**	**Course Code**	**Course Title**	**Credits**
1	Interdisciplinary Engineering Science Course-1 (ESC)	EC201	Probability and Random Process	4
2	Department Core Course-2	EC203	Digital Design-1	4
3	Department Core Course-3	EC205	Signal and Systems	4
4	Department Core Course-4	EC207	Analog Electronics-1	4
5	Department Core Course-5	EC209	Communication Systems	4
6	AEC/VAC	AEC/VAC	AEC/VAC	2
7	Community Engagement Course	MS299	--------	2

II Year: EVEN SEMESTER

S.No	Course Category	Course Code	Course Title	Credits
1	Interdisciplinary Engineering Science Course-2 (ESC)	EC202	Electromagnetic Field Theory	4
2	Department Core Course-6	EC204	Digital Design-II	4
3	Department Core Course-7	EC206	Digital Communication	4
4	Department Core Course-8	EC208	Computer Architecture	4
5	Department Core Course-9	EC210	Analog Electronics-II	4
6	AEC/VAC	AEC/VAC	AEC/VAC	2

III Year: ODD SEMESTER

S.No	Course Category	Course Code	Course Title	Credits
1	Department Core Course-10	EC301	Digital Signal Processing	4
2	Department Core Course-11	EC303	Linear Integrated Circuit	4
3	Department Core Course-12	EC305	Microwave & RF Communication	4
4	Department Elective Course -1		Table 1	4

Table 1: Department Elective Course -1

S. No	Course Code	Course Title
1	EC307	Semiconductor Device Electronics
2	EC309	Biomedical Electronics and Instrumentation
3	EC311	Algorithm Design and Analysis
4	EC313	Microprocessor & Interfacing
5	EC315	IC Technology
6	EC317	Control System

III Year: EVEN SEMESTER

S.No	Course Category	Course Code	Course Title	Credits
1	Department Core Course-13	EC302	VLSI Design	4
2	Department Core Course-14	EC304	Embedded System	4
3	Department Elective Course-2		Table 2	4
4	Department Elective Course -3		Table 3	4

Table 2: Department Elective Course -2

S. No	Course Code	Course Title
1	EC306	Flexible Electronics
2	EC308	Analog Filter Design
3	EC310	Testing and Diagnosis Digital System Design
4	EC312	Software Define Radio
5	EC314	Machine Learning
6	EC316	Wireless Sensor Network

Table 3: Department Elective Course -3

S. No	Course Code	Course Title
1	EC318	RF MEMS Design Technology
2	EC320	Soft Computing
3	EC322	Operating System
4	EC324	Speech Processing
5	EC326	Digital Image Processing
6	EC328	Information Theory and Coding

IV Year: ODD SEMESTER

S.No	Course Category	Course Title	Credits
1	Department Elective Course-4	Table 4	4
2	Department Elective Course -5	Table 5	4

Table 4: Department Elective Course -4

S. No	Course Code	Course Title
1	EC401	Radar Signal Processing
2	EC403	Statistical Signal Processing
3	EC405	System on Chip Design
4	EC407	Optical Communication
5	EC409	Computer Vision
6	EC411	Bio-Medical Signal Processing

Table 5: Department Elective Course -5

S. No	Course Code	Course Title
1	EC413	MEMS and Sensor Design
2	EC415	Nanophotonics Devices for Communications
3	EC417	Spread Spectrum Communication
4	EC419	Adaptive Signal Processing
5	EC421	Data Analytics
6	EC423	Multi-rate Signal Processing

IV Year: EVEN SEMESTER

S.No	Course Category	Course Title	Credits
1	Department Elective Course-6	Table 6	4

Table 6: Department Elective Course-6

S. No	Course Code	Course Title
1	EC402	Smart Antennas
2	EC404	Wireless Communications
3	EC406	Deep Learning
4	EC408	Low-power VLSI Design
5	EC410	Estimation and Detection Theory
6	EC412	Fundamentals of MIMO

1. Minor in electronics and communication engineering (For students of other disciplines)

Core courses		**Elective courses**	
Course code	**Course title**	**Course codes**	**Course title**
EC203	Digital Design -I	EC202	Electromagnetic Filed Theory
EC207	Analog Electronics -1	EC206	Digital Communication
EC209	Communication systems	EC208	Computer Architecture
		EC210	Analog Electronics-II
		EC301	Digital Signal Processing
		EC303	Linear Integrated Circuits
		EC304	Embedded Systems
		EC305	Microwave and RF Communication
		EC306	Flexible Electronics
		EC307	Semiconductor Device Electronics
		EC309	Biomedical Electronics and Instrumentation
		EC313	Microprocessor And Interfacing
		EC317	Control System
		EC326	Digital Image Processing
		EC402	Smart Antennas
		EC404	Wireless Communications
		EC407	Optical Communication
		EC409	Computer Vision
		EC413	MEMS and sensor design
		EC417	Spread spectrum communication

2. Minor in VLSI Design

Core courses		Elective courses	
Course code	**Course title**	**Course codes**	**Course title**
EC204	Digital Design -II	EC210	Analog Electronics-II
EC207	Analog Electronics-I	EC208	Computer Architecture
EC302	VLSI Design	EC304	Embedded Systems
		EC307	Semiconductors Device Electronics
		EC308	Analog Filter design
		EC310	Testing And Diagnosis Digital System Design
		EC313	Microprocessor And Interfacing
		EC314	Machine Learning
		EC315	IC Technology
		EC318	RF MEMS Design Technology
		EC405	System On-Chip Design
		EC408	Low Power VLSI Design
		EC409	Computer Vision
		EC413	MEMS and Sensor Design

3. Minor in signal processing & machine intelligence

Core courses		**Elective courses**	
Course code	**Course title**	**Course codes**	**Course title**
EC201	Probability and random Processes	EC311	Algorithm Design and Analysis
EC205	Signal and systems	EC312	Software Define Radio
EC301	Digital Signal Processing	EC314	Machine Learning
		EC316	Wireless sensor Network
		EC320	Soft Computing
		EC322	Operating System
		EC324	Speech Processing
		EC326	Digital Image Processing
		EC328	Information Theory and Coding
		EC401	Radar Signal Processing
		EC402	Smart Antennas
		EC403	Statistical Signal Processing
		EC406	Deep Learning
		EC407	Optical Communication
		EC409	Computer Vision
		EC410	Estimation and Detection Theory
		EC411	Bio-Medical Signal Image Processing
		EC412	Fundamentals of MIMO
		EC419	Adaptive Signal Processing
		EC421	Data Analytics
		EC423	Multi-rate Signal Processing

II Year: ODD SEMESTER

INTERDISCIPLINARY ENGINEERING SCIENCE COURSE-1 (ESC)
EC201- PROBABILITY AND RANDOM PROCESSES

Details of course: -

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Probability and Random Processes	3	1	0	Basic engineering Mathematics, basics of Signals and Systems

Course Objective:
To introduce the principles of probability theory and random processes for their application in electronics and communication engineering, signal processing, machine intelligence and Natural language Processing.

Course Outcomes:

1. Demonstrate the basic principles of probability and use of axioms of probability to prove basic theorems
2. Calculate the probability density functions, Cumulative distribution function and statistical averages of continuous, discrete and mixed random variables
3. Compute the correlation and Covariance of random vectors and estimate the unknown parameters
4. Analyze the spectral analysis of stochastic random process through LTI systems and explore its statistical Parameters
5. Apply the special classes of random process and apply the same to solving realistic situation

S. No.	Content	Contact Hours
Unit 1	Introduction to the Theory of Probability, Axioms of Probability, Repeated Trials, Introduction to Random Variables (RVs), Probability Distributions and Density Functions, Conditional Distribution and Density Functions, Function of one Random Variable, Statistical Averages: Mean, Variance and Moments and Characteristic Functions. Specific RVs: Uniform Distribution, Exponential Distribution, Gaussian Distribution, Rayleigh RV, Chi-Square, Rician Distribution, Nakagami-m Distribution, Bernoulli RV, Binomial RV, Poisson RV.	10
Unit 2	Two Random Variables, Joint Density and Distribution Function of Two Random Variables, Marginal Density and Distribution function,	8

	Correlation, Covariance, Vector Space of Random Variables, Joint Moments, Joint Characteristic Functions, Joint Conditional Densities, Sequences of Random Variables.	
Unit 3	Correlation Matrices, Covariance Matrices and their Properties, Conditional Densities of Random Vectors, Characteristic Functions and Normality, Markov Inequality, Tchebycheff Inequality and Estimation of an Unknown Parameter and Cauchy-Schwarz Inequality, Central Limit Theorem, Law of Large Numbers (LLN).	8
Unit 4	Introduction to Stochastic Process, Statistical Averages for Random Processes: Mean, Autocorrelation, Cross correlation, Autocovariance and Cross covariance. Stationary Processes, Wide-sense stationary Processes, Time average, Ergodicity and Ergodic Processes, Classification of Random processes: uncorrelated, orthogonal, statistically independent, Cyclo stationary Processes. Introduction to Spectral Analysis: Power Spectral Density. Transmissions of Random Processes through LTI Systems: System Response, Mean and Autocorrelation of the Output, PSD of the output.	8
Unit 5	Random walks: Introduction, random walks on graphs, modelling stochastic process and random walk analysis in biology. Probabilistic Forecasting techniques: Montecarlo simulations, Bayesian forecasting, Time series analysis and applications of forecasting techniques in Finance weather etc. Markov Chains: Introduction, Markov chain applications in Natural language processing.	8
Total		42

Books: -

S. No.	Name of Authors /Books / Publishers
1.	Probability, Random Variables and Stochastic Processes by Athanasios Papoulis and S. Unnikrishna Pillai, MGH, India Edition, 4th Edition
2.	Probability and Random Processes with applications to Signal Processing, H. Stark and J. W. Woods, Pearson Education, 3rd Edition
3.	Probability and Random Processes: With Applications to Signal Processing and Communications, Scott L. Miller and Donald G. Childers, 2nd Edition
4.	Probability and random processes for electrical engineers, Alberto leon-Garcia, 3rd dition
5.	Principles of Forecasting: A hand book for researchers and practitioners, 1st edition

DEPARTMENT CORE COURSE-2 (DCC)
EC203 DIGITAL DESIGN-1

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Digital Design-1	3	0	2	Basic knowledge of Number system, Logic gates and Boolean algebra

Course Objective:

To develop a comprehensive understanding of designing various digital electronic circuits and their applications.

Course Outcomes:

1. Apply knowledge of Boolean algebra and minimization techniques to design various combinational circuits and combinational building blocks
2. Apply the knowledge of sequential logic circuit design for various applications
3. Understand the concept of various memories and their application in designing programming logic device.
4. Analyse and design of various A/D and D/A converters and timing circuits.
5. Understand and analysis of various logic family circuits.

S. No.	Content	Contact Hours
Unit 1	Introduction to Number Systems and Logic gates & Tristate logic, Application of Parity generator/detector and Hamming code, Boolean algebra, minimization of switching function by Karnaugh map method and Tabulation Method with don't care terms, Designing of various combinational circuits, Arithmetic Circuits, Code converters, Magnitude Comparator etc., Design of Encoders, Decoders, Multiplexer, De-multiplexer, Priority encoder and their applications,	12
Unit 2	Introduction to sequential circuits, Gated Flip Flops, Conversion of Flip Flops, Design of Synchronous and Asynchronous Counters, Up-Down Counter, Shift Registers and Ring Counter and their applications	10
Unit 3	Introduction to Semiconductor memories: ROM, PROM, EPROM, EEPROM, Static and dynamic RAM, Implementation of Logic Circuits using ROM, PLA and PLDs.	05
Unit 4	Concept of D/A & A/D conversion, Weighted Resistor type. R-2R Ladder type D/A converter. Single slope & Dual slope A/D converter, successive approximation type, Flash type ADC. Applications of switching transistors in bi-stable, monostable, astable and Schmitt trigger circuits with their applications.	10
Unit 5	Introduction to Logic families and their parameters, Analysis of TTL, ECL, I^2L &CMOS logic gates, Comparisons and application of various logic family	05

	circuits,	
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Modern Digital Electronics by R. P. Jain (TMH) 2003, 4^{th} edition
2	Digital Principles and Application by Malvino & Leach (TMH). 2014, 8^{th} edition
3	Digital Electronics and Logic Design by M. Mano (PHI) 2008, 4^{th} edition
4	Digital circuits and Design by S. Salivahanan & S.Arivazhagan(Oxford Press), 5^{th} edition , 2018

DEPARTMENT CORE COURSE-3 (DCC)
EC205- SIGNALS AND SYSTEMS

Details of course: -

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Signals and Systems	3	0	2	Knowledge of basic of mathematics and physics

Course Objective: Describe signals and systems mathematically in time domain and transform domains, and demonstrate the mathematical modeling of signals and systems in engineering.

Course Outcomes:

1. Classification of signals and systems with understanding of LTI system
2. Apply various transform techniques for the analysis and design of continuous time signals on LTI systems.
3. Apply various transform techniques for the analysis and design of discrete time signals on LTI systems
4. Appraise sampling theorem, reconstruction of a signal from its discrete samples.
5. Analyze LTI systems using power/energy spectral density.

S. No.	Content	Contact Hours
Unit 1	Introduction: Basic concepts & definitions of continuous and discrete time Signals & their classification, continuous & discrete time system and their properties, elementary Signals. Linear time invariant systems response for continuous time systems and discrete time systems. Properties of continuous and discrete LTI systems. System representation through differential equations and difference equations.	8
Unit 2	Introduction to Fourier Transform Analysis: continuous and discrete time Fourier series and its properties, Fourier Transform for continuous and discrete time signals/system. Concept of bandwidth estimation for signal and system. Magnitude and phase spectra of continuous and discrete time signal, response of LTI system using Fourier transform. Application Fourier transform as linear filtering.	10
Unit 3	The Laplace Transform. The Region of Convergence for Laplace Transforms. The Inverse Laplace Transform. Geometric Evaluation of the Fourier Transform from the Pole-Zero Plot. Properties of the Laplace Transform. Some Laplace Transform Pairs. Analysis and Characterization of LTI Systems Using the Laplace Transform. System Function Algebra and Block Diagram Representations. The Unilateral Laplace Transform.	8
Unit 4	Z-Transform: Basic principles of z-transform, z-transform definition, Relationship between z-transform and Fourier transform, Region of Convergence, Properties of ROC, Properties of z-transform, Poles and Zeros,	8

	Inverse z-transform using Contour integration, Residue Theorem, Power Series expansion and Partial fraction expansion.	
Unit 5	Sampling: Representation of continuous time signals by its sample –Types of sampling, sampling theorem, aliasing. Reconstruction of a Signal from its samples. Mathematical Background: Representation of signals using ortho-normal basis functions. Power and Energy spectral density. Correlation functions. Hilbert Transform and its properties. Pre-envelope and Complex Envelope.	8
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Signals & Systems by Alan V. Oppenheim, Alan S. Willsky and S. Hamid Nawab, Pearson, 2ndEdition, Pearson Education,2013.
2	Signal & Systems by Simon Haykin and Barry Van Veen; 2ndEdition, John Wiley & Sons, 2007.
3	Linear Systems and Signals by B.P. Lathi, Oxford Publication, 2nd Edition, 2009.
4	Schaum's Outline of Signals and Systems, 4thEdition, by HweiP. Hsu, McGraw Hill, 2020.
5	Fundamentals of Signals and Systems, 2nd Edition by Roberts, McGraw Hill, 2007.
6	Signal & Systems by Tarun Kumar Rawat, Oxford University Press, 2020, 2nd edition

Department Core Course-4 (DCC)
EC207- ANALOG ELECTRONICS-I

Details of course: -

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Analog Electronics – I	3	0	2	Basic Knowledge of semiconductor physics

Course objective:
To develop an understanding of the physical mechanisms of semiconductors that govern the operation of diodes, BJTs, MOSFETs and to use this information to analyze and design circuits. Lab exercises are also significant components of the course.

Course Outcomes:
1. EC201.1 Explain the principles of operation of semiconductor devices such as diode, BJT and MOSFET.
2. EC201.2 Determine parameter values for large and small signal models for diodes, BJTs and MOSFETs based on knowledge of the device structure, dimensions, and bias conditions.
3. EC201.3 Determine, compare, and contrast the performance parameters of single stage amplifier circuits using BJTs and MOSFETs
4. EC201.4 Identify the high frequency limitations of BJTs and MOSFETs and determine the performance of multistage amplifiers.
5. EC201.5 Analyze and design analog electronic circuits using discrete components.
6. EC201.6 Design, construct and take measurement of various analog circuits and compare experimental results in the laboratory with theoretical analysis

S. No.	Content	Contact Hours
Unit 1	Review of semiconductor physics, p-n Junction diode: Physical operation, I-V characteristic and diode equation, Large-signal model, Concept of load line, p-n junction capacitances (depletion and diffusion), small signal (low and high frequency) model, Breakdown in p-n diodes, Zener diode.	8
Unit 2	Diode Applications: Rectifier circuits, Zener diode based voltage regulators, limiting and clamping circuits, voltage multipliers, switching behavior of p-n diode, SPICE model of p-n diode, an example of p-n diode data sheet.	6
Unit 3	Bipolar Junction Transistor(BJT): Physical structure and modes of operation, BJT current components, The Ebers-Moll model, BJT characteristics, and large-signal equivalent circuit, BJT Biasing for Discrete-Circuit Design, BJT small-signal equivalent, Basic single stage BJT amplifier configurations, BJT as a switch, SPICE BJT model and simulation examples.	11
Unit 4	Metal oxide semiconductor Field Effect Transistors MOSFET: Physical structure and V-I characteristics of Enhancement/Depletion- type MOSFETs	11

	(n/p-channel), Biasing in MOS amplifier circuits, Small signal equivalent circuit of MOSFET, Basic configurations of single stage MOS amplifier circuits, MOSFET as an analog switch, SPICE MOSFET models and simulation examples.	
Unit 5	Multistage Amplifiers: Analysis of multistage amplifier using BJT and MOSFETs, Significance of coupling and bypass capacitor, types of coupling: DC, RC and Transformer BJT and MOS based constant current sources	6
	Total	42

Books: -

S. No	**Name of Books/Authors/Publisher**
1	Microelectronics circuits by Sedra and Smith; Oxford university press, 5th edition
2	Fundamentals of Microelectronics circuits by B. Razavi, 3rd edition
3	Microelectronics by Millman and Grabel; Tata McGraw Hill, 2nd edition
4	Electronic Devices and Circuits by B Kumar and Shail Bala Jain, PHI, 2nd edition
5	Microelectronics circuits by Rashid, PWS Publishing Company, 2000, 2nd edition
6	Electronic Devices and circuit theory by Robert L. Boylestad, Louis Nashelska Pearson, 9th edition

DEPARTMENT CORE COURSE-5 (DCC)
EC209- COMMUNICATION SYSTEMS

Details of course: -

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Communication Systems	3	0	2	Signals and Systems, Probability and stochastic process

Course Objective: The main objective of this course is to understand and implement the basic analog and digital communication techniques/ circuits with the help of theoretical and practical problem solving.

