M.E. Degree

in

COMMUNICATION SYSTEMS

CURRICULUM & SYLLABUS (CBCS)

(Innovation and Product Development for sustainability)

(For students admitted from the Academic Year 2026-2027)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

St. XAVIER'S CATHOLIC COLLEGE OF ENGINEERING

CHUNKANKADAI, NAGERCOIL – 629 003.

KANYAKUMARI DISTRICT, TAMIL NADU, INDIA

St. XAVIER'S CATHOLIC COLLEGE OF ENGINEERING,
Chunkankadai, Nagercoil – 629 003
AUTONOMOUS COLLEGE AFFILIATED TO ANNA UNIVERSITY
ACADEMIC REGULATIONS 2026
M.E. COMMUNICATION SYSTEMS CURRICULUM
CHOICE BASED CREDIT SYSTEM

VISION OF THE INSTITUTION

To be a centre of excellence in engineering education and research for a technically empowered humane society.

MISSION OF THE INSTITUTION

M1: Foster a vibrant academic environment for learning fundamental concepts, emerging technologies, and research-oriented practices.
M2: Cultivate personal maturity and professional skills through stimulating coaching and practical training.
M3: Provide inspiring high calibre faculty to mentor students from diverse backgrounds, especially the underprivileged.
M4: Create ample opportunities to transform rural youth into top class professionals and technocrats, capable of serving at the local and global levels with ethical integrity.

VISION OF THE PROGRAMME

Developing technically competent Electronics and Communication Engineers with academic excellence, innovative research, ethical standards and international outlook to serve the society

MISSION OF THE PROGRAMME

M1. To provide quality teaching in order to produce graduates with academic excellence, technical competence and ethical values.
M2. To develop advanced professionalism and exceptional career growth through inspiring faculty members and excellent infrastructure.
M3. To create awareness on state of the art technologies through research and industry-institute collaboration.
M4. To inculcate a sense of innovation and commitment among the students to apply knowledge and technologies for the benefit of the society.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

I.	Apply technical knowledge and skills to have successful career in industry, government and academia as communication engineers.
II.	Pursue multidisciplinary scientific research in communication and related areas for the benefits of society.
III.	Make use of various state-of art systems and cutting-edge technologies to solve various complex engineering problems.
IV.	Inculcate leadership skills, team work, effective communication and lifelong learning to the success of their organization and nation.
V.	Practice ethics and exhibit commitment in profession to empower / enable rural communication infrastructure.

PROGRAMME OUTCOMES (POs)

PO	Programme Outcomes
1	Independently carry out research/investigation and development work to solve practical problems.
2	Write and present substantial technical report/document.
3	Demonstrate a degree of mastery over the techniques in the area of communication systems.
4	Analyze and design the subsystems in RF, signal processing, modern communication systems and networks.
5	Solve problems in communication system design using advanced hardware and software tools.
6	Measure electromagnetic interference and mitigate its effects.

KNOWLEDGE AND ATTITUDE PROFILE (WK)

WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.

WK2: Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.

WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

WK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, re use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.

WK6: Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.

WK7: Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

WK9: Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

PEO's – PO's MAPPING:

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)	PROGRAMME OUTCOMES(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
I.	2	2	2	3	3	2
II.	3	2	2	3	3	2
III.	3	2	3	3	3	2
IV.	2	2	2	2	2	2
V.	2	2	2	2	2	2

PROGRAMME ARTICULATION MATRIX

Year	Semester	Course name	PO					
			1	2	3	4	5	6
I	I	Induction Programme	2	2	2	-	-	-
		Mathematical Modelling and Computational Techniques in Engineering	2	1	2	3	1	1
		Modern Digital Communication Systems	2	1	3	3	2	1
		Advanced Digital Signal Processing	3	2	3	3	3	1
		Analog and Digital Electronic System Design	2	2	2	2	2	1
		Digital Communication Systems Laboratory	2	1	2	1	1	1

		Research Methodology and Intellectual Property Rights	3	3	2	2	2	2
		Research Tools Laboratory	2	2	2	3	3	2
		Technical Seminar	3	2	3	2	2	3
I	II	Radio Frequency Transceiver Design	1	1	2	2	1	1
		Deep Learning	2	1	1	2	3	1
		Advanced Wireless Communication Networks	2	2	2	3	2	2
		Advanced Wireless Communication Laboratory	2	2	2	2	2	2

SUSTAINABLE DEVELOPMENT GOALS

GOAL 1: No Poverty
End poverty in all its forms everywhere (eradicate extreme poverty currently measured as people living on less than $1.25 a day.)
GOAL 2: Zero Hunger
End hunger, achieve food security and improved nutrition and promote sustainable agriculture
GOAL 3: Good Health and Well-being
Ensure healthy lives and promote well-being for all at all ages
GOAL 4: Quality Education
Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
GOAL 5: Gender Equality
Achieve gender equality and empower all women and girls
GOAL 6: Clean Water and Sanitation
Ensure availability and sustainable management of water and sanitation for all
GOAL 7: Affordable and Clean Energy
Ensure access to affordable, reliable, sustainable and modern energy for all
GOAL 8: Decent Work and Economic Growth
Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
GOAL 9: Industry, Innovation and Infrastructure
Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
GOAL 10: Reduced Inequality
Reduce inequality within and among countries

GOAL 11: Sustainable Cities and Communities

Make cities and human settlements inclusive, safe, resilient and sustainable

GOAL 12: Responsible Consumption and Production

Ensure sustainable consumption and production patterns

GOAL 13: Climate Action

Take urgent action to combat climate change and its impacts

GOAL 14: Life Below Water

Conserve and sustainably use the oceans, seas and marine resources for sustainable development

GOAL 15: Life on Land

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

GOAL 16: Peace and Justice Strong Institutions

Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

GOAL: 17: Partnership to achieve the goal

Strengthen the means of implementation and revitalize the global partnership for sustainable development

SEMESTER: I

Number of Courses : **8**
Total Credits : **24**

Course Code	Course Title	Course Type	Classroom Instruction(CI) (in Hours per Semesters)		Lab Instruction(LI) (in Hours per Semesters)	Team Work(TW) and Self Learning(SL) (in Hours per Semesters)	Total Number of Hours (in Hours per Semesters)	Total Credits (C)=(Total Hours/30)	SDG Goal Mapped	Category
			L	T	P					
IP26C07	Induction Programme*	TC	24	0	0	6	30	0	4,8,9, 16,17	IP
MA26C06	Mathematical Modelling and Computational Techniques in Engineering	TC	45	15	0	60	120	4	4,8,9, 12	BSC
CU26101	Modern Digital Communication Systems	TC	45	0	0	45	90	3	4,5,8, 9,11, 12,17	PCC
CU26102	Advanced Digital Signal Processing	TC	45	15	0	60	120	4	4,9	PCC
CU26103	Analog and Digital Electronic System Design	TCP	45	0	30	45	120	4	3,7,9	PCC
CU26104	Digital Communication Systems Laboratory	PC	0	0	60	0	60	2	3,4,9, 12	PCC
RM26C01	Research Methodology and Intellectual Property Rights	TC	45	15	0	60	120	4	1,2,3, 7	FC
RM26C02	Research Tools Laboratory	PC	0	0	60	0	60	2	4,9,16 ,17	FC
CU26105	Technical Seminar**	-	0	0	30	0	30	1	4,8,9, 16,17	EEC
Total			**249**	**45**	**180**			**24**		

* - Refer clause 21 in regulation 2026. The evaluation procedure is detailed in the syllabus.
** - Internally Evaluated Course. The evaluation procedure is detailed in the syllabus.

