



GOVERNMENT COLLEGE OF ENGINEERING, SALEM
(NAAC Accredited with A⁺, An Autonomous Institution, Affiliated to Anna University, Chennai)

POSTGRADUATE CURRICULUM

(Applicable to the students admitted in M.E. Programme, from the Academic Year 2026-2027)

Programme: M.E. Communication Systems

Regulations: 2026

Overview of Credits

Sem	BS	ES(PC)	ES(PE)	SD	MC	AC	Total
I	4	14		1	3	0	22
II		14	6			0	20
III			6	8			14
IV				14			14
Total	4	28	12	23	3	0	70
% of Category	5.71	40.00	17.14	32.86	4.29	0	100

Abbreviations:

Course Type:

T - Theory
L - Laboratory
PW -Project Work

Category :

BS - Basic Science
ES - Engineering Science [Programme Core(**PC**)
Programme Elective(**PE**)]
SD - Skill Development
MC -Mandatory Course
AC- Audit Course

Others :

TCP -Total Contact Periods
L - Lecture
T - Tutorial
P - Practical

Semester I											
Sl. No.	Course Code	Course Name	Course Type	Hours per Semester				Credits	Category	Weightage	
				L	T	P	TCP			CA %	ES %
1.	26MP104	Advanced Mathematical Methods for Communication Systems	T	45	15	0	60	4	BS	40	60
2.	26CO101	Antennas and Radiating Systems	T	45	15	0	60	4	ES(PC)	40	60
3.	26CO102	Cognitive Radio	T	45	0	0	45	3	ES(PC)	40	60
4.	26CO103	Advanced Digital Communication Techniques	T	45	0	0	45	3	ES(PC)	40	60
5.	26MLC01	Research Methodology and IPR	T	45	0	0	45	3	MC	40	60
6.	26CO104	Antennas and Radiating Systems Laboratory	L	0	0	60	60	2	ES(PC)	60	40
7.	26CO105	Advanced Digital Communication Techniques Laboratory	L	0	0	60	60	2	ES(PC)	60	40
8.	26CO106	Technical Seminar	-	0	0	30	30	1	SD	100	-
9.	26AC00X	Audit Course - I	T	30	0	0	30	0	AC	100	-
Total							435	22			

Semester II											
Sl. No.	Course Code	Course Name	Course Type	Hours per Semester				Credits	Category	Weightage	
				L	T	P	TCP			CA %	ES %
1.	26CO201	RF and Microwave Circuit Design	T	45	0	0	45	3	ES(PC)	40	60
2.	26CO202	Advanced Digital Signal Processing	T	60	0	0	60	4	ES(PC)	40	60
3.	26CO203	Advanced Wireless Communication	T	45	0	0	45	3	ES(PC)	40	60
4.	26COEXX	Programme Elective – I	T	45	0	0	45	3	ES(PE)	40	60
5.	26COEXX	Programme Elective – II	T	45	0	0	45	3	ES(PE)	40	60
6.	26CO204	Advanced Digital Signal Processing Laboratory	L	0	0	60	60	2	ES(PC)	60	40
7.	26CO205	Advanced Wireless Communication Laboratory	L	0	0	60	60	2	ES(PC)	60	40
8.	26AC00X	Audit Course - II	T	30	0	0	30	0	AC	100	0
Total							390	20			

Semester III											
Sl. No.	Course Code	Course Name	Course Type	Hours per Semester				Credits	Category	Weightage	
				L	T	P	TCP			CA %	ES %
1.	26COEXX	Programme Elective – III	T	45	0	0	45	3	ES(PE)	40	60
2.	26COEXX	Programme Elective – IV	T	45	0	0	45	3	ES(PE)	40	60
3.	26CO301	Dissertation Phase – I	PW	0	0	240	240	8	SD	60	40
Total							330	14			

Semester IV											
Sl. No.	Course Code	Course Name	Course Type	Hours per Semester				Credits	Category	Weightage	
				L	T	P	TCP			CA %	ES %
1.	26CO401	Dissertation Phase – II	PW	0	0	420	420	14	SD	60	40
Total							420	14			
Total Credits for the Programme = 22 +20+14+14								70			

Programme Electives

Sl. No.	Course Code	Course Name	Course Type	Hours per Semester				Credits	Category	Weightage	
				L	T	P	TCP			CA %	ES %
Programme Elective - I (Semester II)											
1.	26COE01	6G Communication Systems	T	45	0	0	45	3	ES(PE)	40	60
2.	26COE02	Optical Communication Networks	T	45	0	0	45	3	ES(PE)	40	60
3.	26COE03	Vehicular Information and Communication Systems	T	45	0	0	45	3	ES(PE)	40	60
4.	26COE04	Wireless Network Security	T	45	0	0	45	3	ES(PE)	40	60
Programme Elective - II (Semester II)											
5.	26COE05	AI for Communication Systems	T	45	0	0	45	3	ES(PE)	40	60
6.	26COE06	Pattern Recognition and Machine Learning	T	45	0	0	45	3	ES(PE)	40	60
7.	26COE07	Radar & RF Signal Engineering	T	45	0	0	45	3	ES(PE)	40	60
8.	26COE08	Signal Detection and Estimation	T	45	0	0	45	3	ES(PE)	40	60
Programme Elective - III (Semester III)											
9.	26COE09	Satellite Communication Systems	T	45	0	0	45	3	ES(PE)	40	60
10.	26COE10	Massive MIMO and mmWave System	T	45	0	0	45	3	ES(PE)	40	60
11.	26COE11	Software Defined Networking	T	45	0	0	45	3	ES(PE)	40	60
12.	26COE12	IOT and Edge Communication	T	45	0	0	45	3	ES(PE)	40	60
Programme Elective - IV (Semester III)											
13.	26COE13	Image and Video Processing	T	45	0	0	45	3	ES(PE)	40	60
14.	26COE14	Wavelets and Subband Coding	T	45	0	0	45	3	ES(PE)	40	60
15.	26COE15	Electromagnetic Interference and Compatibility	T	45	0	0	45	3	ES(PE)	40	60
16.	26COE16	Biomedical Communication Systems	T	45	0	0	45	3	ES(PE)	40	60

Audit Courses

Sl. No.	Course Code	Course Name	Course Type	Hours per Semester				Credits	Category	Weightage	
				L	T	P	TCP			CA %	ES %
1.	26AC001	English for Research paper writing	T	30	0	0	30	0	AC	100	0
2.	26AC002	Disaster Management	T	30	0	0	30	0	AC	100	0
3.	26AC003	Sanskrit for Technical Knowledge	T	30	0	0	30	0	AC	100	0
4.	26AC004	Value Education	T	30	0	0	30	0	AC	100	0
5.	26AC005	Constitution of India	T	30	0	0	30	0	AC	100	0
6.	26AC006	Pedagogy Studies	T	30	0	0	30	0	AC	100	0
7.	26AC007	Stress Management by Yoga	T	30	0	0	30	0	AC	100	0
8.	26AC008	Personality Development through Life Enlightenment Skills	T	30	0	0	30	0	AC	100	0
9.	26AC009	Sustainable Development Goals	T	30	0	0	30	0	AC	100	0

26MP104	ADVANCED MATHEMATICAL METHODS FOR COMMUNICATION SYSTEMS (M.E.-Communication Systems)			SEMESTER		I		
Prerequisites				Category	BS	Credits	4	
Basic knowledge of calculus, matrices, probability and fundamental engineering mathematics is required.				Hours/ Semester	L	T	P	TH
					45	15	0	60
COURSE OBJECTIVES								
1.	To understand variational principles and solve problems using Euler’s equation.							
2.	To analyze queueing models using birth-death and Mark ovian processes.							
3.	To study graph models, representations and connectivity properties in networks.							
4.	To apply graph algorithms for shortest path, spanning tree and traversal problems.							
5.	To solve optimization problems using linear programming and transportation models.							
UNIT-I		CALCULUS OF VARIATIONS						9+3
Variation and Its Properties – Euler–Lagrange Equation – Functionals Dependent on First- and Higher-Order Derivatives – Functionals Dependent on Several Independent Variables – Applications of Calculus of Variations – Direct Method: Ritz Method.								
UNIT-II		QUEUEINGMODELS						9+3
Markovian Queues – Birth and Death Processes – Single-server and Multi-server Queueing Models – Little’s Law – Queues with Finite Waiting Rooms – Queues with Impatient Customers (Balking and Reneging) – Finite Source Models – M/G/1 Queue – Pollaczek–Khinchin Formula.								
UNIT-III		GRAPHS						9+3
Graphs and Graph Models – Basic Terminology and Types of Graphs – Adjacency Matrix and Incidence Matrix Representations – Graph Isomorphism – Connectivity – Euler Paths and Circuits– Hamilton Paths and Circuits.								
UNIT-IV		GRAPHALGORITHMS						9+3
Paths and Trees – Spanning Trees – Directed Graphs – Graph Colouring – Basic Graph Algorithms: Dijkstra's Algorithm, Depth-First Search (DFS), Breadth-First Search (BFS), Prim's Algorithm and Kruskal's Algorithm.								
UNIT-V		OPTIMIZATION TECHNIQUES						9+3
Linear Programming–Formulation o fLinear Programming Problems–Graphical Method– Simplex Method – Big-M Method – Transportation Problems –Assignment Problems.								
L:45, T:15, P:0, Total: 60 Hours								
Weightage:								
Continuous Assessment: 40%								
End Semester Examinations: 60%								

REFERENCE BOOKS:					
1.	Elsgolts,L.D.,“Calculus of Variations”, Dover Publications Inc., 2007.				
2.	Gross,D., and Harris,C.M.,“Fundamentals of Queueing Theory”, 4 th Edition, Wiley, New York, 2008.				
3.	Deo, Narsingh, “Graph Theory with Applications to Engineering and Computer Science”, Prentice Hall of India (PHI), New Delhi, 1974.				
4.	Taha, H.A.,“Operations Research : An Introduction”, 10 th Edition, Pearson, 2017.				
5.	SwarupKanti.,Gupta,P.K.,and Mohan Man, “Operations Research”, Sultan Chand & Sons, New Delhi, 2014.				
E-RESOURCES:					
1.	NPTEL – Calculus of Variations https://nptel.ac.in/courses/111/105/111105039				
2.	MIT OpenCourseWare – Discrete Stochastic Processes (Queueing Models Support) https://ocw.mit.edu/courses/6-262-discrete-stochastic-processes-spring-2011/				
3.	NPTEL – Graph Theory https://nptel.ac.in/courses/106/106/106106169				
4.	GeeksforGeeks – Graph Algorithms (Dijkstra, BFS, DFS, MST) https://www.geeksforgeeks.org/graph-data-structure-and-algorithms/				
5.	NPTEL – Operations Research (Linear Programming & Optimization) https://nptel.ac.in/courses/112/105/112105249				
COURSE OUTCOMES (COs)/ At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs		
CO1	Explain calculus of variations, queueing models, graph theory, graph algorithms and optimization techniques used in engineering problem solving.	PO3	PSO1		
CO2	Apply Euler’s equation, Ritz method, Markovian queues, graph representations, and linear programming methods to solve engineering problems.	PO1, PO3	PSO1		
CO3	Analyze engineering problems using birth–death and queueing models, graph theory and algorithms, and linear programming methods for optimization and decision making.	PO1, PO3	PSO1, PSO2		
CO4	Evaluate solutions of variational problems, queueing systems, graph algorithms and optimization models for engineering decision making.	PO1, PO3	PSO2		
CO5	Design mathematical models using calculus of variations, queueing theory, graph theory and optimization techniques to obtain optimal solutions.	PO1, PO2, PO3	PSO1, PSO2		
The Course Articulation Matrix (CAM) for defined COs					
	PO1	PO2	PO3	PSO1	PSO2
CO1	-	-	2	2	-
CO2	3	-	3	3	-
CO3	3	-	3	3	3
CO4	2	-	2	-	2
CO5	2	2	2	2	2
Average	2.5	2	2.4	2.5	2.3

Activities:

1.	Solve an optimization problem using Euler's equation or Ritz method.
2.	Analyze an M/M/1 or M/M/c queueing model and verify Little's Law.
3.	Construct adjacency/incidence matrix for a given graph and test connectivity, Eulerpathor Hamilton path.
4.	Implement Dijkstra's Algorithm and find minimum spanning tree using Prim's or Kruskal algorithm.
5.	Solve a linear programming problem using Simplex method and solve transportation or assignment problem.

Rubrics for evaluation: CO4 (Evaluation of Mathematical Methods for Engineering Decision Making)

Sl. No.	Criterion	Marks	Excellent (7-8)	Good (4-6)	Satisfactory (1-3)
1.	Understanding of Mathematical Methods	8	Demonstrates strong understanding of mathematical methods and Their applicability	Shows adequate understanding with minor gaps	Demonstrates limited understanding
2.	Selection and Justification of Appropriate Model/Algorithm	8	Appropriate model/algorithm selected with clear and logical justification	Suitable model/algorithm selected with minor issues	Incorrect or unclear model/algorithm selection
3.	Formulation and Implementation of Mathematical Approach	8	Mathematical approach is correctly formulated and systematically implemented	Minor errors in formulation or implementation	Incomplete or incorrect formulation and implementation
4.	Accuracy, Validity and Interpretation of Analysis	8	Analysis mathematically correct, valid, and appropriately interpreted	Minor computational, analytical, or interpretation errors	Major computational, analytical, or interpretation errors
5	Technical Presentation and Communication of Results	8	Results are critically analyzed and clearly presented in asystematic and professional manner	Interpretation and presentation are acceptable with minor issues	Poor analysis, interpretation, and presentation
	Total	40			

Rubrics for evaluation: CO5 (Development of Mathematical Models and Engineering Solutions)

Sl. No.	Criterion	Marks	Excellent (7-8)	Good (4-6)	Satisfactory (1–3)
1.	Problem Formulation and Mathematical Modelling	8	Engineering problem is clearly formulated with an appropriate mathematical model	Minor issues in formulation or modelling	Problem formulation and modelling are unclear
2.	Selection of Mathematical Method/Algorithm	8	Appropriate mathematical method or algorithm is selected with clear justification	Suitable method or algorithm selected with Minor issues	Inappropriate or unclear method/algorithm selection
3.	Methodology and Solution Development	8	Mathematical model, method, or algorithm is correctly developed and systematically implemented	Methodology is adequate with minor errors	Incorrect or incomplete methodology
4.	Solution Accuracy and Validation	8	Solutions are accurate and properly verified or validated	Validation is adequate with minor issues	Poor or incomplete validation of solutions
5.	Analysis, Engineering Interpretation and Technical Presentation	8	Results are effectively analyzed, related to engineering applications, and communicated through clear, organized, and technically sound Reports and presentations	Interpretation and presentation are acceptable with minor issues	Poor interpretation of results and inadequate presentation / documentation
	Total	40			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	12	12	-	-	12	2
CO2	24	24	-	-	24	3
CO3	24	24	-	-	24	3
CO4	-	-	40		20	2
CO5	-	-		40	20	2
Total	60	60	40	40	100	

Note: Strength=3 (ifpercentage>20%);Strength=2(ifpercentage10%to20%); Strength = 1 (if percentage <10%);

26CO101	ANTENNAS AND RADIATING SYSTEMS		SEMESTER			I	
Prerequisites			Category	ES(PC)	Credits		4
Electromagnetic Fields			Hours/ Semester	L	T	P	TCP
				45	15	0	60
COURSE OBJECTIVES							
1.	To understand the basic concepts and parameters of antennas.						
2.	To study the characteristics of wire antennas and antenna arrays.						
3.	To learn the principles and applications of aperture, horn, and reflector antennas.						
4.	To understand modern antenna technologies such as microstrip, MIMO, and RFID antennas.						
5.	To study antenna measurement techniques and test environments.						
UNIT - I		ANTENNA FUNDAMENTALS & WIRE ANTENNAS					9+3
Types of Antennas, Radiation Mechanism, Current distribution on thin wire antenna. Fundamental parameters of Antennas, Friis Transmission equation. Linear Wire Antennas Infinitesimal dipole, small dipole, half wave dipole, Loop Antennas: Small Circular loop, Circular Loop of constant current, Circular loop with non-uniform current.							
UNIT - II		LINEAR ARRAYS					9+3
Linear Arrays: Two element array, N Element array: Uniform Amplitude and spacing, Broadside and End fire array, Binomial array, Chebyshev array, beamforming, Super directivity, Planar array, Design consideration.							
UNIT - III		APERTURE, HORN AND REFLECTOR ANTENNAS					9+3
Aperture Antennas: Huygens's Field Equivalence principle, Babinet's principle, radiation equations, Rectangular Aperture, Circular Aperture. Horn Antennas: E-Plane, H-plane Sectoral horns, Pyramidal and Conical horns. Reflector Antennas: Plane reflector, parabolic reflector, Cassegrain reflectors.							
UNIT - IV		MODERN ANTENNAS					9+3
Micro strip Antennas: Basic Characteristics, Feeding mechanisms, Method of analysis, Rectangular Patch, Circular Patch, reconfigurable, MIMO, mm wave, THz antennas, Antennas for WBAN – RFID Antennas and implantable antennas.							
UNIT - V		ANTENNA MEASUREMENTS					9+3
Antenna test environments, anechoic/reverb chambers, gain, pattern, impedance, polarization, VSWR & S-Parameter Measurements.							
Total : 60 Hours							
Weightage:							
Continuous Assessment 40%							
End Semester Examinations 60%							

REFERENCE BOOKS:

1.	Balanis, C. A. (2016). Antenna theory: Analysis and design. John Wiley & Sons
2.	Gross, F. B. (2011). Frontiers in antennas: Next generation design and engineering. McGraw Hill.
3.	Drabowitch, S., Papiernik, A., Griffiths, H. D., Encinas, J., & Smith, B. L. (2013). Modern antennas. Springer.
4.	Krauss, J. D. (2017). Antennas. John Wiley & Sons.
5.	Stutzman, W. L., & Thiele, G. A. (2012), Antenna theory and design. John Wiley & Sons

E-RESOURCES:

1.	https://nptel.ac.in/courses/108106122
2.	https://nptel.ac.in/courses/108101092
3.	https://onlinecourses.nptel.ac.in/noc22_ee63
4.	Microwave engineering and antennas Coursera
5.	https://ocw.mit.edu

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Explain the basic concepts of various types of antenna and antenna arrays	PO3	PSO1
CO2	Apply antenna theory to analyze the performance of dipole antenna, linear arrays, reflector antennas, and microstrip antennas.	PO1, PO3	PSO2
CO3	Analyze modern antenna systems and antenna measurement techniques.	PO1, PO2, PO3	PSO2
CO4	Evaluate different antenna technologies for communication applications based on performance, societal needs, and regulatory requirements.	PO1, PO3	PSO1
CO5	Develop and communicate antenna design solutions using modern simulation tools while working effectively in teams and managing project activities.	PO2, PO3	PSO2

The Course Articulation Matrix (CAM) for defined Cos

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1			3	3	
CO2	3		3		3
CO3	3	2	3		3
CO4	3		3	3	
CO5		3	3		3

Activities:

1. Compare different antenna types (microstrip, horn, reflector, MIMO) for 5G/6G applications.
2. Design a microstrip patch antenna for Wi-Fi / 5G application.

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Technical Understanding	20	Clear explanation of all antenna types with correct theory	Minor gaps in explanation	Basic understanding only
2.	Performance Comparison	20	Detailed and accurate comparison using parameters	Partial comparison with few parameters	Limited comparison
3.	5G/6G Application Relevance	20	Strong justification for each antenna in modern systems	Some relevance explained	Weak application link
4.	Analysis & Evaluation	20	Critical evaluation with clear reasoning	Some evaluation present	Simple listing only
5.	Presentation / Report Quality	20	Well-structured, clear diagrams/tables	Good presentation with minor issues	Basic presentation
	Total	100			

Rubrics for Evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Design Calculations	20	Accurate and complete design steps	Minor errors in calculations	Partial design steps
2.	Simulation Setup	20	proper model setup with correct parameters	Minor setup issues	Basic simulation done
3.	Radiation Pattern & Results	20	Clear interpretation of gain, return loss, VSWR	Some interpretation	Basic results shown
4.	Optimization/Improvement	20	Iterative design improvement shown	Some tuning done	Limited improvement
5.	Technical Report Quality	20	Well-organized, clear diagrams, results & conclusion	Good report with minor issues	Basic documentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	20	20			20	2
C02	20	20			20	2
C03	20	20			20	2
C04			40		20	2
C05				40	20	2
Total	60	60	40	40	100	

Note: Purely as anExample: Strength = 3 (if percentage >20%);

Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26C0102		COGNITIVE RADIO		SEMESTER		I	
Prerequisites			Category	ES(PC)	Credits	3	
1. Wireless Communication			Hours/ Semester	L	T	P	TCP
				45	0	0	45
COURSE OBJECTIVES							
1.	To understand the fundamentals, architecture, and design principles of Software Defined Radio (SDR) and Cognitive Radio systems.						
2.	To Provide knowledge of Cognitive Radio architecture, cognitive functions, spectrum management, and dynamic spectrum access mechanisms						
3.	To Understand of spectrum sensing and spectrum opportunity identification techniques for efficient spectrum utilization.						
4.	To analyse the spectrum management functions using cognitive radio systems and cognitive radio networks.						
5.	To analyze Cognitive Radio network architectures, protocols, and emerging applications in next-generation wireless communication systems.						
UNIT - I		SOFTWARE DEFINED RADIO AND ITS ARCHITECTURE					9
Software Defined Radio (SDR): Definition, characteristics and potential benefits – Evolution of software radio architectures – Technology trade-offs and architectural implications – Essential functions of Software Defined – Radio-SDR hardware architecture-SDR software architecture-Top-level SDR component interfaces –Interface topologies for plug-and-play modules.							
UNIT - II		COGNITIVE RADIO ARCHITECTURE					9
Definition, characteristics and need for Cognitive Radio – Cognitive cycle and cognitive engine – Functional architecture of Cognitive Radio –Cognitive Radio architecture layers – Spectrum sensing engine, spectrum management, spectrum mobility and spectrum sharing functions – Policy engine and reconfigurable transceiver architecture, learning engine and decision engine.							
UNIT - III		SPECTRUM SENSING AND IDENTIFICATION					9
Primary Signal Detection: Energy Detector, Cyclostationary Feature Detector, Matched Filter, Cooperative Sensing , Definition and Implications of Spectrum Opportunity, Spectrum Opportunity Detection, MAC Layer Performance Measures, Global Interference Model, Local Interference Model, Fundamental Trade-offs: Sensing Accuracy versus Sensing Overhead.							
UNIT - IV		COGNITIVE RADIO NETWORK SECURITY					9
Overview of IEEE 802.22 – Standard–IEEE 802.22 Physical Layer–IEEE 802.22 Medium Access Control – Primary User Emulation Attacks–Security Vulnerabilities in IEEE 802.22							
UNIT - V		COGNITIVE RADIO NETWORKS AND APPLICATIONS					9
Cognitive Radio Network (CRN) architectures – MAC protocols for Cognitive Radio networks – Routing in Cognitive Radio Ad Hoc Networks (CRAHNs) – Security issues and attacks in Cognitive Radio networks – Machine Learning and Artificial Intelligence techniques for Cognitive Radio – Applications of Cognitive Radio in 5G/6G, IoT, Public Safety Networks and Smart Wireless Systems.							
Total : 45 Hours							

Weightage:

Continuous Assessment 40%

End Semester Examinations 60%

REFERENCE BOOKS:

1.	Alexander M. Wyglinski, Maziar Nekovee, and Thomas Hou Y, "Cognitive Radio Communications and Networks - Principles and Practice", Elsevier Inc., 2010
2.	Kwang-Cheng Chen and Ramjee Prasad, "Cognitive Radio Networks", John Wiley & Sons Ltd, 2009
3.	Arslan H, "Cognitive Radio, Software Defined Radio and Adaptive Wireless Systems", University of South Florida, USA, Springer, 2007.
4.	Khattab, Ahmed, Perkins, Dmitri, Bayoumi, Magdy, "Cognitive Radio Networks - From Theory to Practice", Springer Series: Analog Circuits and Signal Processing, 2009.
5.	E. Biglieri, A.J. Goldsmith., L.J. Greenstein, N.B. Mandayam, H.V. Poor, "Principles of Cognitive Radio", Cambridge University Press, 2013.