Course Outcomes:
1. Comprehend introductory principles of communication systems such as types of signals and the process of modulation
2. Elucidate the process of amplitude, frequency and phase modulation and describe the design of their transmitters, and receivers
3. Apply sampling theory and analyze pulse code modulation and delta modulation.
4. Apply the knowledge of random variables and processes to study noise in communication systems.
5. Compare the noise performance and design tradeoffs of various modulation schemes.

S. No.	Content	Contact Hours
Unit 1	Introduction to Probability, Random Process and Stochastic Process. Introduction to Communication Systems, Source of Information, Communication Channels, Base band Signals, Representation of Signals and Systems, Probabilistic Considerations, Modulation Process, Primary Communication Resources, Analog versus Digital Communication, Applications of Communications Systems.	6
Unit 2	Linear modulation: Time and Frequency domain expression of AM (including intensity modulation of light), DSB, SSB and VSB. Generation of Linearly modulated signals. Coherent Demodulation and Envelope Detection. Angle Modulation: Instantaneous Frequency; Phase and Frequency Modulation, Single tone FM and its Spectral Analysis, NBFM and WBFM, Bandwidth requirements of Angle Modulated Signals, Demodulation of Angle Modulated Signals.	14
Unit 3	Radio and Television Broadcasting: AM Radio Broadcasting and FM radio and TV Broad Casting. Frequency Division Multiplexing, Radio	12

	Transmitters and Receivers, Analog Pulse Modulation: Generation and Demodulation of Pulse Amplitude Modulation, Pulse Width Modulation, Pulse Position Modulation, PAM/TDM System, Spectra of Pulse Modulated Signals, SNR Calculations for Pulse Modulation Systems. Waveform Coding: Sampling Theorem for Band Pass Signals, Quantization, PCM, DPCM, Delta Modulation, Adaptive Delta Modulation- Design of Typical Systems and Performance Analysis.	
Unit 4	Noise in Communication Systems: Thermal noise, Shot Noise and White Noise. Noise Equivalent Bandwidth, Noise Figure and Noise Temperature. Time Domain Representation of Narrowband Noise. Properties of Narrowband Noise. Noise in CW Modulation Systems. Figure of Merit: Noise performance of Linear and Exponential modulation. Pre-emphasis and De-emphasis in FM. Comparison of the Noise Performance of CW Modulation Schemes.	10
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Communication System by Simon Haykin John Wiley & sons. 3rd Edition
2	Modern Analog and Digital Communication by B.P. Lathi, Oxford University Press, 4th Edition
3	Electronic Communication Systems by Kennedy, Tata McGraw-Hill, 5th Edition
4	Principles of Communication System by Taub & Schilling, Tata McGraw-Hill, 4th Edition
5	Communication Systems by Proakis John Wiley & Sons., 2nd Edition

II Year: EVEN SEMESTER

INTERDISCIPLINARY CORE COURSE-2 (ESC)

EC202- ELECTROMAGNETIC FIELD THEORY

Details of course: -

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Electromagnetic Field Theory	3	1	0	Basic knowledge of vector calculus, Electric and Magnetic fields and its laws.

Course Objective:
To develop a comprehensive understanding of electromagnetic theory, including vector analysis, Maxwell's equations, electromagnetic wave propagation, transmission lines, and waveguides, to solve complex engineering problems.

Course Outcomes (CO):

1. Apply knowledge of Vector Analysis and Coordinate Systems and their transformations.
2. Apply Maxwell's equations to solve problems in electromagnetics.
3. Elucidate, formulate and analyze electromagnetic wave propagation in various kinds of media.
4. Analyze and design transmission lines, utilizing parameters, impedance matching and optimize performance metrics.
5. Apply waveguide theory to analyze rectangular waveguides and solve field equations for different modes.

S. No.	Content	Contact Hours
Unit 1	Operational Vector Analysis: Review of Coordinate systems and Transformations– Cartesian, Circular and Spherical coordinates and Transformations. Vector Calculus – Differential length, Area and Volume; Line, Surface and Volume Integrals; Del Operator, Gradient of a scalar, Divergence of a vector and Divergence theorem, Curl of a vector and Stokes theorem.	06
Unit 2	Maxwell's Equation:Continuity equation and Relaxation Time, Electric and Magnetic Boundary conditions; Poisson's and Laplace equations, Displacement current,Significance of loss tangent, Maxwell equations in their general time varying forms, Phasor notations of signals, Maxwell equations in phasor notation, Helmoltz wave equations.	10
Unit 3	Electromagnetic Wave Propagation: Electromagnetic Wave Equation in a general medium and its solution, Wave propagation in lossless and lossy dielectrics, Plane waves in free space, Plane waves in good conductors, skin	10

	effect, Power and Poynting's vector, Reflection and refraction of plane waves at normal and oblique incidence.	
Unit 4	Transmission Lines: Transmission line parameters and equations; Input impedance, VSWR, and Power; Complex reflection coefficient, Short and Open Circuit Stubs, Smith Chart, Some applications of Transmission lines, Transients on transmission lines.	08
Unit 5	Waveguides: Rectangular waveguides, Field equations for Transverse Electric and Magnetic modes, Wave propagation in the guide and its propagational characteristics, Power transmission and attenuation, Waveguide current and mode excitation.	08
	Total	42

Books:-

S. No	**Name of Books/Authors/Publisher**
1	Elements of Electromagnetics by M. N. O. Sadiku, Oxford University Press, 5th edition
2	Engineering Electromagnetics by Hayt and Buck, Tata McGraw Hill, 8th edition
3	Fields and Waves in Communications Electronics by Ramo, Whinnery and Van Duzer, John Wiley & Sons, 3rd edition
4	Field and Wave Electromagnetics by David K Cheng, Pearson Education (India), 2nd edition

DEPARTMENT CORE COURSE-6 (DCC)
EC204- DIGITAL DESIGN - II

Details of course: -

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Digital Design - II	3	-	1	Digital Design - I

Course Objective: To prepare the students for accomplishing design of finite state machines and VHDL/Verilog coding for digital circuits.

Course Outcomes (CO):

1. Realize the combinational and sequential digital circuits using VHDL/Verilog.
2. Design Mealy/Moore Finite state machine, state table conversion and reduction.
3. Illustrate asynchronous sequential machines and minimization.
4. Simplify races, hazards, and faults for digital circuits.
5. Implement the expression using programmable logic devices and algorithm state machine.

S. No.	Content	Contact Hours
Unit 1	**VHDL/ Verilog-** Introduction to FPGAs, Basics of HDLs, Entity declaration, Architecture modelling: Data Flow, Behavioral, structural, Data Types, Operators, Attributes, Signals and Variables, Coding of combinational and sequential circuits, Generic coding.	8
Unit 2	**Synchronous Finite State Machine-** Introduction to synchronous sequential circuits and finite state machine, realization of state table and state diagram from verbal description, complete design and coding of Mealy and Moore machines, Conversion of Moore to Mealy and Mealy to Moore, Minimization of completely and incompletely specified sequential machines.	8
Unit 3	**Asynchronous Finite State Machine-** Introduction to Asynchronous FSM, General Model and Classification of Asynchronous Sequential Circuit, Fundamental mode Analysis, Design of Asynchronous sequential circuits, completely and incompletely specified state machines and reduction of flow tables.	10
Unit 4	**Hazard, Races and Fault Detection-** Introduction to hazards, static, dynamic, functional, and essential hazards, hazards in combinational circuits and their elimination, hazard in sequential circuits, design of hazard-free switching circuits, Races and cycles in Asynchronous sequential machine, concept of secondary state assignment, fault and fault models: stuck-at faults, fault detection methods.	8
Unit 5	**PLDs and Algorithmic State Machine -** Introduction and classification of PLDs, ROM, Implementation of combinational logic circuits using ROM, PLA, PAL. Basics of CPLD, FPGA, ASIC. Introduction	8

	to ASM, ASM Chart: state box, decision box, conditional box, conversion of state diagram into ASM, representation of sequential circuits using ASM, synthesis of ASM chart.	
Total		**42**

Books:-

S. No.	Name of Books/Authors/ Publishers
1.	A Verilog HDL Primer by J. Bhaskar; BS Publication, 3rd edition
2.	Verilog Digital Systems Design by Z. Navabi; Tata McGraw Hill, 1st edition
3.	Switching and Finite Automata Theory by Z. Kohavi; TMH, 3rd edition
4.	Fundamental of Logic Design by Roth; Cengage learning, 6th edition
5.	Advanced Digital design with Verilog HDL by Michael D Ciletti, 2nd edition
6.	Digital Logic State Machine Design" by D. J. Comer; Oxford University Press, 3rd edition
7.	Contemporary Logic Design by R. H. Katz, G. Borriello; PHI, 3rd edition

DEPARTMENT CORE COURSE-7 (DCC)
EC206- DIGITAL COMMUNICATION

Details of course: -

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Digital Communication	3	0	2	Probability & Random Process

Course Objective: To understand the key modules of digital communication systems with emphasis on error performance of a digital communication system in presence of noise and other interferences.

Course Outcomes (CO):
1. Understand the basic digital communication systems
2. Introduce signal space concept for signal energy and Euclidean distance calculation
3. Analyze and evaluate the performance of digital communication system in the presence of noise.
4. Acquired knowledge about different Mary modulation techniques
5. Describe and analyze the digital communication system with spread spectrum modulation.

S. No.	Content	Contact Hours
Unit 1	**Baseband Shaping for Data Transmission:** Introduction to digital communication systems, Line coding and its power spectral density, Pulse Shaping, Inter Symbol Interference, Nyquist Criterion for Zero ISI & for Distortion-less Baseband Binary Transmission, Correlative Coding, Signaling with Duo-Binary Pulses, Eye Diagram, Equalization, Adaptive Equalization for Data Transmission, Scrambling and Descrambling.	8
Unit 2	**Signal space concepts:** Analogy between Signals and Vectors, Geometric Structure of the Signal Space, L2 Space, Distance, Norm and Inner Product, Decomposition of a Signal and Signal Components, Complex Signal Space and Orthogonality, Orthogonal Signal Set, Baseband Pulse Data Transmission, Gram-Schmidt Orthogonalization Procedure.	8
Unit 3	**Detection and Estimation:** Review of Gaussian Random Process, Detection of Known Signals in Noise, Optimum Threshold Detection, Optimum Receiver for AWGN Channel, Matched Filter and Correlation Receivers, Decision Procedure: Maximum A- Posteriori Probability Detector- Maximum Likelihood Detector, Probability of Error, Bit Error Rate, Wiener Filter for Waveform Estimation, Linear Prediction.	10
Unit 4	**Digital modulation schemes:** Coherent Binary Schemes: ASK, FSK, PSK, MSK, GMSK. Coherent M-ary Schemes, Non-Coherent Schemes, Calculation of Average Probability of Error for Different Modulation Schemes, Power Spectra of Digitally Modulated Signals, Performance Comparison of Different Digital Modulation Schemes. DQPSK, QPSK, OQPSK, pi/4 QPSK, 8-PSK, 16 QAM, 64 QAM.	10
Unit 5	**Spread Spectrum Modulation:** Pseudo-Noise Sequences, Direct Sequence	6

	Spread Spectrum [DSSS], Resistance to Jamming, Signal Space Dimensionality, Processing Gain, Frequency-Hop Spread Spectrum, Acquisition and Synchronization, Applications.	
	Total	42

Books: -

S. No	Name of Books/Authors/Publisher
1	Digital Communication Systems by Simon Haykin; John Wiley & Sons, 2nd edition
2	Modern Digital and Analog Communication, 3rd Edition by B.P. Lathi; Oxford University Press, 3rd edition
3	Digital Communications by John G. Proakis; McGraw Hill, 4th edition
4	Principles of Communication Systems by H. Taub and Schilling, ; McGraw Hill Education; 4th edition
5	Analog and Digital Communication by Couch; Pearson Education, 8th edition
6	Digital Communications: Fundamentals & Applications, by Bernard Sklar; Pearson education, 3rd edition

DEPARTMENT CORE COURSE-8 (DCC)
EC208- COMPUTER ARCHITECTURE

Details of Course:

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Computer Architecture	3	0	2	Digital Electronics

Course Objective:
To introduce fundamentals concepts of computer architecture.

Course Outcomes (CO):
1. Explain computer architecture, types of instructions, addressing modes, modes of data transfer, types of memories and pipelining.
2. Demonstrate ALU, arithmetic algorithms, pipelining and parallel processing.
3. Organize different types of CPUs, memories and input output devices.
4. Design ALU, hardwired control unit, microprogrammed control unit, system memory and basic computer system.
5. Simulate ALU Design, array multiplier, multiplication algorithms (shift & add and Booth's) and memory.

S. No.	Content	Contact Hours
Unit 1	Register Transfer and Microoperation: Register Transfer Language, Register Transfer, Bus and Memory Transfer, Arithmetic Micro operations, Logic Micro operations, Shift Micro operations, Design of ALU.	4
Unit 2	Computer Organization and Design: Instruction Codes, Computer Registers, General Register Organization, Stack Organization, Instruction Formats, Addressing Modes, Timing & Control, Instruction Cycle, Memory Reference Instructions, Input-Output and Interrupt related instruction cycle, Design of Hardwired and Microprogrammed Control Unit, Microprogramming.	12
Unit 3	Input – Output Organization: Peripheral devices, Input – Output interface, Asynchronous Data Transfer, Modes of Data Transfer, Priority Interrupt, Direct Memory Access, Input – Output Processor.	5
Unit 4	Memory: Memory hierarchy, Main Memory, Auxiliary Memory, Associative Memory, Cache Memory, Virtual Memory, Memory Management Hardware.	5
Unit 5	Computer Arithmetic: Introduction, Addition and Subtraction, Multiplication Algorithms, Division Algorithms, Floating Point Arithmetic Operation, Decimal Arithmetic Unit, Decimal Arithmetic Operations. Hardware implementation of arithmetic algorithms.	11
Unit 6	Introduction to RISC, Parallel Processing, Concept of Pipelining, Arithmetic Pipelining, Instruction Pipelining, Vector Processing, Array Processors.	5
TOTAL		42

Books:

S. No.	Name of Books/ Authors/ Publisher
1	M. Morris Mano, "Computer System Architecture", PHI, 3rd Edition, 1992
2	J. P. Hayes, "Computer Architecture and Organization", Tata McGraw Hill, 3rd Edition, 2002
3	William Stallings, "Computer Organization and Architecture", Pearson Education India, Ninth Edition, 2013, 9th edition
4	D. A. Patterson and J. L. Hennessy, "Computer Organization and Design", Morgan Kaufmann, Elsevier, 5th edition, 2014
5	A. S. Tannenbaum and T. Austin, "Structured Computer Organization", Pearson, Sixth Edition, 2013, 6th edition

DEPARTMENT CORE COURSE-9 (DCC)
EC210- ANALOG ELECTRONICS – II

Details of course: -

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Analog Electronics – II	3	0	2	Knowledge of semiconductor devices (BJT, MOSFET)

Course Objective:
To familiarize students to the analysis and design of analog electronic circuits which form the basic building blocks of almost any electronic system.

Course Outcome (CO):

1. EC202.1 Identify the high frequency limitations of BJTs and MOSFETs and determine frequency response of single and multistage amplifiers.
2. EC202.2 Explain the concept of and analyze the performance of negative feedback circuits.
3. EC202. Describe the concept of positive feedback and criterion for oscillations, analyses and design different BJT oscillators and Crystal oscillator.
4. EC202.4 Differentiate between the voltage, current and power amplifier and design the power amplifiers for required applications.
5. EC202.5 Explain the concept of differential amplifiers and current mirrors
6. EC202.6 Design, construct and take measurement of various analog circuits and compare experimental results in the laboratory with theoretical analysis.

S. No.	Content	Contact Hours
Unit 1	Frequency Response: s-Domain analysis: Poles, Zeros, and Bode plots, the amplifier transfer function, Low-frequency/ high-frequency response of common-source/common emitter amplifiers, common base/ common-gate amplifier, frequency-response of emitter and source follower.	8
Unit 2	Frequency response of cascaded stages: Cascode configurations, the common-collector and common emitter cascade, frequency response of the differential amplifier. SPICE simulation example.	8
Unit 3	Feedback: Properties of feedback amplifiers, basic feedback topologies, analysis and characteristics of various feedback amplifier circuits. Loop gain, stability problem, effect of feedback on the amplifier poles, stability study using bode plots, frequency compensation.	10
Unit 4	Principles of oscillations, Barkhausen criterion, Frequency stability, Various types of oscillators: RC Phase shift, Wein bridge, Hartley, Colpitt, Crystal oscillators. Amplitude limiter circuits. Output stage and Power Amplifiers: Classification of output stages, class A, B and AB output stages, Biasing the class AB circuit, variations on the class AB configuration, Power BJTs,	10

	MOS power transistors, IC power amplifiers.	
Unit 5	Review of current mirrors, large and small signal analysis of BJT and MOSFET based differential amplifiers.	6
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Microelectronics circuits by Sedra and Smith; Oxford university press, 1982, 5th edition
2	Fundamentals of Microelectronics circuits by B. Razavi, 2012, 3rd edition
3	Microelectronics by Millman and Grabel; Tata McGraw Hill, 1987, 2nd edition
4	Electronic Devices and Circuits by B Kumar and Shail Bala Jain, PHI, 2007, 2nd edition
5	Microelectronics circuits by Rashid, PWS Publishing Company, 2000, 2nd edition

3rd Year: FIFTH SEMESTER (ODD)

Department Core Course-10 (DCC)

EC301: Digital Signal Processing

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Digital Signal Processing	3	0	2	NIL

Course Objective: This course aims to provide in-depth knowledge to the student about various digital signal processing techniques, the design of digital filters and learn the concept of DFT, FFT algorithms, and design of digital filters using different approximations.