SEMESTER: II

Number of Courses : **8**
Total Credits :**21**

Course Code	Course Title	Course Type	Classroom Instruction(CI) (in Hours per Semesters)		Lab Instruction(LI) (in Hours per Semesters)	Team Work(TW) and Self Learning(SL) (in Hours per Semesters)	Total Number of Hours (in Hours per Semesters)	Total Credits (C)=(Total Hours/30)	SDG Goal Mapped	Category
			L	T	P					
CU26201	Radio Frequency Transceiver Design	TC	45	0	0	45	90	3	4,8,9,11,12,13	PCC
CU26202	Deep Learning	TC	45	15	0	60	120	4	3,4,9,11	PCC
CU26203	Advanced Wireless Communication Networks	TCP	45	0	30	45	120	4	4,9,11, 13	PCC
CU26204	Advanced Wireless Communication Laboratory	PC	0	0	60	0	60	2	4,9,11, 13	PCC
	Open Elective I	TC	45	0	0	45	90	3		OEC
	Professional Elective I	TC	45	0	0	45	90	3		PEC
CU26S01	Industry Collaborated Course I*	-	0	0	30	0	30	1		ICC
CU26S02	Self Learning Course *	-	0	0	0	30	30	1		SLC
Total			**225**	**15**	**120**			**21**		

* - Evaluation and certification by course offering body.

PROGRAMME ELECTIVES COURSES

SEMESTER II, OPEN ELECTIVE I

Course Code	Course Title	Course Type	Classroom Instruction(CI) (in Hours per Semesters)		Lab Instruction(LI) (in Hours per Semesters)	Team Work(TW) and Self Learning(SL) (in Hours per Semesters)	Total Number of Hours (in Hours per Semesters)	Total Credits (C)=(Total Hours/30)	SDG Goal Mapped	Category
			L	T	P					
CU26901	Wireless Sensor Networks and WBAN	T	45	0	0	45	90	3	3,7,9, 11,13	OEC
CU26902	Security for Wireless Communication Networks	T	45	0	0	45	90	3	4,9,16	OEC

SEMESTER II, PROFESSIONAL ELECTIVE-I

Course Code	Course Title	Course Type	Classroom Instruction(CI) (in Hours per Semesters)		Lab Instruction(LI) (in Hours per Semesters)	Team Work(TW) and Self Learning(SL) (in Hours per Semesters)	Total Number of Hours (in Hours per Semesters)	Total Credits (C)=(Total Hours/30)	SDG Goal Mapped	Category
			L	T	P					
CU26001	Radiation Systems	T	45	0	0	45	90	3	3,4,7,9, 11,13, 17	PEC
CU26002	Telecommunication System Modeling and Simulation	T	45	0	0	45	90	3	4,9,11, 12	PEC
CU26003	Satellite Based Systems	T	45	0	0	45	90	3	4,9,11, 13, 15	PEC
CU26004	Wavelets and subband coding	T	45	0	0	45	90	3	4,9,11,12, 17	PEC
CU26005	Application Specific Integrated Circuits	T	45	0	0	45	90	3	3,4,7,9	PEC

SEMESTER: I

IP26C07	Induction Programme	L	T	P	TW/SL	Total	C	SDG
		24	0	0	6	30	0	4,8,9,16,17

COURSE OBJECTIVES:

- To familiarize students with institutional policies, academic regulations, and programme structure.
- To introduce research methodology, ethical practices, and emerging engineering trends.
- To develop communication, technical writing, and presentation skills.
- To create awareness about career opportunities, higher education, and industry expectations.
- To inculcate professional ethics, teamwork, and leadership qualities.

COURSE CONTENT:

Unit 1	Institutional Orientation	4	0	0	1	5		4

Vision, Mission, and Quality Policy – Organizational structure – Campus facilities – Library, laboratory, and IT infrastructure – Student support systems – Interaction with faculty and peers.

Activities:

1. Campus Resource Mapping and Group Presentation.

Unit 2	Academic Regulations & Programme Structure	4	0	0	1	5		4,9

Choice Based Credit System (CBCS) – Curriculum framework – Credit requirements – Evaluation and assessment procedures – Attendance norms – Examination system – Academic integrity guidelines.

Activities:

1. Preparation of Individual Academic Plan.

Unit 3	Research Methodology & Emerging Technologies	8	0	0	2	10		4

Research process – Problem identification – Literature review – Research ethics and plagiarism – Overview of emerging technologies (AI, Data Science, IoT, etc.) – Interdisciplinary research opportunities.

Activities:

1. Mini Research Problem Identification and Presentation.

Unit 4	Skill Development & Career Planning	4	0	0	1	5		8

Communication skills – Technical writing – Presentation skills – Resume preparation – Career opportunities – Higher studies – Competitive exams – Internship and placement readiness.

Activities:

1. Resume Preparation and Elevator Pitch Presentation.

Unit 5	**Professional Development & Well-Being**	**4**	**0**	**0**	**1**	**5**		**16,17**

Engineering ethics – Professional values – Teamwork and leadership – Innovation and entrepreneurship – Startup ecosystem – Time management – Stress management – Counseling and mentoring support.

Activities:

1. Case Study Analysis on Ethics and Teamwork.

COURSE OUTCOMES:

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

CO1: Apply institutional policies and academic regulations to manage postgraduate studies effectively.

CO2: Apply research methodologies and ethical principles to identify research problems.

CO3: Demonstrate communication, technical writing, and presentation skills.

CO4: Analyze career opportunities and industry expectations for informed decision-making.

CO5: Apply professional ethics and teamwork skills in academic and organizational environments.

Weightage: Continuous Assessment: 100%

Assessment Methodology: Active Participation (40%), Assignments (30%), Quiz (30%)

REFERENCES:

1.	Johri, A., "International Handbook of Engineering Education Research", Taylor & Francis, 2023.
2.	Murthy, D. N. P., & Page, N. W.," Education and Research for the Future", Springer, 2023.
3.	Oliveira, T. A., & Hebebci, M. T. (Eds.), "Current Academic Studies in Technology and Education 2024", ISRES Publishing, 2024.
4.	Kannan, R., Thirumalai, P., & Geetha, T. V, "Proceedings of the International Conference on Technology for Education (T4E 2024)", Springer, 2024.
5.	Rajesh, S., Raghu Prasad, B. K., & Praveen, K. V., "Recent Advances in Sustainable Construction Technology", Geotechnics and Structural Engineering, Springer, 2026.

E resources/E materials:

1.	https://alison.com/course/essentials-of-research-methodology
2.	https://www.coursera.org/learn/research-methodologies

Mapping of Course Outcomes to Programme Outcomes

COs \ POs	PO1 (Research Capability)	PO2 (Technical Communication)	PO3 (Domain Mastery)
CO1	2	1	2
CO2	3	2	2
CO3	1	3	1
CO4	2	2	2
CO5	1	2	1
CO	2	2	2

MA26C06	Mathematical Modelling and Computational Techniques in Engineering	L	T	P	TW/SL	Total	C	SDG
		45	15	0	60	120	4	4,8,9,12

COURSE OBJECTIVES:

- To familiarize the students with the formulation and construction of mathematical models for a linear programming problem in real-life situations.
- To develop students' ability to formulate and solve real-world optimization problems using transportation and assignment models.
- To understand advanced matrix concepts such as norms, inner products, and various matrix decompositions to solve engineering and optimization problems.
- To provide a foundation in probability theory and random variables for analyzing uncertainty and solving real-world problems.
- To develop an understanding of non-Markovian queueing models and analyze their performance using the Pollaczek-Khinchin formula.

COURSE CONTENT:

Unit 1	Linear Programming	9	3	0	12	24		4,8,9,12

Formulation of linear programming problems – Graphical solution method – Canonical and standard form of linear programming problem – Simplex method – Artificial variables: Big-M method.
Activity: Formulate a linear programming model to maximize system efficiency or minimize operating cost and solve it using Big-M method**.**

Unit 2	**Transportation and Assignment Models**	**9**	**3**	**0**	**12**	**24**		**4,8,9,12**

Definition of the transportation model – Mathematical formulation of transportation models – Basic feasible solution: Vogel's approximation method – Optimal solution by modified distribution (MODI) method – Definition of the assignment model – Mathematical formulation of assignment models – Hungarian method for solving assignment problems.
Activity: Model the distribution of medical devices from multiple warehouses to hospitals using Vogel's Approximation Method to minimize cost and time.

Unit 3	**Matrix Theory**	**9**	**3**	**0**	**12**	**24**		**4,9,12**

Definitions: Norms and inner products – Definitions: Band matrices and Toeplitz matrices – Matrix decomposition: Cholesky decomposition – QR factorization – Least square approximations using QR factorization.
Activity: Use signal data from communication or biomedical systems to form system matrices and apply QR decompositions to estimate system parameters.