E-RESOURCES:

1.	http://www.wirelessinnovation.org/Cognitive_Radio_Architecture
2.	http://www.xgtechnology.com/innovations/cognitive-radio-networks/
3.	https://booksite.elsevier.com/samplechapters/9780123747150/01~Front_Matter.pdf
4.	https://content.e-bookshelf.de/media/reading/L-578781-3f712e4db7.pdf
5.	http://www.radio-electronics.com/info/rf-technology-design/cognitive-radio-cr/technologytutorial.php

COURSE OUTCOMES (COs) /

At the end of the course, the students will have the ability to

		Mapping POs	Mapping PSOs
CO1	Explain the concepts, architecture, functional components, and design trade-offs of Software Defined Radio (SDR) systems.	PO1, PO3	PSO1
CO2	Describe the architecture, cognitive cycle, spectrum management functions, and decision-making mechanisms of Cognitive Radio systems.	PO1, PO2,	PSO1, PSO2
CO3	Analyze various spectrum sensing and spectrum opportunity detection techniques used for dynamic spectrum access in Cognitive Radio networks.	PO1, PO2, PO3	PSO1, PSO2
CO4	Examine the IEEE 802.22 standard, identify security vulnerabilities, and evaluate security threats in Cognitive Radio networks.	PO1, PO2, PO3	PSO2
CO5	Apply Cognitive Radio concepts to advanced wireless communication systems including 5G/6G and IoT.	PO2, PO3	PSO2

The Course Articulation Matrix (CAM) for defined Cos

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2		3	2	
CO2	2	1		2	3
CO3	3	1	3	3	3
CO4	3	2	3		3
CO5		3	3		3

Activities:

1.	Use MATLAB/NS-3/Python simulations to compare CRN protocols.(CO4)
2.	Analyze spectrum management functions, IEEE 802.22 standards, and security challenges in Cognitive Radio Networks. (CO5)

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Analysis of Security Threats	25	Thorough analysis of attacks and vulnerabilities with technical justification	Good analysis with minor gaps	Limited analysis
2.	Spectrum Management Concepts	25	Clearly explains spectrum sharing, mobility, and management functions	Adequate explanation with few errors	Partial understanding
3.	Problem Solving Ability	20	Proposes effective mitigation techniques with strong justification	Proposes feasible solutions	Limited solutions suggested
4.	Understanding of IEEE 802.22 Standard	10	Comprehensive explanation of PHY, MAC, and operational framework	Good understanding with minor omissions	Basic understanding demonstrated
5.	Technical Presentation/Report	20	Well-structured, professional, and technically sound	Organized and mostly accurate	Adequate but lacks clarity
	Total	100			

Rubrics for Evaluation: C05

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Understanding of CRN Architecture	20	Demonstrates complete understanding of CRN architectures and protocols	Good understanding with minor gaps	Basic understanding of architecture and protocols
2.	Knowledge of AI/ML Techniques in Cognitive Radio	20	Clearly explains AI/ML techniques and their applications	Explains major concepts with minor omissions	Basic explanation of AI/ML applications
3.	Evaluation of Emerging Applications (5G/6G, IoT, Public Safety, Smart Wireless Systems)	20	Critically evaluates multiple applications with examples	Discusses applications with reasonable understanding	Identifies applications with limited discussion
4.	Analysis and Problem-Solving Ability	20	Provides logical analysis and justified conclusions	Performs adequate analysis	Limited analytical ability
5.	Technical Report / Presentation and Communication Skills	20	Excellent organization, clarity, and technical communication	Good presentation with minor deficiencies	Satisfactory presentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	20	20			20	2
C02	20	20			20	2
C03	20	20			20	2
C04			40		20	2
C05				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26CO103		ADVANCED DIGITAL COMMUNICATION TECHNIQUES		SEMESTER		I	
Prerequisites			Category	ES(PC)	Credits	3	
Digital Communication Probability Theory and Random Processes			Hours/ Semester	L	T	P	TCP
				45	0	0	45
COURSE OBJECTIVES							
1.	To understand signal space representation, communication channel models and synchronization techniques used in modern digital communication systems.						
2.	To analyze optimum receiver structures and detection techniques for reliable communication in noisy environments.						
3.	To evaluate pulse shaping and equalization techniques for transmission over bandlimited channels.						
4.	To study coherent and non-coherent digital modulation techniques used in communication systems.						
5.	To apply error control coding techniques for improving communication reliability and bandwidth efficiency.						
UNIT – I		SIGNAL SPACE REPRESENTATION AND COMMUNICATION SYSTEM MODELS					9
Digital communication system architecture – Signal space concepts – Gram-Schmidt orthogonalization procedure – Geometric representation of signals – Signal constellation diagrams – Communication channel models – AWGN channel – Channels with memory – Synchronization fundamentals – Carrier synchronization – Timing synchronization – Coded digital communication system architectures.							
UNIT - II		DETECTION THEORY AND RECEIVER STRUCTURES					9
Detection theory fundamentals – Decision regions – Maximum a Posteriori (MAP) detection – Maximum Likelihood (ML) detection – Correlation receiver – Matched filter receiver – Probability of error analysis – Coherent detection – Non-coherent detection – Binary detection in noise – Receiver comparison and performance evaluation.							
UNIT - III		COMMUNICATION OVER BANDLIMITED CHANNELS					9
Bandlimited communication channels – Nyquist criterion for zero ISI – Pulse shaping techniques – Raised cosine and root raised cosine filters – Eye diagram analysis – Controlled ISI systems – Optimum demodulation in the presence of ISI and AWGN – Linear equalizers – Zero forcing equalizer – MMSE equalizer – Decision feedback equalizer.							
UNIT - IV		DIGITAL MODULATION TECHNIQUES					9
Digital modulation formats – BPSK – BFSK – QPSK – MSK – Coherent generation and detection – Signal space representation – Bit error probability – Power spectral density – M-PSK – M-QAM – Comparison of modulation schemes in terms of BER, bandwidth efficiency and power efficiency.							
UNIT - V		ERROR CONTROL CODING					9
Linear block codes – Generator and parity check matrices – Cyclic codes – Reed Solomon codes – Convolutional codes – State diagram – Tree diagram – Trellis diagram – Viterbi decoding – Turbo codes – Introduction to LDPC codes – Coding gain – Coding for bandwidth and power efficiency.							
Total : 45 Hours							
Weightage:							
Continuous Assessment 40%							
End Semester Examinations 60%							

REFERENCE BOOKS:

1.	Simon Haykin, Digital Communications, John Wiley & Sons, 2014.
2.	Marvin K. Simon, Sami M. Hinedi and William C. Lindsey, Digital Communication Techniques: Signal Design and Detection, PHI Learning, 2014.
3.	John G. Proakis and Masoud Salehi, Fundamentals of Communication Systems, Pearson Education, 2005.
4.	Bernard Sklar, Digital Communications: Fundamentals and Applications, 2 nd Edition, Pearson Education, 2017.
5.	Wayne Tomasi, Advanced Electronic Communication Systems, 6 th Edition, Pearson Education, 2014.

E-RESOURCES:

1.	NPTEL – Digital Communication https://nptel.ac.in/courses/117101051
2.	NPTEL – Digital Communication Systems https://nptel.ac.in/courses/108104091
3.	MIT OpenCourseWare – Digital Communication Systems https://ocw.mit.edu
4.	IEEE Communications Society https://www.comsoc.org
5.	MATLAB Communication Toolbox Documentation https://www.mathworks.com/help/comm

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Analyze signal space representations, communication channel models and synchronization techniques used in digital communication systems.	PO3	PSO1
CO2	Evaluate optimum receiver structures and detection techniques for communication over noisy channels.	PO1, PO3	PSO1
CO3	Analyze pulse shaping and equalization techniques for transmission through bandlimited channels.	PO1, PO3	PSO1
CO4	Evaluate digital modulation techniques and select appropriate modulation schemes for communication applications.	PO1, PO2, PO3	PSO1
CO5	Apply error control coding techniques to improve reliability, bandwidth efficiency and power efficiency of communication systems.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	-	-	3	3	-
CO2	3	-	3	3	-
CO3	3	-	3	3	-
CO4	3	2	3	3	-
CO5	3	3	3	2	3

Activities:

1.	Simulation Activity: (C04) Develop MATLAB/Python/GNU Octave programs for BPSK, QPSK, M-PSK or M-QAM systems and evaluate BER performance under AWGN channels. Compare bandwidth efficiency and power efficiency using simulation results.
2.	Self-Learning / Mini Case Study: (C05) Study one coding technique such as Reed-Solomon Coding, Turbo Coding, LDPC Coding or Convolutional Coding used in modern communication systems. Prepare a technical report and presentation with suitable examples and performance comparison.

Rubrics for Evaluation: C04

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Modulation scheme selection	20	Appropriate scheme with justification	Relevant scheme selected	Requires guidance
2.	Simulation implementation	25	Correct implementation and outputs	Minor errors	Partial implementation
3.	BER analysis	20	Accurate interpretation	Adequate interpretation	Limited analysis
4.	Validation and comparison	15	Complete comparison	Partial comparison	Minimal comparison
5.	Report and presentation	20	Well-structured report	Adequate report	Incomplete report
	Total	100			

Rubrics for Evaluation: C05

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Literature survey	20	Comprehensive survey	Good survey	Limited references
2.	Coding technique understanding	20	Excellent conceptual clarity	Moderate understanding	Basic understanding
3.	Performance evaluation	20	Accurate evaluation	Acceptable evaluation	Limited evaluation
4.	Technical report	20	Well-documented report	Adequate report	Poor documentation
5.	Presentation	20	Clear and confident	Good presentation	Limited clarity
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	20	20			20	2
C02	20	20			20	2
C03	20	20			20	2
C04			40		20	2
C05				40	20	2
Total	60	60	40	40	100	

Note:Purely as anExample: Strength = 3 (if percentage >20%);
Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26MLC01	RESEARCH METHODOLOGY AND IPR			SEMESTER		I	
Prerequisites			Category	MC	Credits		3
			Hours/ Semester	L	T	P	TH
				45	0	0	45
COURSE OBJECTIVES							
1.	To develop the subject of the research						
2.	To encourage the formation of higher level of trained intellectual ability, critical analysis, rigor and independence of thought.						
3.	To initiate individual judgement and skill in the application of research theory and methods						
4.	To gain knowledge to file patents.						
5.	To develop skills required in writing research proposals, reports and dissertations.						
UNIT - I		INTRODUCTION TO RESEARCH					9
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of the research problem, Approaches to investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.							
UNIT - II		EFFECTIVE LITERATURE STUDIES APPROACHES, ANALYSIS					9
Developing the theoretical framework of research - Developing operational statements of the problem - Criteria for evaluating research approach - Hypotheses: Parametric and non-parametric testing- Establishing the reliability and validity of findings with literature review and experiments – documentation, Plagiarism, Research ethics.							
UNIT - III		EFFECTIVE TECHNICAL WRITING AND RESEARCH PROPOSAL					9
Developing a Research Proposal, Formats for thesis, report and research papers, Documentation and presentation tools- introduction to LATEX and MS Office - presentation and assessment by a review committee							
UNIT - IV		NATURE OF INTELLECTUAL PROPERTY					9
Patents, Designs, Trade and Copyright, The process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.							
UNIT - V		PATENT RIGHTS					9
Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filing, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licensing of related patents, patent agents, Registration of patent agents.							
L:45, Total:45 Hours							
Weightage:							
Continuous Assessment 40%							
End Semester Examinations 60%							

REFERENCE BOOKS:	
1.	Kothari.C.R, Research Methodology – Methods and Techniques, New age Publications, New Delhi, 2009
2.	Stuart Melville and Wayne Goddard, "Research methodology: An introduction for science & Engineering students"
3.	Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
4.	Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
5.	Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007
6.	Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in the New Technological Age", 2016.
7.	T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

E-RESOURCES:	
1.	https://nptel.ac.in/courses/121106007

COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs
CO1	Explain the fundamental concepts of research methodology, literature review techniques, technical documentation, intellectual property rights, and patent systems.		
CO2	Apply research approaches, data collection methods, hypothesis testing, research ethics, and documentation practices in engineering research problems.	PO1	PSO2
CO3	Analyze research problems, evaluate literature findings, validate research outcomes, and examine intellectual property and patenting procedures.	PO1	PSO2
CO4	Assess the effectiveness of research methodologies, technical reports, research proposals, and patent protection strategies for engineering applications.	PO2, PO3	PSO1
CO5	Develop research proposals, technical reports, and innovative intellectual property solutions by integrating research methodology and patenting concepts.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs					
COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	-	-	-	-	-
CO2	3	-	-	-	2
CO3	3	-	-	-	2
CO4	-	3	2	2	-
CO5	3	3	3	2	2
AVERAGE	3	3	2.5	2	2

Activities:					
1.	Evaluation of Research Methodologies, Technical Reports, and Patent Case Studies through Self-Learning Activities and Report Submission				
2.	Development of Research Proposals, Technical Reports, and Innovative Patent Concepts through Self-Learning Activities and Technical Presentation.				
Rubrics for evaluation: CO4					
Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Selection of Research Paper and Patent	20	Highly relevant and appropriate selection	Relevant selection	Basic selection
2.	Analysis of Research Methodology	20	Comprehensive evaluation with critical insights	Adequate evaluation	Limited evaluation
3.	Assessment of Patent Protection Strategy	20	Thorough assessment with clear justification	Good assessment	Basic assessment
4.	Technical Report Preparation	20	Well-structured and professionally documented	Good organization with minor errors	Basic documentation
5.	Conclusions and Recommendations	20	Insightful conclusions with strong recommendations	Relevant conclusions	Basic conclusions
	Total	100			
Rubrics for evaluation: CO5					
Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Problem Identification and Objective Formulation	20	Clearly defined problem and objectives	Adequately defined problem and objectives	Basic problem identification
2.	Research Proposal Development	20	Comprehensive and feasible proposal	Good proposal with minor gaps	Basic proposal
3.	Innovation and Patent Concept Development	20	Highly innovative and patentable concept	Moderately innovative concept	Limited innovation
4.	Technical Report Documentation	20	Professional and well-organized report	Good report with minor deficiencies	Basic report preparation

5.	Technical Presentation and Defence	20	Excellent presentation with strong justification	Good presentation and justification	Satisfactory presentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	12	12			12	2
CO2	24	24			24	2
CO3	24	24			24	2
CO4			40		20	3
CO5				40	20	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26CO104	ANTENNAS AND RADIATING SYSTEMS LABORATORY		SEMESTER			I
Prerequisites		Category	ES(PC)	Credits		2
Antenna and Radiating Systems, Electromagnetic Fields and Transmission Lines		Hours/ Semester	L	T	P	TCP
			0	0	60	60
COURSE OBJECTIVES						
1.	To understand the basic principles and working of different types of antennas.					
2.	To design and analyze microstrip patch antennas using various feeding techniques.					
3.	To study the radiation characteristics and performance parameters of common antennas such as dipole, loop, Yagi–Uda, horn, and parabolic antennas.					
4.	To observe the effect of antenna modifications, such as slots, array spacing, and reconfigurable structures, on antenna performance.					
5.	To develop practical skills in antenna design, simulation, measurement, and radiation pattern analysis.					
Experiments						
1.	Design and analyze a rectangular microstrip patch antenna using different feeding techniques, namely edge feed, inset feed, and coaxial probe feed.					
2.	Design and analyze a circular microstrip patch antenna using a coaxial feeding technique.					
3.	Study the effect of slot incorporation on the performance of a microstrip antenna.					
4.	Analyze the performance characteristics of a half-wave dipole antenna.					
5.	Analyze the performance characteristics of a folded dipole antenna.					
6.	Analyze the performance characteristics of a Yagi–Uda antenna.					
7.	Analyze the performance characteristics of a loop antenna.					
8.	Measure and analyze the radiation pattern of a horn antenna.					
9.	Analyze the performance characteristics of a parabolic antenna.					
10.	Design and analyze a frequency-reconfigurable antenna.					
11.	Design and study the radiation patterns of broadside and end-fire antenna arrays.					
12.	Study the effect of varying the inter-element spacing on the radiation pattern of a broadside and end fire array.					
13.	Design a two-element MIMO antenna and evaluate its diversity performance parameters.					
Total : 60 Hours						
Weightage: Continuous Assessment 60% End Semester Examinations 40%						

REFERENCE BOOKS:

1.	Constantine A. Balanis, "Antenna Theory Analysis and Design", John Wiley & Sons, 2012.
2.	Elliot, R.S: "Antenna theory and design", PHI, New Delhi, 1985.
3.	Antennas for All Applications – John D. Kraus and Ronald J. Marhefka, McGraw-Hill.
4.	Introduction to Antennas and Propagation, Wiley.
5.	Antenna Theory and Practice and H. T. Friis, Wiley.

E-RESOURCES:

1.	https://ansyshelp.ansys.com/public/Views/Secured/Electronics/v242/en/PDFs/An%20Introduction%20to%20HFSS.pdf
2.	https://www.academia.edu/3356546/High_Frequency_Structure_Simulator_HFSS_Tutorial
3.	https://www.researchgate.net/publication/322726818_Microstrip_Antennas
4.	https://www.youtube.com/watch?v=fTbte1c2b_w
5.	https://share.google/96Zd0j2bzHTLTzRLk

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Understand the basic concepts, types, and characteristics of antennas.	PO3	PSO1
CO2	Apply antenna design principles and use simulation tools to study antenna performance.	PO1, PO3	PSO2
CO3	Design and analyze different antennas and antenna arrays for specified applications.	PO1, PO3	PSO2
CO4	Evaluate antenna performance by comparing parameters such as gain, bandwidth, radiation pattern, and efficiency.	PO1, PO3	PSO1
CO5	Develop improved antenna designs and propose solutions for modern wireless communication systems.	PO1, PO3	PSO2

The Course Articulation Matrix (CAM) for defined Cos

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1			3	3	
CO2	3		3		3
CO3	3		3		3
CO4	3		3	3	
CO5	3		3		3

Activities:

1.	Prepare technical reports comparing antenna characteristics for 5G applications
2.	Design and simulate a novel or modified antenna for 6G application.

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Technical Understanding	20	Clear explanation of all antenna types with correct theory	Minor gaps in explanation	Basic understanding only
2.	Performance Comparison	20	Detailed and accurate comparison using parameters	Partial comparison with few parameters	Limited comparison
3.	5G Application Relevance	20	Strong justification for each antenna in modern systems	Some relevance explained	Weak application link
4.	Analysis & Evaluation	20	Critical evaluation with clear reasoning	Some evaluation present	Simple listing only
5.	Presentation/Report Quality	20	Well-structured, clear diagrams/tables	Good presentation with minor issues	Basic presentation
	Total	100			

Rubrics for Evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Design Calculations	20	Accurate and complete design steps	Minor errors in calculations	Partial design steps
2.	Simulation Setup	20	proper model setup with correct parameters	Minor setup issues	Basic simulation done
3.	Radiation Pattern & Results	20	Clear interpretation of gain, return loss, VSWR	Some interpretation	Basic results shown
4.	Optimization/Improvement	20	Iterative design improvement shown	Some tuning done	Limited improvement
5.	Presentation/report	20	Well-organized, clear diagrams, results & conclusion	Good report with minor issues	Basic documentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Laboratory component		Percentage allocation	Mapping Strength
	Observation and Record	Model Test		
CO1	20	20	20	2
CO2	20	20	20	2
CO3	20	20	20	2
CO4	20	20	20	2
CO5	20	20	20	2
Total	100	100	100	

Note:Purely as anExample: Strength = 3 (if percentage >20%);
Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26CO105		ADVANCED DIGITAL COMMUNICATION TECHNIQUES LABORATORY		SEMESTER		I	
Prerequisites			Category	ES(PC)	Credits		2
Advanced Digital Communication Techniques			Hours/ Semester	L	T	P	TCP
				0	0	60	60
COURSE OBJECTIVES							
1.	To implement and analyze digital modulation techniques using simulation tools.						
2.	To investigate receiver structures and detection techniques under noisy channel conditions.						
3.	To evaluate pulse shaping, eye pattern and equalization techniques in digital communication systems.						
4.	To design and analyze channel coding techniques for reliable communication.						
5.	To develop SDR-based digital communication systems using modern software and hardware tools.						
LIST OF EXPERIMENTS:							
PART A – SOFTWARE BASED EXPERIMENTS							
1.	Signal Space Representation of Digital Communication Signals						
2.	BER Analysis of BPSK Modulation Scheme						
3.	BER Analysis of QPSK Modulation Scheme						
4.	Performance Evaluation of M-QAM Modulation Schemes						
5.	Implementation of Matched Filter Receiver						
6.	Implementation of Correlation Receiver						
7.	Eye Pattern Analysis of Communication Systems						
8.	Pulse Shaping using Raised Cosine and Root Raised Cosine Filters						
9.	Analysis of Intersymbol Interference and Equalization						
10.	Implementation of Linear Block Codes						
11.	Implementation of Cyclic Codes						
12.	Convolutional Coding and Viterbi Decoding						
13.	Performance Analysis of Turbo Codes						
14.	Baseband Digital Communication using SDR Platform						
15.	Passband Digital Communication using SDR Platform						
Total : 60 Hours							

LIST OF SOFTWARE	
Open Source Software	
1.	GNU Octave
2.	Python
3.	NumPy
4.	SciPy
5.	Matplotlib
6.	GNU Radio
AVAILABLE LICENSED SOFTWARE	
7.	LabVIEW Communication System Design Suite
LIST OF EQUIPMENT	
1.	Software Defined Radio (SDR) Hardware Kit
2.	SDR Antenna Kit
3.	Personal Computer / Workstation
Weightage: Continuous Assessment 60% End Semester Examinations 40%	
REFERENCE BOOKS:	
1.	Simon Haykin, "Communication Systems", 5th Edition, Wiley, 2009.
2.	John G. Proakis and Masoud Salehi, "Digital Communications", 5th Edition, McGraw-Hill, 2008.
3.	Bernard Sklar and Fredric J. Harris, "Digital Communications: Fundamentals and Applications", 2nd Edition, Pearson, 2017.
4.	Ian Glover, Peter Grant and Michael K. Ryan, "Digital Communications", 3rd Edition, Pearson, 2020.
5.	Michael Rice, "Digital Communications: A Discrete-Time Approach", 2nd Edition, Pearson, 2018.
E-RESOURCES:	
1.	https://wiki.gnuradio.org/index.php/Main_Page
2.	https://numpy.org/doc/stable/?utm_source
3.	https://docs.scipy.org/doc/scipy/reference/signal.html?utm_source=chatgpt.com
4.	http://digimat.in/nptel/courses/video/117105144/L01.html
5.	https://www.youtube.com/watch?v=fTbte1c2b_w
6.	https://onlinecourses.nptel.ac.in/noc21_ee11/preview
7.	https://share.google/96Zd0j2bzHTLTzRLk

COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs
CO1	Implement and analyze digital modulation techniques using simulation tools.	PO3	PSO1
CO2	Evaluate receiver structures and detection techniques under noisy channel conditions.	PO1, PO3	PSO1
CO3	Investigate pulse shaping, eye pattern and equalization techniques in digital communication systems.	PO1, PO3	PSO1
CO4	Design and analyze channel coding techniques for reliable communication.	PO1, PO2, PO3	PSO1, PSO2
CO5	Develop SDR-based digital communication systems through simulation, experimentation and technical presentation.	PO1, PO2, PO3	PSO2

The Course Articulation Matrix (CAM) for defined Cos

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	-	-	2	2	-
CO2	2	-	2	2	-
CO3	2	-	2	2	-
CO4	2	2	2	2	2
CO5	2	2	2	-	2

Activities:

1.	Simulation Activity (CO4): Implement and compare Block Codes, Convolutional Codes and Turbo Codes using MATLAB/Python/GNU Octave. Analyze coding gain and BER performance under AWGN channel.
2.	SDR Activity (CO5) Develop a simple digital communication system using SDR platform for transmission and reception of digitally modulated signals. Record observations and present performance metrics.

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Technical Understanding of Channel Coding	20	Clear explanation of channel coding, error detection	Minor gaps in explanation	Basic understanding only
2.	Coding Technique Design	20	Correctly designs encoding and decoding techniques	Design is mostly correct with minor errors	Basic or partially correct design
3.	Performance Analysis	20	Detailed and accurate analysis using BER, SNR, coding gain	Partial analysis using few performance parameters	Limited analysis
4.	Simulation/Implementation & Evaluation	20	Successfully implements and evaluates the coding technique	Implementation works with minor issues and limited evaluation	Basic implementation with limited results

5.	Analysis & Presentation/Report Quality	20	Well-structured report with clear results, graphs/tables	Good presentation with minor issues	Basic presentation
	Total	100			

Rubrics for Evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Technical Understanding of SDR	20	Clear explanation of SDR architecture, components and digital communication principles with correct theory	Minor gaps in explanation of SDR concepts	Basic understanding only
2.	SDR System Development & Simulation	20	Successfully develops a complete SDR-based communication system through simulation with appropriate parameters	Develops the system with minor implementation issues	Basic or partially functional system
3.	Experimental Implementation	20	Effectively performs experiments and demonstrates reliable SDR communication with meaningful observations	Experiment is performed with minor issues	Basic experimentation with limited observations
4.	Performance Analysis & Evaluation	20	Detailed analysis using BER, SNR, constellation/waveform and other relevant parameters with clear conclusions	Partial analysis using selected parameters	Limited analysis or simple result listing
5.	Technical Presentation/Report Quality	20	Well-structured report and presentation with clear block diagrams, results, graphs and excellent technical explanation	Good report with minor issues	Basic documentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:				
CO	Laboratory component		Percentage allocation	Mapping Strength
	Observation and Record	Model Test		
C01	20	20	20	2
C02	20	20	20	2
C03	20	20	20	2
C04	20	20	20	2
C05	20	20	20	2
Total	100	100	100	
Note: Purely as an Example: Strength = 3 (if percentage >20%); Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);				

26CO106		TECHNICAL SEMINAR		SEMESTER			I
Prerequisites			Category	SD	Credits		1
			Hours/ Semester	L	T	P	TH
				0	0	30	30
COURSE OBJECTIVES							
1.	To work on a specific technical topic in Engineering design related topics to acquire the skills of oral presentation						
2.	To acquire technical writing abilities for seminars and conferences.						
3.	To identify and compare technical and practical issues related to the area of course specialization.						
4.	To outline annotated bibliography of research demonstrating scholarly skills						
5.	Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting						
CONTENTS							
1.	The students will work for two hours per week guided by a group of staff members.						
2.	They will be asked to talk on any topic of their choice related to Engineering design, and search relevant journal paper on the selected topics for presentation and to engage in dialogue with the audience.						
3.	Student is expected to present two seminars per semester.						
4.	The student will have to present a seminar of not less than fifteen minutes and not more than thirty minutes on the technical topic along with the journal reference copy.						
5.	A Faculty Advisor and two experts from the Department will evaluate the seminar.						
6.	Evaluation will be based on the technical presentation, seminar paper and also on the interaction during the seminar using the specific rubrics.						
Total=30 Hours							
Weightage: Continuous Assessment 100%							
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to				Mapping POs	Mapping PSOs		
CO1	Explain the selected engineering design topic and its technical background using appropriate literature sources						
CO2	Collect, review, and summarize technical information from journals, conference papers, and industry reports.			PO1	PSO2		
CO3	Analyze and compare technical approaches, practical issues, and recent developments related to the selected topic.			PO1	PSO2		
CO4	Evaluate research findings, identify gaps, and respond to technical queries during seminar discussions.			PO2, PO3	PSO1		
CO5	Prepare and deliver a professional technical seminar report and presentation demonstrating communication, documentation, and scholarly skills.			PO1, PO2, PO3	PSO1, PSO2		

The Course Articulation Matrix (CAM) for defined COs						
COs / POs		PO1	PO2	PO3	PS01	PS02
CO1		2	1		1	1
CO2		3			1	2
CO3		3	2		2	2
CO4			3	2	2	
CO5		3	3	3	2	2
AVERAGE		2.75	2.25	2.50	1.60	1.75
Activities:						
1.	Literature Review and Annotated Bibliography					
2.	Technical Seminar Presentation and Discussion					
Rubrics for evaluation: 1						
Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)	
1.	Topic Selection and Relevance	20	Highly relevant and current topic	Relevant topic	Limited relevance	
2.	Literature Search Quality	20	Comprehensive and credible sources	Adequate sources	Few or weak sources	
3.	Annotated Bibliography	20	Clear, concise, and analytical summaries	Adequate summaries	Minimal analysis	
4.	Technical Understanding	20	Strong understanding of the topic	Moderate understanding	Limited understanding	
5.	Documentation and Formatting	20	Professional and error-free	Minor formatting issues	Poor formatting	
	Total	100				
Rubrics for evaluation: 2						
Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)	
1.	Technical Content and Accuracy	20	Highly accurate and in-depth	Generally accurate	Superficial content	
2.	Organization and Clarity	20	Excellent flow and clarity	Adequate organization	Poor organization	
3.	Presentation Skills	20	Confident, engaging, professional delivery	Adequate delivery	Weak delivery	

4.	Response to Questions	20	Accurate and insightful responses	Adequate responses	Unable to answer satisfactorily
5.	Report Quality and Referencing	20	Well-structured report with proper references	Adequate report	Poor documentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Component		Percentage allocation	Mapping Strength
	Review 1	Review 2		
CO1	10	10	10	2
CO2	10	10	10	2
CO3	10	10	10	2
CO4	35	35	35	3
CO5	35	35	35	3
Total	100	100	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26CO201	RF AND MICROWAVE CIRCUIT DESIGN		SEMESTER			II
Prerequisites		Category	ES(PC)	Credits		3
1. Microwave Engineering 2. Electromagnetic Field Theory		Hours/ Semester	L	T	P	TCP
			45	0	0	45
COURSE OBJECTIVES:						
1.	To Understand the fundamentals of RF and microwave engineering, including transmission structures, passive components, and high-frequency circuit behavior.					
2.	To Design and analyze RF active circuits such as amplifiers, oscillators, mixers, and power amplifiers for communication applications.					
3.	To Apply impedance matching, stability analysis, and computer-aided design (CAD) techniques in RF circuit development.					
4.	To Explore microwave resonators, filters, and modern RF subsystems used in contemporary wireless communication systems.					
5.	To Evaluate and optimize RF circuit performance through simulation, measurement, and performance analysis techniques.					
UNIT - I		INTRODUCTION TO RF AND MICROWAVE				9
Importance of RF and Microwave Engineering – RF and Microwave Applications – Frequency Spectrum and RF Units – RF Behaviour of Passive Components: High Frequency Resistors, Capacitors and Inductors – Transmission Line Fundamentals – Equivalent Circuit Representation – Reflection Coefficient – Standing Wave Ratio (SWR) – Propagation Constant – Phase and Group Velocity – Smith Chart and Impedance Matching Applications.						
UNIT - II		RF DEVICES AND CIRCUITS				9
RF Amplifier Design – Power Gain Equations – Unilateral and Bilateral Gain – Maximum Gain Design – Low Noise Amplifier Design – Stability Considerations – RF Oscillator Design – One-Port and Two-Port Negative Resistance Oscillators – Large Signal Oscillator Analysis – RF Mixers: Single Balanced and Double Balanced Mixers – Mixer Performance Parameters.						
UNIT - III		RF SYSTEM DESIGN				9
Impedance Matching Techniques – Lumped Element Matching Networks – Microstrip Matching Networks – RF Biasing Networks – Amplifier Design Concepts – Power Relations in RF Systems – Cascaded RF Circuits – Receiver and Transmitter Building Blocks – Design Considerations for Portable RF Systems.						
UNIT - IV		RF POWER AMPLIFIERS AND SYSTEM DESIGN				9
Feedback Concepts in RF Circuits – Stability Analysis – Gain Margin and Phase Margin – Root Locus Techniques – Time Domain and Frequency Domain Compensation – Power Amplifier Fundamentals – Class A, AB, B, C, D, E and F Amplifiers – Efficiency and Linearity Trade-offs – ACPR Metric – Power Amplifier Design Considerations.						
UNIT - V		MICROWAVE RESONATORS AND FILTERS				9
Resonator Fundamentals – Lumped and Distributed Resonators – Transmission Line Resonators – Waveguide Cavities – Resonator Excitation Methods – RF Filter Characteristics –Filter Realization Techniques – Coupled Resonator Filters – Filter Implementation and Applications.						
Total : 45 Hours						

Weightage:

Continuous Assessment 40%

End Semester Examinations 60%

REFERENCE BOOKS:

1.	Mathew M. Radmanesh, "Radio Frequency & Microwave Electronics", Pearson Education Asia, Second Edition,
2.	Reinhold Ludwig and Powel Bretchko," RF Circuit Design – Theory and Applications", Pearson Education Asia, First Edition.
3.	Devendra K. Misra, "Radio Frequency and Microwave Communication Circuits – Analysis and Design", Wiley Student Edition, John Wiley & Sons, 2 nd edition, July 2004.
4.	Christopher Bowick, Cheryl Aljuni and John Biyler, "RF Circuit Design", Elsevier Science, 2008.
5.	Joseph Carr, "Secrets of RF Design", Tata McGraw Hill Publications, 3 rd Edition, 2004.