Course Outcomes:

1. Analyze DFT, FFT algorithms, and circular convolution for efficient digital signal processing.
2. Design and realize digital filters using FIR and IIR structures for various filter applications.
3. Implement linear-phase FIR filter design using windowing and frequency sampling techniques.
4. Apply analog filter design methods to create IIR filters using impulse invariance and bilinear methods.
5. Evaluate finite word length effects and their impact on the performance of IIR and FIR filters.

S. No.	Content	Contact Hours
Unit 1	Review of DTFT and z-transform, Introduction to Discrete Fourier Transform (DFT), Properties of DFT, Circular Convolution, Linear Convolution Using Circular Convolution, Filtering methods based on DFT, FFT Algorithms, Decimation-in-time Algorithms, Decimation-in-frequency Algorithms, Linear Filtering Approach for Computing DFT, Discrete Cosine Transform (DCT), Use and Application of DCT.	10
Unit 2	Realization of Digital Filters: Non-recursive and recursive structure, FIR filter structure (Direct form, Cascade form, Linear	8

	phase structure, polyphase structure), IIR filter structure, Direct form-I, Direct form-II, Cascade form, parallel form, polyphase structure), Lattice structure, Lattice structure for all-zero system, Lattice structure for all-pole system, Lattice ladder structure.	
Unit 3	FIR Filter Design: Linear Phase FIR filter, Frequency Response of Linear-phase FIR filters, Design Techniques for Linear-Phase FIR Filters, Fourier Series Method, Filter Design using Windowing Techniques (Rectangular Window, Hamming Window, Hanning Window), Frequency Sampling Techniques.	10
Unit 4	IIR Filter design:Analog Filter Design, Design of IIR filter from Analog Filter, IIR Filter design Using Impulse Invariance Method and Bilinear transformation Method, Design of Butterworth and Chebyshev IIR Filters; Frequency Transformation in Digital Domain	10
Unit 5	Finite word length effect in digital filters, fixed- and floating-point numbers, representation of negative number, effect of truncation, finite word length effect in realization of IIR and FIR system, Recent trends in DSP processor.	4
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	S. K. Mitra, ``Digital Signal Processing- A Computer-based approach, ‘’, Tata McGraw-Hill, 2007
2	John G. Proakis, Dimitris G. Manolakis, `` Digital Signal Processing: Principles, Algorithms, And Applications, ‘’ Pearson Education, 2007.
3	Tarun Kumar Rawat, “Digital Signal Processing”, Oxford University Press, 2016.
4	Alan V. Oppenheim and Ronald W.Schafer, ``Digital signal processing,’’ Prentice Hall of India, 2004.
5	Emmanuel C.Ifeachor, and Barrie.W.Jervis, “Digital Signal Processing”, Second Edition, Pearson Education, Prentice Hall, 2002

Department Core Course-11 (DCC)

EC303: Linear Integrated Circuit

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Linear Integrated Circuits	3	0	2	Analog Electronics

Course Objective: To introduce Op Amp; a versatile building block and to design analog circuits and systems for signal conditioning, processing and generation functions.

Course Outcomes:

CO1: Describe the internal blocks of an operational amplifier along with its specifications.

CO2: Design circuits based on the linear and non-linear applications of an op-amp and special application Ics.

CO3: Design of active filters, impedance converters, operational transconductance amplifiers (OTA), and other basic building blocks using OTAs.

CO4: Analyze different analog multipliers and their applications in modulation, etc.

CO5: Apply specific ICs such as the IC 555 timer, and PLLs to demonstrate circuits for applications in communication.

S. No.	Content	Contact Hours
Unit 1	Operational Amplifier: The ideal Op Amp, Building blocks of analog ICs: current mirrors and repeaters, current and voltage sources, differential amplifiers, input stages, active load, gain stages, output stages, level shifters, non-ideal parameters, Monolithic IC operational amplifiers, specifications, slew rate and methods of improving slew rate.	10
Unit 2	Linear applications of IC op-amps: Inverting and non-inverting amplifier configurations, integrators, differentiators, summers, effect of finite GBP, stability consideration, active and passive compensation of op amp. Non-Linear applications of IC op-amps: Log/ antilog modules, Precision Rectifier, Op-amp as comparator, Schmitt Trigger, Square and Triangular wave generator, mono stable and astable-multivibrators.	10
Unit 3	Analog filter design : Basics second order functions, op-amp RC and active filter design, immittance converters and inverters, generalized impedance converter, inductance simulation, Sinusoidal oscillators, amplitude stabilization and control. Operational Transconductance Amplifier (OTA), Basic building blocks using OTA, Application examples.	10
Unit 4	Analog Multiplier and its applications: Gilbert multiplier cell 2-quadrant and 4-quadrant operations, IC analog multiplier AD534, modulation, demodulation and frequency changing, voltage-	6

	controlled filters and oscillators.	
Unit 5	IC timer and phase locked loop: the IC 555 timer, operational modes, time delay, astable and monostable operations , voltage-controlled oscillators, IC PLL: basic PLL principle, three modes of operation, PLL as AM detector, FM detector, frequency synthesis, FM demodulator, PLL motor speed control and voltage to frequency converter.	6
Total		**42**

Books:-

S. No	Name of Books/Authors/Publisher
1	Applications and Design with Analog Integrated Circuits/ J. Michel Jacob/ PHI, 2004
2	Design of Analog Filters/Rolf Schaumann and Mac E.VanValkenburg/ Oxford Indian Edition, 2005
3	Analysis and Design of Analog Integrated Circuits/ Paul R.Gray, Robert G.Meyer/ Wiley, Third edition, 2009
4	Design with Operational Amplifiers and Analog Integrated Circuits/ Sergio Franco/ TMH, 2013
5	Microelectronic circuits: Analysis and Design/ M.H. Rashid/ CENGAGE Learning, 2nd Edition, 2009

Department Core Course-12 (DCC)

EC305: Microwave & RF Communication

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Microwave and RF Communication	3	0	2	Electromagnetic Filed Theory

Course Objective: This course aims to provide in-depth knowledge to the student about various microwave components, Microwave amplifiers, oscillators and its applications in communication systems

Course Outcomes:

- CO1: To define and explain the microwave sub bands, various parameters and its applications.
- CO2: To describe the various components of microwave and their practical applications
- CO3: To describe various microwave tubes, state of art performance figures, relative advantages, and applications of competing devices
- CO4: To describe various semiconductor microwave devices, their state-of-the-art performance figures and comparison from practical point of view
- CO5: To learn basics of microwave antennas.

S. No.	Content	Contact Hours
Unit 1	Introduction to RF and Microwave Communication Systems: RF and Microwave sub-bands, microwave signal attenuation in different frequency bands, Scattering matrix: Reflection and Transmission coefficients. Symmetry, reciprocity, power, zero, and unitary properties. Planner Transmission Line: Microstrip line, types of Microstrip line, their comparison and application.	8
Unit 2	Microwave components: Waveguide couplings, bends and twists, Directional couplers, hybrid couplers, Matched load, Attenuators and phaseshifters, E-plane, H-plane and Hybrid Tees, Hybrid ring, Waveguidediscontinuities, Windows, Irises and	10

	Tuning screws, Diode Detector; Isolators and Circulators, tunable detector, slotted line carriage.	
Unit 3	Microwave Tubes: Limitation of conventional active devices at microwave frequencyVelocity modulation, Principle of operation, performance characteristics and application of two cavity Klystron, Multi-cavity Klystron, Reflex Klystron, TWT, Magnetron. Slow wave structures and their applications.	10
Unit 4	Microwave Semiconductor Devices: PIN diode, Tunnel diode, LSA diode, varactor diode, Parametric Amplifier, Gunn Devices, IMPATT, and TRAPATT, their principle of operation, characteristics, and applications.	8
Unit 5	Introduction to Antennas, Antenna parameters: Radiation intensity. Directivity. Power gain. Beam Width. Band Width. Radiation pattern, Analysis of Hertzian dipole, halfwave dipole, and monopole antenna. Microstrip Antennas: Basic characteristics of microstrip antennas, feeding methods, design of rectangular patch antennas	6
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Microwave Devices & Circuits/ Liao, S.Y./2nd Ed, PHI, 2003
2	Foundations for Microwave Engineering/ Collin, R.E. /2nd Ed, TMH, 2007
3	Microwave and Radar Engineering/M.Kulkarni /5th Ed,Umesh,2003
4	Understanding Microwaves/AllanW.Scott/1sted,Wiley-Interscience/1993

Department Elective Course-1 (DEC-1)

EC307: Semiconductor Device Electronics

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Semiconductor Device Electronics	3	1	0	Analog Electronics

Course Objective: To develop basic semiconductor physics concepts for better understanding of current and future devices so that their applications to electronic and optoelectronic device based circuits can be appreciated.

Course Outcomes: CO1: Describe the Short Channel Effects in Semiconductor Devices. CO2: Elucidate the Silicon on Insulator Technology (SOI) Technology. CO3: Classify and describe Multigate devices based on FETs. CO4: Explain Ferroelectric Field Effect transistor and their operation. CO5: Elucidate the Reliability issues in Emerging Devices.

S. No.	Content	Contact Hours
Unit 1	Short Channel Effects: CMOS scaling theory, Velocity Saturation, Mobility effects, Temperature effects, Channel Length Modulation, Subthreshold conduction, High-k dielectric, DIBL, GIDL, Hot carrier effects	8
Unit 2	SOI Technology: Requirements of high-performance nanoscale devices, Silicon-oninsulator: FDSOI and PDSOI, Subthreshold swing	8
Unit 3	Multi-gate Transistors: Fin-FET, Gate-all-around, Mobility in Multigate MOSFETs, Radiation effect in multi-gate FETs	8
Unit 4	Ferroelectric Transistors and Stacked Transistors: Feature, Principle and Development of Ferroelectric transistors, Doped-ferroelectric layer, Fe-FET memory, Idea of Negative Capacitance FET. Concept of area scaling and channel stacking, General properties, and ideas about Nanosheet and Fork-sheet FET, Complementary FET, and their circuit applications	10
Unit 5	Reliability issues in Emerging Devices: Self-heating effect, Work function variations, Metal grain granularities (MGG), Random dopant fluctuation (RDF), Line edge roughness, Early aging	8
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Operation and Modelling of MOS Transistor/ Tsvidis Y. and McAndrew C, / 3rd Ed. 2011, Oxford Univ. Press, ISBN 978-0-19-517015-3
2	FinFET and Other multi-gate transistor/ Colinge J. P., / 2008, Springer, ISBN 978-0-387-71751-7
3	Ferroelectric gate Field effect transistor, device physics and application/ Yoon S. M,/ 2020, Springer
4	High -K materials in Multi-gate FET Devices/ CRC press, Taylor and Francis
5	Advance Theory of Semiconductor Devices / Karl,Hess,PrenticeHall(India)
6	Semiconductor Physics &Devices / Neamen / Donald A/Tata McGraw-Hill..
7	Semiconductor Devices Modeling &Technology /DasGupta,N. /PrenticeHall (India)

EC309: Bio-Medical Electronics & Instrumentation

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Bio-Medical Electronics & Instrumentation	3	1	0	NIL

Course Objective: To familiarize students with the fundamental principles and concepts of biomedical electronics and the functioning of biological systems from an engineering perspective.

Course Outcomes:

- CO1: Analyze the human physiological systems and their interaction with biomedical instruments. analyze biomedical signals such as ECG, EEG, and EMG for diagnostic and monitoring purposes.
- CO2: Utilize appropriate electrode and transducers for measuring various physiological parameters.
- CO3: Evaluate the principles, functioning, and applications of various medical imaging modalities like X-Ray, CT, MRI, and ultrasound.
- CO4: Apply signal processing methods to filter, analyze, and interpret biomedical signals for enhanced diagnostics.

S. No.	Content	Contact Hours
Unit 1	Principles of biomedical instrumentation and techniques, SOURCES OF BIOMEDICAL SIGNALS, General block diagram of a medical instrumentation system, Physiological systems, Action Potential, Biopotential of electrodes, polarization, Functional organization of peripheral nervous system,	10
Unit 2	ECG, EEG, EMG, ERG **Biomedical Instrumentation Systems** Block diagram and working principles of: o Electrocardiogram (ECG) o Electroencephalogram (EEG) o Electromyography (EMG) o Electroretinography (ERG)	8

	◦ Blood pressure monitors ◦ Spirometers • Patient monitoring systems • Implantable medical devices (pacemakers, defibrillators, etc.)	
Unit 3	**Medical Imaging Systems:** Introduction to medical imaging modalities, X-Ray imaging and computed tomography (CT), Ultrasound imaging,Magnetic Resonance Imaging (MRI), Nuclear medicine (PET, SPECT), Basics of image processing in medical systems	8
Unit 4	**Biomedical Signal Processing:** Fundamentals of signal processing, Noise removal and artifact rejection,Feature extraction and analysis, Frequency-domain and time-domain analysis, Applications in diagnostics and monitoring	8
Unit 5	**Recent Trends in Biomedical Electronics** Introduction to Artificial Intelligence in healthcare, Wearable healthcare devices and applications, Robotics in surgery and rehabilitation, Nanotechnology in medical devices, Advanced biosensors and lab-on-chip devices	8
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Handbook Of Biomedical Instrumentation / R.S.Khandpur/3rd Edition/ Tata McGraw Hill Publishers 2014.
2	Biomedical Instrumentation and Measurements /Leslie Cromwell/ 2nd Edition/PHI 1990.
4	Medical Instrumentation: Application and Design / John G. Webster/5th Edition/Wiley 2020.

EC311: Algorithms Design and Analysis

Details of course:-

Course Title	Course Structure			Pre-Requisite: Nil
	L	T	P	
Algorithms Design and Analysis	3	1	0	NIL

Course Objective: Upon completion of this course, students will be able to do the following:

1. Analyze the asymptotic performance of algorithms.
2. Write rigorous correctness proofs for algorithms.
3. Demonstrate a familiarity with major algorithms and data structures.
4. Apply important algorithmic design paradigms and methods of analysis.
5. Synthesize efficient algorithms in common engineering design situations

Course Outcomes:

CO1: Analyze the correctness, efficiency and asymptotic runtime complexity of algorithms including formulating recurrence relations.

CO2: Understand and analyse different sorting algorithms.

CO3: Understand and design algorithms using greedy strategy, divide and conquer approach, dynamic programming, demonstrate a familiarity with major algorithms and data structures.

CO4: Able to Describe the classes P, NP, and NP Complete and be able to prove that a certain problem is NP-Complete.

S. No.	Contents	Contact Hours
Unit 1	Introduction: Concept of algorithmic efficiency, run time analysis of algorithms, Asymptotic Notations. Growth of Functions, Master's Theorem	06
Unit 2	Searching and Sorting: Structure of divide-and-conquer algorithms; examples: binary search, quick sort, Stassen Multiplication; merge sort, heap sort and Analysis of divide and conquer run time recurrence relations.	06
Unit 3	Greedy Method: Overview of the greedy paradigm examples of exact optimization solution: minimum cost spanning tree, approximate solutions: Knapsack problem, Kruskal's algorithm and Prim's algorithm for finding Minimum cost Spanning Trees, Dijkstra's and Bellman Fort Algorithm for finding Single source shortest paths.	10
Unit 4	Dynamic programming: Principle of dynamic programming. Applications: Floyd-Warshall algorithm for all pair shortest paths. Matrix multiplication, Traveling salesman Problem, longest Common sequence, Back tracking: Overview, 8-queen problem, and Knapsack problem.	06
Unit 5	Branch and bound: LC searching Bounding, FIFO branch and bound, LC branch and bound application: 0/1 Knapsack problem.	06
Unit 6	Computational Complexity: Complexity measures, Polynomial Vsnon-polynomial time complexity; NP-hard and NP-complete classes, examples: Circuit Satisfiablity, Vertex cover, Subset Sum problem, Randomized Algorithms, String Matching, NP-Hard and NP-Completeness, Approximation Algorithms, Sorting Network, Matrix Operations, Polynomials and FFT, Number Theoretic Algorithms.	08
	Total	42

Books: -

S. No	Name of Books/Authors/Publisher
1	Introduction toAlgorithms/T .H .Cormen, C .E .Leiserson, R .L .Rivest/ PHI/Fourth edition/2022
2	Fundamentals of Computer Algorithms/E. Horowitz, S. Sahni, and S. ajsekaran/Galgotia Publication/Second edition/2019
3	Computer Algorithms/Sara Basse, A. V. Gelder/Addison Wesley/Third Edition/2002

EC313: Microprocessor and Interfacing

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Microprocessor and Interfacing	3	0	2	Digital Design-I (Digital Electronics)

Course Objective: To introduce the basic architecture of microprocessors, assembly language programming, and interfacing with peripherals like USART, Priority Interrupt Controller, Programmable Timers, Memory, etc.

Course Outcomes:
CO1: Understand Microprocessor Fundamentals: focusing on the 8-bit microprocessor (8085) architecture, instruction sets, and addressing modes. Develop, basic assembly language programs for microprocessor-based applications.

CO2: Comprehend the architecture, memory segmentation, and bus cycles of the 8086 microprocessors. Apply addressing modes and develop assembly language programs for the 8086 microprocessor.

CO3: Analyze and use programmable devices like 8257 (DMA), 8255 (PPI), 8251 (USART), and 8259 (Programmable Priority Controller) in system design.

CO4: Understand the operation and interfacing of the Programmable Interval Timer (8253/8254), ADC and DAC interfacing, and its applications.

CO5: Gain knowledge about advanced microprocessors such as 80186/80286, and the transition to 32-bit and 64-bit processors.