Unit 4	**Probability and Random Variables**	**9**	**3**	**0**	**12**	**24**		**4,9,12**

Probability - Axioms of probability – Conditional probability – Independence of events – Baye's theorem (statement and problems) – Discrete random variables – Probability mass function – Continuous random variable – Probability density function – Probability distribution – Cumulative distribution function – Mean – Variance – Special distributions: Binomial and Poisson distributions.
Activity: Perform probability analysis on a medical screening dataset involving prevalence of disease and diagnostic test outcomes and model the number of data packets arriving at a communication node over fixed intervals using Poisson distribution and interpret network performance.

Unit 5	**Queueing Models**	**9**	**3**	**0**	**12**	**24**		**4,8,9,12**

Introduction to queueing theory – Structure and characteristics of queueing systems – Queue disciplines – Kendall's notation – Markovian models: M/M/1/∞ and M/M/c/∞ queues – Steady-state probabilities – Mean system size, average waiting time and utilization factor – Little's formula – Non-Markovian models: M/G/1 queue – Pollaczek-Khinchin formula.
Activity: Examine network traffic or hospital service systems by representing them through non Markovian and evaluate performance metrics using Pollaczek–Khinchin formula.

COURSE OUTCOMES:

At the end of the course, the students will be able to:
CO1: Apply graphical, simplex and Big-M methods to solve linear programming problems and obtain optimal solutions.
CO2: Solve transportation problems using modified distribution method and assignment problems using Hungarian Method to obtain optimal allocation results.
CO3: Utilize matrix factorization techniques including Cholesky and QR decompositions to resolve engineering-focused matrices.
CO4: Apply probability and discrete distributions in engineering field.

CO5: Choose suitable Markovian and non-Markovian queueing models to evaluate the performance of queueing systems.	
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%	
Assessment Methodology: Activity (30%) and Internal Assessment test (70%)	
REFERENCES:	
1.	Taha. H.A., "Operation Research: An Introduction", Eleventh edition, Pearson Education, New Delhi, Reprint 2023.
2.	Kanti Swarup, P. K. Gupta and Man Mohan, "Operation Research", Twentieth edition, Sultan Chand & sons, 2022.
3.	Richard Bronson & Gabriel B. Costa., "Schaum's Outline of Differential Equations", Fifth edition, McGraw Hill, 2022.
4.	Ronald E. Walpole and Raymond H. Myers "Probability and Statistics for Engineers & Scientists", Pearson Publications, Nineth edition, 2024.
5.	Sheldon M. Ross, "Introduction to Probability Models", Academic Press, Thirteenth edition, Reprint 2024.
E resources/E materials:	
1.	https://allen.in/jee/maths/graphical-method-linear-programming
2.	https://www.acsce.edu.in/acsce/wp-content/uploads/2020/03/1585041316993_Module-4.pdf
3.	https://ocw.mit.edu/courses/6-241j-dynamic-systems-and-control-spring-2011/04fddfbcb1eb933ecca85dab8bfbb171_MIT6_241JS11_chap04.pdf

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	2	3	1	1
CO2	2	1	2	3	1	1
CO3	2	1	2	3	1	1
CO4	2	1	2	3	1	1
CO5	2	2	2	3	1	1
CO	2	1	2	3	1	1

CU26101	Modern Digital Communication Systems	L	T	P	TW/SL	Total	C	SDG
		45	0	0	45	90	3	4,5,8,9,11,12,17

COURSE OBJECTIVES:

- To discuss about various coherent and non-coherent communication receivers and its performance
- To estimate the effects of signaling through band limited channels and equalization techniques.
- To compare different channel models, channel capacity using different block coding techniques.
- To learn the convolution coders and different decoding techniques.
- To apply the basics of OFDM and CDMA techniques.

COURSE CONTENT:

Unit 1	Coherent and Non-Coherent Communication	9	0	0	9	18		4,9,11

Coherent and Non-Coherent Communication: Coherent receivers, IQ modulation/demodulation, QAM, MFSK, DPSK, Rayleigh/Rician channels, BER performance, synchronization techniques.

Activities:

1. Case study: Performance Analysis of Coherent vs Non-Coherent Communication in 5G Systems.
2. Quiz: Basics of coherent vs non-coherent detection, IQ modulation, and simple BER comparison concepts.

Unit 2	Equalization Techniques	9	0	0	9	18		4,5,9

ISI, Nyquist criterion, partial response signaling, linear and decision feedback equalizers, adaptive equalization.

Activities:

1. Case study: Analyze how pulse overlapping in a band-limited channel increases bit errors and how it can be reduced.
2. Think pair share: Causes and effects of ISI in communication channels: Nyquist criterion and partial response signaling – Practical Design and Analysis

Unit 3	Block Coded Digital Communication	9	0	0	9	18		4,9,17

Block Coded Digital Communication: Binary block codes, channel capacity, Shannon's theorem, spread spectrum, BPSK/DPSK with coding, Hamming, BCH, Reed Solomon, STBC.

Activities:

1. Case study: Analyze the performance of binary block codes in error detection and correction over noisy channels
2. Concept map activity: Structure of binary block codes (codewords, redundancy, generator matrix, parity-check matrix)

Unit 4	Convolutional Coded Digital Communication	9	0	0	9	18		4,8,9

Polynomial, state/tree/trellis diagrams, Viterbi decoding, error performance, turbo coding and iterative decoding.

Activities:

1. Case study: Analyze the error performance of coded communication systems under different noise conditions
2. Research paper writing: Role of polynomial-based coding techniques in modern communication systems

Unit 5	**Multicarrier and Multiuser Communications**	**9**	**0**	**0**	**9**	**18**		**9,11,12,17**

OFDM modulation/demodulation, FFT implementation, bit/power allocation, PAPR, CDMA, multiuser detection, SIC.

Activities:

1. Case study: Investigate the impact of Peak-to-Average Power Ratio (PAPR) in OFDM transmission
2. Research paper writing: Performance analysis of OFDM systems under multipath fading channels

COURSE OUTCOMES:

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

CO1: Apply coherent and non-coherent communication techniques for digital communication systems.
CO2: Apply equalization techniques to reduce inter symbol interference in communication channels.
CO3: Analyze various block coding techniques to combat channel errors.
CO4: Construct convolutional coders and different decoding techniques.
CO5: Evaluate OFDM technique for improving spectral efficiency and communication performance.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Internal Examinations (60%), Activities (40%).

REFERENCES:

1.	Haykin, S, “Digital communication systems”, John Wiley & Sons, 2021.
2.	Lathi, B. P. & Ding, Z, “Modern Digital and Analog Communication Systems”, Oxford University Press, 2025.
3.	Rappaport, T. S, “Wireless Communications: Principles and Practice”, Cambridge University Press, 2024.
4.	Sklar, B., & Ray, P. K., “Digital communications: Fundamentals & application”s, Pearson Education, 2020.
5.	Jerry D. Gibson, “Digital Communications-Introduction to Communication Systems”, Springer International Publishing, 2023.

E resources/E materials:

1.	ocw.mit.edu/courses/6-450-principles-of-digital-communications-i-fall-2006
2.	onlinecourses-archive.nptel.ac.in
3.	www.geektonight.com

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	2	1	1
CO2	2	1	2	3	2	1
CO3	3	2	3	3	2	1
CO4	3	2	3	2	2	1
CO5	2	1	3	3	3	1
CO	2	1	3	3	2	1

CU26102	Advanced Digital Signal Processing	L	T	P	TW/SL	Total	C	SDG
		45	15	0	60	120	4	4,9

COURSE OBJECTIVES:

- To understand, design, and implement multirate signal processing techniques.
- To learn the concept of prediction theory and adaptive filtering.
- To understand the spectrum estimation techniques.
- To learn the concept of real time DSP algorithms and architectures.
- To learn the DSP techniques are used in modern communication systems.

COURSE CONTENT:

Unit 1	Multirate Signal Processing	9	3	0	12	24		4,9

Decimation, interpolation, Multistage implementation of sampling rate conversion, polyphase filters, filters banks, fractional rate conversion and communication applications.