E-RESOURCES:

1.	http://www.qsl.net/va3iul/Files/RF_courses_lectures.htm
2.	http://www.seas.ucla.edu/brweb/teaching.html
3.	http://nptel.ac.in/courses
4.	https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SEC1405.pdf
5.	https://mrcet.com/downloads/digital_notes/ECE/IV Year/10082021/MWE Digital notes.pdf

COURSE OUTCOMES (COs) /

After successful completion of the course, students will be able to:

**Mapping
POs****Mapping
PSOs**

CO1	Explain the behavior of passive components and transmission lines at RF and microwave frequencies.	PO3	PSO1, PSO2
CO2	Design and analyze RF amplifiers, oscillators and mixers using appropriate performance metrics.	PO1, PO3	PSO1, PSO2
CO3	Apply impedance matching and RF system design principles to communication circuits.	PO1, PO2, PO3	PSO1, PSO2
CO4	Analyze feedback systems and evaluate the performance of RF power amplifiers.	PO1, PO3	PSO2
CO5	Design and evaluate RF resonators and filters for microwave applications.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined Cos

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1			2	2	3
CO2	3		2	1	2
CO3	3	2	3	2	2
CO4	2		3		2
CO5	2	2	2	2	2

Activities:

1.	Simulation and performance evaluation of Class A, Class B and Class AB power amplifiers.(CO4)
2.	Design and analysis of microwave resonators and coupled resonator filters.(CO5)

Rubrics for Evaluation: C04

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem Understanding & Circuit Selection	25	Correctly identifies amplifier classes and design requirements	Minor omissions in requirements	Basic understanding of concepts
2.	Circuit Design & Simulation Setup	25	Accurate circuit design with proper component selection and simulation parameters	Minor design/simulation errors	Acceptable design with limited justification
3.	Results Interpretation & Discussion	25	Results clearly interpreted with meaningful comparison and conclusions	Good interpretation with minor gaps	Basic discussion of results
4.	Technical Report & Presentation	25	Well-organized report, clear graphs/tables, professional presentation	Good report with minor issues	Adequate report and presentation
	Total	100			

Rubrics for Evaluation: C05

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem Definition & Specification Analysis	25	Clearly identifies resonator/filter specifications and design requirements	Minor omissions in specifications	Basic understanding of concepts
2.	Resonator/Filter Design Methodology	25	Correct design procedure with appropriate resonator and filter selection	Implementation is correct with minor issue	Basic implementation with limited functionality
3.	Simulation & Performance Evaluation	25	Accurate simulation and evaluation of frequency response, insertion loss, return loss, bandwidth and Q-factor	Good comparison with adequate metrics	Limited performance analysis
4.	Analysis & Interpretation of Results	25	Comprehensive analysis with comparison to design specifications and proper conclusions	Good analysis with minor gaps	Basic discussion of results
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	20	20			20	2
C02	20	20			20	2
C03	20	20			20	2
C04			40		20	2
C05				40	20	2
Total	60	60	40	40	100	

Note:Purely as anExample: Strength = 3 (if percentage >20%);
Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26CO202	ADVANCED DIGITAL SIGNAL PROCESSING		SEMESTER			II
Prerequisites		Category	ES(PC)	Credits		4
Digital Signal Processing Basic Probability and Linear Algebra		Hours/ Semester	L	T	P	TCP
			60	0	0	60
COURSE OBJECTIVES						
1.	To understand the fundamentals of discrete random signals, stationarity, correlation functions and power spectral density used in advanced signal processing.					
2.	To apply simple and practically useful spectrum estimation methods for finite-length signals encountered in communication and signal analysis applications.					
3.	To analyze signal modelling, linear prediction and optimum filtering methods with emphasis on conceptual clarity and solvable numerical problems.					
4.	To design basic adaptive filters and multirate signal processing structures for communication, speech and audio processing applications.					
5.	To use MATLAB/Python/Scilab-based self-learning activities for simulation, interpretation, documentation and presentation of advanced DSP concepts.					
UNIT - I	DISCRETE RANDOM SIGNAL PROCESSING					9+3
Discrete random processes - Ensemble average - Mean, variance and autocorrelation - Wide sense stationary processes - Ergodicity - Auto-covariance and cross-covariance - Autocorrelation and cross-correlation matrices - Properties of correlation functions - White noise process - Wiener-Khinchin relation - Power spectral density - Filtering of random processes - Basic idea of spectral factorization - Introduction to AR, MA and ARMA processes - Yule-Walker equations with simple numerical examples.						
UNIT - II	SPECTRUM ESTIMATION					9+3
Estimation of spectra from finite duration data - Bias, variance and consistency of estimators - Non-parametric methods: periodogram, modified periodogram, Bartlett, Welch and Blackman-Tukey methods - Effect of windowing and averaging - Introduction to parametric spectrum estimation using AR models - Harmonic signal detection - Conceptual overview of high resolution methods: MUSIC and ESPRIT - Comparison of spectrum estimation methods through simple examples.						
UNIT - III	SIGNAL MODELING AND OPTIMUM FILTERS					9+3
Signal modelling concepts - Least squares method - Linear prediction - Forward and backward prediction - Levinson-Durbin recursion - Lattice filter fundamentals - FIR Wiener filter - Wiener filtering for noise reduction and prediction - Basic discrete Kalman filter: prediction and correction steps - Applications in communication signal estimation. Note: Continuous-time and extended Kalman filters are introduced only as advanced self-study topics.						
UNIT - IV	ADAPTIVE FILTERS					9+3
Need for adaptive filters - FIR adaptive filter structure - Mean square error surface - Method of steepest descent - LMS algorithm - Convergence and step-size selection - Normalized LMS algorithm - Introduction to RLS algorithm and matrix inversion lemma - Applications: adaptive noise cancellation, channel equalization and echo cancellation - Simulation-based comparison of LMS and NLMS algorithms.						

UNIT - V	MULTIRATE DIGITAL SIGNAL PROCESSING	9+3	
Decimation by a factor D - Interpolation by a factor I - Sampling rate conversion by a rational factor I/D - Anti-aliasing and anti-imaging filters - Implementation of sampling rate conversion - Basic polyphase structure - Applications of multirate signal processing - Interfacing systems with different sampling rates - Narrow-band low-pass filtering - Subband coding of speech/audio signals - Introduction to digital filter banks and quadrature mirror filters.			
Total : 60 Hours			
Weightage: Continuous Assessment 40% End Semester Examinations 60%			
REFERENCE BOOKS:			
1.	Monson H. Hayes, Statistical Digital Signal Processing and Modeling, John Wiley and Sons, 2008.		
2.	John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, 4th Edition, Pearson Education, 2013.		
3.	Sanjit K. Mitra, Digital Signal Processing: A Computer-Based Approach, 4th Edition, McGraw Hill Education, 2013.		
4.	Allen B. Downey, Think DSP: Digital Signal Processing in Python, 2nd Edition, Green Tea Press, 2016. Free online version available.		
5.	Steven W. Smith, The Scientist and Engineer's Guide to Digital Signal Processing, California Technical Publishing, free online edition.		
E-RESOURCES:			
1.	NPTEL - Advanced Digital Signal Processing: https://nptel.ac.in/courses/108106136/		
2.	NPTEL - Digital Signal Processing: https://nptel.ac.in/courses/117101001		
3.	Think DSP online book: https://greenteapress.com/wp/think-dsp/		
4.	The Scientist and Engineer's Guide to DSP: https://www.dspguide.com/		
5.	SciPy Signal Processing Documentation: https://docs.scipy.org/doc/scipy/reference/signal.html		
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to			
CO1	Explain the concepts of discrete random processes, correlation functions and power spectral density used in advanced digital signal processing.	PO3	PSO1
CO2	Apply non-parametric and basic parametric spectrum estimation methods to analyze finite-length signals in communication and signal processing applications.	PO1, PO3	PSO1, PSO2
CO3	Analyze signal modelling, linear prediction, Wiener filtering and basic Kalman filtering techniques for estimation and prediction problems.	PO1, PO3	PSO1, PSO2
CO4	Develop adaptive filtering and multirate signal processing solutions for noise cancellation, channel equalization, sampling-rate conversion and speech/audio applications.	PO1, PO3	PSO1, PSO2
CO5	Carry out simulation-based investigation, self-learning, literature review, technical report writing and presentation of advanced DSP applications using modern computational tools.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	-	-	3	3	-
CO2	3	-	3	3	2
CO3	3	-	3	3	2
CO4	3	-	3	3	3
CO5	3	3	3	2	3

Activities:

1.	Simulation Activity (CO4): Implement and compare LMS and NLMS adaptive filters for noise cancellation or channel equalization using MATLAB/Python/Scilab. Students shall submit plots, error curves and short interpretation notes.
2.	Self-Learning / Mini Case Study (CO5): Study one simple ADSP application such as ECG noise removal, audio noise reduction, speech subband coding, communication channel equalization or spectrum analysis of a recorded signal. Prepare a concise report and presentation with references and simulation outputs.

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Algorithm / method selection	20	Selects suitable ADSP algorithm with clear justification.	Selects relevant algorithm with minor gaps.	Needs guidance in algorithm selection.
2.	Simulation implementation	25	Correct and complete implementation with proper parameters.	Mostly correct implementation with minor errors.	Partially working implementation.
3.	Result analysis	20	Interprets plots, error curves and outputs accurately.	Provides acceptable interpretation.	Limited interpretation.
4.	Debugging and validation	15	Validates results using test cases and parameter variation.	Performs basic validation.	Minimal validation.
5	Report and presentation	20	Clear report with figures, observations and conclusion.	Adequate report with minor omissions.	Incomplete or unclear report.
	Total	100			

Rubrics for Evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Literature survey and self-learning	20	Uses appropriate books, lecture notes and open resources effectively.	Uses relevant references with minor gaps.	Uses limited references.

2.	Application understanding	20	Explains ADSP application clearly with practical relevance.	Explains application with moderate depth.	Basic explanation only.
3.	Tool usage and demonstration	20	Uses MATLAB/Python/Scilab effectively with meaningful outputs.	Uses tools with minor errors.	Requires guidance for tool usage.
4.	Technical report writing	20	Well-structured report with proper citations and interpretation.	Clear report with minor deficiencies.	Report lacks clarity or citations.
5.	Communication and presentation	20	Confident presentation and answers questions appropriately.	Good presentation with minor issues.	Limited clarity in presentation.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	20	20			20	2
CO2	20	20			20	2
CO3	20	20			20	2
CO4			40		20	2
CO5				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26CO203	ADVANCED WIRELESS COMMUNICATION	SEMESTER			II	
Prerequisites		Category	ES(PC)	Credits		3
1. Analog and Digital Communication Systems 2. Cellular Mobile Communication Concepts		Hours/ Semester	L	T	P	TCP
			45	0	0	45
COURSE OBJECTIVES						
1.	To understand wireless channel propagation and channel modeling techniques.					
2.	To analyze wireless channel capacity under various communication environments.					
3.	To study the architecture and key technologies of 5G wireless communication systems.					
4.	To learn 5G radio access methods, waveforms, and propagation models.					
5.	To understand advanced wireless networking techniques such as Massive MIMO, CoMP, relaying, and network coding					
UNIT - I	WIRELESS CHANNEL PROPAGATION AND MODEL					9
Radio wave propagation – Transmit and receive signal models - Free space path loss, Two ray model Empirical Path-loss models: Okumura model - COST -231 Hata model, Longley-Rice Model, NLOS Multipath Fading Models: Rayleigh, Rician, Nakagami, Shadowing Distributions, Statistical Multipath channel models: Discrete time model, Space-time channel models.						
UNIT - II	CAPACITY OF WIRELESS CHANNELS					9
AWGN channel capacity, capacity of flat fading channels, channel distribution Information known at transmitter or receiver and both capacity comparisons, Capacity of frequency selective fading channels-time invariant- time variant, Capacity of MISO, SIMO systems.						
UNIT - III	5G ARCHITECTURE AND MILLIMETER WAVE COMMUNICATIONS:					9
Key building blocks of 5G – 5G use cases and System Concepts – The 5G Architecture. Millimeter Wave Communications : Hardware technologies for mmW systems Architecture and mobility – Massive MIMO – Resource Allocation and Transceiver algorithms for Massive MIMO.						
UNIT - IV	5G WAVEFORMS AND CHANNEL MODELS					9
5G Radio Access Technologies: Design principles - Multi-carrier with filtering - Nonorthogonal Multiple Access - Radio access for dense deployments – Radio Access for V2X Communication - Radio access for massive machine-type communication - 5G wireless propagation channel models: Modeling requirements and scenarios - The METIS channel models.						
UNIT - V	ADVANCED WIRELESS NETWORKS					9
Coordinated multi-point transmission in 5G: Joint Transmission CoMP enablers - Distributed cooperative transmission - JT CoMP with advanced receivers - Relaying and network coding in 5G: Multi-flow wireless backhauling - Buffer-aided relaying.						
Total: 45 Hours						
Weightage: Continuous Assessment 40% End Semester Examinations 60%						

REFERENCE BOOKS:	
1.	Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2007.
2.	Andreas.F. Molisch, Wireless Communications, John Wiley, India, 2006.
3.	AfifOsseiran, Jose F. Monserrat and Patrick Marsch, - 5G Mobile and Wireless Communications Technology, Cambridge University Press, 2016.
4.	Jonathan Rodriguez, - Fundamentals of 5G mobile networks, John Wiley & Sons, Ltd, 2015.
5.	Xiang, W., Zheng, K., & Shen, X. (2017). 5G mobile communications. Springer.

E-RESOURCES:	
1.	https://ptacts.uspto.gov/ptacts/public-informations/petitions/1548902/download-documents?artifactId=HZymnPujC75z_5Ehu4qN3wGRSCQ9-936LRdVh1qU3vrWpNu1FTqWdcA
2.	https://ie.u-ryukyu.ac.jp/~wada/system18/5G_Book.pdf
3.	http://www.kepstr.eltech.ru/tor/digicom/books/goldsmith.pdf
4.	https://web.stanford.edu/class/ee359/doc/WirelessComm_Ch1-6_Dec182019.pdf
5.	https://www.southampton.ac.uk/~sqc/ELEC6214/AWCNS-L1.pdf

COURSE OUTCOMES (COs) / After successful completion of the course, students will be able to:		Mapping POs	Mapping PSOs
CO1	Analyze wireless propagation mechanisms and fading channel models in wireless communication systems.	PO1, PO3	PSO1, PSO2
CO2	Evaluate the capacity and performance of wireless channels under different fading and diversity conditions.	PO1, PO3	PSO1, PSO2
CO3	Explain the architecture, key technologies, and operation of 5G wireless communication systems.	PO1, PO2	PSO1, PSO2
CO4	Analyze 5G radio access techniques, waveforms, and channel models for various deployment scenarios.	PO1, PO3	PSO2
CO5	Design and evaluate advanced wireless networking solutions using Massive MIMO, CoMP, relaying, and network coding techniques.	PO1, PO2, PO3	PSO2

The Course Articulation Matrix (CAM) for defined Cos					
COs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	-	3	1	2
CO2	3	-	2	2	2
CO3	2	1		1	2
CO4	2		2		1
CO5	2	2	3		2

Activities:	
1.	Develop and simulate an advanced wireless communication system using MATLAB/NS-3.
2.	Implement a simple network coding algorithm and compare performance with conventional routing.

Rubrics for evaluation: CO4 Simulation-Based Assignment

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Understanding of 5G Radio Access Technologies	20	Demonstrates comprehensive understanding of NOMA, dense deployment, V2X, and mMTC concepts	Demonstrates good understanding with minor gaps	Basic understanding of concepts
2.	Analysis of Waveforms and Channel Models	20	Thorough analysis and comparison of waveforms/channel models with strong technical justification	Good analysis with adequate comparison	Basic analysis with limited comparison
3.	Application to Real-world Scenarios	20	Effectively applies concepts to V2X, IoT, or dense network scenarios with innovative solutions	Appropriate application with good justification	Basic application with limited relevance
4	Simulation/Case Study Results	20	Accurate implementation, comprehensive results, and insightful interpretation	Good implementation and analysis	Partial implementation with basic analysis
5.	Technical Presentation/Report	20	Well-organized report, excellent presentation, clear communication, and responses to questions	Good report and presentation	Adequate documentation and presentation
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem Understanding & Literature Survey	25	Clearly explains network coding concepts, routing techniques, and relevant literature	Good understanding with minor gaps	Basic understanding of concepts
2.	Algorithm Design & Implementation	25	Correctly implements network coding algorithm with efficient design and proper documentation	Implementation is correct with minor issue	Basic implementation with limited functionality
3.	Performance Evaluation	25	Comprehensive comparison of throughput, delay, packet delivery ratio, and bandwidth utilization	Good comparison with adequate metrics	Limited performance analysis
4.	Results Interpretation & Discussion	25	Provides insightful interpretation and technical justification of results	Good interpretation with reasonable conclusions	Basic discussion of results
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	20	20			20	2
C02	20	20			20	2
C03	20	20			20	2
C04			40		20	2
C05				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26CO204	ADVANCED DIGITAL SIGNAL PROCESSING LABORATORY		SEMESTER			II
Prerequisites		Category	ES(PC)	Credits		2
		Hours/ Semester	L	T	P	TCP
			0	0	60	60
COURSE OBJECTIVES						
1.	To implement and analyze advanced digital signal processing algorithms using MATLAB/Octave.					
2.	To design and evaluate FIR and IIR digital filters for communication signal processing applications.					
3.	To perform spectral analysis and system characterization using digital signal processing techniques.					
4.	To implement multirate signal processing techniques including decimation, interpolation and sampling rate conversion.					
5.	To investigate advanced DSP applications in communication systems through simulation studies, technical analysis and self-learning.					
LIST OF EXPERIMENTS:						
1.	Determination of Power Spectrum of a Given Signal					
2.	Simulation of Low Pass FIR Filter using Window Method					
3.	Simulation of High Pass FIR Filter using Window Method					
4.	Simulation of Low Pass IIR Filter					
5.	Simulation of High Pass IIR Filter					
6.	Generation of Sinusoidal Signals through Digital Filtering					
7.	Generation and Detection of DTMF Signals					
8.	Simulation of Decimation Process					
9.	Simulation of Interpolation Process					
10.	Simulation of Integer and Rational Sampling Rate Conversion					
11.	Simulation of Impulse Response of First Order System					
12.	Simulation of Impulse Response of Second Order System					
13.	Generation of Pseudo Random Noise Sequence					
14.	Comparative Analysis of FIR and IIR Filter Characteristics					
15.	Simulation of Adaptive Noise Cancellation using LMS Algorithm					
Total : 60 Hours						

LIST OF EQUIPMENT				
1.	MATLAB with Signal Processing Toolbox.			
2.	GNU Octave.			
3.	DSP Simulation Software.			
4.	Personal Computer with MATLAB/Octave Environment.			
5.	Communication Signal Data Sets.			
Weightage: Observation & Record 60% Activities/Internal Test 40%				
REFERENCE BOOKS:				
1.	John G. Proakis and Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications", 4th Edition, Pearson, 2007.			
2.	Sanjit K. Mitra, "Digital Signal Processing: A Computer-Based Approach", 4th Edition, McGraw-Hill Education, 2011.			
3.	A. V. Oppenheim and Ronald W. Schafer, "Discrete-Time Signal Processing", 3rd Edition, Pearson, 2010.			
4.	S. Salivahanan, A. Vallavaraj and C. Gnanapriya, "Digital Signal Processing", 2nd Edition, McGraw-Hill Education, 2011.			
5.	Emmanuel C. Ifeachor and Barrie W. Jervis, "Digital Signal Processing: A Practical Approach", 2nd Edition, Pearson Education, 2002.			
E-RESOURCES:				
1.	https://www.mathworks.com/help/signal/?utm_source=chatgpt.com https://wiki.gnuradio.org/index.php/Main_Page			
2.	https://docs.octave.org/?utm_source=chatgpt.com			
3.	https://numpy.org/doc/stable/?utm_source			
4.	https://docs.scipy.org/doc/scipy/reference/signal.html?utm_source=chatgpt.com			
5.	https://docs.scipy.org/doc/scipy/reference/signal.html?utm_source			
6.	https://numpy.org/doc/stable/?utm_source			
7.	https://ocw.mit.edu/?utm_source			
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to			Mapping POs	Mapping PSOs
CO1	Implement and analyze digital signal processing algorithms for spectral estimation and signal generation applications.		PO3	PSO1
CO2	Design and evaluate FIR and IIR digital filters for communication signal processing applications.		PO3	PSO1

CO3	Investigate multirate DSP systems including decimation, interpolation and sampling rate conversion techniques.	PO1, PO3	PSO1, PSO2
CO4	Utilize MATLAB/Octave and advanced DSP tools to model, simulate and analyze discrete-time systems and adaptive filtering algorithms.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate advanced DSP techniques through independent simulation studies, technical reports and presentations related to communication systems.	PO1, PO2, PO3	PSO2

The Course Articulation Matrix (CAM) for defined Cos

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	-	-	2	2	-
CO2	-	-	2	2	-
CO3	2	-	2	2	2
CO4	2	2	2	2	2
CO5	2	2	2	-	2

Activities:

1.	Develop MATLAB/Octave programs for: - Spectral Analysis - FIR and IIR Filter Design - Multirate Signal Processing - Adaptive Filtering Compare simulated results with theoretical characteristics and prepare a technical summary.
2.	Conduct a technical study on one advanced DSP application in Communication Systems such as: - Adaptive Noise Cancellation - Speech Processing - OFDM Signal Processing - Channel Equalization - Wireless Communication Signal Analysis - Spectrum Estimation Techniques Present the findings through a seminar and technical report.

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	MATLAB/Octave Coding and Implementation	20	Correct, efficient and well-structured implementation of advanced DSP algorithms	Minor coding errors with limited assistance	Partial implementation requiring considerable guidance
2.	Simulation Execution	25	Correct simulation with appropriate parameters and accurate outputs	Simulation executed with minor errors or parameter	Incomplete simulation or incorrect outputs

				variations	
3.	Analysis of Simulation Results	20	Accurate interpretation of waveforms, spectra, system responses and adaptive filter performance	Adequate analysis with minor omissions	Limited analysis and interpretation
4.	Validation and Comparison	15	Comprehensive validation and comparison with theoretical/expected results	Partial comparison with limited justification	Minimal comparison and justification
5.	Report and Presentation	20	Well-structured report with clear graphs, observations and conclusions; effective presentation	Adequate report and presentation with minor deficiencies	Incomplete report and presentation with limited explanation
	Total	100			

Rubrics for Evaluation: C05

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Selection and Implementation of DSP Technique	20	Independently selects and correctly implements an appropriate advanced DSP technique for communication applications	Selects and implements a suitable technique with minor assistance	Requires guidance for selection and partial implementation
2.	Independent Simulation Study	25	Performs a complete simulation independently with appropriate parameters and test conditions	Performs simulation with minor errors or limited assistance	Incomplete simulation requiring considerable guidance
3.	Performance Evaluation	20	Accurately evaluates performance using relevant parameters and provides meaningful interpretation	Adequate performance evaluation with minor omissions	Limited evaluation and interpretation
4.	Technical Report	15	Well-organized report with methodology, simulation results, graphs, discussion and valid	Adequate report with minor technical or presentation deficiencies	Incomplete report with limited technical discussion

			conclusions		
5.	Technical Presentation and Self-Learning	20	Presents confidently, explains results clearly, demonstrates independent learning and answers questions accurately	Gives a clear presentation with minor difficulties in explanation or answering questions	Limited presentation skills and requires guidance to explain the work
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Laboratory component		Percentage allocation	Mapping Strength
	Observation and Record	Model Lab		
CO1	20	20	20	2
CO2	20	20	20	2
CO3	20	20	20	2
CO4	20	20	20	2
CO5	20	20	20	2
Total	100	100	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26CO205	ADVANCED WIRELESS COMMUNICATION LABORATORY		SEMESTER		II
Prerequisites		Category	ES(PC)	Credits	2
Advanced Digital Communication Techniques		Hours/ Semester	L	T	P
			0	0	60
TCP					
60					
COURSE OBJECTIVES					
1.	To implement and analyze digital modulation techniques using simulation tools.				
2.	To investigate receiver structures and detection techniques under noisy channel conditions.				
3.	To evaluate pulse shaping, eye pattern and equalization techniques in digital communication systems.				
4.	To design and analyze channel coding techniques for reliable communication.				
5.	To develop SDR-based digital communication systems using modern software and hardware tools.				
LIST OF EXPERIMENTS:					
PART A – SOFTWARE BASED EXPERIMENTS					
1.	Signal Space Representation of Digital Communication Signals				
2.	BER Analysis of BPSK Modulation Scheme				
3.	BER Analysis of QPSK Modulation Scheme				
4.	Performance Evaluation of M-QAM Modulation Schemes				
5.	Implementation of Matched Filter Receiver				
6.	Implementation of Correlation Receiver				
7.	Eye Pattern Analysis of Communication Systems				
8.	Pulse Shaping using Raised Cosine and Root Raised Cosine Filters				
9.	Analysis of Intersymbol Interference and Equalization				
10.	Implementation of Linear Block Codes				
11.	Implementation of Cyclic Codes				
12.	Convolutional Coding and Viterbi Decoding				
13.	Performance Analysis of Turbo Codes				
14.	Baseband Digital Communication using SDR Platform				
15.	Passband Digital Communication using SDR Platform				
Total : 60 Hours					

LIST OF SOFTWARE Open Source Software	
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- | | |
|----|------------|
| 1. | GNU Octave |
| 2. | Python |
| 3. | NumPy |
| 4. | SciPy |
| 5. | Matplotlib |
| 6. | GNU Radio |

AVAILABLE LICENSED SOFTWARE	
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|----|---|
| 7. | LabVIEW Communication System Design Suite |
|----|---|

LIST OF EQUIPMENT	
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|----|---|
| 1. | Software Defined Radio (SDR) Hardware Kit |
| 2. | SDR Antenna Kit |
| 3. | Personal Computer / Workstation |

Weightage:	
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Observation & Record 60%	
Activities/Internal Test 40%	

REFERENCE BOOKS:	
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- | | |
|----|---|
| 1. | John G. Proakis and Masoud Salehi, "Digital Communications", 5th Edition, McGraw-Hill, 2008. |
| 2. | Simon Haykin, "Communication Systems", 5th Edition, Wiley, 2009. |
| 3. | Theodore S. Rappaport, "Wireless Communications: Principles and Practice", 2nd Edition, Pearson, 2002. |
| 4. | Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005. |
| 5. | David Tse and Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005. |

E-RESOURCES:	
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- | | |
|----|---|
| 1. | https://wiki.gnuradio.org/?utm_source |
| 2. | https://docs.octave.org/?utm_source |
| 3. | https://www.mathworks.com/help/comm/?utm_source |
| 4. | http://www.digimat.in/nptel/courses/video/117102062/L01.html |
| 5. | https://numpy.org/doc/stable/?utm_source |
| 6. | http://kcl.digimat.in/nptel/courses/video/117104099/L01.html |
| 7. | https://ocw.mit.edu/?utm_source |

COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs
CO1	Implement and analyze digital modulation techniques using simulation tools.	PO3	PSO1
CO2	Evaluate receiver structures and detection techniques under noisy channel conditions.	PO1, PO3	PSO1
CO3	Investigate pulse shaping, eye pattern and equalization techniques in digital communication systems.	PO1, PO3	PSO1
CO4	Design and analyze channel coding techniques for reliable communication.	PO1, PO2, PO3	PSO1, PSO2
CO5	Develop SDR-based digital communication systems through simulation, experimentation and technical presentation.	PO1, PO2, PO3	PSO2

The Course Articulation Matrix (CAM) for defined Cos

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	-	-	2	2	-
CO2	2	-	2	2	-
CO3	2	-	2	2	-
CO4	2	2	2	2	2
CO5	2	2	2	-	2

Activities:

1.	Simulation Activity (CO4): Implement and compare Block Codes, Convolutional Codes and Turbo Codes using MATLAB/Python/GNU Octave. Analyze coding gain and BER performance under AWGN channel.
2.	SDR Activity (CO5) Develop a simple digital communication system using SDR platform for transmission and reception of digitally modulated signals. Record observations and present performance metrics.