S. No.	Content	Contact Hours
Unit 1	Introduction to the microprocessor, history of computers, timing, and control,memory devices-semiconductor memory organization, category of memory, 8-bit microprocessor (8085): Architecture, Instruction set, Addressing mode, assembly language programming	10
Unit 2	16-bit microprocessor (8086): architecture, physical address, segmentation, memory organization, bus cycle, addressing modes, assembly language programming of 8086.	12
Unit 3	Data transfer scheme: introduction, types of transmission, 8257(DMA),8255(PPI), serial data transfer (USART 8251), programmable priority controller (8259).	10

Unit 4	Programmable interval timer/ counter (8253/8254): introduction, Operating modes, interfacing of 8253, application. ADC/DAC: introduction ADC IC (0808/0809), DAC and ADC interfacing and applications.	6
Unit 5	Introduction to 80186/80286, Advance microprocessor: introduction to32-bit and 64-bit microprocessor.	4
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Microprocessor Architecture, Programming and Applications with 8085/Gaonkar Ramesh S/Penram International Publishing, 6th edition, Jan 2013
2	Microprocessor interfacing/D.V. Hall/TMH,Third edition, July 2017
3	Microcomputer systems: the 8086/8088 family architecture programming and design/ Y C Liu and G. A. Gibson/Pearson 2nd edition, 2009
4	The Intel Microprocessor 8086/8088. 80186, 80286, 80386 and 80486 Architecture Programming and Interfacing/ Barry B Brey/ Pearson, 8th Edition January 2012.
5	Digital system design and microprocessors/John P. Hayes/McGraw Hill publication/ January 2005

EC315:IC Technology

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
IC Technology	3	1	0	Nil

Course Objective: To provide an understanding of the manufacturing methods and their underlying scientific principles in the context of technologies used for VLSI chip fabrication.

Course Outcomes: CO1: Describe the CMOS Circuits. CO2: Explain the Operating Principles of MOS Transistors. CO3: Elucidate the Fabrication of CMOS Integrated Circuits. CO4: Apply MOSFET based Circuit Characterization.

S. No.	Content	Contact Hours
Unit 1	Introduction to CMOS Circuits: MOS Transistor Switches, CMOS Logic, Circuit and System Representation	6
Unit 2	Operating Principles of MOS Transistors: Complementary Device Current Voltage equations, Complementary CMOS Inverter- DC characteristics	6
Unit 3	Fabrication of CMOS Integrated Circuits: Introduction, Crystal and growth, Cleaning and Etching of wafers, Oxidation of Silicon, Thin Film Deposition, Basic CMOS Technology, Basic n-well CMOS process, P-well process, Twin-Tub process, Ion-Implantation and Diffusion, Silicon-on-Insulator process, CMOS Process Enhancements, Interconnects, Circuit Elements, Latch-Up, Prevention techniques.	16
Unit 4	Circuit Characterization: Introduction, Resistance Estimation, Capacitance Estimation, Switching characteristics, Analytic delay models, Gate delay, CMOS-gate transistor sizing, Power Dissipation, Scaling of MOS transistor dimensions.	14
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	handhi, S. K. VLSI Fabrication Principles: Silicon and Gallium Arsenide. John Wiley and Sons Inc., New York , 1983.
2	Sze, S. M. Physics of Semiconductor Devices, Second edition Wiley Eastern Limited, New Delhi , 1981.
3	Sze, S. M. VLSI Technology, Second Edition, McGraw-Hill Book Company, New Delhi , 1988.
4	Nicollian, E. H. and J. R. Brews MOS (Metal Oxide Semiconductor) Physics and Technology , John Wiley and Sons, New York , 1982.
5	May G. S. and S. M. Sze , Fundamentals of Semiconductor Fabrication , Wiley, 2004.
6	Plummer J. D., Deal M. D. and P. B. Griffin , Silicon VLSI Technology: Fundamentals, Practice and Modeling , Pearson/PH, 2001.

EC317: Control Systems

Details of course:-

Course Title	Course Structure			Pre-Requisite:
	L	T	P	
Control Systems	3	1	0	Signals and Systems, Network Theory

Course Objectives:

1. To introduce students to the fundamental concepts of control systems, including system classification, feedback mechanisms, and mathematical modeling techniques.
2. To help students understand stability and performance analysis of control systems using tools like root locus, Bode plots, and Nyquist plots.
3. To develop the ability to design compensators, such as lead-lag compensators, to meet specific system requirements
4. To enable students to analyze the effects of system parameters on stability and performance using classical and frequency-domain approaches.
5. To provide a comprehensive understanding of state-space modeling, including controllability, observability, and state-feedback design in control systems.

Course Outcomes:

CO1: Explain the classification of control systems, their mathematical models, and the role of feedback in achieving stability and performance improvement.

CO2: Apply classical techniques, including root locus, Bode plots, and Nyquist criteria, to determine the stability and performance of control systems.

CO3: Analyze system responses in time and frequency domains to assess transient and steady-state behavior and evaluate system performance indices.

CO4: Investigate the impact of controllers and compensators, such as P, PI, PID, lead, and lag compensators, on the dynamic behavior and stability of control systems

CO5: Assess state-space representations for controllability and observability, and design state-feedback solutions to enhance control system performance.

S. No.	Content	Contact Hours
Unit 1	Introduction to Control System: Linear, Non Linear, Time Varying and Linear Time Invariant System, Mathematical Modelling of Physical Systems, Differential Equations of Physical Systems, Transfer Functions, Block Diagram Algebra and Signal Flow Graphs. Feedback and Non feedback Systems. Reduction of Parameter Variations by use of Feedback Control Over System Dynamics. Feedback Control of Effects of Disturbance	10
Unit 2	Time Response Analysis: Standard Test Signals, Time Response of First-order Systems, Time Response of Second-Order Systems, Steady-State Error and Error Constants, Effect of Adding a Pole/ Zero to a System, P, PI and PID Control Action and Their Effect, Design Specifications of Second-Order Systems and Performance Indices. The Concept of Stability, Necessary Conditions for Stability, Hurwitz Stability Criterion, Routh Stability Criterion and relative Stability Analysis. The Root Locus Concept, Construction of Root Loci, Root Contours, Systems with Transportation Lag, Sensitivity of the Roots of the Characteristic equation, MATLAB: Analysis and Design of Control Systems	12
Unit 3	Frequency Response Analysis: Correlation Between Time and Frequency Response, Polar Plots, Nyquist plots Bode Plots. Stability in Frequency Domain: Mathematical Preliminaries, Nyquist Stability Criterion, Calculation of Gain Margin and Phase Margin in Nyquist Plot and Bode Plot, Assessment of Relative Stability Using Nyquist Criterion and Closed-Loop Frequency Response	10
Unit 4	Compensator and Physical System Design: Design of Lag, Lead, Lead Lag compensator; DC and AC Servomotors,Synchro Error Detector and Tacho Generator.	04
Unit 5	Control Systems Analysis in State Space: State-Space Representations of Transfer-Function Systems in physical variable, phase variable and canonical form, Solving the Time-Invariant State Equation, state transition matrix and its properties,controllability and observability.	06
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Modern Control Engineering/ Katsuhiko Ogata/Fifth Edition Prentice Hall 2015
2	Automatic Control Systems/ Dr. Farid Golnaraghi, Dr. Benjamin C. Kuo/ 10th Edition Tata McGraw Hills 2017
3	Control System Engineering: I J Nagrath , M Gopal/ 7th Edition New Age International Private Limited 2021

III Year: SIXTH SEMESTER (EVEN)

Department Core Course-13 (DCC)

EC302: VLSI Design

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
VLSI Design	3	0	2	-

Course Objective:To give the student an understanding of the different design steps required to carry out a complete digital VLSI (Very-Large-Scale Integration) design in silicon.

Course Outcomes:

CO 1. Describe the technology, design concepts, electrical properties and modelling of MOS device.
CO2. Analyze static and timing parameters of inverters and design inverters as per specification
CO3. Design static combinational logic circuits using CMOS, Transmission gates and complementary pass transistor logic
CO4. Apply dynamic circuit techniques to combinational circuit design
CO5. Design and analyze Static and Dynamic Sequential logic circuit and evaluate timing parameters
CO6. Describe design process of memory, design methodologies and apply concept of hierarchy, modularity and locality in designs

S. No.	Content	Contact Hours
Unit 1	Introduction to VLSI, Manufacturing process of CMOS integrated circuits, CMOS n-well process design rules packaging integrated circuits, stick diagram, IC layout and design tools, trends in process technology MOS transistor, Energy band diagram of MOS system, MOS under external bias, derivation of threshold voltage equation, gradual channel approximation, MOS I V characteristics secondary effects in MOSFETS MOSFET scaling and small geometry effects, MOS capacitances, MOS C-V characteristics	8
Unit 2	MOS inverters: Resistive load inverter, inverter with n-type MOSFET	8

	load, CMOS inverter: Switching Threshold, Noise Margin, Dynamic behaviour of CMOS inverter,computing capacitances, Propagation delay,Inverter design with delay constraint, Estimation of interconnect Parasitics, Calculation of interconnect delay Static and Dynamic power consumption, energy, and energy delay product calculations	
Unit 3	Designing Combinational Logic Gates in MOS and CMOS: MOS logic circuits with depletion MOS load. Static CMOS Design: Complementary CMOS, Ratioed logic, Pass transistor logic, pseudo nMOS logic, DCVSL logic Dynamic CMOS logic, clocked CMOS logic CMOS domino logic, NP domino logic, speed and power dissipation of Dynamic logic, cascading dynamic gates.	8
Unit 4	Designing sequential logic circuits: Timing matrices for sequential circuits, classification of memory elements, static latches and registers, the bistability principle, multiplexer based latches , Master slave Edge triggered register, static SR flip flops,dynamic latches and registers, dynamic transmission gate edge triggered register, the C2MOS register, TSPC register Pulse registers, sense amplifier based registers, Pipelining, Latch verses Register based pipelines, NORA-CMOS. Two-phase logic structure	10
Unit 5	Semiconductor memories, DRAM, SRAM, Nonvolatile memory, Flash memory, Introduction to memory peripheral circuits VLSI designing methodology –Introduction, VLSI designs flow, Computer aided design technology: Design capture and verification toolsDesign Hierarchy Concept of regularity, Modularity & Locality, VLSI design style, Design quality	8
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	CMOS digital integrated circuits by Sung MO Kang Yusuf Leblebici, Tata McGraw Hill Publication.
2	Digital integrated circuits a design perspective by Jan M Rabaey, Anantha Chadrakasan Borivoje Nikolic, Pearson education.
3	Principle of CMOS VLSI Design by Neil E Weste and Kamran, Eshraghian, Pearson education.

Department Core Course-14 (DCC)

EC304: Embedded Systems

Details of Course: -

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Embedded Systems	3	0	2	Knowledge of Computer Architecture and Microprocessor

Course Objective:

To introduce fundamentals of 16 and 32-bit Microcontrollers and assembly language programming. The course also focuses on the interfacing of different interrupt-driven peripherals. It also covers in detail Real-Time Operating Systems, Bus architecture, and Digital Signal Processors.

Course Outcomes:

CO1:Explain the basic principles, architecture, and significance of microcontrollers.
CO2:Demonstrate programming skills using PIC and ARM microcontrollers, focusing on memory interfacing and peripherals.
CO3:Describe the internal architecture and interfacing of peripheral devices with microcontrollers.
CO4:Illustrate the principles, applications, and working of digital signal processors and their variants.
CO5:Analyze the memory organization of ARM microcontrollers, RT-Linux introduction, RTOS kernels, and real-time scheduling bus structures.

Syllabus:

Unit	Content	Contact Hours
1	Overview of Embedded Systems: Characteristics of Embedded Systems. Comparison of Embedded Systems with general purpose processors. General architecture and functioning of micro controllers. PIC micro controllers: Architecture, memory interfacing, interrupts, instructions, programming and peripherals.	12
2	ARM: Architecture, memory interfacing, interrupts, instructions and Assembly Language programming. Exception processing and pipeline architecture and applications.	12
3	Digital Signal Processors: DSP Architecture, DSP applications, algorithms, data path, memory, addressing modes, peripherals. TI and Sharc family of DSP processors.	6
4	SRAM, DRAM working and organization. Interfacing memory with ARM 7.	8

5	RTOS: RT-Linux introduction, RTOS kernel, Real-Time Scheduling Bus structure: Time multiplexing, serial, parallel communication bus structure. Bus arbitration, DMA, PCI, AMBA, I2C and SPI Buses.	4
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Computers as components: Principles of Embedded Computing System Design/ Wayne Wolf/ Morgan Kaufman Publication/ 2000
2	ARM System Developer's Guide: Designing and Optimizing System Software/ Andrew N. Sloss, Dominic Symes, Chris Wright, Morgan Kaufman Publication/ 2004
3	Design with PIC Microcontrollers/ John B. Peatman, Pearson Education Asia/ 2002
4	The Design of Small-Scale embedded systems/ Tim Wilmshurst, Palgrav/ 2003
5	Embedded System Design/Marwedel, Peter, Kluwer Publishers/ 2004

Department Elective Course-2 (DEC-2)

EC306: Flexible Electronics

Details of Course: -

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Flexible Electronics	3	1	0	Basics of Semiconductor Devices

Course Objective:

To introduce flexible electronic devices and their analog/digital/bio-medical applications, thin film transistor structural diversity, modeling, and parameters extraction, contact resistance and differential model, solar cell, organic LED and others so that the student is equipped to design and analyse a preliminary flexible electronic device/circuit.

Course Outcomes:

CO1:Identify different thin-layer materials for a flexible transistor, solar cells, and LED
CO2:Interpret structural diversity, operation, and characteristics of thin film transistor (TFT)
CO3:Determine analytical models and performance parameters for different TFT structures
CO4:Analyze Multilayer structures for flexible solar cells, LED, and their applications
CO5:Illustrate analog and digital electronic applications using flexible electronic devices

Details of the Course:

Unit	Content	Lecture Hours
1.	Introduction to Flexible Electronics, Benefits over conventional technology, Applications and Limitations. Organic Materials: Semiconductors (p-/n- type), Electrodes, Dielectrics, Substrates, Organic semiconductors, Charge Injection and Transport, concept of HOMO/LUMO, Solution processed fabrication techniques.	8
2	Thin Film Transistor: Structure. Operating Principle, Electrical Characteristics, Extraction of performance parameters, Classification of different Thin Film Structures: Single Gate, Dual Gate, Cylindrical, Vertical TFT, Front and Back Gate Biasing, Advanced structures for flexible transistor, Impact of structural Parameters on TFT performance.	10

3.	Contact Resistance: Origin of Contact Resistance and RC Model for flexible TFT, Resistance Extraction using TLM and Differential Model for linear and saturation regions, Analytical modeling for single gate, dual gate and cylindrical TFTs	8
4.	Organic LEDs: Electrical Characteristics, Multi-layered Architecture, Charge Blocking layers, Injection and Transport Layers, Organic solar cell: Structure, parameters, and characteristics. Applications: Display, sensors, bio-medical applications and Implantable bioelectronics	8
5.	Analog and Digital applications of Flexible TFT: Inverter design and characteristics, all-p DLL and ZVLL configurations for logic gates, Bootstrapping, Voltage Amplifier, all-p SRAM cell, OTFT driven OLED circuit.	8
TOTAL		**42**

Books:

1.	Hagen Klauk, Organic Electronics: Materials, Manufacturing and Applications, Wiley-VCH, 2006.
2.	B. K. Kaushik, B. Kumar, S. Prajapati and P. Mittal, Organic Thin Film Transistor Applications: Materials to Circuits, CRC Press, 2016.
3.	K. Mullen and U. Scherf, Organic Light Emitting Device: Synthesis Properties and Applications, Wiley-VCH, 2005.
4.	Hagen Klauk, Organic Electronics II: More Materials and Applications, Wiley-VCH, 2012.
5.	F. U. A. Nathan, Y. Wu and Beng S Ong, Organic Thin Film Transistor Integration, A Hybrid Approach, Wiley-VCH, 2011.

EC308: Analog Filter Design

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Analog Filter Design	3	0	2	Signals and Systems, Network Analysis, Basic Electronics

Course Objective: To introduce the fundamental concepts of analog filters and their applications in signal processing and the design and analysis of passive and active analog filters.

Course Outcomes:
CO1: Analyze and classify analog filters based on their frequency response and transfer functions
CO2: Design passive and active analog filters using Butterworth, Chebyshev, and Bessel approximations
CO3: Evaluate the performance of analog filters in terms of frequency response, phase response, and stability.
CO4: Implement analog filter circuits using operational amplifiers and passive components
CO5: Apply analog filter design principles to real-world engineering problems in communication and signal processing.

S. No.	Content	Contact Hours
Unit 1	Overview of analog filters and their applications Classification of filters: low-pass, high-pass, band-pass, and band-stop. Filter specifications: passband, stopband, cutoff frequency, ripple, and roll-off Introduction to transfer functions and pole-zero plots	8
Unit 2	- RC, RL, and RLC circuits as basic filter structures, First-order and second-order passive filters, Frequency response, and Bode plots. Limitations of passive filters	10
Unit 3	Introduction to operational amplifiers (Op-Amps) in filter design, First-order and second-order active filters Sallen-Key topology and its variants Multiple feedback (MFB) filters	8

Unit 4	Butterworth filters: maximally flat magnitude response Chebyshev filters: equiripple response in passband or stopband Bessel filters: linear phase response Elliptic filters: equiripple in both passband and stopband Cascading first-order and second-order filters,Design of higher-order Butterworth and Chebyshev filters Sensitivity analysis and stability considerations	10
Unit 5	Component selection and practical considerations Tuning and testing of analog filters, Introduction to switched-capacitor filters Simulation of analog filters using MATLAB, SPICE, or Multisim Frequency response and transient analysis Comparison of theoretical and simulated results	6
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Analog Filter Design/M. E. Van Valkenburg /Oxford University Press/1982
2	Design of Analog Filters/R. Schaumann and M. E. Van Valkenburg /Oxford University Press, 2001
3	Active Filter Design/Alan B. Williams /Artech House on Demand/1975

EC310: Testing and Diagnosis of Digital System Design

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Testing and Diagnosis of Digital System Design	3	1	0	NIL

Course Objective: To provide students with a comprehensive understanding of digital system testing techniques, fault detection methods, fault tolerance mechanisms, and design for testability concepts.

Course Outcomes:

CO1: Analyze combinational and sequential digital circuits for various types of faults.
CO2: Generate test vectors for faults in digital circuits.
CO3: Identify machines from the input-output sequence.
CO4: Design the fault-tolerant digital systems.
CO5: Describe the methods of design for testability.

S. No.	Content	Contact Hours
Unit 1	Defect, Fault, Error and Failure, fault modelling, fault detection, fault equivalence, fault dominance. Types of faults: stuck at faults, bridging faults, stuck open faults, transient faults, permanent faults.	6
Unit 2	Controllability and Observability: SCOAP, test generation for combinational logic circuits: Path sensitization, Boolean difference method, D-algorithm, PODEM.	8
Unit 3	Testing of sequential circuits: Successor tree, homing tree, distinguishing tree, synchronizing tree, machine identification experiments, checking experiments. Types of faults in RAM, Fault detection in memories: MARCH algorithms.	10
Unit 4	Self-checking circuits, Self-checking in Programmable Logic Arrays. Fault tolerance techniques for combinational and sequential circuits.	8

Unit 5	Design for testability: Random test generation, transition count testing, signature analysis, syndrome testable design, Built In Self Test, Level sensitive scans design, BILBO, BIDCO, Boundary Scan Standard.	10
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Essentials of Electronic Testing for Digital Memory and mixed-signal VLSI Circuits/ Michael L Bushnell and Vishwani D Agrawal, /Springer
2	An Introduction to Logic Circuit Testing/ PK Lala/ Springer Nature, 2008.