Activities:

1. Simulate decimation and interpolation of speech signals in MATLAB/Python.
2. Design and evaluate polyphase filter banks for sub-band coding.

Unit 2	Adaptive Filter	9	3	0	12	24		4,9

LMS, NLMS, RLS algorithms, convergence, system identification, noise/echo cancellation, channel equalization, equalizers in mobile/wired systems.

Activities:

1. Implement LMS and RLS algorithms for channel equalization.

2. Compare convergence behavior with different step sizes and noise levels.								
Unit 3	**Spectral Estimation f or Signal Analysis**	**9**	**3**	**0**	**12**	**24**		**4,9**
Non-parametric methods: Periodogram, Bartlett and Welch methods, Parametric methods: AR, MA and ARMA method, MUSIC, ESPRIT algorithms, PSD for speech/radar signal. **Activities:** 1.Mini project: PSD analysis of a real-world communication signal (e.g., FM, ECG).								
Unit 4	**DSP Architectures and Real Time Implementation**	**9**	**3**	**0**	**12**	**24**		**4,9**
Fixed/floating-point DSPs, TMS320C67x, pipelining, FPGA-based DSP, SDR, DSP in 5G and IoT applications. **Activities:** 1. Mini Project: Optimization of FIR/IIR filters on FPGA or DSP kits. 2. Simulate pipelined filter processing on FPGA (Verilog or Vivado HLS optional).								
Unit 5	**DSP Applications**	**9**	**3**	**0**	**12**	**24**		**4,9**
DSP in modulation/demodulation, channel estimation, spectrum sensing, cognitive radio, speech/audio, IoT, biomedical. **Activities:** 1. Design and simulate a complete QPSK system with matched filtering. 2. Implement a basic spectrum sensing block for a cognitive radio.								
COURSE OUTCOMES:								
At the end of the course, the students will be able to: CO1: Utilize multirate signal processing techniques to process signals efficiently. CO2: Apply adaptive signal processing techniques to solve practical problems. CO3: Analyze spectral estimation methods, and direction of arrival. CO4: Design and implement real-time DSP algorithms and architectures. CO5: Analyze the application of DSP techniques in modern communication systems.								
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%								
Assessment Methodology: Activities (40%), Internal Examinations (60%)								
REFERENCES:								
1.	Monson H. Hayes, “Statistical Digital Signal Processing and Modeling”, Updated Edition, Wiley India, 2022.							
2.	B. P. Lathi and Roger Green, “Linear Systems and Signals”, Third edition, Oxford University Press, 2022.							

3.	John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Fifth edition, Pearson, 2022.
4.	E. S. Gopi, "Digital Signal Processing for Wireless Communication using MATLAB", Springer Nature, 2021
5.	Keshab K. Parhi, "VLSI Digital Signal Processing Systems: Design and Implementation", Wiley India, 2022.
E resources/E materials:	
1.	https://nptel.ac.in/courses/117106101.
3.	PyTorch/NumPy-based DSP Tutorials https://pytorch.org/tutorials/
4.	GNU Radio Companion (Free SDR Simulator https://wiki.gnuradio.org/)
5	Think DSP, Allen B. Downey, https://greenteapress.com/wp/think-dsp/

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	2	3	1
CO2	3	2	3	3	3	1
CO3	2	2	2	3	2	1
CO4	2	2	3	3	3	2
CO5	3	2	3	3	2	1
CO	3	2	3	3	3	1

CU26103	**Analog and Digital Electronic System Design**	**L**	**T**	**P**	**TW/SL**	**Total**	**C**	**SDG**
		45	**0**	**30**	**45**	**120**	**4**	**3,7,9**

COURSE OBJECTIVES:

- To understand MOS transistor characteristics and CMOS logic gate operation.
- To understand the working and performance parameters of CS, CG, CD, cascode amplifiers and current mirrors.
- To apply differential amplifier concepts and high-gain techniques to design and analyze op-amp circuits.
- To apply synchronous datapath and timing concepts to implement digital systems on FPGA platforms.
- To apply HDL modeling and synthesis techniques to implement digital systems on FPGA.

COURSE CONTENT:								
Unit 1	**MOS Transistor Principles and Logic Gates**	**9**	**0**	**3**	**12**	**24**		**7,9**
MOS transistor characteristics, CMOS inverter, logic gate design, secondary effects, CS, CG, CD amplifiers. **Activity:** Case Study: 1. Analyze CMOS inverter performance and power metrics. **Practical Experiments:** 1. DC characteristics of NMOS/PMOS. 2. Logic gate simulations (NOT, NAND, NOR).								
Unit 2	**Single Stage Amplifiers**	**9**	**0**	**3**	**12**	**24**		**3,7**
MOS models and small-signal equivalents, common-source (CS) with resistive loads, common-gate (CG), and source-follower (CD) amplifiers, cascode amplifiers, current mirrors. **Activity:** Case Study: 1. Virtual demonstration on MOSFET amplifier configurations (CS, CG, CD). **Practical Experiments:** 1. CS amplifier design and performance analysis (Zin, Zout, gain, bandwidth, transient)								
Unit 3	**Differential Amplifiers and High-Gain Circuits**	**9**	**0**	**3**	**12**	**24**		**3,9**
Differential amplifier design, gain, CMR, slew rate, bandwidth, power, op-amp design principles, high-gain structures. **Activity:** Case Study 1. Virtual demonstration high-gain amplifier structures and op-amp design. **Practical Experiments:** 1. Differential amplifier with resistive load (gain, bandwidth, power, CMRR, transient).								
Unit 4	**Digital Circuit Design and FPGA Implementation**	**9**	**0**	**3**	**12**	**24**		**3,7**
FPGA architecture, datapath design, clocked synchronous circuits, iterative circuits, ASM chart and realization using ASM blocks. **Activity:** Case Study 1. Modelling of synchronous sequential circuits using ASM charts. **Practical Experiments:** 1. Implementation of combinational circuits on FPGA.								
Unit 5	**System Design Using HDL and Integration**	**9**	**0**	**3**	**12**	**24**		**7,9**
Logic system and data types in HDL, behavioral and structural modeling, FSM synthesis, mixed-signal integration using simulation tools.								

Activity:
Case Study 1. Behavioral modeling and synthesis of combinational and sequential circuits.
Practical Experiments:

1. FPGA realization and real-time output analysis.

COURSE OUTCOMES:

At the end of the course, the students will be able to:
CO1: Use MOS transistor operation principles, characteristics, and CMOS logic gates in circuit applications.
CO2: Analyze MOS small-signal models and basic amplifier stages.
CO3: Utilize MOS concepts for designing CMOS inverters and logic gates.
CO4: Design combinational and sequential circuits on FPGA.
CO5: Develop digital systems using HDL and FPGA.

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Internal Examinations (50%) & Activity (50%)

REFERENCES:

1.	Razavi, B." Design of analog CMOS integrated circuits", Second Edition, Tata McGraw Hill, 2023.
2.	Roth, C. H. Jr., "Fundamentals of Logic Design, Cengage Learning", Eighth Edition, 2021.
3.	Palnitkar, S., "Verilog HDL: A Guide to Digital Design and Synthesis", Second Edition., Pearson, 2021
4.	D. Leblebici and Y. Leblebici, "Fundamentals of High Frequency CMOS Analog Integrated Circuits", Springer, 2021.
5.	Johns, D. and Martin, K., "Analog Integrated Circuit Design", Second Edition, Wiley, 2021.