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Coding Technique Implementation	20	Correct implementation of all coding techniques	Minor implementation errors	Partial implementation requiring guidance
2.	Simulation Execution	25	Correct simulation with accurate BER and coding gain results	Minor execution errors	Incomplete simulation or incorrect outputs
3.	Performance Analysis	20	Accurate BER comparison and coding gain interpretation	Adequate analysis with minor omissions	Limited analysis and interpretation

4.	Validation and Comparison	15	Comprehensive comparison with theoretical justification	Partial comparison with limited justification	Minimal Comparison and justification
5.	Report and Presentation	20	Well-structured report with clear graphs and conclusions	Adequate report with minor deficiencies	Incomplete report and presentation
	Total	100			

Rubrics for Evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	SDR System Design and Configuration	20	Correct hardware/software configuration with appropriate parameter selection	Minor configuration errors	Configuration completed with significant guidance
2.	Implementation and Signal Transmission	25	Successful transmission and reception with correct implementation	Minor implementation issues	Partial implementation with frequent errors
3.	Performance Measurement	20	Accurate measurement and interpretation of BER, SNR, throughput, or other relevant metrics	Adequate measurement and interpretation	Limited measurement and analysis
4.	Observation and Validation	15	Comprehensive validation with comparison to expected results	Partial validation with limited comparison	Minimal validation and observations
5.	Report and Demonstration	20	Well-organized report, effective demonstration, and confident presentation	Adequate report and demonstration	Incomplete report or ineffective demonstration
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Laboratory component		Percentage allocation	Mapping Strength
	Observation and Record	Model Lab		
CO1	20	20	20	2
CO2	20	20	20	2
CO3	20	20	20	2
CO4	20	20	20	2
CO5	20	20	20	2
Total	100	100	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26CO301		DISSERTATION PHASE - I		SEMESTER		III	
Prerequisites			Category	SD	Credits		8
			Hours/ Semester	L	T	P	TH
				0	0	240	240
COURSE OBJECTIVES							
1.	To develop the ability to solve a specific problem right from its identification and literature review until the successful solution of the same.						
2.	To train the students in preparing project reports and to face reviews and viva voce examination.						
CONTENTS							
1.	Each student shall undertake an individual technical project under the guidance of a faculty member with expertise in the selected domain. The selected topic shall be relevant to the field of Communication Systems and may involve theoretical investigations, analytical studies, simulation-based research, or engineering case studies.						
2.	The student shall formulate a well-defined engineering problem with clearly stated objectives, scope, and expected outcomes. A comprehensive literature review shall be conducted to analyze existing research, identify knowledge gaps, and establish the technical background for the proposed work.						
3.	An appropriate research methodology shall be developed, including problem formulation, design approach, analytical methods, computational tools, simulation techniques, or experimental procedures, as applicable. The work shall demonstrate the application of engineering principles, design methodologies, analytical reasoning, and technical problem-solving skills.						
4.	The student shall present and defend the work through a report, presentation and viva-voce examination before a panel of examiners, including one external examiner, to assess technical competence, analytical ability, presentation skills, and understanding of the chosen topic. The evaluation shall be based on the quality of problem identification, literature survey, and technical methodology, originality of work, report quality, presentation, and viva-voce performance.						
5.	The candidate has to be in regular contact with his guide and the topic of the dissertation must be mutually decided by the guide and student.						
Total=240 Hours							
Weightage: Continuous Assessment 60% End Semester Examinations 40%							
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to				Mapping POs		Mapping PSOs	
CO1	Explain the research problem, background, objectives, and relevant engineering concepts through comprehensive literature review.						
CO2	Apply research methodologies, analytical tools, and engineering principles for problem formulation and investigation.			PO1		PSO2	
CO3	Analyze existing literature, identify research gaps, and formulate appropriate approaches to solve engineering problems.			PO1		PSO1, PSO2	
CO4	Evaluate alternative methodologies, technical feasibility, and preliminary results for addressing the identified research problem.			PO2, PO3		PSO1	
CO5	Develop a structured dissertation proposal including problem statement, objectives, methodology, work plan, and preliminary findings.			PO1, PO2, PO3		PSO1, PSO2	

The Course Articulation Matrix (CAM) for defined COs					
COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1					
CO2	3				3
CO3	3			2	2
CO4		3	3	3	
CO5	3	3	3	3	2
AVERAGE	3.0	3.0	3.0	2.67	2.33
Activities:					
1.	Research Gap Identification and Literature Survey				
2.	Dissertation Proposal Development				
Rubrics for evaluation: 1					
Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Problem identification and relevance	20	Clearly defined, novel, and significant research problem	Relevant problem with minor limitations	Basic problem formulation
2.	Literature Survey	20	Relevant survey with proper references	Adequate survey	Limited literature survey
3.	Methodology implementation	20	Effective implementation with technical rigor	Adequate implementation	Partial implementation
4.	Technical competence	20	Strong understanding and execution capability	Good understanding	Basic understanding
5.	Review presentation and discussion	20	Excellent presentation and response to queries	Good presentation	Basic presentation
	Total	100			
Rubrics for evaluation: 2					
Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Research objectives and scope	20	Well-defined and achievable objectives	Adequately defined objectives	Objectives lack clarity
2.	Methodology selection	20	Appropriate and technically sound methodology	Adequate methodology	Limited methodology justification
3.	Feasibility and resource planning	20	Comprehensive feasibility assessment	Moderate feasibility study	Basic planning
4.	Preliminary investigation/results	20	Meaningful preliminary work and analysis	Partial investigation completed	Minimal progress
5.	Review presentation and technical discussion	20	Excellent presentation and response to queries	Good presentation	Limited discussion
	Total	100			

Rubrics for evaluation: 3

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Dissertation proposal quality	20	Comprehensive and professionally prepared proposal	Good proposal structure	Basic proposal
2.	Technical progress achieved	20	Significant progress with validated outcomes	Moderate progress	Limited progress
3.	Analysis and interpretation	20	Strong analytical approach and interpretation	Adequate analysis	Basic analysis
4.	Work plan and future scope	20	Realistic and well-defined execution plan	Adequate planning	Limited planning
5.	Presentation, report and viva voce	20	Excellent communication and defense of work	Good presentation	Basic presentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Component			Percentage allocation	Mapping Strength
	Review 1	Review 2	Review 3		
CO1	40			10	2
CO2	30	10		20	2
CO3	20	30		20	2
CO4	10	40	20	25	3
CO5		20	80	25	3
Total	100	100	100	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);

Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26CO401		DISSERTATION PHASE - II		SEMESTER		IV	
Prerequisites			Category	SD	Credits		14
			Hours/ Semester	L	T	P	TH
				0	0	420	420
COURSE OBJECTIVES							
1.	To develop the ability to solve a specific problem right from its identification and literature review until the successful solution of the same.						
2.	To train the students in preparing project reports and to face reviews and viva voce examination						
CONTENTS							
1.	Each student shall undertake an individual technical project under the guidance of a faculty member with expertise in the selected domain. The selected topic shall be relevant to the field of Communication Systems and may involve theoretical investigations, analytical studies, simulation-based research, or engineering case studies.						
2.	The student shall formulate a well-defined engineering problem with clearly stated objectives, scope, and expected outcomes. A comprehensive literature review shall be conducted to analyze existing research, identify knowledge gaps, and establish the technical background for the proposed work.						
3.	An appropriate research methodology shall be developed, including problem formulation, design approach, analytical methods, computational tools, simulation techniques, or experimental procedures, as applicable. The work shall demonstrate the application of engineering principles, design methodologies, analytical reasoning, and technical problem-solving skills.						
4.	The student shall present and defend the work through a report, presentation and viva-voce examination before a panel of examiners, including one external examiner, to assess technical competence, analytical ability, presentation skills, and understanding of the chosen topic. The evaluation shall be based on the quality of problem identification, literature survey, and technical methodology, originality of work, report quality, presentation, and viva-voce performance.						
5.	The candidate has to be in regular contact with his guide and the topic of the dissertation must be mutually decided by the guide and student.						
Total=420 Hours							
Weightage: Continuous Assessment 60% End Semester Examinations 40%							
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to				Mapping POs		Mapping PSOs	
CO1	Explain the research problem, methodology, experimental procedures, and technical concepts related to the dissertation work						
CO2	Apply advanced engineering principles, computational tools, experimental techniques, and research methodologies to solve the identified problem.			PO1		PSO2	
CO3	Analyze experimental, simulation, or analytical results and interpret findings to validate the proposed research objectives.			PO1		PSO1, PSO2	
CO4	Evaluate the effectiveness, feasibility, and significance of the developed solution through validation, comparison, and performance assessment.			PO2, PO3		PSO1	
CO5	Develop and successfully demonstrate an innovative engineering solution, dissertation report, technical publication, and research presentation.			PO1, PO2, PO3		PSO1, PSO2	

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1					
CO2	3				3
CO3	3			2	2
CO4		3	3	3	
CO5	3	3	3	3	2
AVERAGE	3.0	3.0	3.0	2.67	2.33

Activities:

1. Research Paper Preparation and Publication Review
2. Prototype / Simulation Demonstration and Thesis Preparation

Rubrics for evaluation: 1

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Problem identification and relevance	20	Clearly defined, novel, and significant research problem	Relevant problem with minor limitations	Basic problem formulation
2.	Literature Survey	20	Relevant survey with proper references	Adequate survey	Limited literature survey
3.	Methodology implementation	20	Effective implementation with technical rigor	Adequate implementation	Partial implementation
4.	Technical competence	20	Strong understanding and execution capability	Good understanding	Basic understanding
5.	Review presentation and discussion	20	Excellent presentation and response to queries	Good presentation	Basic presentation
	Total	100			

Rubrics for evaluation: 2

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Experimental / Simulation results	20	Comprehensive and reliable results obtained	Adequate results	Limited results
2.	Analysis and interpretation	20	Strong analytical interpretation and insight	Moderate analysis	Basic analysis
3.	Validation and comparison	20	Thorough validation with literature / theory/experiments	Adequate validation	Limited validation
4.	Novelty and technical contribution	20	Significant research contribution and originality	Moderate contribution	Limited novelty
5.	Review presentation and technical defense	20	Excellent technical defense and communication	Good communication	Basic communication
	Total	100			

Rubrics for evaluation: 3

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Achievement of objectives and outcomes	20	All objectives successfully achieved and validated	Most objectives achieved	Partial achievement
2.	Quality of dissertation report	20	Professional, publication-quality dissertation	Good report quality	Basic report quality
3.	Innovation and engineering contribution	20	Significant contribution with strong originality	Moderate contribution	Limited contribution
4.	Results, conclusions and future scope	20	Comprehensive conclusions and meaningful future work	Adequate conclusions	Limited conclusions
5.	Final presentation and viva voice	20	Excellent presentation, confidence, and technical defense	Good presentation	Basic presentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Component			Percentage allocation	Mapping Strength
	Review 1	Review 2	Review 3		
CO1	40			10	2
CO2	30	20		20	2
CO3	20	40	20	20	2
CO4	10	30	60	25	3
CO5		10	20	25	3
Total	100	100	100	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26COE01	6G COMMUNICATION SYSTEMS		SEMESTER		II		
Prerequisites			Category	ES(PE)	Credits	3	
5G Communication Networks			Hours/ Semester	L	T	P	TCP
				45	0	0	45
COURSE OBJECTIVES							
1.	To understand the evolution of wireless communication from 1G to 6G and the key drivers for 6G.						
2.	To learn the architecture and design principles of next-generation 6G networks.						
3.	To Study enabling technologies such as AI, RIS, THz communication, and Integrated Sensing and Communication.						
4.	To Analyze spectrum utilization, physical layer innovations, and network intelligence in 6G.						
5.	To Explore emerging applications, challenges, and future research directions in 6G communications.						
UNIT - I		EVOLUTION TOWARDS 6G NETWORKS					9
Evolution from 1G to 5G – Limitations of 5G Networks – Vision and Requirements of 6G – Key Performance Indicators (KPIs) – Ultra-Low Latency and Massive Connectivity – Global Standardization Activities – ITU-R and 3GPP Roadmaps – Use Cases of 6G Networks.							
UNIT - II		6G NETWORK ARCHITECTURE					9
Architecture Overview – Layered Architecture – Physical – Network – Application Layer – Functional Components – Core and Access Network – Edge Nodes - Network Design Principles – Integration with Existing Networks.							
UNIT - III		ENABLING TECHNOLOGIES					9
Cell-Free Massive MIMO – Network Topology, User-Centric Approach & Centralized Processing – Communication Process – Performance Assessment- Applications of Massive MIMO in 6G – Terahertz Communications – Free Space Optical (FSO) in 6G.							
UNIT - IV		SPECTRUM AND PHYSICAL LAYER TECHNOLOGIES					9
Spectrum Bands – Spectrum Management – Role of Physical Layer in 6G – Artificial Intelligence/ Machine Learning in 6G PHY – Hardware Architectures for AI in Radio – Security Issues at 6G PHY – System Model – Channel Estimation in RIS-Aided Single-User Systems.							
UNIT - V		APPLICATIONS, SECURITY AND FUTURE DIRECTIONS					9
Extended Reality (XR) and Metaverse Applications – Internet of Everything (IoE) – Autonomous Vehicles and V2X Communication – Industry 5.0 and Smart Manufacturing – Security, Privacy and Trust in 6G – Green and Sustainable Communications – Challenges and Future Research Directions.							
Total : 45 Hours							
Weightage:							
Continuous Assessment 40%							
End Semester Examinations 60%							

REFERENCE BOOKS:					
1.	Paulo Sergio, Ramjee Prasad, "6G The Road to the Future Wireless Technologies 2030", River Publishers, 2021.				
2.	SenthilKumar, Loganathan, Gyan, Ravi, "6G Wireless Communications and Mobile Networking", BR Publications, 2026.				
3.	Valeria, Luca, Anna Maria, "The Road Towards 6G: Opportunities, Challenges and Applications", Springer, 2024.				
4.	Yulei, Sukhdeep, Tarik, Aloknath, "6G Mobile Wireless Networks" Springer, 2022.				
5.	Wen Tong , Peiying Zhu, "6G: The Next Horizon From Connected People and Things to Connected Intelligence", 2021.				
E-RESOURCES:					
1.	6G The Road to the Future Wireless Technologies 2030				
2.	6G Wireless Communications and Mobile Networking				
3.	https://onlinecourses.nptel.ac.in/noc25_ee88/preview				
4.	https://nptel.ac.in/courses/108106588				
5.	http://www.digimat.in/nptel/courses/video/108106588/L02.html				
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs		
CO1	Explain the evolution, vision, requirements, and key performance metrics of 6G communication systems.	PO1, PO2, PO3	PSO1, PSO2		
CO2	Apply architecture and operational principles of AI-native and integrated 6G networks.	PO1, PO2, PO3	PSO1, PSO2		
CO3	Analyze the enabling technologies supporting next-generation 6G wireless communications.	PO1, PO2, PO3	PSO1, PSO2		
CO4	Analyze the 6G system using simulation tool to compute and future research trends.	PO1, PO2, PO3	PSO1, PSO2		
CO5	Demonstrate professional competency by working individually or in teams to communicate, present and justify solutions related to 6G communication systems through seminar presentation or prepare technical report.	PO1, PO2, PO3	PSO1, PSO2		
The Course Articulation Matrix (CAM) for defined Cos					
COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	1	1	3	2	1
CO2	2	1	3	2	1
CO3	3	1	3	3	2
CO4	3	2	2	2	3
CO5	3	2	2	3	3

Activities:	
1.	To design and simulate a Cell-Free Massive MIMO-based 6G communication system and evaluate its performance in terms of spectral efficiency, throughput, latency, and energy efficiency using MATLAB/Simulink/Python (NumPy, MATLAB Engine, or NS-3) (CO4)
2.	Technical Seminar Presentation on Emerging 6G Technologies/Applications (CO5) (Independent study)

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem formulation & boundary conditions	30	Clearly identifies a 6G research problem and defines objectives	Research problem identified but objectives need refinement	Problem statement is vague with unclear objectives
2.	Simulation Design & Implementation	30	Appropriate simulation tool selected; model is correctly designed and implemented	Simulation implemented with minor errors or incomplete parameter selection	Simulation implemented with minor errors or incomplete parameter selection
3.	Results Analysis & Performance Evaluation	20	Results are accurately analyzed using suitable KPIs and justified with research insights	Results are accurately analyzed using suitable KPIs and justified with research insights	Results are accurately analyzed using suitable KPIs and justified with research insights
4.	Report presentation	20	Report is well-structured, professionally presented, and properly referenced	Report is well-structured, professionally presented, and properly referenced	Report is well-structured, professionally presented, and properly referenced
	Total	100			

Rubrics for Evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Understanding of 6G Concepts	20	Clearly explains the selected 6G technology, architecture, applications	Explains major concepts but lacks depth in some areas	Limited understanding of the selected 6G topic
2.	Technical Analysis & Solution Justification	30	Presents well-reasoned solutions supported by technical evidence, examples, and current research findings	Solutions are presented with partial justification and limited supporting evidence	Solutions lack proper justification and technical support

3.	Evidence of Self-Learning	30	Extensive use of recent journals, conference papers, standards	Uses relevant sources but with limited diversity	Very limited use of technical literature and supporting sources
4.	Presentation & Communication Skills	20	Presentation is clear and well-structured	Presentation needs improvement	Poorly structured
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	20	20			20	2
CO2	20	20			20	2
CO3	20	20			20	2
CO4			40		20	2
CO5				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26COE02	OPTICAL COMMUNICATION NETWORKS		SEMESTER			II
Prerequisites		Category	ES(PE)	Credits		3
1. Optical Communication 2. Computer Networks		Hours/ Semester	L	T	P	TCP
			45	0	0	45
COURSE OBJECTIVES						
1.	To understand the basic concepts of optical communication systems and optical components.					
2.	To learn the principles of coherent optical communication and detection techniques.					
3.	To study the architecture and operation of optical networks.					
4.	To understand routing, wavelength assignment, and traffic management in optical networks.					
5.	To learn the protection and restoration techniques used for improving the reliability of optical networks.					
UNIT - I	OPTICAL SYSTEM COMPONENTS AND NETWORK DESIGN					9
Optical System Components – MZIM, Multiplexers; filters; switches; wavelength converters; optical amplifiers – EDFA, Raman Amplifiers and hybrid; Transmission system Engineering – System Model, Aimer penalty – transmitter, receiver, cross talk, dispersion compensation, wavelength stabilization, FWM.						
UNIT - II	COHERENT SYSTEMS					9
Basic principles of Coherent detections – Practical constraints – Injection laser line width state of polarization, local oscillator power, fiber limitations; Modulation formats – ASK, FSK, PSK, DPSK and polarization shift keying (POL SK); Demodulation schemes – Homodyne, Heterodyne – Synchronous and Non synchronous detection; Comparison; Carrier recovery in Coherent detection.						
UNIT - III	OPTICAL NETWORK ARCHITECTURES					9
Introduction to Optical Networks; First Generation optical networks –SONET / SDH Network, Second Generation (WDM) Optical Networks, Need for Multilayered Architecture-, Layers and Sublayers, Spectrum partitioning, Optical Network Nodes, Network Access Stations, Overlay Processor, Logical network overlays.						
UNIT - IV	NETWORK CONNECTIONS					9
Connection Management and Control; Static Networks, Wavelength Routed Networks; Linear Light wave networks; Logically Routed Networks; Routing and Wavelength Assignment, Traffic Grooming in Optical Networks.						
UNIT - V	OPTICAL NETWORK SURVIVABILITY					9
Protection and Restoration Objectives, Fault Protection and Restoration Techniques in the Logical Layer – Point-to-Point Systems, SONET Self-Healing Rings, Interconnection Techniques, Architectures with Arbitrary Mesh Topologies, Optical-Layer Protection: Point-to-Point and Ring Architectures, Mesh Architectures						
Total : 45 Hours						
Weightage:						
Continuous Assessment 40%						
End Semester Examinations 60%						

REFERENCE BOOKS:

1.	Max Ming-Kang Liu, "Principles and Applications of Optical Communication", Tata McGraw Hill Education Pvt., Ltd., New Delhi. 2010.
2.	Thomas E. Stern, Georgios Ellinas, Krishna Bala, "Multiwavelength Optical Networks – Architecture, Design and control ", Cambridge University Press, 2 nd Edition, 2009.
3.	Rajiv Ramaswami and Kumar N. Sivarajan, "Optical Networks : A Practical Perspective", Harcourt Asia Pte Ltd., Second Edition 2006.
4.	C. Siva Ram Murthy and Mohan Gurusamy, "WDM Optical Networks: Concepts Design, and Algorithms", PHI, EEE, 2001
5.	Biswanath Mukherjee, "Optical WDM Networks", Springer, 2006.

E-RESOURCES:

1.	https://www.udemy.com/course/the-opticalnetworks/?srsltid=AfmBOopgoIQlGeIJCyaaOIMaz6NEL9mjmQZF15Nt1C88wvU-oUmTfT
2.	http://www.digimat.in/nptel/courses/video/117104127/L23.html
3.	https://nptel.ac.in/downloads/117101054/
4.	http://ece.eng.wayne.edu/~avrutsky/Teaching/ECE5870/NotesFall10.html
5.	Optical Networks Tutorial (tutorialspoint.com)

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Understand the working principles of optical system components, coherent optical communication systems, optical network architectures, network connections, and network survivability techniques.	PO1, PO2, PO3	PSO1, PSO2
CO2	Explain the operation and performance of optical devices, coherent detection methods, optical networks, routing mechanisms, and protection schemes used in optical communication.	PO1, PO2, PO3	PSO1, PSO2
CO3	Apply the concepts of optical transmission, coherent communication, network design, wavelength routing, and survivability techniques to solve optical network problems.	PO1, PO2, PO3	PSO1, PSO2
CO4	Perform simulations and analyze the performance of optical components, coherent systems, optical networks, routing methods, and protection mechanisms.	PO1, PO2, PO3	PSO1, PSO2
CO5	Design and implement simple optical network models using optical devices, routing techniques, traffic management, and network protection methods with suitable software tools.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined Cos

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	1	1	3	2	1
CO2	2	1	3	2	1
CO3	3	1	3	3	2
CO4	3	2	2	2	3
CO5	3	2	2	3	3

Activities:

1.	Using any simulation software , design and simulate a coherent optical communication network connecting four network nodes. Implement a suitable routing algorithm and 1+1 protection mechanism to ensure uninterrupted communication during a link failure. Analyze the network performance under both normal and failure conditions by evaluating Bit Error Rate (BER), Q-factor, Optical Signal-to-Noise Ratio (OSNR), throughput, and latency . Compare the results obtained before and after the protection mechanism is activated, validate the results with theoretical expectations, and provide appropriate conclusions regarding the effectiveness of the routing and protection scheme.
2.	A company wants to establish a reliable optical communication network between different cities. Design an optical network using any suitable simulation software . Implement a routing method and a protection scheme to maintain communication during a link failure. Simulate the network and analyze its performance in terms of BER, Q-factor, OSNR, throughput, and latency . Compare the network performance before and after applying the protection mechanism and present your findings in the form of a case study report or technical seminar presentation .