EC312: Software Defined Radio

Details of course :-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Software Defined Radio	3	1	0	Digital Communication, Probability and Random Processes

Course Objective:Introduce Software Defined Radio, Cognitive Radio fundamentals, Dynamic Spectrum Access & Sharing and key applications.

Course Outcomes

CO1: Describe the fundamental concepts of software-defined radio, cognitive radio, spectrum management and associated policy challenges.

CO2: Outline the fundamental technologies enabling cognitive radios for dynamic spectrum environments.

CO3: Illustrate spectrum awareness, sensing& identification, dynamic spectrum access &sharing, and fundamental trade-offs.

CO4: Analyze different transmission techniques and challenges to achieve solutions for dynamic spectrum access.

CO5: Elucidate and examine cognitive radio network architectures, reconfiguration, adaptation&optimization. User cooperative wireless communications, throughput maximization and interference management.

S. No.	Content	Contact Hours
Unit 1	Introduction to Cognitive Radio: Hardware and software architectures of cognitive radio, Smart Antennas used in Cognitive Radio, Spectrum Management, Opportunities in Spectrum Access, and Policy Challenges for Cognitive Radios.	**6**
Unit 2	Technologies in Cognitive Radio: Radio Flexibility and Capability, Comparison of Radio Capabilities and Properties, Available Technologies for Cognitive Radios Radio Frequency Translation for Software Defined Radio Receiver Design Considerations, Transmitter Design Considerations,	**6**

	Candidate Architectures for SDR.	
Unit 3	Spectrum awareness, sensing and identification: Primary Signal Detection, From Detecting Primary Signals to Detecting Spectrum Opportunities, Fundamental Trade-offs: Performance versus Constraint, Fundamental Trade-offs: Sensing Accuracy versus Sensing Spectrum Access and sharing Unlicensed Spectrum Sharing, Licensed Spectrum Sharing, Secondary Spectrum Access, Non-Real-Time SSA, Real-Time SSA.	**9**
Unit 4	Transmission Techniques: Wireless Transmission for Dynamic Spectrum Access, Non-contiguous Orthogonal Frequency Division Multiplexing, NC-OFDM-Based Cognitive Radio: Challenges and Solutions, Overhead Interference Avoidance Problem, Spectral Footprint Minimization, Spectrum Usage Reporting, Potential Interference Analysis, Link Rendezvous, Distributed Sensing and Operation Channel Awareness and Multiple Signals in Space.	**9**
Unit 5	Reconfiguration, adaptation, and optimisation: Adaptation Engine Operating Parameters, Parameter Relationships, Cognitive Adaptation Engines Cognitive radio network architectures: Overview of Architectures Topology-Aware CRN Architectures, Publish-Subscribe CRN Architecture, Introduction to User cooperative communications, Relay Channels and User Cooperation in Wireless Networks,Multi-hop Relay Channel, Cross-layer optimization for multi-hop cognitive radio networks, Mathematical Models at Multiple Layers A Case Study: The Throughput Maximization Problem Numerical Results for the Throughput Maximization.	**12**
	Total	**42**

Books:-

S. No	Name of Books / Authors/ Publishers
1	Cognitive Radio Communications and Networks Principles and Practice/ Alexander M. Wyglinski, Maziar Nekovee, Y. Thomas Hou/ Elsevier/ 2010.
2	Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems/ Edited by HÜSEYIN ARSLAN, University of South Florida, Tampa, FL, USA/Springer, 2007.
3	Cognitive Radio Technology/ Bruce A. Fette/ Elsevier, 2009.

EC314: Machine Learning

Details of course: -

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Machine Learning	3	0	2	Probability theory, linear algebra, and programming language (C, Python, MATLAB)

Course Objective: To provide theoretical basis of machine learning and a set of concrete algorithms with programming.

Course Outcomes:

CO1: Describe the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc.

CO2: Explain the underlying mathematical relationships within and across Machine Learning algorithms.

CO3: Compare and contrast different paradigms for learning (supervised, unsupervised, etc.).

CO4: Analyze the concept of neural networks and design the same.

CO5: Design the appropriate machine learning techniques for different real-world problems.

S. No.	Content	Contact Hours
Unit 1	**Introduction to machine learning, Basic concepts**: Definition of learning systems, Goals and applications of machine learning. Aspects of developing a learning system: training data, concept representation, function approximation. Types of Learning: Supervised learning and unsupervised learning. Overview of classification: setup, training, test, validation dataset, overfitting. Machine Learning Fundamentals: Bias and Variance, Cross-validation, Confusion matrix, Sensitivity and Specificity, ROC and AUC.	10
Unit 2	**Supervised Learning**: Linear Regression, Multivariate Regression, Maximum Likelihood Estimation, Logistic regression, Discriminant Analysis, Naive Bayes, Support vector machines: Optimal hyperplane, Kernels. **Regularization Techniques**: Ridge Regression (L2 Norm), Lasso Regression (L1 Norm), Elastic-Net Regression. Classification	8

	Families: Linear Discriminative, Non-linear Discriminative, Decision Trees, Probabilistic (conditional and generative), Nearest Neighbor	
Unit 3	**Unsupervised Learning:** Clustering, K-means, EM Algorithm, Gaussian Mixture Models, PCA (Principal components analysis), ICA (Independent components analysis), latent semantic indexing. Spectral clustering, Markov models Hidden Markov models (HMMs). **Ensemble Methods**: Random Forest, Combining Classifiers: Bagging, boosting (The Ada boost algorithm), Classification errors, Model selection, and Feature selection.	10
Unit 4	**Reinforcement Learning and Control**: MDPs. Bellman equations, Value iteration and policy iteration, Linear quadratic regulation (LQR). LQG. Q-learning. Value function approximation, Policy search. Reinforce. POMDPs.	6
Unit 5	**Introduction to Deep Learning**: History of Deep Learning, Types of errors, Bias-variance trade-off, Overfitting-underfitting, Brief review of concepts from Vector Calculus and Optimization, Gradient Descent, Variants of Gradient Descent, Momentum, Computation graph, Vectorization and Broadcasting, Perceptron, Neural Networks, Generative learning algorithms.	8
	Total	42

Books: -

S. No	Name of Books/Authors/Publisher
1	Machine Learning/Tom.M.Mitchell/McGraw Hill International Edition, 2017.
2	Introduction to Machine Learning/Ethern Alpaydin/Eastern Economy Edition, Prentice Hall ofIndia, 2005.
3	Deep Learning/Ian Goodfellow, Yoshoua Bengio, and Aaron Courville/MIT Press Ltd, Illustrated edition, 2016.
4	Pattern Recognition and Machine Learning/Christopher M. Bishop/Springer, 2nd edition, 2009.

EC316: Wireless Sensor Networks

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Wireless Sensor Networks	3	1	0	Basics of Communication and Networking

Course Objective:To introduce basic concepts of Wireless Sensor Networkswith the knowledge of designing, deploying, and optimizing sensor-based communication systems which is reliable and power efficient for monitoring and control applications.

Course Outcomes:

CO1: Explain basic working of Sensor Networks and various protocols related to the same
CO2: Illustrate and analyse architecture and placement strategies of Sensors
CO3: Analyze routing and congestion algorithms
CO4: Design, develop, and carry out performance analysis of sensors on specific applications
CO5**:** Describe and implement solutions to real world problems using sensor devices, enumerating itsprinciples of working

S. No.	Content	Contact Hours
Unit 1	**Adhoc Networks:** Introduction. Routing protocols: proactive and reactive methods, backbone and position based, and power efficient routing.	8
Unit 2	**Sensor Networks:** Introduction and applications. Design issues and architecture.	8
Unit 3	**Sensor deployment:** Issues and challenges, Self organization, Localization.	10
Unit 4	**Data Fusion:** Tree construction algorithms and analysis, Asymptotic capacity, - Lifetime optimization formulations.	8
Unit 5	**Routing protocols:** data centric, hierarchical, location based, energy efficient routing etc.	4
Unit 6	Querying, data collection and processing.	4
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Handbook of Algorithms for Wireless Networking and Mobile Computing/AzzedineBoukerche/ Chapman & Hall, CRC, 2006.
2	Handbook of Sensor Networks: Compact Wireless and Wired sensing systems/ Mohammad Ilyas and ImadMahgoub/ CRC Press, 2005.
3	Wireless Sensor Network Designs/ Anna Hac/ John Wiley & Sons Ltd, 2003.
4	Wireless Sensor Networks: A systems perspective/ NirupamaBulusu and Sanjay Jha/ Artech House, 2005.
5	Wireless Sensor Networks: Architecture and Protocols/ Jr., Edgar H. Callaway/ Auerbach, 2003.
6	Wireless Sensor Networks/ C.S. Raghavendra, Krishna M. Sivalingam and TaiebZnati/ Springer, 2005.

Department Elective Course -3

EC318: RF MEMS Design and Technology

Course Title:	Course Structure			Pre-Requisite
	L	T	P	
RF MEMS Design and Technology	3	0	2	Electromagnetic Filed Theory

Course Objective:

1. Introduction to basics of RF MEMS and sensor system
2. To study the essential material properties of RF MEMS devices
3. To study various sensing and transduction techniques for RF MEMS
4. To know various fabrication and machining processes of different RF MEMS devices
5. To be able to design various RF MEMS devices in a 3-D simulator

Course Outcomes:

CO1: To know important concepts applicable to RF MEMS and their fabrication.
CO2: Understanding the working of RF MEMS sensors, actuators, switches, etc.
CO 3: Apply the concept of RF MEMS technology to design different devices for different applications
CO 4: Applications of RF MEMS device and their integration with system
CO 5: Be familiar with design and analysis the RF MEMS based devices in the 3-D simulator

S. No.	Contents	Contact Hours
Unit **1.**	Introduction and origin of MEMS, driving force for MEMS development, fabrication process and RF MEMS. RF MEMS material and fabrication technologies: Conventional IC fabrication processes, bulk micro machining, surface micro machining, LIGA process.	6
Unit **2.**	RF MEMS Sensors, Classification and terminology of sensors, evolution of semiconductor sensors, sensor characterization basic concept of acoustic, mechanical, magnetic, radiation, thermal sensors and integrated sensors.	8
Unit **3.**	Actuation mechanism for RF MEMS devices: Electrostatic switching, approaches for low-actuation-voltage switches, mercury contact switches, magnetic switching, electromagnetic switching, thermal switching, The RF MEMS switch; Cantilever based MEMS switch, Membrane based switch design microwave	10

	material and mechanical considerations.	
Unit **4.**	RF MEMS based components: transmission lines, membrane supported micro-strip line, coplanar waveguide, micro-machined waveguide, inductors, capacitors and tunable capacitors.	8
Unit **5.**	MEMS based RF and microwave circuits: RF MEMS antenna and reconfigurable antenna, phase shifter, resonators, filters etc. Integration and packaging for RF MEMS devices.	10
	TOTAL	**42**

Books:-

S. No	Name of Books/Authors/Publisher
1.	RF MEMS and Their Applications/ Vijay K. Varadan, K.J. Vinoy, K.A. Jose/ 1st Ed, John Wiley & Sons Inc2003
2.	RF MEMS Switches and Integrated Switching Circuits/ Ai Qun Liu/ 2nd Ed,Springer-Verlag New York Inc, 2010.
3.	RF MEMS Theory,Design and Technology/ Gaberiel M.Rebiz/1st Ed, John Wiley & Sons,2003.

EC320: Soft Computing

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Soft computing	3	1	0	Basic mathematics

Course Objective: A comprehensive of soft computing techniques and their applications in solving real-world problems.

Course Outcomes:

- CO1: Explain the fundamental concepts of soft computing techniques and their applications.
- CO2: Analyze various neural network architectures.
- CO3: Design fuzzy systems
- CO4: Explain fundamentals and operators of Genetic Algorithm.
- CO5: Apply soft computing techniques to solve real time problems.

S. No.	Content	Contact Hours
Unit 1	Introduction of soft computing, Soft Computing vs. Hard Computing, various types of Soft Computing Techniques, Applications of Soft Computing. Elementary search techniques: introduction to artificial intelligence, Breadth First Search, Depth First Search Techniques, other Search Techniques like Hill Climbing, Best First Search, A* Algorithm, AO* Algorithms and various types of Control Strategies, production systems	12
Unit 2	Neural Networks: Structure and Function of a single neuron: Biological Neuron, Artificial Neuron, definition of ANN, Taxonomy of Neural Net, Difference between ANN and Human Brain, Characteristics and Applications of ANN. Single Layer Network, Perceptron Training Algorithm.	10
Unit 3	Fuzzy Logic: Fuzzy set theory, Fuzzy Set Vs Crisp Set, Crisp relation & Fuzzy Relations. Fuzzy systems: Crisp Logic, Fuzzy Logic, Introduction & Features of Membership Functions. Fuzzy rule base system: Fuzzy Propositions, Formation, Decomposition & Aggregation of Fuzzy Rules, Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Decision Making & Applications of Fuzzy Logic.	10

Unit 4	Genetic Algorithm: Fundamentals, basic concepts, working principle, encoding, fitness function, reproduction. Genetic modeling: Inheritance operator, cross over, inversion & deletion, mutation operator, Bitwise operator, Generational Cycle, Convergence of GA, Applications & advances in GA. Fuzzification: Differences & similarities between GA & other traditional method.	10
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Principles of Soft Computing/S. N. Sivanandam and S. N. Deepa / 3rd Ed, Wiley, 2018.
2	Soft computing: fundamentals and applications /Pratihar and Dilip Kumar/ 2nd Ed, Alpha Science International, Ltd. 2013.
3	Fuzzy Logic, Intelligence, Control and Information /J. Yen and R. Langari /1st Ed, Pearson Education, 2022.
4	Artificial Intelligence Foundations of Computational Agents/David L. Poole and Alan K. Mackworth/ 3rd Ed,Cambridge university press, 2023.
5	Introduction to Soft Computing: Neuro-fuzzy and Genetic Algorithms /Samir Roy/ 1st Ed,Pearson India, 2013.

EC322: Operating Systems

Details of course: -

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Operating Systems	3	0	2	Data Structures

Course Objectives:

1. To provide students with a comprehensive understanding of operating systems' fundamental principles, architecture, and components.
2. To enable students to explore concepts related to process management, scheduling algorithms, and concurrency control.
3. To equip students with knowledge of memory management, including paging, segmentation, virtual memory, and handling memory allocation issues.
4. Introduce students to file organisation, access mechanisms, directory structures, and efficient I/O management strategies.
5. To provide insight into modern operating systems' features and design, such as Linux, Unix, and Windows.

Course Outcomes:

CO1: Describe the evolution, structure, classification and various functions of operating systems.
CO2: Illustrate process management and CPU scheduling.
CO3: Analyze deadlock, its characteristics, prevention, detection and recovery.
CO4: Assess various memory management schemes, such as virtual and cache memory, and their impact on performance.
CO5: Analyse I/O management & Disk Scheduling, file system, and implementation issues.
CO6: Explain and contrast features, functionalities, and design philosophies of modern operating systems like Windows, Linux, and Unix.

S. No.	Content	Contact Hours
Unit 1	Introduction: Operating system and function, Evolution of the operating system, Batch, Interactive, Time Sharing and Real-Time System, System protection. Operating System Structure: System Components, System Structure, Operating System Services.	6
Unit 2	Concurrent Processes: Process concept, Principle of Concurrency, Producer-Consumer Problem, Critical Section problem, Semaphores, Classical problems in Concurrency, Inter Process Communication, Process Generation, and Process Scheduling. CPU Scheduling: Scheduling Concept, Performance Criteria of Scheduling Algorithm, Evolution, Multiprocessor Scheduling.	9
Unit 3	Deadlock: System Model, Deadlock Characterization, Prevention, Avoidance and Detection, Recovery from Deadlock combined approach.	6
Unit 4	Memory Management: Base machine, Resident monitor, Multiprogramming with fixed partition, Multiprogramming with variable partition, Multiple base register, Paging, Segmentation, Virtual memory concept, Demand paging, Performance, Paged replacement algorithms, Allocation of frames, Thrashing, Cache memory organisation, Impact on performance.	9
Unit 5	I/O Management & Disk Scheduling: I/O devices and organisation of I/O function, I/O Buffering, DISK I/O, Operating System Design Issues. File System: File Concept, File Organization and Access Mechanism, File Directories, File Sharing, Implementation Issues	8
Unit 6	Case Studies: Windows, Linux and Unix	4
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Operating System Concepts/Silbersachatz, Galvin, Gagne/10th Edition, Pearson, 2018.
2	ModernOperating Systems/Tannenbaum/4th Edition, Pearson, 2016.
3	Unix Concepts and Applications/ Sumitabha Das/4th Edition, McGraw Hill.
4	Operating System Concepts/Milenekovic/McGraw Hill, 1992.
5	An Introduction to Operating System/Harvey M Dietel/ Pearson Education, 2004.
6	Beginning Linux Programming/Neil Matthew, Richard Stones/4th Edition, Wiley, 2007.

EC324: Speech Processing

Details of course: -

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Speech Processing	3	0	2	Signals and Systems, Probability Theory, and Digital Signal Processing

Course Objective: This course provides the foundation knowledge on speech production and perception along with processing of speech signal in digital domain.

Course Outcomes:

CO1: Analyse the speech production mechanism.

CO2: Illustrate the signal processing methods for speech recognition.

CO3: Describe various speech features extraction methods in time and frequency domain.

CO4: Design speech recognition system and identify implementation issues.

CO5: Explain models for automatic speech recognition.