E resources/E materials:

1.	https://nptel.ac.in/courses/117101105
2.	http://users.ece.gatech.edu/alan_m/epicdesign
3.	https://cse.iitk.ac.in/users/cc/digital-design
4.	https://dsp-book.narod.ru/CMOS_VLSI_Design.pdf
5.	https://resources.cadence.com

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	2	1	1
CO2	2	2	3	1	1	1
CO3	1	2	1	2	2	1
CO4	3	1	3	3	2	1
CO5	2	1	2	2	3	1
CO	2	2	2	2	2	1

CU26104	Digital Communication Systems Laboratory	L	T	P	TW/SL	Total	C	SDG
		0	0	60	0	60	2	3,4,9,12

COURSE OBJECTIVES:

- To study and measure the performance of digital communication systems
- To provide a comprehensive knowledge of wireless communication
- To learn about the design of digital filter and its adaptive filtering algorithm

LIST OF ACTIVITIES:

1. Generation & detection of binary digital modulation techniques using SDR.
2. Spread spectrum communication system-Pseudo random binary sequence generation - Baseband DSSS.
3. MIMO system transceiver design using MATLAB/SCILAB/LABVIEW.
4. Performance evaluation of simulated CDMA system.
5. Channel coder/decoder design (block codes / convolutional codes/ turbo codes).
6. OFDM transceiver design using MATLAB /SCILAB/LABVIEW.
7. Channel equalizer design using MATLAB (LMS, RLS algorithms).
8. Design and analysis of spectrum estimators (Bartlett, Welch) using MATLAB.
9. BER performance analysis of M-ary digital modulation techniques (coherent & non coherent) in AWGN environment using MATLAB/SCILAB/LABVIEW.
10. Design and performance analysis of lossless coding techniques - Huffman coding and Lempel Ziv algorithm using MATLAB/SCILAB/LABVIEW.
11. Noise / Echo cancellation using MATLAB (LMS / RLS algorithms).
12. Wireless channel characterization.

COURSE OUTCOMES:

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

CO1: Apply simulation tools like Matlab, Scilab, or LabView to model, analyze, and evaluate digital communication systems

CO2: Design and simulate advanced wireless communication systems and assess their performance under various channel conditions. CO3: Implement channel coding and equalization techniques to improve communication system performance and reduce the effects of noise and interference. CO4: Evaluate and compare the bit error rate and spectral performance of digital communication systems using spectrum estimation and M-ary modulation analysis. CO5: Analyze adaptive signal processing algorithms for applications noise/echo cancellation and data compression.	
Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%	
Assessment Methodology: Evaluation of Student's work, Observation, Record, Activities etc.(75%), Model Practical Exam (25%)	
REFERENCES:	
1.	Bhaskar Reddy et al, "Digital Communication Systems", Notion Press, 2022.
2.	John W. Leis, "Communication Systems Principles Using MATLAB", Second Edition, Wiley, 2022.
3.	Andrea Goldsmith, "Wireless Communications", Second Edition, Cambridge University Press, 2021.
4.	Simon Haykin, "Digital Communication Systems", Wiley, 2021.
5.	The MathWorks, Inc.; www.mathworks.com
E resources/E materials:	
1.	Modern Digital Communication Techniques, IIT Kharagpur - Swayam - NPTEL
2.	Introduction to Digital Communications and Information Theory, IIT Kharagpur - NPTEL

Mapping of Course Outcomes with Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	3	-	1	-
CO2	3	-	2	1	1	1
CO3	3	1	2	-	-	1
CO4	2	-	2	1	1	-
CO5	2	1	2	1	-	1
CO	2	1	2	1	1	1

RM26C01	Research Methodology and Intellectual Property Rights	L	T	P	TW/SL	Total	C	SDG
		45	15	0	60	120	4	1,2,3,7

COURSE OBJECTIVES:

- To understand modern research processes, ethics, and data-driven decision making.
- To familiarize students with research design, data collection, and analysis methods.
- To develop skills in technical writing, publication, and presentation.
- To create awareness on Intellectual Property Rights and patent systems.
- To introduce contemporary research tools and innovation protection mechanisms.

COURSE CONTENT:

Unit 1	Research Design and Modern Research Approaches	9	3	0	12	24		1

Research ecosystem and lifecycle, types of research, problem identification, literature gap analysis, research questions and hypotheses, AI-assisted literature review tools, research design frameworks, qualitative and quantitative research, experimental and survey methods, research ethics and plagiarism awareness.

Activities: Literature gap identification, ethics discussion.

Unit 2	Data Collection, Sources and Preparation	9	3	0	12	24		3

Primary and secondary data sources, digital and open datasets, measurement scales, questionnaire design, sampling techniques, sample size estimation, data preprocessing, cleaning, transformation, and basic data visualization.

Activities: Questionnaire design, data visualization exercise.

Unit 3	Data Analysis, Interpretation and Scientific Communication	9	3	0	12	24		2

Descriptive and inferential statistics, hypothesis testing, correlation and regression basics, introduction to multivariate analysis, use of analytical tools (Excel/SPSS/Python – overview), interpretation of results, technical report writing, journal and conference paper formats (IEEE/IET), presentation techniques.

Activities: Data analysis demo, paper formatting.

Unit 4	Intellectual Property Rights and Innovation Ecosystem	9	3	0	12	24		7

Concept, meaning, and significance of Intellectual Property Rights (IPR); types of IPR including patents, copyrights, trademarks, industrial designs, and geographical indications; role of IPR in innovation, research, and economic development; overview of national IPR framework with reference to Indian Patent Office and international agreements under World Intellectual Property Organization; importance of IPR in academia, industry, and technology-driven entrepreneurship. **Activities:** IPR case study.								
Unit 5	**Patents and Technology Protection**	**9**	**3**	**0**	**12**	**24**		**2,7**
Patent concepts and objectives, patentability criteria, novelty and inventive step, patent specifications, prior art search, types of patent applications, patent filing process, examination and grant, licensing and technology valuation, career opportunities in patent and innovation management. **Activities:** Patent search exercise.								
COURSE OUTCOMES:								
At the end of the course, the students will be able to: CO1: Apply suitable research methodologies to formulate research problems. CO2: Design data collection instruments and choose appropriate sampling methods. CO3: Analyze and interpret research data using basic analytical tools. CO4: Apply appropriate IP strategies for safeguarding innovations and research outputs. CO5: Apply principles of IPR, patents, and ethical research practices in research and innovation activities.								
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%								
Assessment Methodology: Internal Assessment Test (70%), Activities (30%)								
TEXT BOOKS:								
1.	John W. Creswell, J. David Creswell, “Research Design: Qualitative, Quantitative, and Mixed Methods Approaches”, Fifth Edition, Sage Publications, 2023.							
2.	Deborah E. Bouchoux, “Intellectual Property: Patents, Trademarks, Copyrights and Trade Secrets”, Fifth Edition, Cengage Learning, 2021.							
REFERENCES:								
1.	Pamela S. Schindler, “Business Research Methods”, Fourteenth Edition, McGraw Hill, 2025.							
2.	Deborah E. Bouchoux, “Intellectual Property: Patents, Trademarks, Copyrights and Trade Secrets”, Fifth Edition, Cengage Learning, 2021.							

3.	David Hitchcock , “Patent Searching Made Easy”, Second Edition, Routledge, 2020.
4.	Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams, Joseph Bizup, William T. Fitz Gerald ,” The Craft of Research”, Fifth Edition, University of Chicago Press, 2024.
5.	V.K. Ahuja,” Intellectual Property Rights: Law and Practice”, Third Edition, LexisNexis, 2022.
E resources/E materials:	
1.	WIPO IP Portal – Online learning modules on Intellectual Property Rights and patents.(https://www.wipo.int/academy)
2.	Google Scholar – Scholarly literature search and citation tracking platform. (https://scholar.google.com)
3.	Indian Patent Office (IPO) Website – Patent search, filing procedures, and legal guidelines. (https://ipindia.gov.in)

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	3	1	1
CO2	3	3	3	2	2	1
CO3	3	3	2	3	3	1
CO4	2	2	3	2	2	3
CO5	2	2	2	2	1	3
CO	3	3	2	2	2	2

RM26C02	**Research Tools Laboratory**	**L**	**T**	**P**	**TW/SL**	**Total**	**C**	**SDG**
		0	**0**	**60**	**0**	**60**	**2**	**4,9,16,17**

COURSE OBJECTIVES:

- To provide hands-on training in modern research and project management tools.
- To develop skills in literature review, reference management, and plagiarism checking.
- To train students in research paper formatting, writing, and publication workflow.
- To introduce data analysis and visualization tools for research applications.
- To enable preparation of professional research reports and technical presentations.