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem formulation & system setup	20	Clear definition of optical system/ network scenario with correct parameters, topology, and constraints.	System is defined but some parameters or constraints are missing.	System definition is unclear or incomplete.
2.	Selection & use of simulation tools	20	Appropriate optical simulation tools (e.g., OptiSystem/MATLAB) are correctly selected and effectively used.	Tools are used with minor configuration or modeling errors.	Incorrect tool selection or poor usage.
3.	Modeling of optical components and network design	25	Accurate modeling of optical components, coherent systems, routing, and protection schemes.	Model is correct but with minor design or configuration issues.	Incomplete or incorrect system modelling.
4.	Performance analysis & evaluation	25	Thorough analysis of parameters like BER, Q-factor, OSNR, latency, and correct interpretation of results.	Analysis is done but interpretation is limited.	Poor or missing performance analysis.
5.	Result validation & comparison	5	Results are properly validated and compared with expected/theoretical values.	Validation done but limited comparison.	No proper validation or incorrect results.
6.	Report presentation	5	Well-structured, clear, and professionally presented report.	Moderately structured report.	Poor or incomplete report.
	Total	100			

Rubrics for Evaluation: C05

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem formulation & network design specification	20	Clear and complete definition of optical network model with correct topology, devices, routing, traffic, and protection requirements.	Problem defined with minor missing specifications.	Problem definition is unclear or incomplete.
2.	Network design & modeling	25	Correct design of optical network with proper integration of devices, routing methods, traffic grooming, and protection schemes.	Design is correct but with minor errors in configuration.	Incomplete or incorrect network design.
3.	Implementation using simulation tools	25	Proper implementation using suitable tools (e.g., OptiSystem/MATLAB) with correct configuration and execution.	Implementation is correct but with minor errors.	Incorrect or incomplete implementation.
4.	Routing, traffic management & protection setup	20	Correct application of routing, wavelength assignment, traffic grooming, and protection mechanisms.	Partial implementation with minor issues.	Poor or incorrect implementation of routing/protection.
5.	Result analysis & validation	10	Results are well analyzed and correctly validated with proper justification.	Results are analyzed but limited interpretation.	Results are not properly analyzed or incorrect.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	20	20			20	2
C02	20	20			20	2
C03	20	20			20	2
C04			40		20	2
C05				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26COE03	VEHICULAR INFORMATION AND COMMUNICATION SYSTEMS		SEMESTER			II
Prerequisites		Category	ES(PE)	Credits		3
		Hours/ Semester	L	T	P	TCP
			45	0	0	45
COURSE OBJECTIVES						
1.	To introduce the fundamentals of automotive data acquisition, signal processing, and data communication systems used in modern vehicles.					
2.	To provide knowledge of automotive instrumentation systems, sensors, displays, and driver information systems.					
3.	To develop an understanding of the architecture, operation, and applications of Electronic Control Units (ECUs) in vehicle systems.					
4.	To familiarize students with automotive multimedia and sound systems, including audio processing and in-vehicle entertainment technologies.					
5.	To impart knowledge of vehicle positioning, navigation, guidance systems, and their applications in intelligent transportation and connected vehicles.					
UNIT - I	DATA PROCESSING IN MOTOR VEHICLES					9
Requirements, Electronic Control Unit (ECU), Architecture, CARTRONIC, Advanced Data Processing in In-Vehicle Communications.						
UNIT - II	AUTOMOTIVE NETWORKING					9
Cross-system functions, Requirements for bus systems, Classification of bus systems, Applications in the vehicle, Coupling of networks, Real-Time Automotive Networking Examples, Applications in EVs and Autonomous Vehicles						
UNIT - III	INSTRUMENTATION					9
Information and communication areas, Driver information systems, Instrument clusters, Display types, Automotive Communication Interfaces: CAN, MOST, and FlexRay in Instrumentation.						
UNIT - IV	ECU RECORDING EQUIPMENT AND AUTOMOTIVE SOUND SYSTEMS					9
Legal requirements, Design variations, parking aid with ultrasonic sensors, Further Development, Radio tuners, Conventional tuners, Digital receivers, Reception quality, Reception improvement, Auxiliary equipment, Vehicle antennas.						
UNIT - V	POSITIONING ROUTE PLANNING AND ROUTE GUIDANCE					9
Dead Reckoning, Global Positioning System, Sensor fusion. Conventional map matching, Seamless Connectivity: Integration of Bluetooth, USB, and Wi-Fi in Automotive Systems, Fuzzy logic Based Map matching, Map aided Sensor calibration, Shortest Path, Heuristic Search, Bidirectional Search, Hierarchical search, Guidance while En Route, Guidance while off Route, Guidance with dynamic information and contemporary Issues.						
Total : 45 Hours						
Weightage:						
Continuous Assessment 40%						
End Semester Examinations 60%						

REFERENCE BOOKS:	
1.	Bosch, Automotive Handbook,2022, 11th Edition, SAE publication.
2.	Yilin Zhao –Vehicle location and Navigation Systems, 2016,1st Edition, Artech House Inc.,
3.	L Vlacic, M Parent, F Harashima, Intelligent Vehicle Technologies Theory and Applications, 2015,1st Edition, Butterworth Heinemann.
4.	Sussman, Joseph. Perspectives on Intelligent Transportation Systems (ITS). 2010,1st Edition, Springer, New York.
5.	Mashrur A. Chowdhury, and Adel Sadek, Fundamentals of Intelligent Transportation Systems Planning,2003,1st Edition, Artech House, Inc.

E-RESOURCES:	
1.	https://pmc.ncbi.nlm.nih.gov/articles/PMC12527079/
2.	https://blog.rgbsi.com/7-types-of-vehicle-connectivity
3.	https://www.youtube.com/watch?v=YnNrReCuaXg&t=4
4.	https://my.avnet.com/abacus/solutions/markets/automotive-and-transportation/automotive/communications-and-connectivity/v2v-communication/
5.	https://dl.acm.org/doi/abs/10.1007/s42979-025-03736-5

COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs
CO1	Explain the fundamentals of automotive electronic systems, ECUs, vehicle networks, and instrumentation systems used in modern vehicles.	PO3	PSO1
CO2	Analyze the performance of automotive communication, sensing, recording, and vehicle antennas.	PO1, PO3	PSO2
CO3	Apply GPS, route planning, map matching, and wireless communication technologies in automotive navigation systems.	PO1, PO2, PO3	PSO2
CO4	Evaluate automotive electronic, communication, and networking systems for modern vehicles, considering technical, economic, and societal aspects.	PO1, PO3	PSO1
CO5	Develop and present solutions for automotive navigation, instrumentation, and communication systems using modern engineering tools and teamwork skills.	PO2, PO3	PSO2

The Course Articulation Matrix (CAM) for defined Cos					
COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1			3	3	
CO2	3		3		3
CO3	3	3	3		3
CO4	3		3	3	
CO5		3	3		3

Activities:

1.	Study and compare CAN, FlexRay, MOST, and Automotive Ethernet used in modern vehicles. Present findings through a seminar and technical report.
2.	Use MATLAB/Simulink or similar software to model a vehicle navigation system. Implement concepts such as GPS, dead reckoning, sensor fusion, and route guidance.

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Understanding of Automotive Networks	20	Demonstrates comprehensive understanding with accurate technical details.	Demonstrates good understanding with minor omissions.	Demonstrates basic understanding with limited technical depth.
2.	Comparative Analysis	20	Provides thorough comparison using relevant parameters such as speed, reliability, latency, cost, and applications.	Provides good comparison covering most parameters.	Provides limited comparison with few parameters
3.	Research and Technical Content	20	Uses high-quality references; content is accurate, current, and well-organized.	Uses relevant references with minor gaps in content.	Limited references and technical depth.
4.	Technical Report Quality	20	Report is well-structured, properly formatted,	Report is clear and organized with minor formatting issues.	Report is adequate but lacks clarity or organization
5.	Seminar Presentation and Communication	20	Presentation is highly effective, confident, well-structured	Presentation is clear and informative with minor communication issues.	Presentation conveys basic information but lacks confidence or clarity.
	Total	100			

Rubrics for Evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem Understanding and System Design	20	Clearly defines navigation system requirements and develops a comprehensive system model	Develops a suitable model with minor omissions.	Develops a basic model with limited integration of concepts.

2.	Implementation Using MATLAB/Simulink	20	Accurately implements GPS, dead reckoning, sensor fusion, and route guidance using simulation tools.	Correct implementation with minor errors.	Partial implementation with noticeable errors.
3.	Simulation Results and Analysis	20	Thoroughly analyzes simulation results and validates system performance	Adequately analyzes results with minor gaps.	Provides basic analysis with limited interpretation.
4.	Innovation and Problem Solving	20	Demonstrates creative approaches to improve navigation accuracy,	shows some innovative features and improvements.	Limited innovation; follows standard procedures.
5.	Presentation and Demonstration	20	Report is well-organized, technically sound	Report is organized with minor deficiencies.	Report contains basic information but lacks clarity or completeness.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	20	20			20	2
CO2	20	20			20	2
CO3	20	20			20	2
CO4			40		20	2
CO5				40	20	2
Total	60	60	40	40	100	

Note:Purely as anExample: Strength = 3 (if percentage >20%);

Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26COE04	WIRELESS NETWORK SECURITY		SEMESTER		II		
Prerequisites			Category	ES(PE)	Credits	3	
Wireless Communication, Computer Networks, Communication Systems			Hours/ Semester	L	T	P	TCP
				45	0	0	45
COURSE OBJECTIVES							
1.	To understand the fundamentals of wireless network security and security requirements.						
2.	To study cryptographic techniques and authentication mechanisms used in wireless networks.						
3.	To analyze security threats, vulnerabilities and attacks in wireless communication systems.						
4.	To evaluate security protocols and intrusion detection mechanisms for wireless networks.						
5.	To examine emerging trends and technologies in wireless network security.						
UNIT - I		INTRODUCTION TO WIRELESS NETWORK SECURITY					9
Wireless Networks – Security Requirements – Security Services and Mechanisms – Security Threats and Vulnerabilities – Security Architecture – Wireless LAN Security – Security Challenges in Mobile and Ad Hoc Networks – Security Design Principles.							
UNIT - II		CRYPTOGRAPHY AND AUTHENTICATION					9
Cryptographic Fundamentals – Symmetric Key Cryptography – Public Key Cryptography – Hash Functions – Digital Signatures – Key Management – Authentication Protocols – Wireless Authentication Mechanisms – Public Key Infrastructure (PKI).							
UNIT - III		SECURITY IN WIRELESS NETWORKS					9
Security in IEEE 802.11 Networks – WEP, WPA, WPA2 and WPA3 Protocols – Security in Cellular Networks – GSM Security – 3G Security Architecture – LTE Security – Security Issues in Wireless Sensor Networks – Security in Mobile Ad Hoc Networks (MANETs).							
UNIT - IV		NETWORK ATTACKS AND INTRUSION DETECTION					9
Wireless Network Attacks – Eavesdropping – Spoofing – Replay Attacks – Denial of Service Attacks – Jamming Attacks – Routing Attacks – Intrusion Detection Systems – Anomaly Detection – Security Monitoring and Incident Response.							
UNIT - V		ADVANCED WIRELESS SECURITY TECHNOLOGIES					9
Security in IoT Networks – Security in 5G and Beyond Networks – Software Defined Network (SDN) Security – Network Function Virtualization Security – Blockchain for Wireless Security – AI and Machine Learning for Network Security – Zero Trust Security Architecture – Future Trends in Wireless Network Security.							
Total : 45 Hours							
Weightage:							
Continuous Assessment 40%							
End Semester Examinations 60%							

REFERENCE BOOKS:					
1.	William Stallings, Network Security Essentials: Applications and Standards, Pearson Education, 7 th Edition, 2020.				
2.	William Stallings, Cryptography and Network Security: Principles and Practice, Pearson Education, 8 th Edition, 2023.				
3.	Yi Qian, Security in Wireless Communication Networks, Wiley, 1st Edition, 2019.				
4.	Vijay K. Garg, Wireless Communications and Networking, Morgan Kaufmann, 2nd Edition, 2020.				
5.	Kami Makki, Wireless and Mobile Network Security, Springer, 1st Edition, 2021.				
E-RESOURCES:					
1.	NPTEL – Network Security Courses				
2.	IEEE Xplore Digital Library				
3.	Cisco Networking Academy Resources				
4.	OWASP Security Resources				
5.	National Institute of Standards and Technology (NIST) Cybersecurity Resources				
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to			Mapping POs	Mapping PSOs	
CO1	Explain wireless network security requirements, threats and security mechanisms.		PO1	PSO1	
CO2	Analyze cryptographic techniques and authentication protocols used in wireless networks.		PO1, PO2	PSO1, PSO2	
CO3	Evaluate security architectures and protocols employed in wireless communication systems.		PO2, PO3	PSO1, PSO2	
CO4	Analyze wireless network attacks and design appropriate intrusion detection and mitigation mechanisms.		PO2, PO3	PSO2	
CO5	Evaluate advanced wireless security technologies for IoT, 5G/6G and next-generation communication networks.		PO2, PO3	PSO2	
The Course Articulation Matrix (CAM) for defined Cos					
COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	-	-	3	-
CO2	3	3	-	3	3
CO3	-	3	3	3	3
CO4	-	3	3	-	3
CO5	-	3	3	-	3

Activities:					
1.	Simulation and analysis of wireless network security attacks and defense mechanisms using network simulation tools such as NS-3, OMNeT++, Cisco Packet Tracer or Wireshark. (CO4)				
2.	Technical seminar / case study on emerging wireless security technologies such as IoT Security, 5G/6G Security, Blockchain-based Network Security, AI-enabled Intrusion Detection Systems and Secure Software Defined Networks. (CO5)				
Rubrics for Evaluation: CO4					
Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem identification and security analysis	20	Security problem and threats are clearly identified and analyzed	Problem identified with minor gaps in analysis	Problem identification lacks clarity
2.	Simulation / Implementation	30	Simulation or implementation is completed successfully with correct configuration	Simulation completed with minor errors	Simulation incomplete or contains major errors
3.	Analysis of security mechanisms and results	20	Results are thoroughly analyzed and security measures are justified	Results analyzed with limited justification	Analysis and justification are inadequate
4.	Evaluation of attack mitigation techniques	20	Appropriate mitigation techniques are selected and effectively evaluated	Mitigation techniques are selected with limited evaluation	Evaluation of mitigation techniques is inadequate
5.	Report presentation	10	Report is clear, well-structured and technically sound	Report is structured but needs improvement	Poorly structured report
	Total	100			
Rubrics for Evaluation: CO5					
Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Understanding of the topic	20	Demonstrates comprehensive understanding of the selected security technology and concepts	Demonstrates adequate understanding with minor gaps	Demonstrates limited understanding of concepts

2.	Technical analysis and critical evaluation	30	Provides in-depth analysis and critical evaluation supported by recent literature	Provides analysis with limited critical evaluation	Analysis lacks depth and technical justification
3.	Literature survey and use of resources	20	Extensive use of recent journals, standards and technical resources	Adequate use of relevant resources	Limited use of technical resources
4.	Presentation and communication skills	20	Presentation is clear, organized and technically effective	Presentation is adequate but needs improvement	Presentation lacks clarity and organization
5.	Report quality and documentation	10	Report is well-structured with proper citations and technical content	Report is acceptable with minor deficiencies	Report is poorly organized and inadequately documented
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	20	20			20	2
CO2	20	20			20	2
CO3	20	20			20	2
CO4			40		20	2
CO5				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26COE05	AI FOR COMMUNICATION SYSTEMS		SEMESTER			II
Prerequisites		Category	ES(PE)	Credits		3
		Hours/ Semester	L	T	P	TCP
			45	0	0	45
COURSE OBJECTIVES						
1.	To understand the fundamentals of Artificial Intelligence and intelligent communication systems.					
2.	To explore AI techniques applicable to communication networks and signal processing.					
3.	To analyze intelligent resource management and optimization in wireless networks.					
4.	To evaluate AI-enabled communication architectures and networking solutions.					
5.	To design AI-driven communication systems for next-generation wireless networks.					
UNIT - I	FUNDAMENTALS OF ARTIFICIAL INTELLIGENCE					9
Introduction to Artificial Intelligence; Intelligent agents; Problem-solving techniques; State-space search; Heuristic search algorithms; Knowledge representation; Reasoning under uncertainty; Expert systems; AI tools and frameworks.						
UNIT - II	AI TECHNIQUES FOR COMMUNICATION SYSTEMS					9
Artificial Intelligence in communication engineering; Pattern recognition; Fuzzy logic systems; Evolutionary computing; Genetic algorithms; Optimization techniques; Signal classification; Intelligent decision-making systems.						
UNIT - III	INTELLIGENT WIRELESS COMMUNICATION NETWORKS					9
Spectrum management; Cognitive radio concepts; Dynamic spectrum access; Resource allocation; Interference mitigation; Intelligent routing; Network optimization; QoS enhancement using AI techniques.						
UNIT - IV	AI-ENABLED COMMUNICATION ARCHITECTURES					9
Self-organizing networks; Intelligent traffic management; AI-assisted network monitoring; Network fault diagnosis; Security and intrusion detection; Intelligent IoT communications; Edge intelligence in communication systems.						
UNIT - V	AI FOR BEYOND 5G AND 6G NETWORKS					9
Reconfigurable Intelligent Surfaces (RIS)-Federated Learning in wireless communications; Digital Twin Networks; Semantic Communications- Generative AI for communication network optimization- Autonomous network management- AI-enabled 6G architecture- Challenges and future research directions.						
Total : 45 Hours						
Weightage: Continuous Assessment 40% End Semester Examinations 60%						

REFERENCE BOOKS:					
1.	Stuart Russell and Peter Norvig, "Artificial Intelligence:"A Modern Approach", Pearson, 2021.				
2.	S. Rajasekaran and G. A. Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications", PHI Learning, 2003.				
3.	Andreas F. Molisch, "Wireless Communications", 3rd Edition, Wiley, 2023.				
4.	David Tse and Pramod Viswanath, "Fundamentals of Wireless Communication, Cambridge University Press, 2005.				
5.	Simon Haykin, "Cognitive Radio Technology", Wiley, 2009.				
E-RESOURCES:					
1.	NPTEL – Artificial Intelligence Courses				
2.	IEEE Communications Society				
3.	IEEE Xplore Digital Library				
4.	MIT OpenCourseWare – Artificial Intelligence				
5.	ACM Digital Library				
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs		
CO1	Explain the fundamental concepts of Artificial Intelligence and intelligent communication systems	PO1, PO2	PSO1		
CO2	Apply AI techniques such as fuzzy logic, expert systems, and optimization methods to communication engineering problems.	PO1, PO2, PO3	PSO1, PSO2		
CO3	Analyze intelligent wireless communication networks for spectrum management, routing, and resource allocation.	PO1, PO2, PO3	PSO1, PSO2		
CO4	Evaluate AI-enabled communication architectures for network monitoring, security, and traffic management.	PO2, PO3	PSO1, PSO2		
CO5	Design AI-driven solutions for next-generation communication systems including Beyond 5G and 6G networks.	PO1, PO2, PO3	PSO1, PSO2		
The Course Articulation Matrix (CAM) for defined Cos					
COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	3		3	
CO2	3	3	3	3	3
CO3	2	3	3	3	3
CO4	-	2	3	3	3
CO5	2	3	3	3	3

Activities:					
1.	AI-Based Network Traffic Analysis and Congestion Management (CO4)				
2.	AI-Based Resource Allocation for Beyond 5G Wireless Networks (CO5)				
Rubrics for Evaluation: CO4					
Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem Formulation & Understanding	20	Problem clearly identified with appropriate assumptions	Minor gaps in problem definition	Limited understanding
2.	Technical Analysis	30	Comprehensive analysis with appropriate methodology	Moderate analysis with minor errors	Incomplete analysis
3.	Interpretation of Results	20	Results clearly interpreted and justified	Partial interpretation	Limited interpretation
4.	Technical Presentation	20	Well organized and professionally presented	Adequate presentation	Poor presentation
5.	Report Submission	10	Complete and structured report	Minor improvements required	Incomplete report
	Total	100			
Rubrics for Evaluation: CO5					
Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem Identification	20	Problem clearly identified and justified	Minor ambiguity	Problem not clearly defined
2.	Design Methodology	30	Innovative and technically sound design	Appropriate design with minor gaps	Limited design approach
3.	Technical Analysis & Validation	20	Comprehensive analysis and validation	Moderate analysis	Limited validation
4.	Solution Development / Simulation	20	Complete implementation and verification	Partial implementation	Incomplete implementation
5.	Report & Presentation	10	Professional quality report and presentation	Adequate documentation	Poor documentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	20	20			20	2
C02	20	20			20	2
C03	20	20			20	2
C04			40		20	2
C05				40	20	2
Total	60	60	40	40	100	

Note:Purely as anExample: Strength = 3 (if percentage >20%);
Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26COE06	PATTERN RECOGNITION AND MACHINE LEARNING		SEMESTER		II		
Prerequisites			Category	ES(PE)	Credits	3	
Basic programming skills in Python/MATLAB.			Hours/ Semester	L	T	P	TCP
				45	0	0	45
COURSE OBJECTIVES							
1.	To interpret statistical pattern classification techniques using supervised, unsupervised, and clustering algorithms.						
2.	To analyze structural and syntactic pattern recognition models using grammars and graph-based representations.						
3.	To implement feature extraction and feature selection techniques for efficient pattern representation.						
4.	To develop intelligent problem-solving models using production systems and heuristic search strategies.						
5.	To design AI-based planning and expert systems incorporating knowledge representation and machine learning techniques.						
UNIT - I		PATTERN CLASSIFIER					9
Overview of Pattern recognition – Discriminant functions – Supervised learning – Parametric estimation – Maximum likelihood estimation – Bayesian parameter estimation – Perceptron algorithm – LMSE algorithm – Problems with Bayes approach – Pattern classification by distance functions – Minimum distance pattern classifier –The kernel Trick –Clustering for unsupervised learning and classification – Clustering concept – C-means algorithm – Validity of clustering solutions- Performance Evaluation Metrics.							
UNIT - II		STRUCTURAL PATTERN RECOGNITION					9
Elements of formal grammars – String generation as pattern description – Recognition of syntactic description – Parsing – Stochastic grammars and applications – Graph based structural representation.							
UNIT - III		FEATURE EXTRACTION AND SELECTION					9
Entropy minimization – Karhunen – Loeve transformation – Linear Discriminant Analysis- Feature selection through functions approximation – Binary feature selection.							
UNIT - IV		INTRODUCTION TO AI AND PRODUCTION SYSTEMS					9
Introduction to AI-Problem formulation, Problem Definition - Production systems, Control strategies, Search strategies. Problem characteristics, Production system characteristics -Specialized production system- Problem solving methods - Problem graphs, Matching, Indexing and Heuristic functions -Hill Climbing-Depth first and Breath first, Constraints satisfaction - Related algorithms, Measure of performance and analysis of search algorithms.							
UNIT - V		PLANNING AND EXPERT SYSTEMS					9
Basic plan generation systems - Strips -Advanced plan generation systems – K strips -Strategic explanations - Why, Why not and how explanations. Learning- Machine learning, adaptive Learning- Expert systems - Architecture of expert systems, Roles of expert systems - Knowledge Acquisition –Meta knowledge, Heuristics. Typical expert systems - MYCIN, DART, XOON.							
Total : 45 Hours							

Weightage: Continuous Assessment 40% End Semester Examinations 60%			
REFERENCE BOOKS:			
1.	Schalkoff, R. J. (2012), "Pattern Recognition: Statistical, Structural and Neural Approaches" ,John Wiley & Sons Inc., New York.		
2.	Tou, J. T., & Gonzalez, R. C. (2014), "Pattern Recognition Principles", Addison-Wesley Publication Company, London.		
3.	Duda, R. O., Hart, P. E., & Stork, D. G. (2013), "Pattern Classification and Scene Analysis" , Wiley, New York.		
4.	Morton Nadier and Eric Smith P.(2012), "Pattern Recognition Engineering", John Wiley & Sons, New York.		
5.	Ethem Alpaydin,(2009), "Introduction to Machine Learning (Adaptive Computation and Machine Learning series)", The MIT Press; Second edition.		
6.	Stuart Russell, Peter Norvig,(2015) "Artificial Intelligence: A Modern Approach", Third Edition, Pearson Education / Prentice Hall of India.		
E-RESOURCES:			
1.	nptel.ac.in/courses/106106046		
2.	nptel.ac.in/courses/117108048		
3.	https://nptel.ac.in/courses/106/106/106106202		
4.	https://scikit-learn.org/stable/user_guide.html		
5.	https://www.coursera.org/learn/machine-learning		
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs
CO1	Analyze statistical pattern recognition techniques and classification algorithms for solving pattern recognition problems.	PO1, PO3	PSO1
CO2	Evaluate structural and syntactic pattern recognition methods using grammars and graph-based representations.	PO1, PO2	PSO1
CO3	Implement feature extraction and feature selection techniques for efficient pattern representation and classification.	PO1, PO3	PSO2
CO4	Develop intelligent problem-solving models using production systems and heuristic search strategies.	PO1, PO2	PSO1, PSO2
CO5	Design AI-based planning and expert systems incorporating knowledge representation and machine learning techniques for real-world applications.	PO1, PO3	PSO1, PSO2

The Course Articulation Matrix(CAM) for defined Cos

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	-	2	3	-
CO2	2	3	-	3	-
CO3	3	-	2	-	3
CO4	3	2	-	2	3
CO5	3	-	3	2	3

Activities:

1.	Implement the Breadth-First Search (BFS) algorithm using MATLAB/Python to find the shortest path in a graph. Display the traversal order and shortest path. (CO4)
2.	Prepare a case study on the design of an AI-based Expert System for Medical Diagnosis. Discuss the knowledge representation technique, inference engine, and decision-making process. (CO5)

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem Understanding and Formulation	20	Correctly formulates the AI problem and selects an appropriate search method.	Minor errors in problem formulation.	Basic understanding with limited formulation.
2.	Implementation Using Software Tools	20	Correct implementation using software tools with appropriate model selection and execution.	Implementation is mostly correct with minor errors.	Partial implementation requiring guidance.
3.	Simulation Results & Analysis	20	Correct outputs with meaningful performance analysis.	Correct outputs with limited analysis.	Basic outputs with minimal interpretation.
4.	Application & Interpretation	20	Clearly relates the solution to a real-world AI application.	Adequate application discussion.	Limited application relevance.
5.	Documentation & Presentation of result	20	Well-documented code, organized report, and clear demonstration.	Documentation and presentation are adequate with minor deficiencies.	Basic documentation and presentation with limited clarity.
	Total	100			

Rubrics for Evaluation: CO5					
Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Concept Understanding	20	Demonstrates comprehensive understanding of the topic with accurate technical concepts and terminology.	Demonstrates good understanding with minor conceptual gaps.	Demonstrates basic understanding with limited technical depth.
2.	Analysis and Application	20	Critically analyzes the case/topic and effectively applies AI planning, expert system, or knowledge representation concepts.	Adequately analyzes the topic with moderate application of concepts.	Provides basic analysis with limited application of AI concepts.
3.	Innovation and Problem Solving	20	Presents innovative ideas, logical reasoning, and practical solutions supported by appropriate examples.	Provides reasonable solutions with some originality.	Provides basic solutions with limited innovation or justification.
4.	Presentation and Communication	20	Delivers a well-structured presentation with clear organization, effective visuals, and confident communication.	Delivers a clear presentation with adequate organization and communication.	Delivers a basic presentation with limited clarity and organization.
5.	Documentation and Discussion	20	Submits a well-organized report with proper references and effectively answers questions during discussion.	Submits a satisfactory report with minor omissions and responds adequately to questions.	Submits a basic report with limited references
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	20	20			20	2
CO2	20	20			20	2
CO3	20	20			20	2
CO4			40		20	2
CO5				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26COE07	RADAR & RF SIGNAL ENGINEERING		SEMESTER		II		
Prerequisites			Category	ES(PE)	Credits	3	
Electromagnetics, Signals and Systems, Microwave Engineering			Hours/ Semester	L	T	P	TCP
				45	0	0	45
COURSE OBJECTIVES							
1.	Explain the fundamentals of radar systems						
2.	Analyze radar signal models and its waveforms.						
3.	Develop methodologies for target detection, measurement and tracking						
4.	Evaluate radar signal processing in cluttered environments						
5.	Implement advanced radar signal processing techniques						
UNIT - I		RADAR SYSTEMS BASICS					9
Basics: Radar Block diagram, Radar Specific Terms, Radar Systems Classifications and Bands, Electromagnetic Waves (RF Waves), coherence. Radar Antennas, radar cross section. Radar Equation: Radar Range Equation, Radar Losses, Processing Loss, Continuous Wave Radars. Radar transmitters and receivers.							
UNIT - II		RADAR SIGNAL MODELS AND RADAR WAVEFORMS					9
Components of radar signal, amplitude, clutter, noise model and signal to noise ratio, jamming, frequency space and spectral models. Radar Waveforms: The Waveform Matched Filter, The Ambiguity Function, The Pulse Burst Waveform, Frequency-Modulated and Phase-Modulated Pulse Compression Waveforms, Continuous Wave Radar.							
UNIT - III		TARGET DETECTION AND TRACKING					9
Single pulse detection: Single Pulse with Known Parameters, Single Pulse with Known Amplitude and Unknown Phase. Detection of Fluctuating Targets: Pulse Integration, Probability of Detection Calculation, Constant False Alarm Rate, M-out-of-N Detection. Radar Tracking: Measurements and Filtering.							
UNIT - IV		RADAR SIGNAL PROCESSING IN CLUTTER					9
Introduction, Clutter Definition, Volume Clutter, Area Clutter, Clutter RCS, Ground-Based, Amplitude Distribution, Area Clutter Spectrum, Doppler Processing, Moving Target Indicator, Pulse Doppler Processing, Ambiguity Resolution, Limitations of Doppler Processing.							
UNIT - V		SYNTHETIC APERTURE PROCESSING AND SPACE-TIME ADAPTIVE PROCESSING					9
Synthetic Aperture Processing: Strip-map synthetic aperture radar, SAR image formation, Spotlight SAR Inverse Synthetic Aperture Radar, Array Feeding and Beamforming Networks, Space-Time Adaptive Processing- Spatial Filtering, Space-Time Signal Environment, Space-Time Signal Modelling, Processing the Space-Time Signal, Computational Issues in STAP, Reduce – Dimension STAP, Advanced STAP Algorithms and Analysis, Limitations to STAP.							
Total : 45 Hours							
Weightage:							
Continuous Assessment 40%							
End Semester Examinations 60%							

REFERENCE BOOKS:

1. Fundamentals of Radar Signal Processing /Mark A. Richards, / 3rd Ed, McGraw Hill 2022.
2. Handbook of Radar Signal Analysis /Mahafza, B.R., Winton, S.C., &Elsherbeni, A.Z. (Eds.) /1stEd., CRC2021.
3. Introduction to Radar Systems/Skolnik /3rd Ed., McGraw Hill 2002.
4. Peyton Z. Peebles, Jr., "Radar Principles", 2004, John Wiley.
5. Fred E. Nathanson, "Radar Design Principles: Signal Processing and The Environment", 2nd Edition, 1999, PHI.