S. No.	Content	Contact Hours
Unit 1	The Speech Production mechanism: Physiological and Mathematical Model, Relating the physiological and mathematical model, Categorization of Speech Sounds based on the source-system and the articulatory model.	8
Unit 2	Basic Speech Signal Processing Concepts: Discrete time speech signals, relevant properties of the fast Fourier transform and Z-transform for speech recognition, convolution, linear and non-linear filter banks, Spectral estimation of speech using the Discrete Fourier transform, Pole-zero modeling of speech and linear prediction (LP) analysis of speech, Homomorphic speech signals de convolution, real and complex spectrum, application of cepstral analysis to speech signals.	10
Unit 3	The Speech Recognition Front End: Feature extraction for speech recognition, Static and dynamic features for speech recognition, robustness issues, discrimination in the feature space, feature selection, Mel frequency cepstral co- efficient (MFCC), Linear	8

	prediction cepstral coefficients (LPCC), Perceptual LPCC.	
Unit 4	Distance measures for comparing speech patterns: Log spectral distance, cepstral distances, weighted cepstral distances, distances for linear and warped scales, Dynamic Time Warping for Isolated Word Recognition.	8
Unit 5	Statistical models for speach recognition, Vector quantization models and applications in speaker recognition, Gaussian mixture modeling for speaker and speech recognition, Discrete and Continuous Hidden Markov.	8
	Total	42

Books: -

S. No	Name of Books/Authors/Publisher
1	Speech and Language Processing – An Introduction toNatural Language Processing, Computational Linguistics, and Speech Recognition/Daniel Jurafsky and James H Martin/PearsonEducation, 2013.
2	Fundamentals of Speech Recognition/Lawrence RabinerandBiingHwang/ PearsonEducation, 2003.
3	Digital Processing of Speech Signals/L.R. Rabiner and S. W. Schafer/Pearson Education,2008.
4	Speech and audio signal processing andperception of speech and music/ Ben gold and Nelson Morgan/Wiley- India Edition, 2006 Edition.
5	Discrete-Time Speech Signal Processing – Principles and Practice/ Thomas F Quatieri, Pearson Education, 2001.

EC326: Digital Image Processing

Details of course: -

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Digital Image Processing	3	0	2	Signals and Systems

Course Objective:

1. To make students understand the theoretical foundation of digital image processing concepts.
2. To provide mathematical foundations for digital manipulation of images, image acquisition, preprocessing, enhancement, restoration, morphological operations, and segmentation.
3. To make students learn implementation of algorithms those perform basic image processing operations (e.g., histogram processing, noise removal & image enhancement, and restoration etc.).

Course Outcomes:

CO1:Define two-dimensional signals and systems, image acquisition, sampling, quantization, 2D signals and systems, image transforms, basics of color image processing.
CO2: Explain the mathematical tools used for digital manipulation of images.
CO3: Employ preprocessing, enhancement, filtering, and noise removal techniques.
CO4: Distinguish spatial domain and frequency domain filtering, enhancement, and restoration.
CO5:Evaluate various application specific techniques for enhancement, denoising, morphology, segmentation.
CO6: Develop solutions to real world image processing problems.

S. No.	Content	Contact Hours
Unit 1	Introduction to image processing, Fundamental steps in digital image processing, Concept of visual information, image formation model, Image sampling and quantization. Digital image representation, spatial and grey level resolution, relationship between pixels, Applications of image processing systems. Introduction to various color models: RGB, CMY, CMYK, HSI, HSV, and YCbCr	9
Unit 2	Introduction to Multidimensional signals and systems, 2D-signals, 2D-systems, classification of 2D systems, 2D convolution, 2D Z-transform. Image transform: 2D DFT, discrete cosine, discrete sine, Haar, Walsh, Hadamard, Slant, KL, SVD, Hough, Radon, Ridgelet.	9

Unit 3	Image enhancement: Spatial Domain: linear transformation, image negative, grey level shifting, non-linear transformation, logarithmic transformation, exponential transformation, grey level slicing, bit plane slicing, image averaging, mask processing, histogram manipulations, histogram thresholding, histogram stretching, histogram equalization, noise removing filters, smoothing filters, sharpening filters.	8
Unit 4	Enhancement in frequency domain: ideal low pass filter, Butterworth low pass filter, ideal high pass filter, Butterworth high pass filter, band pass filter, Gaussian filter, homomorphic filtering. Image restoration: degradation model, Noise models, Restoration in presence of noise, Periodic noise removal in frequency domain, Notch filters, Inverse filtering, Wiener Filtering.	8
Unit 5	Introduction to morphological image processing operations, dilation, and erosion, opening and closing, hit-or-miss transformation, boundary extraction, region filling, extraction connected components, convex hull, thinning, thickening, skeletons, pruning. Image segmentation: detection of discontinuities, edge linking and boundary detection, thresholding, region-based segmentation.	8
	Total	42

Books: -

S. No	Name of Books/Authors/Publisher
1	Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing"**,**Pearson Education, 2008, 3rd Edition
2	Anil K. Jain, "Fundamentals of Digital Image Processing", Pearson Education, PHI, 2001
3	Rafael C. Gonzalez, Richard E. Woods and Eddins, "Digital Image Processing using MATLAB"**,**McGraw Hill, second, 2013
4	K. R. Castleman, "Digital Image processing", Pearson Education, 2014
5	I. Pitas, "Digital Image Processing Algorithms and Analysis", John Wiley, 2002
6	Milan Sonka, Vaclav Hlavac, Roger Boyle, "Image Processing, Analysis, and Machine Vision",Brookes/Cole, PWS Publishing Company, Thomson Learning, 4th Edition

EC328: Information Theory and Coding

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Information Theory and Coding	3	1	0	Communication Systems

Course Objective: Introduction to concepts of Information theory and Coding

Course Outcomes:

CO1: Understand and apply fundamental concepts in information theory such as probability, entropy, information content and their inter-relationships

CO2: Compute information theoretic quantities, construct bounds and implement algorithms for source coding and noisy channel theorems

CO3: Apply linear block codes for error detection and correction

CO4: Design binary cyclic codes using shift register and perform syndrome calculations for error detection and correction

CO5: Implementation of encoders for convolutional codes

S. No.	Content	Contact Hours
Unit 1	Information Theory: Introduction, Measure of information, Average information content of symbols in long independent sequences, Averageinformation content of symbols in long dependent sequences. Mark-offstatistical model for information source, Entropy and information rateof mark-off source. Source Coding: Encoding of the source output,Shannon’s encoding algorithm. Communication Channels, Discretecommunication channels, Continuous channels.	12
Unit 2	Fundamental Limits on Performance: Source coding theorem, Huffmancoding, Discrete memory less Channels, Mutual information, ChannelCapacity. Channel coding theorem, Differential entropy and mutualinformation for continuous ensembles, Channel capacity Theorem	8
Unit 3	Introduction to Error Control Coding: Introduction, Types of errors, examples, Types of codes Linear Block Codes: Matrix description,	8

	Error detection and correction, Standard arrays and table look up for decoding	
Unit 4	Binary Cycle Codes, Algebraic structures of cyclic codes, Encoding using an (n-k) bit shift register, Syndrome calculation. BCH codes.	6
Unit 5	RS codes, Golay codes, shortened cyclic codes, Burst error correctingcodes. Burst and Random Error correcting codes. Convolution Codes,Time domain approach. Transform domain approach	8
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Digital and analog communication systems, K. Sam Shanmugam, John Wiley
2	Digital communication, Simon Haykin, John Wiley.
3	ITC and Cryptography, Ranjan Bose, TMH, II edition
4	Digital Communications - Glover and Grant; Pearson Ed.

Fourth Year Seven Semester (ODD)

Department Elective Course -4

EC401: Radar Signal Processing

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Radar Signal Processing	3	1	0	Electromagnetics, signal and systems, Microwave Engineering

Course Objective: Introduction to radar system design with an emphasis on radar signal processing.

Course Outcomes:

CO1: Explain the fundamentals of radar systems

CO2: Analyze radar signal models

CO3: Evaluate radar signal processing in cluttered environments

CO4: Develop methodologies for target detection, measurement and tracking

CO5: Implement advanced radar imaging techniques

S. No.	Content	Contact Hours
Unit 1	Radar Systems Basics: Radar Block diagram, radar specific terms, radar cross section, radar equation,Radar transmitters, receivers,and antennas, coherence,continuous wave radars	8
Unit 2	Radar signal models: components of radar signal, amplitude clutter, noise model and signal to noise ratio, jamming, frequency space and spectral models, matched filtering, wave form resolution, pulse compression.	8
Unit 3	Radar signal processing in clutter: Clutter Analysis, clutter mapping and the moving target indicator, Doppler processing, moving platform effects on doppler spectrum, Moving target indication pulse doppler processing, pulse pair processing, doppler	8

	processing issues,	
Unit 4	Target Detection: single pulse detection,Probability of False Alarm and Detection, detection Modified Radar Range Equation with Swerling Models, Measurements and tracking: range, doppler and angle estimators, sequential least square estimation, Kalman filter and tracking cycle	10
Unit 5	Synthetic Aperture Processing: Strip-map synthetic aperture radar, SAR image formation, spotlight SAR Inverse SAR Imaging,Beamforming and STAP, Spatial filtering, space time signal modelling, adaptive matched filtering	8
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Fundamentals of Radar Signal Processing /Richards / 3rd Ed, McGraw Hill 2022.
2	Introduction to Radar Systems/Skolnik /3rd Ed., McGraw Hill 2002.
3	Handbook of Radar Signal Analysis /Mahafza, B.R., Winton, S.C., &Elsherbeni, A.Z. (Eds.) /1stEd.,CRC2021.

EC403: Statistical Signal Processing

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Statistical Signal Processing	3	1	0	NIL

Course Objective:Statistical Signal Processing involves processing random signals and forms the backbone of modern communication and signal processing systems. This course covers stochastic signals in time and frequency domain, modeling of signals, estimation, detection, spectral estimation, adaptive filters

Course Outcomes:

1. Analyze stationary processes, including spectral and correlation analysis of wide-sense stationary data.
2. Apply parameter estimation techniques like MVUE, MLE, and Bayesian estimation to optimize estimators.
3. Implement MMSE and LMMSE signal estimation in white Gaussian noise using Wiener filtering.
4. Design and adapt FIR Wiener filters using steepest descent, LMS, and RLS algorithms for dynamic systems.
5. Evaluate Kalman filters and Gauss-Markov models for state estimation and steady-state analysis.

S. No.	Content	Contact Hours
Unit 1	**Stationary processes:** Strict sense and wide sense stationarity; Correlation and spectral analysis of discrete-time wide sense stationary processes, white noise, response of linear systems to wide-sense stationary inputs, spectral factorization.	6
Unit 2	**Parameter estimation:** Properties of estimators, Minimum Variance Unbiased Estimator (MVUE Cramer Rao bound, MVUE through Sufficient Statistics, Maximum likelihood estimation- properties. Bayesian estimation-Minimum Mean-square error(MMSE) and Maximum a Posteriori(MAP) estimation.	10
Unit 3	**Signal estimation in white Gaussian noise:** MMSE, conditional expectation; Linear minimum mean square error (LMMSE) estimation, orthogonality	10

	principle and Wiener Hoff equation. **Wiener Filtering:**FIR Wiener filter, linear prediction-forward and backward predictions, Levinson-Durbin Algorithm, Non-causal IIR wiener filter, Causal IIR Wiener filtering.	
Unit 4	**Iterative and adaptive implementation of FIR Wiener filter:** Steepest descent algorithm, LMS adaptive filters, convergence analysis, least-squares(LS) method, Recursive LS (RLS) adaptive filter, complexity analysis, application- neural network.	8
Unit 5	**Kalman filters:** Gauss-Markov state variable models; innovation and Kalman recursion, steady-state behaviour of Kalman filters	8
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Manolakis D. G., V. K. Ingle, and S. M. Kogon, Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, McGraw Hill, Inc., 2000.
2	Kay S. M., Fundamentals of Statistical Signal Processing: Estimation Theory, Prentice-Hall, Inc., 1993.
3	H. L. Van Trees, Detection, Estimation and Modulation Theory, Part I, John Wiley, 1968.
4	H. V. Poor, An Introduction to Signal Detection and Estimation, 2nd edition, Springer, 1994.
5	S. J. Orfanidis, Optimum Signal Processing, 2nd Edition, 2007 republication of the 1988 McGraw-Hill edition.

EC405: System on Chip Design

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
System on Chip Design	3	1	0	Microprocessor and embedded systems

Course Objective:To develop fundamental concepts to design, verify, and optimize a System-on-Chip using modern methodologies and tools, enabling students to contribute effectively to cutting-edge developments in the semiconductor and embedded systems industries.

Course Outcomes: CO1Describe the fundamental principles of SoC design Methodology for Logic and Analog Cores. CO2Analyze the design of different embedded memories. CO3 Interpret various state-of-the-art languages and tools used in the creation of SoCs. CO4Explainthe concepts of System on Chip Design Validation. CO5Classify testing methodologies to develop Debugging and Testing Skills

S. No.	Content	Contact Hours
Unit 1	Introduction- System tradeoffs and evolution of ASIC Technology- System on chip concepts and methodology – SoC design issues -SoC challenges and components.	8
Unit 2	Design Methodologyfor Logic Cores- SoC Design Flow – On-chip buses –Design process for hard cores – Soft and firm cores – Core and SoC design examples.	8
Unit 3	Design Methodology for Memory and Analog Cores- Embedded memories –Simulation modes Specification of analog circuits.	8
Unit 4	Design Validation- Core level validation –Test benches –SoC design validation – Co simulation – hardware/ Software co-verification.	10
Unit 5	Introduction to SoC Testing- SoC Test Issues –Cores with boundary scan –Test methodology for design reuse– Testing of microprocessor cores – Built in self-method –testing of embedded memories.	8
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	System-on-a-chip:DesignandTest/ Rochit Rajsunah/ArtechHouse,2007.
2	System-on-a-chip verification: Methodology and Techniques, Prakash Raslinkar, Peter Paterson & Leena Singh/ Kluwer Academic Publishers,2000.
3	Low Power Methodology Manual for System-on- Chip Design Series: Integrated Circuits and Systems/M.Keating, D.Flynn, R.Aitken, A, GibbonsShi/ Springer,2007.
4	Integrating BIST techniques for on-line SoC testing / A.Manzone, P.Bernardi, M.Grosso, M. Rebaudengo, E. Sanchez, M.SReorda, Centro Ricerche Fiat/ IEEE Symposium on On-Line testing, 2000.

EC407: Optical Communication

Details of course:

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Optical Communication	3	0	2	Basics of Electromagnetic Theory

Course Objective:To introduce fundamental and advanced concepts of Optical Communication

Course Outcomes:

CO1: Describe the vector nature of light, and its propagation mechanism inside an optical fiber (ray and mode theory)

CO2: Apply mode theory to differentiate between the different kind of optical fibers based on their light transmission and dispersion characteristics

CO3: Illustrate the working principles of optical sources (LEDs and LASERS)

CO4: Evaluate the performance of different types of photodetectors, optical switches and optical amplifiers

CO5: Design an optical communication system and evaluate its power and time budget

S. No.	Content	Contact Hours
Unit 1	Ray model, Introduction to the vector nature of light, Propagation of light, Wave model, Introduction to Modes, Modal analysis of a step index fiber, Different types of optical fibers	8
Unit 2	Signal degradation: Attenuation, Dispersion, Types of Dispersion: Material, waveguide and modal dispersion, Graded Index Fibers; Manufacturing of optical fibers	6
Unit 3	Optical Sources: LEDs and LASERs, Efficiency, Performance Metrics	6
Unit 4	Photo-detectors: PN, PIN and APD photodetectors Responsivity, Quantum Efficiency, Speed of photodetectors, Noise	6
Unit 5	Optical Receivers: BER Calculation, Quantum limit, Thermal noise and shot noise limit; Optical link design: Power and time budget of an optical link	8
Unit 6	Optical Switches: Types, Performance Metrics, Electro-optic Switch; Optical Amplifiers: Introduction, Comparison of OAs, EDFA; Optical Modulators; Introduction to Non-linearity, Non-linear effects (Second harmonic generation, Cross phase modulation)	8
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Fibre Optic communication/J.Keiser/ 2nd Edition, McGraw-Hill 1992.
2	Optical communication systems /J.Gowar/ Prentice Hall India1987.
3	Optical Fiber Communication: Principles and Practice/ John M. Senior/2nd Edition 2002

EC409: Computer Vision

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Computer Vision	3	1	0	NIL

Course Objective**:**To introduce fundamentals of Computer Vision and algorithms for image & video processing, object detection, feature extraction, and recognition, motion understanding.

Course Outcomes:

CO1: Analyse and design a range of algorithms for image processing and computer vision.

CO2: Demonstrate fundamentals of image and video Processing techniques.

CO3: Explore Image representation approaches for efficient image processing.

CO4: To introduce fundamentals of object recognition techniques.

CO5: Demonstrate Object motion and tracking algorithms for computer vision applications

CO6: Develop efficient computer vision-based solutions for real world problems.

S. No.	**Content**	**Contact Hours**
Unit 1	Introduction to Computer Vision: role of AI and image processing in CV, industrial Machine Vision Applications, Visual Sensors, camera Calibrations	6
Unit 2	Basics of Image Processing-pixel representation, histogram, transforms. Colour filters, noise removal. Basics of Video Processing- Background subtraction techniques-frame differencing, GMM, object localisation and processing-contours, edges, lines, skeletons	10
Unit 3	Image Representation: Local Wavelet Basis (multi-scale), global Fourier basis (frequency), adaptive basis (PCA and ICA), Basics of object detection- template matching and cascade classifiers.	8
Unit 4	Object Recognition: Object modelling, Bayesian classification, feature selection and boosting, scene and object discrimination.	8
Unit 5	Motion and Tracking: Motion detection and tracking of point features, optical flow, SURF, SIFT. Tracking- Kalman filter, particle filter	10
	Total	**42**

Books:-

S. No	**Name of Books/Authors/Publisher**
1	Computer Vision: A Modern Approach (2nd Edition) 2nd Edition by David A. Forsyth (Author), Jean Ponce (Author)
2	Computer Vision and Image Processing by Bhuyan, CRC Press
3	Computer Vision: Models, Learning, and Inference - Simon J. D. Prince 2012
4	Computer Vision: Theory and Application-Rick Szeliski 2010

EC411: Bio-Medical Signal Processing

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Bio-Medical Signal Processing	3	0	2	NIL

Course Objective:To familiarize students with the fundamental principles and concepts of biomedical signal processing

Course Outcomes:

CO1: Understand the Sources, Types & Characteristics of Different Noises and Artifacts Present in Biomedical Signals.

CO2: Design Time Domain and Frequency Domain Filters for Noise and Artifact Removal from Biomedical signals.