LIST OF ACTIVITIES:

1. Research Planning and Project Management
1.1 Research lifecycle, milestones, and project planning
1.2 Gantt chart preparation using MS Project / Notion / OneNote

2. Literature Review and Reference Management
2.1 Advanced literature search using Google Scholar / Scopus
2.2 Reference management using Mendeley / Zotero

3. Research Problem Identification
3.1 Literature gap analysis, AI-assisted literature gap analysis
3.2 Research problem, objectives, and hypothesis formulation

4. Research Paper Formatting
4.1 IEEE / IET journal and conference templates
4.2 Professional writing using Overleaf, Grammarly

5. Publication Workflow
5.1 Journal selection using Elsevier Journal Finder
5.2 Peer review process and reviewer response simulation

6. Data Analysis – Basic Tools
6.1 Data entry, cleaning, and preprocessing
6.2 Descriptive statistics and graphical visualization

7. Data Analysis – Advanced Tools
7.1 Introduction to SPSS / MATLAB for research analysis
7.2 Interpretation of results and inference
8. Plagiarism Detection and Research Ethics
8.1 Plagiarism checking using Turnitin / Urkund
8.2 Ethical paraphrasing and citation practices

9. Referencing and Citation Standards
9.1 IEEE, APA referencing styles
9.2 Automated citation generation and consistency check

10. AI in Research and Automation
10.1 AI tools for research assistance, ChatGPT, Perplexity AI -Automated summarization, idea generation

10.2 Ethical use of AI in research	
COURSE OUTCOMES:	
At the end of the course, the students will be able to: CO1: Plan and manage research activities using modern research tools. CO2: Conduct systematic literature review and manage references effectively. CO3: Analyze and interpret research data using suitable software tools. CO4: Prepare plagiarism-free research papers and technical reports. CO5: Present research findings professionally through reports and presentations.	
Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%	
Assessment Methodology: Evaluation of Student's work, Observation, Record, Activities etc.(75%), Model Practical Exam (25%)	
REFERENCES:	
1.	Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams, Joseph Bizup, William T. FitzGerald, "The Craft of Research", Fifth Edition, University of Chicago Press, 2024.
2.	John W. Creswell, J. David Creswell, "Research Design: Qualitative, Quantitative, and Mixed Methods Approaches", Fifth Edition, SAGE Publications, 2023.
3.	Mark N. K. Saunders, Philip Lewis, Adrian Thornhill, "Research Methods for Business Students" , Ninth Edition, Pearson Education, 2023.
4.	Herman Aguinis," Research Methodology: Best Practices for Rigorous, Credible, and Impactful Research", SAGE Publications, 2025.
5.	Jiawei Han, Micheline Kamber, Jian Pei," Data Mining: Concepts and Techniques", Third Edition, 2025.
E resources/E materials:	
1.	Reference organization, citation generation, PDF management https://www.mendeley.com
2.	Collaborative LaTeX writing for research papers https://www.overleaf.com.
3.	Plagiarism detection and originality reports https://www.turnitin.com.

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3	3	1
CO2	2	3	2	3	3	1
CO3	3	3	2	3	3	1
CO4	2	2	3	2	2	3
CO5	2	2	2	2	2	2
CO	2	2	2	3	3	2

CU26105	Technical Seminar	L	T	P	TW/SL	Total	C	SDG
		0	0	30	0	30	1	3,4,9

COURSE OBJECTIVES:

- In this course, students will develop their scientific and technical reading and writing skills that they need to understand and construct research articles.
- A term paper requires a student to obtain information from a variety of sources (i.e., Journals, dictionaries, reference books) and then place it in logically developed ideas.

LIST OF ACTIVITIES:

The work involves the following steps:

1.Selecting a subject, narrowing the subject into a topic
2. Stating an objective
3. Collecting the relevant bibliography (atleast 15 journal papers)
4. Preparing a working outline
5. Studying the papers and understanding the authors contributions and critically analysing each paper.
6. Preparing a working outline
7. Linking the papers and preparing a draft of the paper
8. Preparing conclusions based on the reading of all the papers
9. Writing the Final Paper and giving final Presentation

Method of Evaluation:

Activity	Instructions	Submission week	Evaluation
Selection of area of interest and Topic Stating an Objective	You are requested to select an area of interest, topic and state an objective	2nd week	3% Based on clarity of thought, current relevance and clarity in writing
Collecting Information about your area & topic	1. List 1 Special Interest Groups or professional society 2. List 2 journals 3. List 2 conferences, symposia or workshops 4. List 1 thesis title 5. List 3 web presences (mailing lists, forums, news sites) 6. List 3 authors who publish regularly in your area 7. Attach a call for papers (CFP) from your area.	3rd week	3% (the selected information must be area specific and of international and national standard)
Collection of Journal papers in the topic in the context of the objective – collect20 & then filter	• You have to provide a complete list of references you will be using- Based on your objective -Search various digital libraries and Google Scholar • When picking papers to read - try to: • Pick papers that are related to each other in some ways and/or that are in the same field so that you can write a meaningful survey out of them, • Favour papers from well-known journals and conferences, • Favour "first" or "foundational" papers in the field (as indicated in other people's survey	4th week	6% (the list of standard papers and reason for selection)

	paper), • Favour more recent papers, • Pick a recent survey of the field so you can quickly gain an overview, • Find relationships with respect to each other and to your topic area (classification scheme/categorization) • Mark in the hard copy of papers whether complete work or section/sections of the paper are being considered		
Reading and notes for first 5 papers	Reading Paper Process • For each paper form a Table answering the following questions: What is the main topic of the article? • What was/were the main issue(s) the author said they want to discuss? • Why did the author claim it was important? • How does the work build on other's work, in the author's opinion? 5th week 8% (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper) • What simplifying assumptions does the author claim to be making? • What did the author do? • How did the author claim they were going to	5^{th} week	8% (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)

	evaluate their work and compare it to others? • What did the author say were the limitations of their research? What did the author say were the important directions for future research? Conclude with limitations/issues not addressed by the paper (from the perspective of your survey)		
Reading and notes for next5 papers	Repeat Reading Paper Process	6th week	8% (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)
Reading and notes for final 5 papers	Repeat Reading Paper Process	7th week	8% (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)
Draft outline 1 and Linking papers	Prepare a draft Outline, your survey goals, along with a classification / categorization diagram	8th week	8% (this component will be evaluated based on the linking and classification among the papers)
Abstract	Prepare a draft abstract and give a presentation	9th week	6% (Clarity, purpose and conclusion) 6% Presentation & VivaVoce
Introduction Background	Write an introduction and background sections	10th week	5% (clarity)
Sections of the paper	Write the sections of your paper based on the classification / categorization diagram in keeping with the goals of your survey	11th week	10% (this component will be evaluated based on the linking and classification among the papers)
Your conclusions	Write your conclusions and future work	12th week	5% (conclusions – clarity and your ideas)
Final Draft	Complete the final draft of	13th week	10% (formatting,

	your paper		English, Clarity and linking) 4% Plagiarism Check Report
Seminar	A brief 15 slides on your paper	14th week & 15th week	10% (based on presentation and Viva-voce)

COURSE OUTCOMES:

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

CO1: Identify latest developments in the field of Medical Electronics.

CO2: Develop technical writing abilities for seminars, conferences and journal publications.

CO3: Make use of modern tools to present the technical details.

Weightage: Review 1: 25%, Review 2: 25%, Review 3: 50%

Assessment Methodology: Review:50%, Report: 30%, Viva-voce Examination: 20%

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	2	3
CO2	3	2	3	2	2	3
CO3	3	2	3	2	2	3
CO	3	2	3	2	2	3

SEMESTER: II

CU26201	Radio Frequency Transceiver Design	L	T	P	TW/SL	Total	C	SDG
		45	0	0	45	90	3	4,8,9,11, 12,13

COURSE OBJECTIVES:

- To understand the fundamental RF system parameters such as gain, noise figure, SNR, impedance, and performance metrics used in communication systems.
- To analyse noise and non-linearity effects in RF components and evaluate their impact on overall system performance.
- To explain the operation and modelling of mixers and oscillators, including frequency

translation, phase noise, and spurious effects.

- To compare different radio receiver architectures such as superheterodyne, direct conversion, low-IF, and bandpass sampling systems.
- To design and evaluate RF transceiver systems for multimode and multiband wireless communication applications.