E-RESOURCES:

1. Radar: Introduction to Radar Systems — Online Course | MIT Lincoln Laboratory
2. Microsoft Word - semreport1.doc (iitb.ac.in)
3. Naren Naik Digital Signal Processing Course (iitk.ac.in)
4. <http://digimat.in/nptel/courses/video/117105075/L41.html>
5. <http://digimat.in/nptel/courses/video/108105154/L22.html>

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Understand foundational radar equations, ambiguity functions, digital filtering and advanced signal processing techniques.		
CO2	Design and apply antennas, digital filters, Pulse processing, aperture processing and Space-Time Adaptive Processing (STAP) for radars.	PO1, PO2, PO3	PSO1 PSO2
CO3	Analyse the radar equations, signal models, clutter rejection, target tracking, Pulse processing, aperture processing, STAP and design and signal-to-noise ratio (SNR) improvements in radar signal environments.	PO1, PO2, PO3	PSO1 PSO2
CO4	Simulate and evaluate radar algorithms using computational software (e.g., MATLAB or Python).	PO3	PSO1 PSO2
CO5	Study and analyse radar signal processing and springs through self-learning activities and present the findings while considering societal and economic impacts.	PO2	PSO1 PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1					
CO2	3	2	3	2	1
CO3	3	3	2	2	1
CO4			2	1	2
CO5		2		1	2

Activities:

- | | |
|----|---|
| 1. | Simulation- Solution to application- oriented problems using software (CO5) |
| 2. | Case Study (CO6) / Technical Seminar Presentation (CO6) (Independent study) |

Rubrics for Evaluation:CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Algorithm & Logic	30	Algorithm is completely accurate; all assumptions are clearly stated.	Minor mathematical slips, logical progression remains intact	Incorrect formulas used, logic is fundamentally flawed.
2.	Code Execution & Efficiency	30	Optimizes simulation execution times. Uses scripting to automate repetitive tasks.	Executes the simulation smoothly. Corrects basic runtime errors independently.	Runs simulation but struggles to resolve execution errors independently.
3.	Debugging and Technical Validation	25	Explains minor anomalies using advanced physics	Validates simulation results against theoretical hand calculations or formulas.	Identifies large discrepancies with theory but cannot explain why they exist.
4.	Reporting & Presentation	15	Delivers industry-grade reports with professional visuals and executive summaries.	Presents clear data visualizations with structured, logical engineering explanations.	Submits low-resolution screenshots with no context or labels.
	Total	100			

Rubrics for Evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Mathematical Derivation	30	Derivation is completely accurate; all assumptions are clearly stated.	Minor mathematical slips, logical progression remains intact.	Major algebraic errors; key derivation steps are missing.
2.	Concept Interpretation	25	Perfect physical interpretation of terms	Good understanding, but lacks depth in explaining boundary conditions.	Completely misunderstands the core radar concept.

3.	Self-Learning and Resource Utilization	15	Use of relevant journals/sources	Limited sources	Very limited sources
4.	Report Presentation and Documentation	30	Presentation is clear and well-structured	Presentation needs improvement	Poorly structured
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	20	20			20	2
CO2	20	20			20	2
CO3	20	20			20	2
CO4			40		20	2
CO5				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26COE08	SIGNAL DETECTION AND ESTIMATION		SEMESTER		II		
Prerequisites			Category	ES(PE)	Credits	3	
Signals and Systems, Probability and Random Processes			Hours/ Semester	L	T	P	TCP
				45	0	0	45
COURSE OBJECTIVES							
1.	To introduce the fundamental principles of random process.						
2.	To apply various decision making systems to analyze and solve complex problems.						
3.	To gain the knowledge of Filtering techniques.						
4.	To explore about the concepts and techniques of Parameter Estimation.						
5.	To impart knowledge of Signal Detection methods and their applications.						
UNIT - I		RANDOM PROCESSES					9
Introduction and Definitions - Properties of correlation functions - Gaussian Process - Poisson Process - Bernoulli and Binomial Processes - Random Walk and Wiener Processes - Markov Process - Linear Time-Invariant Systems - Sampling Theorem - Hilbert Transform and Analytic Signals.							
UNIT - II		STATISTICAL DECISION THEORY					9
Bayes' Criterion - Binary Hypothesis Testing - M-ary Hypothesis Testing - Minimax Criterion - Neyman-Pearson Criterion - Composite Hypothesis Testing - Sequential Detection.							
UNIT - III		LINEAR MINIMUM MEAN-SQUARE ERROR FILTERING					9
Linear Transformation and Orthogonality Principle - Wiener Filters - Discrete Wiener Filters - Unrealizable Filter - Realizable Filter - Kalman Filter.							
UNIT - IV		SIGNAL PARAMETER ESTIMATION					9
Maximum Likelihood Estimation - Generalized Likelihood Ratio Test - Bayes' Estimation - Cramer-Rao Inequality - Multiple Parameter Estimation - Best Linear Unbiased Estimator - Least-Square Estimation - Recursive Least-Square Estimator.							
UNIT - V		DETECTION AND ESTIMATION PROBLEMS					9
Binary Detection - M-ary Detection - Linear Estimation - Nonlinear Estimation - General Binary Detection with Unwanted Parameters - Binary Detection in Colored Noise.							
Total : 45 Hours							
Weightage:							
Continuous Assessment 40%							
End Semester Examinations 60%							

REFERENCE BOOKS:

1.	MouradBarkat, "Signal detection and estimation", Artech house, Inc., 2nd Edition, 2005.
2.	K. Sam Shanmugan & A.M. Breipohl, "Random Signals: Detection, Estimation and Data Analysis", Wiley India Pvt. Ltd, 2011.
3.	Lonnie C. Ludeman, "Random Processes: Filtering, Estimation and Detection", Wiley India Pvt. Ltd., 2010.
4.	Steven. M.Kay, "Fundamentals of Statistical Signal Processing: Volume I Estimation Theory", Prentice Hall, USA, 1998.
5.	Srinath, Rajasekaran, Viswanathan, "Introduction to Statistical Signal Processing with Applications", 2003, PHI.

E-RESOURCES:

1.	https://fac.umc.edu.dz/fstech/cours/Electronique/M1%20R&T/Cours-Techniques%20Radars%20(M1-ST)/Annexes/Signal%20Detection%20And%20Estimation.pdf
2.	https://nptel.ac.in/courses/117103018/
3.	https://www.coursera.org/learn/information-theory
4.	https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-432-stochastic-processes-detection-and-estimation-spring-2004/
5.	https://viit.digimat.in/nptel/courses/video/108105059/L29.html

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Explain the characteristics of stochastic processes (Gaussian, Poisson, Markov), properties of correlation functions, and the core principles governing statistical decision-making, linear filtering, and parameter estimation.	PO2, PO3	PSO1, PSO2
CO2	Apply Bayes' criterion, Neyman-Pearson tests, Wiener/Kalman filters, and classical estimation techniques like Maximum Likelihood and Least-Squares to solve structured signal processing problems.	PO1, PO2, PO3	PSO1, PSO2
CO3	Analyze the efficiency, bounds and error probabilities of detection and estimation algorithms when operating in both white and colored noise environments.	PO1, PO2, PO3	PSO2
CO4	Design and validate statistical signal processing algorithms through Simulation-based Mini Projects using software tools (e.g., MATLAB/Python) to solve real-world problems in communication, radar, or telemetry systems.	PO1, PO2, PO3	PSO1, PSO2
CO5	Conduct comprehensive Case Studies and prepare structured Technical Reports evaluating modern engineering applications of detection and estimation theory.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined Cos

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1		1	3	2	3
CO2	1	1	3	3	2
CO3	2	1	3		3
CO4	3	1	2	3	2
CO5	1	3	2	2	3

Activities:

1.	Design and Performance Analysis of Signal Detection Algorithms in AWGN and Colored Noise Environments using MATLAB/Simulink/Python (NumPy, SciPy, Matplotlib) (CO4)
2.	investigate recent developments in detection and estimation techniques and present technical findings through a seminar/Case Study. (CO5) (Independent study)

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem formulation & boundary conditions	20	The statistical signal processing problem & its channel/noise parameters are clearly defined.	The problem is defined, but some statistical parameters or system boundary conditions are unclear.	The problem statement is defined, but boundary conditions and stochastic parameters are missing or unclear.
2.	Simulation & plots	30	Simulation scripts (MATLAB/Python) run flawlessly & well-presented and fully labeled.	Simulation runs with minor script errors, plots are complete but have minor formatting.	Simulations are incomplete, buggy, or critical plots
3.	Interpretation of results	20	Results are clearly Interpreted & justified	Results are interpreted but limited justification	Unclear interpretation
4.	Report presentation	10	Report is clear and well structured	Report is structured, but needs improvement	Poorly structured report, lacks key technical details and formatting.
	Total	100			

Rubrics for Evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Understanding of Detection and Estimation Concepts	20	Clearly explains relevant concepts, theories, & mathematical models of detection and estimation.	Explains concepts with minor inaccuracies or limited application.	Limited understanding of concepts and their application.
2.	Analysis of Engineering Problem and Solution	30	Thoroughly analyzes the engineering problem, justifies the selected detection/estimation techniques.	Adequate analysis with partial justification and evaluation.	Superficial analysis with limited justification of techniques used.
3.	Evidence of Self-Learning and Literature Survey	30	Uses relevant journals, conference papers, standards, and recent technical sources.	Uses a moderate number of relevant sources with limited critical review.	Uses very few sources with minimal evidence of self-learning.
4.	Technical Report Quality and Presentation	20	Report is well-structured, technically accurate.	Presentation needs improvement	Poorly organized report and presentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	20	20			20	2
CO2	20	20			20	2
CO3	20	20			20	2
CO4			40		20	2
CO5				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);

Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26COE09	SATELLITE COMMUNICATION SYSTEMS		SEMESTER		III		
Prerequisites			Category	ES(PE)	Credits	3	
Digital Communication			Hours/ Semester	L	T	P	TCP
				45	0	0	45
COURSE OBJECTIVES							
1.	To learn about the science behind the orbiting satellites.						
2.	To know about the various multiplexing schemes.						
3.	To impart knowledge on earth station parameters used for satellite communication.						
4.	To gain knowledge of navigation systems especially GPS in detail.						
5.	To gain knowledge of GPS orbits and satellite position determination.						
UNIT - I	ORBITS, PROPAGATION IMPAIRMENTS AND SPACE LINK						9
Introduction, Satellite orbits, Kepler’s three laws, Orbital Elements, Eclipse effect, Orbit determination, Look angle determination. Satellite subsystems: Attitude and Orbital Control System (AOCS), Telemetry Tracking and Command (TT&C), Power System, Communications System, Satellite transponder, Space Craft Antennas, Frequency Reuse Antennas. Communication link design: Basic transmission theory, EIRP, Completion Link design with and without frequency reuse, System noise temperature G/T ratio, Noise figure and Noise temperature.							
UNIT - II	SATELLITE MULTIPLE ACCESSES: SATELLITE MOBILE AND SPECIALIZED SERVICES						9
Frequency Division Multiple Access (FDMA), Intermodulation, Calculation of C/N, Time Division Multiple Access (TDMA), Satellite Switched TDMA, Demand Assignment Multiple Access (DAMA), CDMA Spread Spectrum Transmission and Reception. Message Transmission by FDMA: M/G/1 Queue, Message Transmission by TDMA, PURE ALOHA, Satellite Packet Switching, Slotted Aloha, Packet Reservation, Tree Algorithm, VSAT Technologies, Network Configurations, Polling VSAT Networks, Mobile Satellite Networks, CDMA MSAT Network.							
UNIT - III	EARTH STATION TECHNOLOGY						9
Transmitters, Receivers, Antennas, Tracking Systems, Transponders, Small earth station Antennas, Equipment for earth station, Lower Orbit Considerations, Coverage and frequency considerations, Direct broadcasting satellite Television and Radio, Satellite Navigation							
UNIT - IV	INTRODUCTION TO GLOBAL NAVIGATION SATELLITE SYSTEMS(GNSSs)						9
The History of GPS, The Evolution of GPS, Development of NAVSTARGPS, GPS working principle, Trilateration, Determining the receiver position in 2D or XY Plane, Determining the receiver position in 3D or X-Y-Z Plane.							
UNIT - V	GPS ORBITS AND SATELLITE POSITION DETERMINATION						9
GPS system segments, Space segment, Control segment, User segment, GPS Signals, Pseudorandom noise (PRN) code, C/A code, P code Navigation data, and Signal structure of GPS. Anti-spoofing (AS), selective availability GPS orbital parameters, description of receiver independent exchange format (RINEX) – Observation data and navigation message data parameters, GPS position determination, least squares method.							
Total : 45 Hours							

Weightage:

Continuous Assessment 40%

End Semester Examinations 60%

REFERENCE BOOKS:

1. Satellite Communications –Timothy Pratt, Charles Bostian, Jeremy Allnutt, 2nd Edition, 2003, John Wiley & Sons.
2. G S RAO, Global Navigation Satellite Systems, McGraw-Hill publications, New Delhi, 2010.
3. Satellite Communications - by Dr.D.C.Agarwal.
4. Satellite Communications: Design Principles – M. Richcharia, 2nd Ed., BSP, 2003.
5. James Ba – Yen Tsui, 'Fundamentals of GPS receivers – A software approach', John Wiley & Sons (2001).

E-RESOURCES:

1. <https://youtube.com/playlist?list=PL3rE2jS8zxAxamj-MY7FvzOZkHUALNndQ>
2. <https://youtube.com/playlist?list=PLAnjLC20C-XQnoowCtt-67WmyxoQPu2Fi>
3. https://youtube.com/playlist?list=PLLy_2iUCG87A55NPtEwWoWPiKs0-9NNT1
4. https://www.youtube.com/watch?v=50U2T6Tmr1E&list=PLLy_2iUCG87A55NPtEwWoWPiKs0-9NNT1&index=3
5. https://www.youtube.com/watch?v=K3xA1NyWObg&list=PLLy_2iUCG87A55NPtEwWoWPiKs0-9NNT1

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Understand the fundamental principles (eg. Link budget calculations), different multiple access techniques, ground station services, GPS and its position.	PO1, PO2	PSO1, PSO2
CO2	Apply the concepts of satellite communication and different Frequency allocations for satellite services. Analyze the satellite orbits and link design for transmission & reception of signals, multiple access technique for a given satellite communication application.	PO1, PO2, PO3	PSO1 PSO2
CO3	Analyze the basic parameters, multiple access techniques (FDMA, TDMA, CDMA) and satellite navigation principles (GPS).	PO1, PO2, PO3	PSO1 PSO2
CO4	Analyze the given system using simulation tool to compute and present the findings through plots the waveforms and diagrams using simulation tools.	PO3	PSO1 PSO2
CO5	Study and analyse satellite system and GPS subsystem Hardware and software and springs through self-learning activities and present the findings while considering societal and economic impacts.	PO2, PO3	PSO1 PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	1	2		1	2
CO2	3	2	3	2	1
CO3	3	3	2	2	1
CO4			2	1	2
CO5		3	2	1	2

Activities:

1.	Design and simulation of satellite parameters using simulation tools (CO4)
2.	Technical seminar presentation on different satellite systems (CO5)

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Scenario Setup & Parameters	25	Configures complex multi-satellite constellations with highly accurate environmental models.	Sets up correct orbital parameters, ground stations, and constraints	Inputs basic parameters. Misses critical environmental factors.
2.	Tool Execution & Workflow	25	Optimizes simulation execution times. Uses scripting to automate repetitive tasks.	Executes the simulation smoothly. Corrects basic runtime errors independently.	Runs simulation but struggles to resolve execution errors independently.
3.	Data Extraction & Analysis	30	Performs advanced sensitivity analysis. Compares multiple design trade-offs visually.	Extracts accurate link budgets, access times, and ground track data	Extracts standard plots but misinterprets key crossover or access times.
4.	Debugging and Technical Validation	20	Explains minor anomalies using advanced physics	Validates simulation results against theoretical hand calculations or formulas.	Identifies large discrepancies with theory but cannot explain why they exist.
	Total	100			

Rubrics for Evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem Analysis and Solution Design	30	Comprehensive analysis and effective solution	Adequate analysis	Basic solution
2.	Software Development and Implementation	25	Efficient and fully functional implementation	Minor issues	Partially functional
3.	Self-Learning and Resource Utilization	15	Extensive use of learning resources	Moderate use	Limited use
4.	Teamwork and Participation	10	Excellent collaboration	Moderate participation	Limited participation
5.	Report Presentation and Documentation	20	Professional report and presentation	Adequate presentation	Poor organization
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	20	20			20	2
CO2	20	20			20	2
CO3	20	20			20	2
CO4			40		20	2
CO5				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

[illegible]

Weightage: Continuous Assessment 40% End Semester Examinations 60%				
REFERENCE BOOKS:				
1.	Marzetta, T. L., Larsson, E. G., Yang, H., & Ngo, H. Q. (2016). Fundamentals of massive MIMO. Cambridge University Press.			
2.	Rappaport, T. S., Heath, R. W., Jr, Daniels, R. C., & Murdock, J. N. (2014). Millimeter wave wireless communications. Pearson Education.			
3.	Osseiran, A., Monserrat, J. F., & Marsch, P. (2016). 5G mobile and wireless communications technology. Cambridge University Press.			
4.	Tranter, W. H., Shanmugan, K. S., Rappaport, T. S., & Kosbar, K. L. (2004). Principles of communication systems simulation with wireless applications. Pearson Education			
5.	Du Preez, J., & Sinha, S. (2016). Millimeter wave antennas for 5G mobile terminals and base stations. Springer.			
E-RESOURCES:				
1.	https://nptel.ac.in/courses/117105132			
2.	http://acl.digimat.in/nptel/courses/video/108105179/L31.html			
3.	https://www.youtube.com/watch?v=x1F5zft6Qtk			
4.	http://www.digimat.in/nptel/courses/video/108105179/L62.html			
5.	http://www.digimat.in/nptel/courses/video/108105179/L62.html			
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to			Mapping POs	Mapping PSOs
CO1	Understand the architecture, benefits, and challenges of Massive MIMO and MMWAVE systems.		--	--
CO2	Analyze system capacity, spectral efficiency, and propagation characteristics at MMWAVE frequencies.		PO1	PSO2
CO3	Apply signal Processing techniques for channel estimation, beamforming, and detection in MIMO.		PO1, PO3	PSO1, PSO2
CO4	Analyze system performance under different fading, mobility, and interference conditions using simulation tools.		PO1, PO2, PO3	PSO1
CO5	Study and analyse Massive MIMO and MMWAVE system Hardware and software and springs through self-learning activities and present the findings while considering societal and economic impacts.		PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs						
COs / POs		PO1	PO2	PO3	PSO1	PSO2
CO1						
CO2		3				3
CO3		3		3	3	3
CO4		3	3	3	3	
CO5		3	3	3	3	3
Activities:						
1.	Performance Analysis of Wireless Communication Systems Using Simulation (CO4)					
2.	Technical Seminar on Massive MIMO and mmWave Technology Exploration (CO5)					
Rubrics for Evaluation: CO4						
Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)	
1.	Problem formulation & different conditions	20	Problem and different interference conditions are clearly defined	Problem defined, but some of the interference conditions are unclear	Problem statement defined but unclear interference conditions	
2.	Simulation & plots	30	Simulation is done and plots are well-presented	Simulation is done, but min or error in plots	Simulations and plots are incomplete	
3.	Interpretation of results	30	Results are clearly Interpreted & justified	Results are interpreted but limited justification	Unclear interpretation	
4.	Report presentation	20	Report is clear and well structured	Report is structured, but needs improvement	Poorly structured report	
	Total	100				
Rubrics for Evaluation: CO5						
Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)	
1.	Understanding system hardware & software	20	Clearly explains system hardware & software	Explanation needs improvement	Limited understanding	
2.	Safety & Economic considerations	30	Clearly discusses societal and economic impacts	Safety aspects discussed but economic impacts not discussed	Poorly explained	

3.	Evidence of self-learning	30	Use of relevant journals/sources	Limited sources	Very limited sources
4.	Presentation & Communication	20	Presentation is clear and well-structured	Presentation needs improvement	Poorly structured
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	20	20			20	2
CO2	20	20			20	2
CO3	20	20			20	2
CO4			40		20	2
CO5				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26COE11		SOFTWARE DEFINED NETWORKING		SEMESTER		III	
Prerequisites			Category	ES(PE)	Credits	3	
Computer Networks			Hours/ Semester	L	T	P	TCP
				45	0	0	45
COURSE OBJECTIVES							
1.	To Understand the evolution of software defined networks						
2.	To Realize the various components of SDN and their uses						
3.	To gain knowledge in Data Center Networking						
4.	To Realize the role of Network function virtualization						
5.	To know about the SDN Applications						
UNIT - I		INTRODUCTION					9
History of Software Defined Networks (SDN) – Modern Data Center – Traditional Switch Architecture – Evolution of SDN – How SDN Works.							
UNIT - II		OPEN FLOW & SDN CONTROLLERS					9
Open Flow Specification – Drawbacks of Open SDN, SDN via APIs, SDN via Hypervisor- Based Overlays – SDN via Opening up the Device – SDN Controllers							
UNIT - III		SDN IN DATA CENTER					9
Data Center Definition - Data Center Demands - Tunneling Technologies for the Data Center - Path Technologies - Ethernet Fabrics - Open SDN versus Overlays - Real-World Data Center Implementations.							
UNIT - IV		NETWORK FUNCTION VIRTUALIZATION					9
Evolution of Network Architecture – NFV Architectural Framework – Benefits of NFV – Virtualization of Network Functions – Designing NFV Networks – Virtualization of Network Infrastructure and Services - comparison of NFC and SDN.							
UNIT - V		SDN APPLICATIONS					9
Reactive versus Proactive Applications - Analyzing Simple SDN Applications - A Simple Reactive Java Application - Background on Controllers - Using the Floodlight Controller - Using the OpenDaylight Controller.							
Total : 45 Hours							
Weightage: Continuous Assessment 40% End Semester Examinations 60%							
REFERENCE BOOKS:							
1.	Paul Goransson and Chuck Black, "Software Defined Networks: A Comprehensive Approach, First Edition", Morgan Kaufmann, 2014.						
2.	Marschke D, Doyle J, Moyer P, "Software Defined Networking (SDN): Anatomy of OpenFlow Volume 1. 2015.						
3.	Chayapathi R, Hassan SF, Shah P. "Network Functions Virtualization (NFV) with a Touch of SDN", Addison- Wesley Professional, 2016.						
4.	B. Wissingh, C. Wood, A. Afanasyev, L. Zhang, D. Oran and C. Tschudin, "Information-Centric Networking (ICN): Content Centric Networking (CCNx) and Named Data Networking (NDN) Terminology", RFC 8793, June 2020.						
5.	Gary Lee Morgan, "Cloud Networking: Understanding Cloud-based Data Centre Networks", Kaufmann Publisher, 2014.						

E-RESOURCES:

1.	https://ridhanegara.staff.telkomuniversity.ac.id/files/2017/04/Paul-Goransson-and-Chuck-Black-Auth.-Software-Defined-Networks.-A-Comprehensive-Approach.pdf
2.	https://ptgmedia.pearsoncmg.com/images/9780134463056/samplepages/9780134463056.pdf
3.	https://sdn.systemsapproach.org/index.html
4.	https://www.nptel.ac.in/courses/106106243
5.	https://www.classcentral.com/course/youtube-software-defined-networking-iii-329776

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping****POs****Mapping****PSOs**

CO1	Explain the fundamentals of Software Defined Networking (SDN), including its evolution, architecture, operation, traditional networking limitations, and modern data center requirements.	PO1, PO3	PSO2
CO2	Apply SDN and Network Function Virtualization (NFV) concepts to design and evaluate data center networks, virtualized network infrastructures, and software-defined network services.	PO1, PO2, PO3	PSO1
CO3	Analyze OpenFlow-based SDN architectures, SDN controllers, APIs, hypervisor-based overlays, and device-centric approaches for programmable network management.	PO1, PO3	PSO1, PSO2
CO4	Develop and demonstrate SDN-based solutions using simulation tools, controller platforms (Floodlight / Open Daylight), programming assignments, coding challenges, or mini-projects to address networking problems.	PO1, PO2, PO3	PSO1, PSO2
CO5	Conduct case studies, technical seminars, field studies, technical report preparation, project expos, market surveys, or student publications to evaluate real-world applications and emerging trends in SDN and NFV technologies.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined Cos

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	1		3		2
CO2	2	1	3	3	
CO3	3		3	3	3
CO4	3	2	2	3	3
CO5	2	3	2	2	3

Activities:

1.	Design, implement, and analyze Software Defined Networking solutions using SDN simulation for efficient network management using Mininet/Python/Wireshark (CO4)
2.	Analyze industrial implementations of SDN/NFV and evaluate their impact on network performance through Case Study/Seminar (CO5)(Independent study)

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem Formulation & Network Design	30	SDN problem, objectives, network topology, and design are clearly defined and justified.	Problem and topology are defined, but some design constraints are unclear.	Problem statement is defined but network design and constraints are poorly specified.
2.	Simulation / Implementation & Performance Analysis	30	SDN simulation or implementation is successfully	Simulation / Implementation is completed with minor errors.	Simulation /implementation is incomplete and performance results are inadequate.
3.	Interpretation of Results	20	Results are clearly analyzed, interpreted, and justified with respect to SDN	Results are interpreted with limited analysis	Interpretation of results is unclear and lacks technical justification.
4.	Report presentation	20	Report is clear and well structured	Report is structured, but needs improvement	Poorly structured report with inadequate technical documentation.
	Total	100			

Rubrics for Evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Understanding of SDN/NFV Concepts and Applications	20	Clearly explains SDN/NFV architecture, controllers, data center networking.	Explanation is adequate but requires further technical details.	Limited understanding of SDN/NFV concepts and applications.
2.	Analysis of Case Study and Industry Relevance	30	Thoroughly analyzes the selected case study/application, discusses and practical relevance.	Case study is analyzed with limited discussion of practical aspects.	Analysis is superficial and lacks technical depth.