CO3: Apply Various Methods for Analyzing Biomedical Signal Characteristics.

CO4: Explore Alternative Techniques of Analyzing Biomedical Signals in Time and Frequency Domain.

S. No.	Content	Contact Hours
Unit 1	Introduction to Biomedical Signals Action Potential and Its Generation, Origin and Waveform Characteristics of fundamental Biomedical Signals Like:Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Phonocardiogram (PCG),Electroneurogram (ENG), Event-Related Potentials (ERPS), Electrogastrogram (EGG)	10
Unit 2	Removal of Noise and Artifacts from Biomedical Signal Random and Structured Noise, Physiological Interference, Stationary and Nonstationary Processes, Noises andArtifacts Present in ECG, Time and Frequency Domain Filtering. Basics of signal averaging, signal averaging as a digital filter, a typical average, software for signal averaging, limitations of signal averaging.	8

Unit 3	ECG Signal Processing: Detection of P, Q, R, S and TWaves in ECG, EEG Rhythms, Waves and Transients, Detection of Waves and Transients, Correlation Analysis and Coherence Analysis of EEG Channels.	8
Unit 4	EEG Signal Processing and Event Detection in Biomedical SignalsEEG Signal and Its Characteristics, EEG Analysis, Linear Prediction Theory, Autoregressive Method, Sleep EEG,Application of Adaptive Filter for Noise Cancellation in ECG and EEG Signals;	8
Unit 5	Analysis of Nonstationary Signals Heart Sounds and Murmurs, Characterization of Nonstationary Signals and Dynamic Systems, Short-TimeFourier Transform, Considerations in Short-Time Analysis and Adaptive Segmentation.	8
	Total	42

Books:-

S. No	Books
1	Handbook Of Biomedical Instrumentation by Khandpur, R.S.; Tata McGraw Hill Publishers. 2003
2	*Rangayyan, R.M., 2015. Biomedical signal analysis (Vol. 33). John Wiley & Sons.*
3	*Tompkins, W.J., 1993. Biomedical digital signal processing. Editorial Prentice Hall.*
4	*Medical Instrumentation: Application and Design by John G. Webster*

Department Elective Course-5 (DEC-5)

EC413: MEMS and Sensor Design

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
MEMS and Sensor Design	3	1	0	

Course Objective: The primary objective of the course is to provide a comprehensive understanding of the concepts, design principles, and manufacturing techniques of Microelectromechanical Systems (MEMS). The course emphasizes the integration of physics, mechanics, and thermos fluid engineering to enable students to design and analyze MEMS devices, considering material properties, scaling effects, and micromanufacturing processes.

Course Outcomes: CO1: Describe the fundamental principles, components, and typical applications of MEMS and microsystems. CO2:Analyze the role of physics, mechanics, and thermo-fluid engineering in the design and operation of MEMS devices and sensors. CO3:Evaluate the effects of scaling in MEMS and selection of appropriate materials for specific applications, considering their properties and compatibility. CO4:Describethe key fabrication methods, including photolithography, ion implantation, surface micromachining, and the LIGA process. CO5: Develop designs for MEMS devices and sensors, including mechanical structures, silicon die layouts, and microfluidic systems, addressing mechanical and process design considerations.

S. No.	Content	Contact Hours
Unit 1	**Overview and working principles of MEMs:** MEMs and Microsystems, typical MEMs products, applications, Microsensors, Microactuation, MEMs with microactuators, Microaccelerometers, Microfluidics	8
Unit 2	**Physics, Mechanics, and Thermo-fluid engineering for MEMs design:** **Physics:** Ionization, doping of semiconductors, diffusion, plasma physics, electrochemistry **Mechanics:** Static bending of thin plates, mechanical vibration, thermomechanics, fracture mechanics, thin film mechanics, finite element stress analysis **Thermofluid engineering:** fluid mechanics basics	10
Unit 3	**Scaling and Materials for MEMs:**	8

	Scaling: scaling in - geometry, rigid body dynamics, electrostatic forces, eletromagnetic forces **Materials:** substrate material, silicon, silicon compounds, gallium arsenide, quarts, piezoelectric crystals, polymers	
Unit 4	**Fabrication and Micromanufacturing:** Photolithography, Ion implantation, diffusion, oxidation, CVD, epitaxy, Bulk micromanufacturing, surface micromachining, LIGA process	8
Unit 5	**Microsystems Design:** Design considerations, Process design, Mechanical design, Design of silicon die, design of microfluidic networks systems	8
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	MEMs and Microsystems Design and Manufacturing / Tai-Ran Hsu / Tata Mcgraw-Hill, edition 1, 2002
2	Foundations of MEMS / Chang Liu / Pearson 2nd edition, 2012
3	Microsystem Design / S. D. Senturia / Kluwer Academic Publishers, 2001

EC415: Nanophotonic Devices for Communications

Details of course:

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Nanophotonic Devices for Communications	3	1	0	Basics of Electromagnetic Theory

Course Objective:To introduce nanophotonic phenomenon and make the students understand the working and applications of devices based on nanophotonics

Course Outcomes:

CO1: Define the fundamentals of nanophotonics and light-matter interaction at nanoscale

CO2:Apply the fundamental principles of photonic crystals to understand the working of photonic-crystal based devices such as waveguides and resonators

CO3:Illustrate the phenomena of surface plasmon resonance and localized surface plasmon resonance and apply them to make devices

CO4:Design devices based on nanophotonics for energy conversion and data storage Applications

CO5: Explain the nanofabrication processes used for the fabrication of nanophotonic devices

S. No.	Content	Contact Hours
Unit 1	Fundamentals of Nanophotonics, Review of Maxwell's equations, Light-Matter Interaction, Diffraction limit	6
Unit 2	1-D, 2-D and 3-D Photonic Crystals, Omni directional Reflector, Photonic Crystal Waveguides and other applications	8
Unit 3	Surface Plasmon Polaritons, Localized Surface Plasmon Resonance, Transmission through nano-aperture, Plasmonic Waveguides, Plasmonic Sensors	10
Unit 4	Broadcast Devices, Energy conversion, Data storage applications; Additional Applications	10
Unit 5	Materials, Fabrication of Nanophotonic Devices: Nanolithography techniques, Wet Etching and Reactive Ion Etching, Lift-off, Sputter deposition, E-beam evaporation etc.	8
	Total	42

Books:

S. No	Name of Books/Authors/Publisher
1	'Principles of Nano-Optics' by Lukas Novotny and Bert Hecht, Cambridge, 2006
2	'Nanophotonic Devices' by Zeev Zalevsky and Ibrahim Abdulhalim, Elsevier, 2014

EC417: Spread Spectrum Communication

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Spread Spectrum Communication	3	1	0	Signals and Systems, Communication Systems, Probability Theory

Course Objective:
1. Explain the differences, in design, implementation, and operation, between code/frequency/time division access and code/frequency/time division multiplexing
2. Generate orthogonal codes and pseudorandom noise sequences using both shift registers and generator function representations
3. Implement the tracking and synchronization methods of wideband signals.
4. To explain the principles and detection methods of code division multiple aceess.
5. Use pseudorandom sequences for purposes of error correction.

Course Outcomes:

CO 1. Describe the various methods of spreading the spectrum and generation of codes.
CO 2. Explain the working of loops to track codes and synchronization techniques.
CO 3. Understand the CDMA principles and various schemes for multi-user detection.
CO 4. Calculate the performance of spread spectrum systems in jamming environment.
CO 5. Evaluate the performance of spread spectrum systems with forward error correction.

S. No.	Content	Contact Hours
Unit 1	Introduction to spread spectrum system : Fundamental concepts of spread spectrum systems, Pseudo noise sequences, direct sequence spread spectrum, frequency hop spread spectrum, Hybrid direct sequence frequency hop spread spectrum, code division multiple access Binary shift register sequences for spread spectrum systems : Introduction, Definitions, Mathematical back ground and sequence generator fundamentals, maximal length sequences, Gold codes.	10
Unit 2	Code tracking Loops : Introduction, Optimum tracking of wideband signals, Base band delay-lock tracking loop, Tau-dither non-coherent tracking loop, Double dither non-coherent tracking loop. Initial synchronization of the receiver spreading code : Introduction, Problem definition and the optimum synchronizer, serial search synchronization techniques, synchronization using matched filter, synchronization by estimated the received spreading code.	8
Unit 3	Cellular code division multiple access CDMA Principles: Introduction, Wide band mobile channel, The cellular CDMA System, Single user receiver in a multi user channel, CDMA System capacity. Multi-User detection in CDMA Cellular radio: Optimal multi-user detection, linear suboptimal detectors, Interference combat detection schemes, Interference Cancellation techniques.	8
Unit 4	Performance of spread spectrum systems in jamming environments: Spread Spectrum Communication system model, Performance of spread spectrum systems without coding,	8
Unit 5	Performance of spread spectrum systems with forward error correction: Elementary block coding concepts, Optimum decoding rule, Calculation of error probability. Elementary convolution coding concepts, viterbi algorithm, Decoding and bit-error rate. Global Positioning System Spread Spectrum Receivers.	8
Total		42

Books:-

S. No	Name of Books/Authors/Publisher
1	Introduction to spread spectrum communication - Rodger Eziemer, Roger L. Peterson and David E Borth - Pearson, 1st Edition,1995
2	Introduction to CDMA wireless Communications - Mosa Ali Abu, Rgheff, Elsevier Publications, 2008.
3	Glisic, S., & Vucetic, B.(1997). Spread spectrum CDMA systems for Wireless Communications (1st ed.). Boston, MA: Artech House.
4	Modern Communication and Spread Spectrum - George R. Cooper, Clare D. Mc Gillem, McGraw Hill, 1986.
5	CDMA; Principles of Spread Spectrum Communication - Andrew J. Viterbi, Pearson Education, 1st Edition, 1995.
6	Wireless Digital Communications - Kamilo Feher, PHI, 2009.
7	WCDMA Design Handbook -Andrew Richardson, Cambridge University Press, 2005.

EC419: Adaptive Signal Processing

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Adaptive Signal Processing	3	0	2	NIL

Course Objective: Adaptive signal processing involves development of various adaptation algorithms and assessing them in terms of convergence rate, computational complexity, robustness against noisy data, hardware complexity, numerical stability etc. This course demonstrates the design of important class of adaptive filters, LMS, RLS and Kalman filters.

Course Outcomes:

CO1: Apply linear and non-linear adaptive filters to solve signal processing and filtering problems.

CO2: Analyze stationary processes, stochastic models, and correlation matrices for process characterization.

CO3: Demonstrate Wiener filter concepts, including minimum mean squared error and channel equalization.

CO4: Evaluate LMS and RLS algorithms for adaptive filtering and their stability in dynamic systems.

CO5:Implement Kalman filter techniques for recursive state estimation and filtering in real-time systems.

S. No.	Content	Contact Hours
Unit 1	**INTRODUCTION:** The filtering problem, Adaptive filters, linear filter structures, approaches to the development of linear adaptive filter algorithms, real and complex forms of adaptive filters, non-linear adaptive filters, Applications. **STATIONARY PROCESSES AND MODELS:** Partial characterization of a discrete time stochastic process, mean ergodic theorem, correlation matrix, correlation matrix of sine wave plus noise, stochastic models, wold decomposition, asymptotic stationarity of an auto regressive process. Complex Gaussian process.	8
Unit 2	**WIENER FILTERS:** Linear optimum filtering problem statement, principle of orthogonality,	8

	minimum mean squared error, Wiener hopf equations, error performance surface. Channel equalization. Linearly constrained minimum variance filter, generalized side lobe cancellers.	
Unit 3	**LINEAR PREDICTION:** Forward Linear Prediction, backward Linear Prediction, Levinson-Durbin algorithm, properties of prediction error filters, Schur-Cohntest, auto regressive modeling of a stationary stochastic process, Cholesky factorization, lattice predictors, joint process estimation, block estimation. **Method of steepest descent:** Steepest descent algorithm, stability of the Steepest descent algorithm.	8
Unit 4	**LEAST MEAN SQUARE (LMS) ALGORITHM:** Overview of the structure and operation of the Least Mean square Algorithm, Least Mean square adaptation Algorithm, stability and performance analysis of the LMS algorithm. Normalized Least Mean Square (NLMS) Algorithm, Concept of method of least squares. **RECURSIVE LEAST SQUARES (RLS) ALGORITHM:** The matrix inversion lemma, the exponentially weighted RLS algorithm, update recursion for the sum of weighted error squares. Convergence analysis of the RLS algorithm.	10
Unit 5	**KALMAN FILTERS:** Recursive minimum mean square estimation for scalar random variables, statement of the Kalman filtering problem, the innovations process, estimation of the state using the innovations process, filtering, initial conditions, variants of the Kalman filter, extended Kalman filtering.	8
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	S. Haykin, Adaptive Filter Theory, Prentice-Hall, 4-th edition, 2001.
2	Ali H. Sayed, Fundamentals of Adaptive Filtering, John Wiley, 2003.
3	B. Farhang-Boroujen, Adaptive Filters: Theory and Applications, John Wiley and Sons, 2013.
4	Manolakis D. G., V. K. Ingle, and S. M. Kogon, Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, McGraw Hill, Inc., 2000.
5	John G. Proakis, Dimitris G.Manolakis, Digital Signal Processing, Principles, Algorithms and Applications , Pearson Education / PHI, 2007.

EC421: Data Analytics

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Data Analytics	3	1	0	Undergraduate courses on probability theory, signal and system, and linear algebra.

Course Objective:
The course objectives of this course are as follows:
1.To explore the fundamental concepts of data analytics.
2.To learn the statistical analysis techniques and probability distributions so that you can analyze different types of data.
3. Interpret the tools required to manage and analyze data analytics
4. To comprehend the various visualization and data exploratory techniques.
5. To learn descriptive statistics, inferential statistics, predictive statistics and Prescriptive analytics.
6. To develop the skills in using recent techniques for solving practical problems.

Course Outcomes:

CO1: Explain the fundamental concepts of data analytics.

CO2: Demonstrate descriptive analytics.

CO3: Explain inferential statistics techniques.

CO4: Apply linear and multiple linear regression analyses.

CO5: Implement different methods of predictive analytics and their applications.

CO6: Design efficient algorithms to solve real-world problems using prescriptive analytics.

S. No.	Content	Contact Hours
Unit 1	Introduction to data analytics, Introduction to probability, sampling and sampling distributions, Hypothesis testing, Hypothesis Formulation, Handling Unstructured Data.	6
Unit 2	Descriptive Statistics: Introduction to the Descriptive Statistics, Probability Distributions, Data Visualization, Exploratory Data Analysis.	8
Unit 3	Inferential Statistics: Inferential Statistics through hypothesis tests,	8

	Permutation & Randomization Test.	
Unit 4	Basic analysis techniques include the Chi-Square test, t-Test, Analysis of variance, correlation analysis, two-sample testing, introduction to ANOVA (Analysis of Variance), Two-way ANOVA, and ANOVA regression.	8
Unit 5	Linear regression and multiple regression, Concepts of Maximum likelihood test (MLE) and Logistic regression, ROC and Regression Analysis Model Building.	6
Unit 6	Regression: Ordinary Least Squares, Ridge Regression, Lasso Regression, Elastic-Net Regression, K Nearest Neighbours Regression & Classification.	6
	Total	42

Books: -

S. No	Name of Books/Authors/Publisher
1.	Hastie, Trevor, et al., The elements of statistical learning. Vol. 2. No. 1. New York: Springer, 2009.
2.	Montgomery, Douglas C., and George C. Runger., Applied statistics, and probability for engineers. John Wiley & Sons.
3	Ian Goodfellow, Yoshoua Bengio, and Aaron Courville Deep Learning MIT Press Ltd, Illustrated edition
4	Christopher M. Bishop Pattern Recognition and Machine Learning - Springer, 2nd edition

EC423: Multi-rate Signal Processing

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Multi-rate Signal Processing	3	0	2	Signals and Systems, and Digital Signal Processing.

Course Objective:To understand the fundamentals of multi-rate signal processing and its applications. To understand the concepts of filter banks and its applications.

Course Outcomes:

CO1: Describe the fundamentals of multirate signal processing and its applications.

CO2: Explain the theory of sampling rate conversion and develop methods for decimating,interpolating with polyphase implementations.

CO3: Analyze multirate filter banks in terms of theoretical and practical aspects of multiratesignal processing.

CO4: Design perfect reconstruction and near perfect reconstruction filter bank.

CO5: Demonstrate multirate Signal processing-based DSP systems.

S. No.	Content	Contact Hours
Unit 1	Introduction, Overview of Sampling and Reconstruction, Review Discrete-Time Systems, digital filters, Oversampling techniques, DT processing of continuous time signals.	6
Unit 2	Fundamentals of Multi-rate Systems, Basic building blocks – Up sampling, down sampling, aliasing, Mathematical framework for sampling rate change, Sampling rate change and filtering, fractional sampling rate change.	8
Unit 3	Interconnection of multi-rate DSP blocks, Multiplexer and Demultiplexer functionality, Polyphase decomposition, Noble Identities, efficient implementation of sampling rate conversion, Applications of Multi-rate DSP - DFT-based Filter banks, Interpolated FIR filter design, Cascaded-Integrator-Comb (CIC) - filters, Trans multiplexer.	10
Unit 4	Signal impairments - Aliasing, Magnitude distortion, Phase distortion, Aliasing cancellation, All pass filters, properties, application in two channel filter banks, Half-band filters, Power	10

	complementary filter pairs, Perfect reconstruction (PR) QMF Bank, Tree structured filter banks, Paraunitary PR Filter Banks, Quantization Effects, Cosine Modulated filter banks.	
Unit 5	Application of Multirate DSP – Delta Sigma A/D conversion, Introduction to wavelets and M-channel perfect reconstruction filter banks.	6
	Total	42

Books: -

S. No	Name of Books/Authors/Publisher
1	MultirateSystems and Filter Banks/P. P. Vaidyanathan/Prentice Hall, PTR, 1993.
2	Digital Signal Processing: A computer-based approach/Sanjit K. Mitra/McGraw Hill, 1998.
3	MultirateDigital Signal Processing/N. J. Fliege/John Wiley, 1999.
4	Multirate Signal Processing for Communication Systems/Fredric J. Harris/Prentice Hall, 2004.