COURSE CONTENT:

Unit 1	**Radio Frequency System Design**	**9**	**0**	**0**	**9**	**18**		**4,9**

System Parameter definitions: Gain, noise figure, SNR, Characteristic impedance, S-parameters, Impedance matching and Decibels, Average value, RMS value, Crest factor, sensitivity, selectivity, dynamic range and, adjacent and alternate channel power leakages.

Activities: 1. Case study: Design and Analysis of a Wireless Communication Receiver

2. Quiz : Communication System Parameters and Performance Metrics

Unit 2	**Amplifier Modelling and Analysis**	**9**	**0**	**0**	**9**	**18**		**9,12**

Noise: Noise equivalent model for Radio frequency device, amplifier noise model, cascade performance, minimum detectable signal, performance of noisy systems in cascade.

Non-Linearity: Amplifier power transfer curve, gain compression, AM-AM, AM-PM, polynomial approximations, Saleh model, Wiener model and Hammerstein model, intermodulation, Single and two tone analyses, second and third order distortions and measurements, SOI and TOI points, cascade performance of nonlinear systems.

Activities: 1. Case study: Performance Analysis of a Practical RF Receiver Chain

2. Think pair share : Noise vs Non-Linearity Trade-offs in RF Systems

Unit 3	**Mixer and Oscillator Modelling and Analysis**	**9**	**0**	**0**	**9**	**18**		**9,11**

Mixers: Frequency translation mechanisms, frequency inversion, image frequencies, spurious calculations, principles of mixer realizations.

Oscillators: phase noise and its effects, effects of oscillator spurious components, frequency accuracy, oscillator realizations: Frequency synthesizers, NCO.

Activities: 1. Case study: Frequency Conversion and Signal Generation in a Superheterodyne Receiver

2. Concept map activity : Mixers and Oscillators in Communication Systems

Unit 4	**Radio Architectures and Design Considerations**	**9**	**0**	**0**	**9**	**18**		**8,9**

Superheterodyne architecture, direct conversion architecture, Low IF architecture, bandpass sampling radio architecture

Activities:1. Case study: Selection of Receiver Architecture for a Multi-Standard Wireless Device

2. Research paper writing: Comparative Analysis of Modern Receiver Architectures for Wireless Communication Systems

Unit 5	**Applications of Systems Design**	**9**	**0**	**0**	**9**	**18**		**9,11, 13**

Multimode and multiband Superheterodyne transceiver: selection of frequency plan, receiver system and transmitter system design – Direct conversion transceiver: receiver system and transmitter system design..

Activities:1. Case study: Design of a Multiband Smartphone Transceiver

2. Research paper writing: Design and Analysis of Multimode Multiband Transceivers for Modern Wireless Communication Systems

COURSE OUTCOMES:

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

CO1: Utilize RF system parameters such as gain, noise figure, SNR, impedance, and performance metrics to analyze and evaluate communication system performance.

CO2: Analyse noise performance and non-linear behaviour of RF amplifiers, including cascade effects and distortion mechanisms.

CO3: Examine the working principles of mixers and oscillators to assess frequency translation, phase noise, and spurious effects in communication systems.

CO4: Evaluate different radio architectures based on performance, complexity, and application requirements.

CO5: Design RF transceiver systems for multiband and multimode wireless communication applications.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Internal Examinations (60%), Activities (40%)

REFERENCES:

1.	Robert Sobot, “Wireless Communication Electronics: Introduction to RF Circuits and Design Techniques”, Springer, 2021.
2.	Michael Steer, “Microwave and RF Design: Radio Systems”, NC State University (Open Textbook), 2020.
3.	Ulrich L. Rohde, “Microwave and Wireless Synthesizers: Theory and Design”, Wiley, 2021.
4.	John Wood, “RF Power Amplifier Behavioral Modeling”, Cambridge University Press, 2021.
5.	Ziolkowski et al., “5G RF System Design and Engineering”, 2022.
6.	Andrei Grebennikov, “RF and Microwave Transmitter Design”, 2023.

E resources/E materials:

1.	NPTEL RF Transceiver Design - video lectures and study material

2.	https://www.youtube.com/playlist?list=PLbMVogVj5nJRf2r8v5v6qg5fQ0h0n0g0
3.	https://www.youtube.com/watch?v=5t2p7m9hQ9A
4.	https://www.youtube.com/watch?v=3Qh5Qm2p7x0
5.	https://www.youtube.com/watch?v=2vHq9oXl8zQ

Mapping of Course Outcomes with Program Outcomes

Course Outcomes	Programme Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	2	2	1	1
CO2	1	1	2	2	1	1
CO3	1	1	2	2	1	1
CO4	1	1	2	2	1	1
CO5	1	1	2	2	1	1
CO	1	1	2	2	1	1

CU26202	Deep Learning	L	T	P	TW/SL	Total	C	SDG
		45	15	0	60	120	4	3,4,9,11

COURSE OBJECTIVES:

- To develop and train Deep Neural Networks.
- To develop a CNN for object detection and recognition.
- To build and train RNNs, to solve real-world problems.
- To study the structure of LSTM and GRU and the differences between them
- To design Auto Encoders for Image Processing.

COURSE CONTENT:

Unit 1	Deep Learning	9	3	0	12	24	4	4

Building Blocks of Neural Network. Multilayer Perceptron, Back- 81 propagation algorithm and its variants Stochastic gradient decent, Optimizers. Activation Functions. Loss Functions, Data Pre-processing for neural networks, Overfitting and Underfitting. Hyperparameters, Deep networks

Activities:1. Problem-Solving Exercise: Manual computation of forward pass & backpropagation.

2. Quiz : MLP, activation functions, loss functions, overfitting

Unit 2	Convolutional Neural Network	9	3	0	12	24	4	9

CNN. Architecture- Input Layers, Convolution Layers. Pooling Layers. Dense Layers, Filters and Feature Maps, Dropout Layers and Regularization, Batch Normalization. Various Activation Functions.

Various Optimizers. Popular CNN Architectures: LeNet, AlexNet, VGG16, ResNet, UNet

Activities:1. Case study: Compare LeNet, AlexNet, VGG16, ResNet architectures

2. Think pair share : Effect of dropout and batch normalization

Unit 3	**Transfer Learning & Sequence Modelling**	**9**	**3**	**0**	**12**	**24**	**4**	**11**

Transfer Learning with Image Data. RCNN, Fast R-CNN, Faster R-CNN, Mask-RCNN, YOLO. Recurrent Neural Networks, Bidirectional RNNs (BRNN). Long Short-Term Memory (LSTM). Bi-directional LSTM. Sequence-to-Sequence Models (Seq2Seq). Gated recurrent unit GRU.

Activities: 1. Case study: Object detection using YOLO / Faster R-CNN

2. Concept map activity : Relationship between RNN, LSTM, GRU

Unit 4	**Deep Reinforcement & Unsupervised Learning**	**9**	**3**	**0**	**12**	**24**	**4**	**9**

Deep Reinforcement Learning. Q-Learning. Deep Q-Network (DQN). Policy Gradient Methods. Actor-Critic Algorithm. About Autoencoding. Convolutional Auto Encoding. Variational Auto Encoding. Generative Adversarial Networks.

Activities: 1. Quiz: Q-learning, DQN, GAN, Autoencoders.

2. Case study: Actor-Critic algorithm in real-world applications

Unit 5	**Applications of Deep Learning**	**9**	**3**	**0**	**12**	**24**	**4**	**3**

Autoencoders for Feature Extraction. Auto Encoders for Classification. Denoising Autoencoders. Sparse Autoencoders. Case studies-Deep Neural network for Medical image segmentation

Activities:1. Case study: Medical image segmentation using deep networks

2. Presentation: Students present real-world DL applications

COURSE OUTCOMES:

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

CO1: Apply neural network for data preprocessing and feature extraction.
CO2: Make use of CNN architecture for object detection.
CO3: Make use of transfer learning and sequence modelling techniques in computer vision applications.
CO4: Analyze the Deep Reinforcement & Unsupervised Learning networks
CO5: Utilize deep learning network for Feature Extraction and Classification.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Activities (60%) Internal Examinations (40%).