3.	Evidence of Self-Learning	30	Uses relevant journals, conference paper, standards to support findings.	Uses a moderate number of relevant sources with limited critical analysis.	Very limited use of technical references and self-learning resources.
4.	Presentation & Communication	20	Presentation is clear and well-structured	Presentation needs improvement	Poorly structured with ineffective communication.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	20	20			20	2
CO2	20	20			20	2
CO3	20	20			20	2
CO4			40		20	2
CO5				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26COE12	IOT AND EDGE COMMUNICATION		SEMESTER			III
Prerequisites		Category	ES(PE)	Credits		3
		Hours/ Semester	L	T	P	TCP
			45	0	0	45

COURSE OBJECTIVES

- | | |
|----|---|
| 1. | Understand advanced IoT communication architectures and edge computing paradigms. |
| 2. | Analyze communication protocols and networking frameworks for large-scale IoT systems. |
| 3. | Evaluate resource allocation, latency, reliability, and energy efficiency in edge-enabled networks. |
| 4. | Investigate security, privacy, and intelligence mechanisms in IoT-edge ecosystems. |
| 5. | Design next-generation IoT and edge communication solutions for Beyond 5G/6G applications. |

UNIT - I	Advanced IoT Communication Architectures	9
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Evolution of IoT- IoT reference architectures- Industrial IoT architectures- Massive Machine Type Communications (mMTC)- IoT communication requirements-Constrained networks- IPv6 over Low Power Networks (6LoWPAN)- MQTT, CoAP, DDS- IoT standardization frameworks.

UNIT - II	Wireless Networking for IoT Systems	9
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Wireless Sensor Networks- LPWAN technologies-LoRaWAN; NB-IoT- LTE-M; Device-to-Device communication- Routing protocols- Energy-efficient communication mechanisms- QoS provisioning-Performance metrics for IoT networks.

UNIT - III	Edge Computing and Intelligent Communication	9
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Edge computing architectures- Fog computing- Computation offloading-Service placement- Resource orchestration-Edge caching-Network slicing- AI-assisted edge communication; Latency-aware communication frameworks.

UNIT - IV	Security and Intelligence in IoT-Edge Networks	9
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Security challenges- Authentication and access control-Privacy preservation- Blockchain-enabled IoT communication- Federated learning for edge networks- Trust management- Intrusion detection; Secure communication protocols.

UNIT - V	Beyond 5G and 6G IoT Communications	9
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Integrated sensing and communication-Digital Twin Networks-Edge AI- Semantic communications- Internet of Everything- UAV-assisted communications- Vehicular IoT-AI-native 6G networks; Future research directions.

Total : 45 Hours

Weightage:

Continuous Assessment 40%

End Semester Examinations 60%

REFERENCE BOOKS:					
1.	Rajkumar Buyya and Satish Narayana Srirama, Fog and Edge Computing: Principles and Paradigms, Wiley, 2019.				
2.	Arshdeep Bahga and Vijay Madisetti, Internet of Things – A Hands-on Approach, Universities Press.				
3.	Hossam Fattah, Wireless Sensor Networks and Internet of Things: Communication Protocols and Applications, CRC Press.				
4.	Pethuru Raj & Preetha Evangeline, "Edge Computing: From Hype to Reality", Springer, 2026.				
5.	Adrian McEwen & Hakim Cassimally, "Designing the Internet of Things", Wiley				
E-RESOURCES:					
1.	IEEE Internet of Things Journal				
2.	IEEE Transactions on Network and Service Management				
3.	NPTEL Courses on IoT and Edge Computing				
4.	ACM Digital Library				
5.	https://www.coursera.org/?utm_source=chatgpt.com				
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs		
CO1	Analyze IoT architectures, communication protocols, wireless networking technologies, and edge computing frameworks.	PO1, PO2	PSO1		
CO2	Apply IoT communication technologies and edge computing techniques to solve communication engineering problems.	PO1, PO2, PO3	PSO1, PSO2		
CO3	Evaluate the performance of IoT and edge communication systems with respect to latency, reliability, and energy efficiency.	PO1, PO2, PO3	PSO1, PSO2		
CO4	Investigate security, privacy, and intelligent networking solutions in IoT-edge communication ecosystems.	PO2, PO3	PSO1, PSO2		
CO5	Design advanced IoT-edge communication solutions for smart applications, Industry 4.0, Beyond 5G, and 6G networks.	PO1, PO2, PO3	PSO1, PSO2		
The Course Articulation Matrix (CAM) for defined Cos					
COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	3		3	
CO2	3	3	3	3	3
CO3	2	3	3	3	3
CO4	-	2	3	3	3
CO5	3	3	3	3	3
Activities:					
1.	Performance Analysis of Edge-Based IoT Communication Networks (CO4)				
2.	Design Edge-Based Smart City Communication System (CO5)				

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem Formulation & Understanding	20	Problem clearly identified with appropriate assumptions	Minor gaps in understanding	Limited understanding
2.	Technical Analysis	30	Comprehensive analysis with proper methodology	Moderate analysis with minor errors	Incomplete analysis
3.	Interpretation of Results	20	Results clearly interpreted and justified	Partial interpretation	Limited interpretation
4.	Technical Presentation	20	Well organized and professionally presented	Adequate presentation	Poor presentation
5.	Report Submission	10	Complete and structured report	Minor improvements required	Incomplete report
	Total	100			

Rubrics for Evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem Formulation and System Architecture Design	20	Problem is clearly defined with well-designed IoT-Edge architecture and communication framework	Problem is defined with minor deficiencies in architecture design	Problem statement and architecture are incomplete or unclear
2.	Implementation / Simulation / Prototype Development	30	Complete implementation with appropriate tools, simulations, and validated results	Implementation completed with minor errors or limitations	Implementation incomplete with significant errors
3.	Performance Evaluation and Analysis	20	Comprehensive analysis using latency, throughput, energy efficiency, reliability, and scalability metrics	Performance metrics analyzed with limited justification	Limited performance evaluation and interpretation
4.	Innovation and Application Relevance	20	Demonstrates innovative solution with strong relevance to Industry 4.0, Smart Cities, Beyond 5G/6G applications	Relevant solution with moderate innovation	Limited innovation and application relevance
5.	Technical Report and Presentation	10	Report is technically sound, well-structured, and presentation is highly effective	Report is adequate with minor organizational issues	Poorly structured report and presentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	20	20			20	2
C02	20	20			20	2
C03	20	20			20	2
C04			40		20	2
C05				40	20	2
Total	60	60	40	40	100	

Note:Purely as anExample: Strength = 3 (if percentage >20%);

Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26COE13		IMAGE AND VIDEO PROCESSING		SEMESTER			III	
Prerequisites				Category	ES(PE)	Credits		3
1. Engineering Mathematics 2. Signals and Systems & DSP 3. Programming Fundamentals				Hours/ Semester	L	T	P	TCP
					45	0	0	45
COURSE OBJECTIVES								
1.	To understand the fundamentals of digital image processing, image representation, and transform techniques.							
2.	To apply image enhancement and restoration methods to improve image quality and recover degraded images.							
3.	To analyze image segmentation and feature extraction techniques for object and pattern identification.							
4.	To evaluate image compression methods and coding standards for efficient storage and transmission.							
5.	To explore video processing, motion analysis, and visual perception concepts for intelligent vision applications.							
UNIT - I		FUNDAMENTALS OF IMAGE PROCESSING AND IMAGE TRANSFORMS						9
Introduction – Image file formats – Digital image structure and visual perception – Applications of Digital image processing – Need for image for transform – Fourier transform – 2 D Discrete Fourier transform and its properties – Importance of phase – Walsh-Hadamard transform – wavelet transform – Discrete cosine transform – karhunen-Loeve (KL) transform – Radon transform, comparison of different image transforms.								
UNIT - II		IMAGE ENHANCEMENT AND RESTORATION						9
Spatial domain methods – Histogram processing – Fundamentals of Spatial filtering – Smoothing spatial filters – Sharpening spatial filters. Frequency domain method – Basics of filtering in frequency domain – image smoothing – image sharpening– Selective filtering. Image Restoration–Introduction to Image restoration – Image degradation, Types of image blur – Classification of image restoration techniques – Image restoration model – Linear and Nonlinear image restoration techniques.								
UNIT - III		IMAGE SEGMENTATION						9
Introduction to image segmentation – Point, Line and Edge Detection – Region based segmentation – Classification of segmentation techniques – Region approach to image segmentation – Feature vector representation for image segmentation – clustering technique – k-means, Fuzzy C-means, Hierarchical clustering – Image segmentation based on thresholding – Edge based segmentation –Edge detection and linking – Hough transform.								
UNIT - IV		IMAGE COMPRESSION						9
Need for image compression – Redundancy – Classification of redundancy in images – image compression scheme – Classification, Fundamentals of information theory – Run length coding –Shannon – Fano coding – Huffman coding – Arithmetic coding – Predictive coding, Transformed based compression – Image compression standard – Wavelet-based image compression – JPEG Standards.								
UNIT - V		VIDEO PROCESSING						9
Video representation: frames, shots, scenes – Temporal continuity and key frame extraction – Motion analysis using optical flow (Horn-Schunck, Lucas-Kanade) – Activity zones and region-of-interest detection – Shot boundary detection and scene segmentation – Real-time video enhancement – Camera calibration and view transformations – Depth estimation from motion – Challenges in video-based perception.								
Total : 45 Hours								

Weightage:

Continuous Assessment 40%

End Semester Examinations 60%

REFERENCE BOOKS:

1. Gonzaleze and Woods, "Digital Image Processing", 3rd edition, Pearson 2.
2. Yao wang, Joem Ostarmann and Ya – quin Zhang, "Video processing and communication ",1st edition, PHI.
3. ScotteUmbaugh, "Digital Image Processing and Analysis-Human and Computer Vision Application with CVIP Tools", 2nd Ed, CRC Press, 2011.
4. M. Tekalp, "Digital Video Processing", Prentice Hall International.
5. Szeliski, R. (2022), "Computer vision: Algorithms and applications" (2nd ed.), Springer.

E-RESOURCES:

1. [NPTEL :NOC:Digital Image Processing \(Electronics and Communication Engineering\)](#)
2. [Preview: Digital Image Processing | SWAYAM](#)
3. <https://www.coursera.org/learn/computer-vision-basics>
4. https://www.mathworks.com/help/images/?utm_source
5. https://www.mdpi.com/journal/electronics?utm_source

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Understand the fundamentals of image processing, enhancement, segmentation, compression, and video processing techniques.	PO1, PO2, PO3	PSO1, PSO2
CO2	Apply image transformation, enhancement, restoration, and segmentation methods to solve image processing problems.	PO1, PO2, PO3	PSO1, PSO2
CO3	Analyze the performance of image and video processing techniques for various applications	PO1, PO2 PO3	PSO1, PSO2
CO4	Design and implement image and video processing solutions using modern software tools and techniques.	PO1, PO2 PO3	PSO1, PSO2
CO5	Develop innovative image processing applications while demonstrating teamwork, communication, ethics, and lifelong learning skills.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix(CAM) for defined Cos

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	1	3	2	1
CO2	3	1	3	3	2
CO3	3	2	3	2	3
CO4	3	2	3	3	3
CO5	2	3	2	3	3

Activities:

1.	Using MATLAB/Python, implement Run Length Encoding (RLE), Shannon-Fano Coding, and Huffman Coding on a gray scale image. Compare their compression ratio, coding efficiency, and execution time.
2.	Prepare a technical presentation on Horn–Schunck and Lucas–Kanade Optical Flow Algorithms for motion estimation in video sequences. Compare their mathematical models, implementation approaches, advantages, limitations, and applications.

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem Selection & Objective	20	Clear problem definition with relevant application	Problem defined with minor gaps	Basic problem statement
2.	Algorithm Design	20	Appropriate and well-structured design	Suitable design with minor issues	Basic design with limited justification
3.	Implementation using MATLAB/Python	20	Complete implementation with correct execution	Functional implementation with few errors	Partial implementation
4.	Result Analysis & Validation	20	Comprehensive analysis using metrics and comparisons	Adequate analysis with limited validation	Basic result interpretation
5.	Documentation & Demonstration	20	Excellent report and presentation of results	Functional implementation with few errors	Satisfactory documentation
	Total	100			

Rubrics for Evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Understanding of the Case Study	20	Comprehensive understanding with strong technical insights	Good understanding with adequate details	Basic understanding of the application

2.	Analysis of Existing Techniques	20	Critical analysis with comparison of techniques	Adequate analysis of techniques	Limited analysis
3.	Innovation & Future Scope	20	Well-justified recommendations and future directions	Reasonable recommendations	Basic suggestions
4.	Presentation & Communication Skills	20	Clear, professional, and engaging presentation	Good presentation with minor issues	Satisfactory presentation
5.	Report Quality & Team Contribution	20	Excellent report and active participation	Good report and participation	Basic report and contribution
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	20	20			20	2
CO2	20	20			20	2
CO3	20	20			20	2
CO4			40		20	2
CO5				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26COE14	WAVELETS AND SUBBAND CODING		SEMESTER		III		
Prerequisites			Category	ES(PE)	Credits	3	
			Hours/ Semester	L	T	P	TCP
				45	0	0	45
COURSE OBJECTIVES							
1.	To understand the basic concepts of signal decomposition, Hilbert spaces, Fourier transforms, sampling, and time-frequency analysis.						
2.	To learn the principles and applications of discrete-time signal representations and filter banks for signal processing.						
3.	To understand multiresolution analysis and construct wavelets for efficient signal representation and analysis.						
4.	To apply continuous wavelet transforms, short-time Fourier transforms, and frame theory to analyze and reconstruct signals.						
5.	To use wavelet and subband coding techniques for compression of speech, audio, image, and video signals.						
UNIT - I		INTRODUCTION TO SIGNAL DECOMPOSITIONS					9
Notations - Hilbert Spaces: Vector Spaces and Inner products, Complete Inner Product Spaces, Orthonormal Bases - Elements of Linear Algebra - Fourier Theory and Sampling - Signal Processing - Time Frequency Representations.							
UNIT - II		DISCRETE-TIME BASES AND FILTER BANKS					9
Series Expansions of Discrete - Time Signals - Two-Channel Filter Banks - TreeStructured Filter Banks - Multichannel Filter Banks - Pyramids and Over complete Expansions - Multidimensional Filter Banks - Tran multiplexers and Adaptive Filtering in Subbands.							
UNIT - III		MULTIREOLUTION ANALYSIS AND CONSTRUCTION OF WAVELETS					9
Multiresolution Concept and Analysis - Construction of Wavelets Using Fourier Techniques - Wavelets Derived from Iterated Filter Banks and Regularity - Wavelet Series and Its Properties - Generalizations in One Dimension – Multidimensional Wavelets - Local Cosine Bases							
UNIT - IV		CONTINUOUS WAVELET AND FRAMES					9
Continuous Wavelet Transform: Analysis and Synthesis, Properties, Morlet Wavelet - Continuous Short-Time Fourier Transform: Properties - Frames of Wavelet and ShortTime Fourier Transforms: Discretization of Continuous-Time Wavelet and Short-Time Fourier Transforms, Reconstruction in Frames, Frames of Wavelets and STFT							
UNIT - V		SIGNAL COMPRESSION AND SUB BAND CODING					9
Compression Systems Based on Linear Transforms - Speech and Audio Compression - Image Compression: Transform and Lapped Transform Coding of Images, Pyramid Coding of Images, Subband and Wavelet Coding of Images, Advanced Methods in Subband and Wavelet Compression - Video Compression - Joint Source-Channel Coding							
Total : 45 Hours							
Weightage:							
Continuous Assessment 40%							
End Semester Examinations 60%							

REFERENCE BOOKS:

1.	Vetterli, M., & Kovačević, J. (1995). Wavelets and subband coding. Prentice Hall.
2.	Soman, K. P., & Ramachandran, K. I. (2013). Insight into wavelets – From theory to practice (3 rd ed.). PHI Learning Private Limited
3.	Rao, R. M., & Bopardikar, A. S. (2012). Wavelet transforms: Introduction to theory and applications (3 rd ed.). Prentice Hall PTR.
4.	Strang, G., & Nguyen, T. (1996). Wavelets and filter banks (2 nd ed.). Wellesley Cambridge Press
5.	Mallat, S. (2008). A wavelet tour of signal processing (3 rd ed.). Academic Press

E-RESOURCES:

1.	https://www.math.purdue.edu/~lucier/692/DJL-image-compression.pdf
2.	https://nptel.ac.in/courses/117101123
3.	https://onlinecourses.nptel.ac.in/noc20_ee51/preview
4.	https://archive.nptel.ac.in/courses/108/101/108101093/

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Explain the fundamentals of signal decomposition, Fourier transforms, sampling theory, time-frequency analysis	PO1	PSO1
CO2	Analyze and design filter banks, pyramids, and multidimensional signal processing techniques.	PO1, PO2	PSO1
CO3	Apply multiresolution analysis to construct and analyze wavelets for signal representation.	PO1, PO2	PSO1
CO4	Perform signal analysis and reconstruction using CWT, STFT, and frame-based techniques with simulation tools.	PO2, PO3	PSO2
CO5	Develop and evaluate signal compression techniques using transform coding, subband coding, and wavelets for speech, audio, image, and video applications.	PO2, PO3	PSO2

The Course Articulation Matrix (CAM) for defined Cos

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3			3	
CO2	3	3		3	
CO3	3	3		3	
CO4		3	3		3
CO5		3	3		3

Activities:					
1.	Develop a MATLAB/Python-based tool for time-frequency analysis of real-world signals and present the results.				
2.	Study JPEG, JPEG2000, MP3, or MPEG standards and present the role of transform and wavelet coding.				
Rubrics for Evaluation: CO4					
Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Signal Selection and Problem Definition	20	Appropriate real-world signal selected with clear objectives and justification	Relevant signal selected with adequate objectives	Signal selected with limited justification
2.	Implementation of Time-Frequency Analysis Tool	20	Accurate implementation of STFT/CWT with efficient coding and visualization	Correct implementation with minor errors	Basic implementation with limited functionality
3.	Analysis and Interpretation of Results	20	comprehensive analysis with meaningful interpretation and conclusions	Good analysis with reasonable conclusions	Basic analysis with limited interpretation
4.	Innovation and Tool Features	20	Includes advanced features, user interaction, or comparative analysis	Includes some additional useful features	Limited additional features
5.	Presentation and Documentation	20	Clear presentation, well-organized report, and effective communication	Good presentation and documentation	Adequate presentation with minor deficiencies
	Total	100			
Rubrics for Evaluation: CO5					
Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Understanding of Compression Standard	20	Demonstrates comprehensive understanding of the selected standard and its applications	Good understanding with minor gaps	Basic understanding of the standard
2.	Analysis of Transform/Wavelet Coding	20	Clearly explains the role of DCT, FFT, or Wavelet transforms with technical accuracy	Good explanation with minor inaccuracies	Basic explanation with limited technical depth
3.	Comparative Evaluation and Critical Analysis	20	Provides insightful comparison of coding techniques and performance metrics	Adequate comparison and analysis	Limited comparison with minimal analysis

4.	Presentation Quality and Communication	20	Well-organized presentation with effective visual aids and confident delivery	Good presentation with minor issues	Adequate presentation with limited clarity
5.	Report Preparation and References	20	Comprehensive report with proper technical writing and relevant references	Good report with adequate references	Basic report with limited references
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	20	20			20	2
CO2	20	20			20	2
CO3	20	20			20	2
CO4			40		20	2
CO5				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26COE15	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY		SEMESTER		III	
Prerequisites		Category	ES(PE)	Credits	3	
Radio Frequency Engineering		Hours/ Semester	L	T	P	TCP
			45	0	0	45
COURSE OBJECTIVES						
1.	To develop a comprehensive understanding of Electromagnetic interference in electronic systems.					
2.	To identify and analyze EMI sources and coupling mechanisms.					
3.	To apply effective mitigation techniques like shielding, grounding, and filtering.					
4.	To comprehend relevant national and international EMC standards and regulations, and gain practical knowledge of EMI/EMC test methods and instrumentation.					
5.	To design electromagnetically compatible electronic systems and PCBs.					
UNIT - I		EMI/EMC CONCEPTS				9
Definitions and Concepts – EMC Environment - EMC Testing Categories - Basic Electromagnetic Theory: Maxwell's equations and their application in EMC, Near-field and far-field approximations, Concepts of impedance						
UNIT - II		EMI COUPLING PRINCIPLES				9
Coupling Paths - basic coupling mechanisms: Conducted Coupling, Capacitive Coupling, Inductive/Magnetic Coupling, Radiative / Electromagnetic Coupling – Crosstalk - Transient Sources - Automotive transients.						
UNIT - III		EMI MITIGATION TECHNIQUES & EMC STANDARDS				9
Shielding – Grounding – Filtering – Cabling – Bonding - Need for Standards - National and International EMC Standardizing Organizations: IEC, FCC, CISPR, ANSI, BSI, CENELEC, ETSI - Key Standards and Specifications: MIL-STD, Electro Magnetic Emission and Susceptibility standards.						
UNIT - IV		EMI TEST METHODS AND INSTRUMENTATION				9
Fundamental Considerations - Emission Testing: Conducted Emissions, Radiated Emissions - Immunity/Susceptibility Testing: Conducted Immunity, Radiated Immunity, ESD Testing, Transient Immunity - Test Equipment						
UNIT - V		PCB DESIGN FOR EMC COMPLIANCE				9
PCB Layout and Stack-up - Signal Integrity Considerations - Mixed-Signal PCB Layout: Grounding and power distribution for mixed-signal systems, Isolation of sensitive circuits - Component Placement for EMC						
Total : 45 Hours						
Weightage:						
Continuous Assessment 40%						
End Semester Examinations 60%						
REFERENCE BOOKS:						
1.	Ott, H. W. (1988). Electromagnetic compatibility engineering (2nd ed.). John Wiley & Sons.					
2.	Paul, C. R. (2010). Introduction to electromagnetic compatibility (2nd ed.). Wiley Interscience.					
3.	Ott, H. W. (1988). Noise reduction techniques in electronic systems (2nd ed.). John Wiley & Sons.					
4.	Keiser, B. (1989). Principles of electromagnetic compatibility (3rd ed.). Artech House.					
5.	Kodali, V. P. (2001). Engineering electromagnetic compatibility: Principles, measurements, and technologies with computer models (2nd ed.). IEEE Press.					

E-RESOURCES:

1.	http:// www.ewh.ieee.org/soc/emcs/ 2
2.	https://archive.nptel.ac.in/courses/108/106/108106138/ 3
3.	https://nptel.ac.in/courses/108106138 4
4.	https://onlinecourses.nptel.ac.in/noc24_ee67/preview

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Identify, categorize, and explain various sources of electromagnetic interference and EMC testing categories and EMI/EMC test methods, recognize the associated instrumentation, and critically evaluate test results for compliance.	--	--
CO2	Analyze and classify the coupling mechanisms (conducted, radiated, capacitive, inductive), and their impact on electronic systems.	PO1, PO2	PSO2
CO3	Design and implement effective EMI control and mitigation techniques, including shielding, grounding, bonding, filtering, and cable management.	PO1, PO3	PSO1
CO4	Evaluate EMC compliance requirements and international standards for electronic products and systems through testing and validation procedures.	PO1, PO3	PSO2
CO5	Integrate EMC principles into the design process of electronic circuits and printed circuit boards (PCBs), optimizing layouts, component placement, and power/ground distribution to ensure inherent electromagnetic compatibility.	PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined Cos

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1					
CO2	2	3			3
CO3	3		3	3	
CO4	3		3		3
CO5		3	3	3	3

Activities:

1.	Design and Testing on PCB Layout for EMC (CO4)
2.	Technical presentation on Grounding & power distribution of mixed signals (CO5)

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Understanding EMI mitigation techniques	20	Clearly explains EMI control strategies	Explanation needs improvement	Limited understanding
2.	Safety & Economic considerations	30	Clearly discusses safety aspects and material comparison cost	Safety aspects discussed but material comparison is not	Poorly explained
3.	Evidence of self-learning	30	Use of relevant journals/sources	Limited sources	Very limited sources
4.	Presentation & Communication	20	Presentation is clear and well-structured	Presentation needs improvement	Poorly structured
	Total	100			

Rubrics for Evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem formulation & Literature Survey	30	Problem and Lit Survey clearly defined	Problem defined, but not sufficient literature to support	Problem statement and Lit survey unclear
2.	Simulation & plots	30	Simulation is done and plots are well-presented	Simulation is done, but minor error in plots	Simulations and plots are incomplete
3.	Interpretation of results	20	Results are clearly Interpreted & justified	Results are interpreted but limited justification	Unclear interpretation
4.	Report presentation	20	Report is clear and well structured	Report is structured, but needs improvement	Poorly structured report
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	20	20			20	2
CO2	20	20			20	2
CO3	20	20			20	2
CO4			40		20	2
CO5				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);

Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26COE16		BIOMEDICAL COMMUNICATION SYSTEMS		SEMESTER		III	
Prerequisites			Category	ES(PE)	Credits		3
Biomedical Signal Processing, Digital Communication, Communication Systems			Hours/ Semester	L	T	P	TCP
				45	0	0	45
COURSE OBJECTIVES							
1.	To understand biomedical signals, physiological parameters and healthcare communication requirements.						
2.	To study biomedical instrumentation and medical data acquisition systems.						
3.	To analyze wireless body area networks and communication protocols used in healthcare applications.						
4.	To evaluate telemedicine, IoT-enabled healthcare systems and medical information networks.						
5.	To examine emerging trends in biomedical communication systems and smart healthcare technologies.						
UNIT - I		INTRODUCTION TO BIOMEDICAL COMMUNICATION SYSTEMS					9
Introduction to Biomedical Engineering – Physiological Signals – ECG, EEG and EMG Signals – Biomedical Sensors and Transducers – Signal Acquisition Systems – Biomedical Instrumentation – Signal Conditioning – Noise and Artifacts in Biomedical Signals.							
UNIT - II		MEDICAL DATA ACQUISITION AND COMMUNICATION					9
Biomedical Data Acquisition Systems – Medical Device Connectivity – Patient Monitoring Systems – Biomedical Signal Transmission Techniques – Healthcare Information Systems – Medical Data Standards – Reliability and Quality of Service Requirements in Healthcare Communications.							
UNIT - III		WIRELESS BODY AREA NETWORKS					9
Wireless Body Area Networks (WBAN) – WBAN Architecture – IEEE 802.15.6 Standard – Wearable Devices – Implantable Medical Devices – Energy Efficient Communication Techniques – Routing and MAC Protocols – Performance Analysis of WBAN Systems.							
UNIT - IV		TELEMEDICINE AND IoT HEALTHCARE SYSTEMS					9
Telemedicine Architecture – Remote Patient Monitoring – Mobile Health (m-Health) Systems – Internet of Medical Things (IoMT) – Cloud-based Healthcare Systems – Edge Computing for Healthcare – Security and Privacy Issues in Healthcare Communications.							
UNIT - V		ADVANCED BIOMEDICAL COMMUNICATION TECHNOLOGIES					9
AI in Healthcare – Machine Learning for Biomedical Data Analysis – Smart Healthcare Networks – 5G/6G Enabled Healthcare Systems – Medical Cyber Physical Systems – Digital Twins in Healthcare – Healthcare Big Data Analytics – Future Trends in Biomedical Communication Systems.							
Total : 45 Hours							
Weightage:							
Continuous Assessment 40%							
End Semester Examinations 60%							

REFERENCE BOOKS:

1.	Rangaraj M. Rangayyan, Biomedical Signal Analysis, Wiley India, 3rd Edition, 2024
2.	John G. Webster and Amit J. Nimunkar, Medical Instrumentation: Application and Design, Wiley, 5 th Edition, 2020.
3.	Mehmet R. Yuce and Jamil Y. Khan, Wireless Body Area Networks: Technology, Implementation and Applications, Pan Stanford Publishing, 2nd Edition, 2019.
4.	Bernard Fong, A.C.M. Fong and C.K. Li, Telemedicine Technologies: Information Technologies in Medicine and Telehealth, Wiley-IEEE Press, 2nd Edition, 2021.
5.	Dac-Nhuong Le et al., Emerging Technologies for Health and Medicine, Wiley, 2022.