Fourth Year Eight Semester (EVEN)

Department Elective Course -6

EC402: Smart Antennas

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Smart Antennas	3	0	2	NIL

Course Objective: To introduce and explore the smart antennas and MIMO antennas for RADAR, and wireless communication systems

Course Outcomes: CO1: Explore the concepts of Antennas and its array beam forming methods CO2: Explore the concepts of smart and adaptive antennas CO3: Apply different adaptive algorithms for smart antennas to achieve minimized interference CO4: Explore the concept of direction of arrival and angle of arrival estimation techniques CO5: Explore the basics of mm Wave massive MIMO architectures

S. No.	Content	Contact Hours
Unit 1	Basics of antennas and its characteristics, antenna arrays and its beamforming analysis, Introduction to Smart Antennas, Architecture of a Smart Antenna System: Transmitter and Receiver, Types of Smart Antennas, Benefits and Drawbacks of Smart Antennas, Applications of Smart Antennas.	8
Unit 2	Fixed Beamforming techniques in smart antennas, Fixed Sidelobe Cancelling, Retrodirective Arrays, Butler Matrix, Spatial Filtering with Beamformers, Switched Beam Systems, Multiple Fixed Beam System, Adaptive Arrays, Uplink Processing, Diversity Techniques, Angle Diversity, Maximum Ratio Combining, Adaptive Beamforming, Fixed Multiple Beams versus Adaptive Beamforming, Downlink Processing	8

Unit 3	Smart antenna receivers and algorithms for radio base stations: Reference signal methods, The least mean square algorithm, The recursive least square algorithm, adaptive beam forming algorithms, Neural network DoA base beam forming, Downlink beamforming.	10
Unit 4	Fundamentals of Matrix Algebra, Array Correlation Matrix, AOA Estimation Methods: Bartlett AOA Estimate, Capon AOA Estimate, Linear Prediction AOA Estimate, Maximum Entropy AOA Estimate, Pisarenko Harmonic Decomposition AOA Estimate, Min-Norm AOA Estimate, MUSIC AOA Estimate, ESPRIT AOA Estimate.	8
Unit 5	Introduction, Multiple-Antenna MS Design, RAKE Receiver Size, Mutual Coupling Effects, Dual-Antenna Performance Improvements, Downlink Capacity Gains, Principles of MIMO systems: SISO, SIMO, MISO, MIMO, Hybrid antenna array for mmWave massive MIMO: Massive Hybrid Array Architectures, Hardware Design for Analog Subarray.	8
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Smart Antenna Engineering'/ Ahmed El Zooghby, , ARTECH HOUSE, INC 2005, First Edition.
2	Smart antenna with MATLAB'/Frank B. Gross/ McGraw-Hill, 2015,2nd Edition
3	SMART ANTENNAS"/ Lal Chand Godara / CRC PRESS
4	mmWave Massive MIMO: A Paradigm for 5G/ Shahid Mumtaz, Jonathan Rodriguez, Linglong Dai/ 2016, First edition

EC404: Wireless Communications

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Wireless Communications	3	0	2	Signals and System, Communication System

Course Objective: To introduce the basic concepts and significance of wireless communication. The mathematical foundations of wireless communication systems include channel modeling and capacity analysis.

Course Outcomes: CO1: Acquire knowledge about the basics of wireless communication CO2: Explain cellular mobile system architecture, fundamentals, and associated concepts CO3: Analyze the evolution of different cellular systems CO4: Explain various wireless technologies and their applications. CO5:Gain knowledge of emerging wireless technologies such as IoT, SDR, and cognitive radio

S. No.	Content	Contact Hours
Unit 1	Introduction to different types of wireless communication, the difference between wired and wireless communication, fundamentals of cellular systems, different generations and standards in cellular communication systems, satellite communication, multiple access schemes (FDMA TDMA, CDMA, SDMA), spectrum Allocation for various Wireless services, challenges of wireless communication-fading, interference, Shanon Channel Capacity, diversity architectures.	6
Unit 2	Mobile Radio Multipath Propogation, Statistical characterisation of Multipath Channel, Delay Spread, Doppler Spread, Free Space Path Loss Model, Outdoor Propogation Model, Indoor Propogation Model, Fading Models- Rayleigh, Rician, Nakagami, Composite Fading – shadowing Distributions, Link power budget Analysis for wired and wireless system,	10

	Ray Tracing.	
Unit 3	Capacity of AWGN Channel, Capacity of Flat Fading Channel-Channel Distribution Information Known, Channel Side Information at Receiver, Channel Side Information at Transmitter and Receiver, Optimal Water Filling Power Allocation, Capacity with receiver diversity, Capacity of Frequency Selective Channel	8
Unit 4	Receiver Diversity- Selection Combining, Maximal Ratio Combining, Equal Gain Combining, Transmit Diversity- Alamouti Scheme, OFDM, MIMO Channels: Physical modeling, Slow and fast fading channels, Capacity, Multiplexing architectures: V-BLAST and D-BLAST. Introduction to Software Defined Radio, UWB Radio, Wireless Adhoc Network, Cognitive Radio, Green Communication, Optical and Wireless Communication, Long Term Evolution, Internet of Things	8
Unit 5	Cellular System Fundamentals: Hexagonal geometry cell and concept of frequency reuse, Channel Assignment Strategies, Distance to frequency reuse ratio, Channel & co-channel interference reduction factor, S/I ratio for Minimum Cochannel and adjacent interference, Handoff Strategies, Umbrella Cell, Trunking and Grade of Service, Cell splitting, Cell sectorization, Repeaters, Microcell Zone. GSM-Architecture, Channel Types, GSM Call Flow, GSM Frame Structure, CDMA- Concept of spread spectrum, Architecture of IS-95 CDMA system, CDMA forward channels, CDMA reverse channels, Power control in CDMA, Capacity of CDMA System, RAKE Receiver	10
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Communication Systems/Simon Haykin/John Wiley, Fourth Edition
2	Fundamentals of wireless communication/David Tse/Cambridge University Press, 2012
3	Wireless Communication/Andrea Goldsmith/Cambridge University Press, 2011
4	Wireless Communications/Andreas.F. Molisch/John Wiley – India, 2006
5	Wireless Communications: Principles and Practice/Theodore S. Rappaport/Cambridge University Press/2024

EC406: Deep Learning

Details of course :-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Deep learning	3	1	0	Calculus, Linear Algebra, and some notions of Machine Learning

Course Objective: To make students understand the basic concepts and significance and the context of neural networks and deep learning. Understand the data needs of deep learning. Have a working knowledge of neural networks and deep learning. Analyze and differentiate between different types of deep learning approaches.

Course Outcomes: CO1: Explain the fundamental concepts of Deep Learning, including various Neural Networks for supervised and unsupervised learning. CO2: Build, train, and deploy different types of Deep Architectures, including Convolutional Networks, Recurrent Networks, and Autoencoders. CO3: Identify the deep learning algorithms that are more appropriate for various types of learning tasks in various domains. CO4: Build deep learning models in TensorFlow and interpret the results. CO5: Implement deep learning algorithms and solve real-world problems.

S. No.	Content	Contact Hours
Unit 1	Introduction to Deep Learning: History of Deep Learning, Types of errors, Bias-variance trade-off, Overfitting-underfitting, Brief review of concepts from Vector Calculus, andOptimization, Gradient Descent, Variants of Gradient Descent, Momentum, Computation graph, Vectorization, and Broadcasting.	4
Unit 2	Neural Networks Basics: Basic concepts of Artificial Neurons, Single and Multi-layer Perceptrons, Feed Forward NN, Backpropagation, and Different activation functions-Sigmoid, ReLU, Hyperbolic, and Softmax. Softmax cross-entropy loss function, BinaryClassification, Logistic Regression, LogisticRegression Cost Function.Shallow neural networks: Neural Network Representation, Gradient descent for NeuralNetworks, Backpropagation, Random Initialization.Training a network: Loss functions, Stochastic gradient descent, AdaGrad,	8

	RMSProp, and Adam.	
Unit 3	Deep Neural Networks: Deep L-layer neural network, Forward Propagation in a DeepNetwork, Building blocks of deep neural networks, Parameters vs Hyperparameters.Improving Deep Neural Networks: Hyperparameter tuning, Regularization, Dropout,Batchnorm, and Optimization.Autoencoders, Variational Autoencoders (VAEs), Regularization in autoencoders, Denoising autoencoders, and Sparse autoencoders.	8
Unit 4	Recurrent Neural Networks: Recurrent Neural Network Model, Different types of RNNs, Gated Recurrent Units (GRUs), Long short-term memory (LSTM), Encoder-Decoder architectures, Bidirectional RNN, Deep RNNs, Deep Reinforcement Learning, Embeddings & Word2vec, Sentiment Prediction RNN.	6
Unit 5	Convolutional Neural Networks: Introduction to CNNs, Kernel filter, Principles behindCNNs, Multiple Filters, CNN applications, Foundations of Convolutional NeuralNetworks, Convolution, and Pooling Operation.Siamese Network, Transfer Learning.ConvNet Architectures: AlexNet, ZFNet, VGG, C3D, GoogLeNet, ResNet,MobileNet-v1, etc.Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks.	8
Unit 6	Deep generative models: Generative Adversarial Networks (GANs), Attacking neuralnetworks with Adversarial Examples and Generative Adversarial Networks, DeepConvolutional GANs, Conditional GAN, Super-Resolution GAN, CycleGAN, PIX2PIXGAN, etc.,Deep Learning Applications: Face recognition and verification, Natural LanguageProcessing, Speech Recognition, Video Analytics, Neural Style Transfer, AI and Healthcare, Detection, Segmentation, Image, and video captioning.	8
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Artificial Neural Networks/Yegnanarayana, B/PHI Learning Pvt. Ltd. 2009
2	Deep Learning/Goodfellow, I., Bengio, Y., and Courville, A./MIT Press 2016

EC408: Low-Power VLSI Design

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Low-Power VLSI Design	3	0	2	Digital CMOS IC, VLSI Design

Course Objective: To introduce different low-power techniques to carry out a low-power IC (Integrated Circuit) in silicon.

Course Outcomes: CO1: Identify the sources of power dissipation in digital ICs and Compute power consumption and apply logical effort theory to size transistors CO2: Apply Voltage Scaling power for Low power at different abstraction levels of VLSI CO3: Apply switching and leakage power techniques at different abstraction levels of VLSI CO4: Design and Analyse arithmetic circuits and evaluate timing parameters CO5: Explain timing issues in synchronous circuits and design asynchronous circuits

S. No.	Content	Contact Hours
Unit 1	Need for Low Power VLSI Chips, Charging and Discharging Capacitance, CMOS Leakage Current, Static Current, BasicPrinciples of Low Power Design, Low Power Figure of MeritsSimulation Power Analysis: SPICE Circuit simulation, DiscreteTransistor Modelling, and Analysis, Gate-level Logic Simulation,Architecture-level Analysis, Data Correlation Analysis in DSPSystems, Monte Carlo SimulationRandom Logic Signals, Probabilistic Power AnalysisTechniques, Propagation of Static Probability in Logic Circuits,Transition Density Signal Model, Gate Level Power Analysis Using Transition Density	8
Unit 2	Circuit: Logical effort and transistor sizing, RC delay models,Sizing an Inverter Chain, Transistor, and Gate Sizing forDynamic Power Reduction, Transistor Sizing for Leakage PowerReduction, Equivalent Pin Ordering, Network Restructuring andReorganization, Special Latches and Flip-flops, Low Power Digital Cell Library	8
Unit 3	Supply Voltage Scaling for Low Power, Architectural-LevelApproaches, Voltage Scaling Using High-LevelTransformations, Multilevel Voltage Scaling (MVS), DynamicVoltage and Frequency Scaling, Adaptive Voltage ScalingSwitched Capacitance Minimization, System-Level	8

	Approach:Hardware–Software Codesign, Transmeta's Crusoe Processor,Bus Encoding, Clock Gating, Gated-Clock FSMs, FSM StateEncoding,FSM Partitioning, Operand Isolation, Precomputation, Glitching Power Minimization	
Unit 4	Leakage Power Minimization: Fabrication of Multiple ThresholdVoltages, VTCMOS Approach, Transistor Stacking, MTCMOSApproach, Power Gating, Clock, Isolation Strategy, StateRetention Strategy, Power-Gating Controller, PowerManagement, Combining DVFS and Power Management,Dual-Threshold Assignment Approach (DTCMOS)Low power clocked tree design, Low voltage and low power arithmetic circuits.	10
Unit 5	Adiabatic logic: Adiabatic Charging, Adiabatic Amplification,Adiabatic Logic Gates, Pulsed Power Supply, Stepwise ChargingCircuits, Partially Adiabatic Circuits, Efficient Charge RecoveryLogic, Positive Feedback Adiabatic Logic Circuits, 2N−2N2P Inverter/Buffer.Timing issues in synchronous circuits (clock skew and clock jitter), Asynchronous circuit Design	8
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Practical Low Power Digital VLSI Design/G. K. Yeap/Kluwer Academic Publishers, 2002.
2	Low-Power VLSI circuits and systems/A. Pal/Springer
3	Digital integrated circuits a design perspective/Jan M Rabaey, Anantha Chadrakasan, Borivoje Nikolic/Pearson education.
4	Principle of CMOS VLSI Design/Neil E Weste and Kamran, Eshraghian/Pearson Education.
5	CMOS digital integrated circuits/Sung MO Kang Yusuf Leblebici,/Tata McGraw Hill Publication.
6	Low-Power CMOS VLSI Circuit Design/K. Roy and S. Prasad/Wiley

EC410: Estimation and Detection Theory

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Estimation and Detection Theory	3	0	0	NIL

Course Objective: To introduce the fundamental concepts of detection and estimation in signal processing.

Course Outcomes: CO1: Explain the principles of statistical detection and estimation theories. CO2: Analyze and compare different detection techniques for signal processing applications. CO3: Apply Bayesian, maximum likelihood, and other estimation methods to real-world problems. CO4: Design and evaluate matched filters and detectors for signal detection. CO5: Implement various non-parametric detection techniques and their applications. CO6: Explain and simulate Kalman filters for estimation in dynamic systems

S. No.	Content	Contact Hours
Unit 1	Gaussian variables and Gaussian processes Problem formulation and objective of signal detection and signal parameter estimation Discrete-time signal detection Bayesian, minimax, and Neyman-Pearson detection criteria Likelihood ratio tests and receiver operating characteristics (ROC) curves Hypothesis testing and comparison techniques, Asymptotic relative efficiency of detectors	10
Unit 2	Matched filter detector and its performance Generalized matched filter Detection of sinusoidal signals with unknown phase, frequency, and arrival time Linear signal models and their applications - Estimator-correlator Linear model for signal detection Gaussian random signals and their statistical properties Detection of weak signals using statistical techniques	10
Unit 3	Detection in the absence of complete statistical descriptions of observations Sign detectors and their properties Wilcoxon detector for nonparametric	6

	detection Detection of quantized observations Robustness of detectors to signal variations	
Unit 4	Minimum variance unbiased estimation Cramér–Rao lower bound (CRLB) and its significance Sufficient statistics and complete statistics Linear models for estimation Maximum likelihood estimation (MLE) and its properties Bayesian estimation principles Risk functions and minimum mean square error (MMSE) estimation A posteriori estimation techniques	10
Unit 5	Linear Bayesian estimation Wiener filtering and its applications Dynamic signal models Discrete Kalman filtering and its applications in tracking systems	6
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	Detection, Estimation, and Modulation Theory - Part I /Harry L. Van Trees/ Wiley
2	Fundamentals of Statistical Signal Processing, Volume 1: Estimation Theory/ by Steven M. Kay /Prentice Hall
3	Fundamentals of Statistical Signal Processing, Volume 2: Detection Theory/ Steven M. Kay/ /PrenticeHall
4	Statistical Signal Processing / Louis L. Scharf /Addison-Wesley

EC412: Fundamentals of MIMO

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Fundamentals of MIMO	3	1	0	Communication Systems

Course Objective: To introduce the basic concepts of MIMO systems and their significance in wireless communication. The mathematical foundations of MIMO systems include channel modeling and capacity analysis.

Course Outcomes:
CO1: Explain the principle of MIMO systems and their advantages over SISO (Single Input SingleOutput Systems.
CO2: Analyze MIMO channel models and compute the capacity of MIMO systems under different conditions.
CO3: Design and evaluate MIMO techniques such as spatial multiplexing, diversity, and beamforming.
CO4: To study the practical implementation challenges and solutions in MIMO systems
CO5:Identify and address practical challenges in implementing MIMO systems in real wireless communication.

S. No.	Content	Contact Hours
Unit 1	Overview of wireless communication systems Evolution from SISO to MIMO Benefits of MIMO: Capacity, Diversity, and Multiplexing Applications of MIMO in modern wireless standards (4G, 5G, Wi-Fi)	6
Unit 2	Channel modeling basics: Rayleigh, Rician, and Nakagami fading MIMO channel matrix representation Spatial correlation and its impact on MIMO performance Keyhole effect and other practical channel impairments	10
Unit 3	Shannon's capacity for SISO systems, MIMO capacity under different channel conditions (CSI known/unknown at the transmitter), Water-filling algorithm for capacity maximization, Ergodic and	8

	outage capacity	
Unit 4	Spatial Multiplexing: BLAST (Bell Labs Layered Space-Time) architectures Diversity Techniques: Alamouti code, OSTBC (Orthogonal Space-Time Block Codes) Beamforming: Principles and algorithms (e.g., Zero-Forcing, MMSE) Hybrid techniques: Combining multiplexing and diversity	8
Unit 5	MIMO in 4G LTE and 5G NR, Massive MIMO: Concept and challenges, MIMO-OFDM (Orthogonal Frequency Division Multiplexing) system, MIMO in mmWave communications- Introduction to simulation tools (MATLAB, Python) Simulating MIMO channels and analyzing performance metrics (BER, Capacity, Hardware implementation challenges: Antenna design, RF impairments, and signal processing	10
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	MIMO Wireless Communications/Claude Oestges and Bruno Clerckx/Academic press 2010
2	Fundamentals of Wireless Communication/David Tse and Pramod Viswanath/Cambridge University Press/2005
3	Space-Time Wireless Systems: From Array Processing to MIMO Communications/H. Bölcskei, D. Gesbert, C. Papadias, and A.-J. van der Veen/Cambridge University Press/2006
4	MIMO-OFDM Wireless Communications with MATLAB/Yong Soo Cho, Jaekwon Kim, Won Young Yang, and Chung G. Kang/John Wiley & Sons (Asia) Pte Ltd/2010
5	Wireless Communications: Principles and Practice/Theodore S. Rappaport/Cambridge University Press/2024