E-RESOURCES:

1.	NPTEL – Biomedical Signal Processing and Healthcare Technologies
2.	IEEE Xplore Digital Library
3.	IEEE Engineering in Medicine and Biology Society (EMBS)
4.	National Institutes of Health (NIH) Resources
5.	World Health Organization (WHO) Digital Health Resources

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Explain biomedical signals, instrumentation systems and physiological data acquisition techniques.	PO1	PSO1
CO2	Analyze medical data communication requirements and healthcare information systems.	PO1, PO2	PSO1, PSO2
CO3	Evaluate wireless body area networks and communication standards used in healthcare applications.	PO2, PO3	PSO1, PSO2
CO4	Analyze telemedicine and IoT-enabled healthcare communication systems.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate emerging biomedical communication technologies for smart healthcare applications.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined Cos

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	-	-	3	-
CO2	3	3	-	3	3
CO3		3	3	3	3
CO4	2	3	3	3	3
CO5	3	3	3	3	3

Activities:

1.	Design and analysis of a telemedicine, IoMT or remote patient monitoring system using suitable simulation tools, communication platforms or case studies. (CO4)
2.	Technical seminar / literature survey on emerging biomedical communication technologies such as Wireless Body Area Networks (WBAN), AI-enabled healthcare systems, 5G/6G healthcare networks, Digital Twins in Healthcare and Smart Healthcare Systems. (CO5)

Rubrics for Evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Problem identification and system analysis	20	Healthcare communication problem is clearly identified and analyzed	Problem identified with minor gaps	Problem identification lacks clarity
2.	System design / Simulation	30	System is designed and simulated successfully with appropriate methodology	Design completed with minor errors	Design or simulation is incomplete
3.	Analysis and interpretation of results	20	Results are thoroughly analyzed and justified	Results analyzed with limited justification	Analysis and interpretation are inadequate
4.	Evaluation of healthcare communication solution	20	Solution is effectively evaluated considering performance and applicability	Evaluation is adequate with minor limitations	Evaluation lacks depth and justification
5.	Report presentation	10	Report is clear, well-structured and technically sound	Report is structured but needs improvement	Poorly structured report
	Total	100			

Rubrics for Evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Understanding of the topic	20	Demonstrates comprehensive understanding of the selected technology	Demonstrates adequate understanding with minor gaps	Demonstrates limited understanding
2.	Technical analysis and critical evaluation	30	Provides in-depth analysis supported by recent research literature	Analysis is adequate with limited critical evaluation	Analysis lacks technical depth

3.	Literature survey and use of resources	20	Extensive use of recent journals, standards and technical resources	Adequate use of relevant resources	Limited use of technical resources
4.	Presentation and communication skills	20	Presentation is clear, organized and technically effective	Presentation is adequate but needs improvement	Presentation lacks clarity and organization
5.	Report quality and documentation	10	Report is well-structured with proper citations and technical content	Report is acceptable with minor deficiencies	Report is poorly organized and inadequately documented
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	20	20			20	2
C02	20	20			20	2
C03	20	20			20	2
C04			40		20	2
C05				40	20	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength =2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26AC001	ENGLISH FOR RESEARCH PAPER WRITING M.E. (Common to all Branches)			SEMESTER		I/II
Prerequisites			Category	AC	Credits	
Basic proficiency in English and familiarity with academic and technical writing.			Hours/ Semester	L	T	P
				30	0	0
COURSE OBJECTIVES						
1.	To develop awareness of the importance of English in academic and research communication.					
2.	To familiarize learners with the structure and organization of research papers.					
3.	To improve learners' ability to use appropriate academic language and expressions in research writing.					
4.	To help learners avoid common language errors and improve the quality of their research papers.					
5.	To enable learners to write and present research work using accepted academic conventions.					
UNIT - I FUNDAMENTALS OF RESEARCH AND ACADEMIC WRITING						
Research and its significance. Purpose, characteristics, and structure of a research paper. Types of research publications. Identifying research problems and defining objectives. Features of academic English, including formal and objective style. Academic vocabulary, clear and concise sentence construction, and avoidance of redundancy and common grammatical errors. Selection of appropriate journals and conferences for publication.						
UNIT - II LANGUAGE PATTERNS IN RESEARCH WRITING						
Common phrases for introducing research problems, stating objectives, describing methods, and presenting results. Use of active and passive voice. Appropriate tense forms in research writing. Cohesion and coherence through linking words and transitions.						
UNIT - III IMPROVING RESEARCH WRITING						
Hedging in academic writing. Paraphrasing and summarizing techniques. Plagiarism and ethical writing practices. Identifying and correcting common language mistakes. Editing and proof reading strategies.						
UNIT - IV REVIEW WRITING AND REVIEW OF LITERATURE						
Purpose and structure of review articles. Review of Literature (RoL): literature search, synthesis of findings, and identification of research gaps. Citation practices and avoidance of plagiarism. Practical exercises in organizing literature and drafting literature review sections.						
UNIT - V WRITING RESEARCH PAPER SECTIONS						
Writing effective titles, abstracts, introductions and conclusions. Presenting findings and discussions clearly. Language for oral presentation of research. Useful phrase banks for different sections of a research paper and research presentations.						
L:30, Total:30 Hours						
Weightage: Continuous Assessment - 100%						

REFERENCE BOOKS:

1.	Wallwork, Adrian. English for Writing Research Papers. 3 rd ed., Springer, 2023.
2.	Swales, John M., and Christine B. Feak. Academic Writing for Graduate Students: Essential Tasks and Skills. 4 th ed., University of Michigan Press, 2020.
3.	Glasman-Deal, Hilary. Science Research Writing for Non-Native Speakers of English. 2 nd ed., Imperial College Press, 2020.
4.	Cargill, Margaret, and Patrick O'Connor. Writing Scientific Research Articles: Strategy and Steps. 3 rd ed., Wiley-Blackwell, 2021.
5.	Day, Robert A., Barbara Gastel, and Michelle Prince. How to Write and Publish a Scientific Paper. 9 th ed., Greenwood, 2022.

E-RESOURCES:

1.	Author Academy – https://authoracademy.springernature.com
2.	Researcher Academy – https://researcheracademy.elsevier.com
3.	Learn English (British Council) - https://learnenglish.britishcouncil.org/skills/writing
4.	Academic Phrase bank – https://www.phrasebank.manchester.ac.uk
5.	Committee on Publication Ethics (COPE) – https://publicationethics.org

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Explain the significance of research communication and describe the structure, purpose, and types of research publications.	PO1, PO2	
CO2	Apply appropriate academic vocabulary, sentence structures, and language conventions in research writing.	PO1, PO2	
CO3	Use academic language patterns, cohesive devices, and appropriate grammatical structures to communicate research ideas effectively.	PO1, PO2	
CO4	Analyze research papers to identify writing styles, language patterns, and common grammatical error	PO1, PO2	
CO5	Demonstrate ethical research writing practices through effective paraphrasing, citation, referencing, and avoidance of plagiarism.	PO1, PO2	

The Course Articulation Matrix (CAM) for defined COs

	PO1	PO2	PO3	PSO1	PSO2
CO1	3	2			
CO2	3	3			
CO3	2	3			
CO4	2	3			
CO5	3	3			

Activities:

1.	(i) Assignment 1: Research Paper Analysis and Language Evaluation Select a published research paper from your discipline and analyze its structure, purpose, and major components. Evaluate the use of academic vocabulary, sentence structures, language patterns, cohesive devices, and grammatical conventions. Comment on the effectiveness of the writing and identify areas for improvement. (ii) Assignment 2: Academic Rewriting and Editing Choose a technical text or an excerpt from a research article and revise it using appropriate academic vocabulary, formal style, cohesive devices, and correct grammatical structures. Explain the revisions made and discuss how they improve the quality and clarity of research communication. (iii) Assignment 3: Review of Literature and Research Gap Identification Select a research topic related to your specialization and review at least five recent research articles. Summarize the major findings using appropriate academic language and transitions, compare the studies, identify research gaps, and present the review in a coherent academic format. (iv) Assignment 4: Analysis of Research Writing Conventions Analyze two published research papers from your discipline and compare their writing conventions, language patterns, organization, and presentation of research findings. Examine the use of academic expressions, cohesion, citation practices, and ethical writing principles. Suggest improvements where necessary.
2.	PRESENTATION: (i) Presentation 1: Ethical Issues in Research Writing Discuss plagiarism, self-plagiarism, authorship issues, citation ethics, and the responsibilities of researchers in academic publishing. Illustrate the discussion with examples from published research articles and explain strategies for maintaining academic integrity. (ii) Presentation 2: Paraphrasing, Citation, and Referencing in Research Writing Present effective techniques for paraphrasing and summarizing research literature. Demonstrate the use of citation and referencing styles commonly adopted in academic publications and discuss methods for avoiding plagiarism. (iii) Presentation 3: Review of Literature and Research Gap Identification Select a research topic from your area of specialization and present a brief review of relevant literature. Summarize key findings from published studies, compare their contributions, identify research gaps, and explain how ethical citation practices are followed in the review process. (iv) Presentation 4: Presenting Research Paper Sections Prepare and present the title, abstract, introduction, methodology, findings, and conclusion of a selected research paper. Highlight the language conventions, organization, and presentation strategies used for effective research communication. (v) Presentation 5: Research Conference and Poster Presentation Design and deliver a short conference-style or poster presentation based on a research article or review paper. Demonstrate effective presentation techniques, audience engagement, response to questions, and adherence to ethical practices in reporting and acknowledging sources.

Rubrics for evaluation: C05

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Understanding and Application of Concepts	25	Shows excellent understanding of the topic	Shows good understanding with minor gaps	Shows basic understanding with several gaps

2.	Analysis and Critical Observation	25	Presents clear and relevant analysis	Adequate analysis with minor omissions	Limited analysis and observations
3.	Organization, Clarity and Coherence	25	Well-organized and easy to follow	Generally organized with minor issues	Organization is weak or inconsistent
4.	Academic Language and Accuracy	25	Accurate academic language with minimal errors	Few language errors that do not affect clarity	Frequent language errors but meaning is understandable
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Assignment	Presentation	Percentage allocation	Mapping Strength
CO1	25		12.5	2
CO2	25		12.5	2
CO3	25		12.5	2
CO4	25		12.5	2
CO5		50	50	3
Total	100	100	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26AC002	DISASTER MANAGEMENT			SEMESTER		I/II	
Prerequisites			Category	AC	Credits		0
			Hours/ Semester	L	T	P	TH
				30	0	0	30
COURSE OBJECTIVES							
1.	To have a critical understanding of key concepts in disaster risk reduction and humanitarian response and critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations and evaluate the strengths and weaknesses of disaster management approaches. Planning and programming in different countries, particularly their home country or the countries they work in.						
UNIT - I		INTRODUCTION					6
Disaster: Definition, Factors and Significance; Difference Between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude. Disaster Prone Areas in India: Study of Seismic Zones; Area Prone to floods and droughts, Landslides and avalanches; Areas prone to cyclonic and coastal hazards with special reference to Tsunami; Post- Disaster diseases and epidemics.							
UNIT - II		REPERCUSSIONS OF DISASTERS AND HAZARDS					6
Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.							
UNIT - III		DISASTER PREPAREDNESS AND MANAGEMENT					6
Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and Other Agencies, Media Reports: Governmental and Community Preparedness.							
UNIT - IV		RISK ASSESSMENT					6
Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People’s Participation in Risk Assessment. Strategies for Survival.							
UNIT - V		DISASTER MITIGATION					6
Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.							
L: 30, Total: 30 Hours							
Weightage:							
Continuous Assessment - 100%							

REFERENCE BOOKS:

- | | |
|----|---|
| 1. | R. Nishith, Singh AK 2012 Disaster Management in India: Perspectives, issues and strategies New Royal Book Company, Lucknow |
| 2. | Sahni, PardeepEt.Al. (Eds.) 2002 Disaster Mitigation Experiences and Reflections. Prentice Hall Of India, New Delhi |

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs****CO1**

Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.

CO2

Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

CO3

develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations

CO4

Critically understand the strengths and weaknesses of disaster management approaches

26AC003	SANSKRIT FOR TECHNICAL KNOWLEDGE			SEMESTER		I/II	
Prerequisites			Category	AC	Credits		0
			Hours/ Semester	L	T	P	TH
				30	0	0	30
COURSE OBJECTIVES							
1.	To get a working knowledge in illustrious Sanskrit, the scientific language in the world. Learning Sanskrit to improve brain functioning. Learning Sanskrit to develop logic in mathematics, science & other subjects enhances the memory power. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature.						
UNIT - I	ALPHABETS						10
Alphabets in Sanskrit –Past/Present/Future Tense –Simple Sentences							
UNIT - II	LITERATURE						10
Order –Introduction of roots –Technical information about Sanskrit Literature							
UNIT - III	CONCEPTS						10
Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics							
L: 30, Total: 30 Hours							
Weightage: Continuous Assessment - 100%							
REFERENCE BOOKS:							
1.	"AbhyasaPustakam"- Dr.Vishwas, Samskrita- Bharati Publication, New Delhi						
2.	"Tech Yourself Sanskrit" PrathamaDeeksha-Vempatikutumbshastri,Rashtriya Sanskrit Sansthan, New Delhi Publication						
3.	India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi.						
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to				Mapping POs		Mapping PSOs	
CO1	Understanding basic Sanskrit language.						
CO2	Ancient Sanskrit literature about science & technology can be understood.						
CO3	Being a logical language will help to develop logic in students						

26AC004		VALUE EDUCATION			SEMESTER		I/II	
Prerequisites				Category	AC	Credits		0
				Hours/ Semester	L	T	P	TH
					30	0	0	30
COURSE OBJECTIVES								
1.	To understand the Importance of value education and self-development. To imbibe good values in students and also know about the importance of character.							
UNIT - I		BASIC VALUES						7
Values and self-development- Social values and individual attitudes-Work ethics, Indian vision of Humanism Moral and Non Moralvaluation-Standards and principles-Value judgments.								
UNIT - II		CONFIDENCE						7
Importance of cultivation of values- Sense of Duty-Devotion-Self-reliance-Confidence-Concentration-Truthfulness-CleanlinesHonesty-Humanity-Power of faith-National Unity-Patriotism-Love for nature-Discipline.								
UNIT - III		PERSONALITY DEVELOPMENT						8
Personality and Behavior Development-Soul and Scientific attitude - Positive – Thinking - Integrity and discipline -Punctuality – Love and Kindness - Avoid fault Thinking - Free from anger - Dignity of labor - Universal brotherhood and religious tolerance –True friendship –Happiness Vs. suffering –love for truth – Aware of self-destructive habits- Association and Cooperation –Doing best for saving nature.								
UNIT - IV		LOVE AND COMPASSION						8
Character and Competence –Holy books Vs. Blind faith –Self –management and Good health – Science of reincarnation –Equality – Non Violence –Humility -Role of Women –All religions and same message –Mind your Mind –Self -control –Honesty –Studying effectively.								
L: 30, Total: 30 Hours								
Weightage: Continuous Assessment - 100%								
REFERENCE BOOKS:								
1.	Chakraborty, S.K. "Values and Ethics for Organization Theory and Practice", Oxford University Press, New Delhi, 1998.							
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to					Mapping POs		Mapping PSOs	
CO1	Knowledge of self-development.							
CO2	Learn the importance of Human values.							
CO3	Developing the overall personality.							

26AC005		CONSTITUTION OF INDIA		SEMESTER		I/II	
Prerequisites			Category	AC	Credits		0
			Hours/ Semester	L	T	P	TH
				30	0	0	30
COURSE OBJECTIVES							
1.	Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.						
UNIT - I		HISTORY OF MAKING OF INDIAN CONSTITUTION					5
History, Drafting Committee (Composition & working)							
UNIT - II		PHILOSOPHY OF THE INDIAN CONSTITUTION					5
Preamble, Salient Features							
UNIT - III		CONTOURS OF CONSTITUTIONAL RIGHTS & DUTIES					5
Fundamental rights, right to equality, right to freedom, right against exploitation, right to freedom of religion, cultural and education rights, right to constitutional remedies, directive principles of state policy, fundamental duties.							
UNIT - IV		ORGANS OF GOVERNANCE					5
Parliament, composition, qualifications and disqualifications, powers and functions, executive, president, governor, council of ministers, judiciary, appointment and transfer of judges, qualifications, powers and functions.							
UNIT - V		LOCAL ADMINISTRATION					5
Districts administration head: role and importance, municipalities: introduction, mayor and role of elected representative, CEO of municipal corporation. Panchayati raj: introduction, PRI: zila panchayat. Elected officials and their roles, CEO zila panchayat: position and role. Block level: organizational hierarchy (different departments), village level: role of elected and appointed officials, importance of grass root democracy.							
UNIT - VI		ELECTION COMMISSION					5
Election Commission: role and functioning. Chief election commissioner and election commissioners. State election commission: role and functioning. Institute and bodies for the welfare of SC/ST/OBC and women.							
L: 30, Total: 30 Hours							
Weightage: Continuous Assessment - 100%							
REFERENCE BOOKS:							
1.	The Constitution of India, 1950 (Bare Act), Government Publication						
2.	Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.						
3.	M. P. Jain, Indian Constitution Law, 7th Edn., LexisNexis, 2014.						
4.	D.D. Basu, Introduction to the Constitution of India, LexisNexis, 2015						

COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs
CO1	Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics		
CO2	Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.		
CO3	Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution		
CO4	Discuss the passage of the Hindu Code Bill of 1956		

26AC006		PEDAGOGY STUDIES			SEMESTER			I/II
Prerequisites				Category	AC	Credits		0
				Hours/ Semester	L	T	P	TH
					30	0	0	30
COURSE OBJECTIVES								
1.	To Review existing evidence on the review topic to inform programme design and policy making undertaken by the DFID, other agencies and researchers. Identify critical evidence gaps to guide the development.							
UNIT - I		INTRODUCTION AND METHODOLOGY						6
Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education, Conceptual framework, Research questions, Overview of methodology and Searching								
UNIT - II		THEMATIC OVERVIEW						6
Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries, Curriculum, Teacher education.								
UNIT - III		EVIDENCE ON THE EFFECTIVENESS OF PEDAGOGICAL PRACTICES						6
Methodology for the in depth stage: quality assessment of included studies, How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices, Pedagogic theory and pedagogical approaches, Teachers' attitudes and beliefs and Pedagogic strategies.								
UNIT - IV		PROFESSIONAL DEVELOPMENT						6
Alignment with classroom practices and follow-up support, Peer support, Support from the head teacher and the community, Curriculum and assessment, Barriers to learning: limited resources and large class sizes.								
UNIT - V		RESEARCH GAPS AND FUTURE DIRECTIONS						6
Research design, Contexts, pedagogy, teacher education, curriculum and assessment, dissemination and research impact.								
L: 30, Total: 30 Hours								
Weightage: Continuous Assessment - 100%								

REFERENCE BOOKS:			
1.	Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.		
2.	Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3) 361-379.		
3.	Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID		
4.	Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic math and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272-282.		
5.	Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.		
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs
CO1	What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?		
CO2	What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?		
CO3	How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?		

26AC007		STRESS MANAGEMENT BY YOGA			SEMESTER		I/II	
Prerequisites				Category	AC	Credits		0
				Hours/ Semester	L	T	P	TH
					30	0	0	30
COURSE OBJECTIVES								
1.	To create a healthy, strong willed and intelligent young society through yoga practices							
UNIT - I		PHYSICAL AND MENTAL HEALTH						6
Pain and disease - free life, Simplified Physical Exercise- Pranayama. Concentration on Pituitary gland- Practical, Goal fixing								
UNIT - II		REJUVENATION OF LIFE FORCE AND WILL POWER						6
Principle of kayakalpa yoga, mind, life force and Biomagnetism, Practical, Concentration on Muladhara- Practical, Analysis of thought –Will power								
UNIT - III		DEVELOPMENT OF VIRTUES						6
Activation of Dormant Brain cells- Practical, Moralization of dezire and its classification, Neutralization of Anger, Results of anger								
UNIT - IV		STREAM LINING OF MIND						6
Definition of Mind-Worries, Eradication of Worries. The science behind blessings. Blessing techniques. Benefits, five basic duties								
UNIT - V		CAUSE AND EFFECT SYSTEM						6
Law of nature, Hereditary Imprints, Fivefold and Two-fold culture, good values and Resolution for world peace								
L: 30, Total: 30 Hours								
Weightage: Continuous Assessment - 100%								
REFERENCE BOOKS:								
1.	"Thirukkural" , Pearls of Inspiration, Translation by Rajaram, Publisher :RUPA							
2.	"Bharathiyar Poems", Amazon Asia – Pacific Holdings Private Limited							
3.	"Yoga for Humane Excellence" ,Vethathiri Maharishi, Vision for Wisdom, Vethathiri Publications							
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to					Mapping POs		Mapping PSOs	
CO1	Maintain good Physical health.							
CO2	Develop will power.							
CO3	Take quick and right decisions.							
CO4	Maintain good relationship with everyone around them his creating a Health Society							

26AC008	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS			SEMESTER		I/II	
Prerequisites			Category	AC	Credits		0
			Hours/ Semester	L	T	P	TH
				30	0	0	30
COURSE OBJECTIVES							
1.	To learn to achieve the highest goal happily,						
2.	To become a person with stable mind, pleasing personality and determination,						
3.	To awaken wisdom in students.						
UNIT - I	NEETISATAKAM – HOLISTICS DEVELOPMENT OF PERSONALITY						6
Verses 19, 20, 21, 22 (Wisdom) - Verses 29, 31, 32 (Pride and Heroism) - Verses 26,28,63,65 (Virtue)							
UNIT - II	NEETISATAKAM — HOLISTIC DEVELOPMENT OF PERSONALITY (CONT'D)						6
Verses 52, 53, 59 (don'ts) - Verses 71.73.75 & 78 (do's) - Approach to day to day works and duties.							
UNIT - III	INTRODUCTION TO BHAGAVADGEETHA FOR PERSONALITY DEVELOPMENT						6
Shrimad Bhagavadgeetha: Chapter 2 — Verses 41, 47, 48 - Chapter 3 — Verses 13,21,27,35 - Chapter 6 - Verses 5,13,17,23,35 - Chapter 18 - Verses 45,40,48 Chapter - 6: Verses 5, 13, 17, 23, 35; Chapter - 18: Verses 45, 46, 48							
UNIT - IV	STATEMENTS OF BASIC KNOWLEDGE - SHRIMAD BHAGAVADGEETHA						6
Chapter 2- Verses 56, 62,68 - Chapter 12 — Verses 13, 14, 15, 16, 17, 18 - Personality of Role model from Shrimad Bhagawat Geeta.							
UNIT - V	ROLE OF BHAGAVADGEETHA IN THE PRESENT SCENARIO						6
Chapter 2 — Verses 17 - Chapter 3 — Verses 36, 37, 42 - Chapter 4 — Verses 18, 38, 39 - Chapter 18 — Verses 37, 38, 63.							
L: 30, Total: 30 Hours							
Weightage: Continuous Assessment - 100%							
REFERENCE BOOKS:							
1.	“Srimad Bhagavad Gita” by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata						
2.	Bhartrihari’s Three Sataskam (Niti- Sringar – Vairagya), P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.						

E-RESOURCES:			
1.	NTPEL: http://nptel.ac.in/downloads/109104115		
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs
C01	Develop their personality and achieve their highest goal of life.		
C02	Lead the nation and mankind to peace and prosperity.		
C03	Practice emotional self-regulation.		
C04	Develop a positive approach to work and duties.		
C05	Develop a versatile personality.		

26AC009	SUSTAINABLE DEVELOPMENT GOALS		SEMESTER		I/II		
PREREQUISITES			Category	AC	Credits	0	
			Hours/ Semester	L	T	P	TCP
				30	0	0	30
COURSE OBJECTIVES							
1.	To understand the concepts of Sustainable Development Goals						
2.	To study sustainability assessment methods, education for sustainable development						
3.	To analyze the problems and solution in environmental management.						
4.	To analyze the issues related to resource utilization.						
5.	To explore knowledge about life cycle assessment.						
UNIT - I		INTRODUCTION TO SUSTAINABLE DEVELOPMENT					6
Need and Importance of Sustainable Development - Historical & Policy perspectives of Sustainable Development - Sustainable Development: World and India Perspective - Introduction to 17 SDGs - Specific learning objectives for different SDGs - Challenges & strategies of attaining SDGs in developed and developing nations.							
UNIT - II		SDG QUALITY EDUCATION					6
Focus of NEP-2020 on SDG - Education for Sustainable Development - Berlin Declaration 2021 on ESD - Integration of ESD - Tools, Systems, and Innovation for Sustainability - Measuring Sustainability.							
UNIT - III		SUSTAINABLE COMMUNITIES AND RESOURCE CONSERVATION					6
Circular economy (basic model of reuse, recycle, and reduce) - Rural & urban Problems & Challenges - Sustainable production and consumption - Renewable energy - Health & Hygiene, water, sanitation & water management - Waste Management.							
UNIT - IV		CLIMATE CHANGE, ENERGY AND SUSTAINABLE DEVELOPMENT					6
The greenhouse effect: Causes and Consequences - Climate Change: A Threat to Sustainable Development - Adaptation to Current and Future Climate Regimes - Consequences: crop failure - Solutions technology and lifestyle changes - Mitigating Climate Change.							
UNIT - V		SUSTAINABLE BUSINESS PRACTICES					6
Corporate Social Responsibility - Sustainable products and services - Business and Environment - Corporations and Ecological Sustainability - Life Cycle Assessment: LCA Overview and Application - World peace and justice: United nations goals for peace and justice - World Government for peace.							
L:30, Total:30 Hours							
Weightage:							
Continuous Assessment - 100%							

REFERENCE BOOKS:	
1.	Onyeka Osuji, "Corporate Social Responsibility in Developing and Emerging Markets", Cambridge, 2022.
2.	Ram Kumar, Ch Lakshmi, Sandee, Janaki, "Smart Cities for Sustainable Development", Springer Switzerland, 2022.
3.	Surender Kumar and Shunsuke Managi, "The Economics of Sustainable Development: The Case of India (Natural Resource Management and Policy)", Springer Switzerland, 2009.
4.	Sushma Goyal, "Management of Resources for Sustainable Devpt", The Orient Blackswan, 2016.
5.	S. Ramaswamy Sathis G. Kumar, "Energy, Environment and Sustainable Development: Issues and Policies", Regal Publications, 2009.
E-RESOURCES:	
1.	https://www.un.org/sustainabledevelopment/
2.	https://www.aiu.ac.in/documents/AIU_Publications/UN-SDG goals
3.	https://www.unesco.org/en/education-sustainable-development
4.	https://onlinecourses.nptel.ac.in/noc23_hs57/preview
5.	https://www.iau-hesd.net/news/5180-berlin-declaration-education-sustainable development-adopted-unesco-esd-conference-17-19
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to	
CO1	Explain the concepts of Sustainable Development and United Nations Sustainable Development Goals (SDGs), sustainability assessment methods, and their significance in national and global contexts.
CO2	Apply the challenges related to resource utilization, circular economy, renewable energy, sustainable production and consumption, environmental management, climate change, and their impact on society and sustainable development.
CO3	Analyze the sustainable business practices, corporate social responsibility, ecological sustainability, life cycle assessment, and global initiatives for achieving environmental protection, social equity, peace, and sustainable growth.
CO4	Design and develop a sustainability assessment project, case study, field survey, or community-based solution for a selected SDG.
CO5	Demonstrate professional competency through technical seminar presentations/group discussions, or preparation of technical reports on emerging trends, innovations, policies, and best practices related to SDG.