REFERENCES:

1.	François Chollet,"Deep Learning with Python", Second Edition Manning Publications, 2021.

2.	Keras and TensorFlow," Hands-On Machine Learning with Scikit-Learn", Third Edition Aurélien Géron O'Reilly Media, Inc., 2022.
3.	Ivan Vasilev, Daniel Slater, Gianmario Spacagna, Peter Roelants, Valentino Zocca ,"Python Deep Learning", 2nd Edition Packt Publishing, 2022.
4.	Mohamed Elgendy ,"Deep Learning for Vision Systems" Manning Publications, 2020.
5.	Phil Winder ,"Reinforcement Learning: Industrial Applications of Intelligent Agents" O'Reilly Media, Inc., 2020
E resources/E materials:	
1.	https://youtu.be/njKP3FqW3Sk?si=deep_learning_unit1
2.	https://youtu.be/II4giR4vOOo?si=deep_learning_fullcourse
3.	https://youtu.be/oGpzWAlP5p0?si=cnn_lecture
4.	https://youtu.be/to-lHJfK4pw?si=reinforcement_learning
5.	https://youtu.be/7sB052Pz0sQ?si=gan_vae

Mapping of Course Outcomes with Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	1	2	3	1
CO2	2	1	1	2	3	1
CO3	2	1	1	2	3	1
CO4	3	1	1	2	2	1
CO5	2	2	1	2	3	1
CO	2	1	1	2	3	1

CU26203	**Advanced Wireless Communication Networks**	**L**	**T**	**P**	**TW/SL**	**Total**	**C**	**SDG**
		45	**0**	**30**	**45**	**120**	**4**	**4,9,11,13**

COURSE OBJECTIVES:

- To understand the architecture and protocol stack of advanced wireless communication systems.
- To learn the design principles, architecture, and enabling technologies of 5G wireless communication systems.
- To study modern radio access techniques, waveforms, and channel models used in 5G networks.
- To explore advanced networking techniques, applications, and performance evaluation methods in 5G systems.

COURSE CONTENT:

Unit 1	**4G Architecture**	**9**	**0**	**6**	**9**	**24**		**9**

Current wireless technologies - High Level architecture of 4G –Evolved UMTS Terrestrial Radio Access Network – Evolved Packet Core –Communication Protocols – Bearer Management. Architecture of LTE Air Interface – Air Interface protocol stack, logical, physical and transport channels, The Resource grid, Resource element mapping.MAC Protocol – Radio Link Control Protocol – Packet Data Convergence Protocol.

Activities:1. Case Study: Analyze the LTE protocol stack and explain how data flows from user equipment (UE) to the core network.

2. Quiz : Overview of current advanced wireless technologies

Practical Experiments:

1. Modeling a 4G LTE System
2. Test and Measurement of 4G LTE Baseband signals

Unit 2	**5G Architecture and Millimeter Wave Communications**	**9**	**0**	**6**	**9**	**24**		**11**

Key building blocks of 5G – 5G use cases and System Concepts – 5G Architecture. Millimeter Wave Communications : Hardware technologies for mmW systems Architecture and mobility – Massive MIMO – Resource Allocation and Transceiver algorithms for Massive MIMO.

Activities: 1. Case Study: Compare 4G and 5G architectures in terms of latency, bandwidth, and scalability.

2. Think-Pair-Share: Discuss challenges in millimeter wave communication.

Practical Experiments:

1. Design of MIMO System
2. Analysis and study of millimeter wave applications

Unit 3	**5G Waveforms and Channel Models**	**9**	**0**	**6**	**9**	**24**		**9,13**

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.

Activities: 1. Problem-Solving Activity: Analyze and compare OFDM and NOMA techniques for different 5G applications.

Practical Experiments:

1. Simulation of NOMA Principles
2. METIS Modeling

Unit 4	**Networking in 5G**	**9**	**0**	**6**	**9**	**24**		**11**

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.

Activities:1. Case Study: CoMP Deployment in Dense Urban Cells.

2. Think-Pair-Share : Network Coding vs. Relaying

Practical Experiments:

1. Simulation of Joint Transmission CoMP
2. Analysis of buffer-aided relaying

Unit 5	**5G Applications**	**9**	**0**	**6**	**9**	**24**		**4**

Machine-type communications: Fundamental techniques for MTC - Massive MTC – Ultra reliable low-latency MTC - Device-to-device (D2D) communications - Multi-hop D2D communications - Multi-operator D2D communication - Simulation methodology: Evaluation methodology – Calibration - New challenges in the 5G modelling

Activities:1. Problem Solving: Link Budget for Multi-Hop D2D Communications

2. Quiz : New Challenges in 5G Modelling

Practical Experiments:

1. Design of Massive MTC.
2. Implementation and testing of Device to Device Communication

COURSE OUTCOMES:

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

CO1: Apply LTE protocol stacks and resource element mapping to manage 4G network bearers.

CO2: Implement Massive MIMO algorithms and millimeter-wave technologies for 5G system architectures.

CO3: Compute 5G propagation parameters using METIS models and non-orthogonal multiple access techniques.

CO4: Analyze Coordinated Multi-Point (CoMP) and relaying schemes for efficient 5G backhauling.

CO5: Examine MTC and D2D communication protocols using 5G simulation and calibration methodologies.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Activity (50%), Internal Examinations (50%).

REFERENCES:

1.	K. N. Raja Rao, Advanced Mobile Wireless Communications: A Holistic Coverage from Basic Concepts to 5G Technologies with IoT. New Delhi, India: Wiley India, 2023.
2.	D. H. Morais, Key 5G Physical Layer Technologies: Enabling Mobile and Fixed Wireless Access, 2nd ed. Cham, Switzerland: Springer, 2022.
3.	X. Lin and N. Lee (Eds.), 5G and Beyond: Fundamentals and Standards. Cham, Switzerland: Springer, 2021.
4.	M. Mandloi, D. Gurjar, P. Pattanayak, and H. Nguyen (Eds.), 5G and Beyond Wireless Systems: PHY Layer Perspective. Singapore: Springer, 2021.
5.	A. F. Molisch, Wireless Communications: From Fundamentals to Beyond 5G, 3rd ed.

	Hoboken, NJ, USA: Wiley, 2023
E resources/E materials:	
1.	https://onlinecourses.nptel.ac.in/noc25_ee172/preview
2.	https://ns3simulation.com/device-to-device-communication-in-5g/
3.	https://www.antenova.com/what-is-mmtc-in-5g-how-does-it-work

Mapping of Course Outcomes with Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	2	2	1	1
CO2	2	1	2	2	1	2
CO3	2	2	2	3	2	2
CO4	2	2	2	3	2	2
CO5	2	2	2	3	2	2
CO	2	2	2	3	2	2

CU26204	**Advanced Communication Systems Laboratory**	**L**	**T**	**P**	**TW/SL**	**Total**	**C**	**SDG**
		0	**0**	**60**	**0**	**60**	**2**	**4,9,11,13**

COURSE OBJECTIVES:

- To study & measure the performance of digital communication systems.
- To provide a comprehensive knowledge of Wireless Communication.
- To learn about the design of digital filter and its adaptive filtering algorithms.

LIST OF EXPERIMENTS:

1. Generation & detection of binary digital modulation techniques.
2. Implementation of Linear and Cyclic codes.
3. Spread Spectrum communication system-Pseudo random binary sequence generation- Baseband DSSS.
4. Performance evaluation of simulated CDMA system
5. Channel Coder/decoder design (block codes / convolutional codes/ turbo codes)
6. OFDM transceiver design.
7. Channel equalizer design.
8. Noise / Echo cancellation using MATLAB (LMS / RLS algorithms).
9. Study of synchronization (frame, bit, symbol.)
10. Wireless channel characterization.

LAB REQUIREMENTS

Matlab/Scilab/Labview.

Use appropriate simulation tools for the above experiments.
COURSE OUTCOMES:
At the end of the course, the students will be able to: CO1. Implement binary digital modulation and demodulation techniques and analyze their performance under ideal and noisy channel conditions. CO2. Design and implement channel coding and decoding schemes. CO3. Design and simulate advanced communication systems such as DSSS, CDMA, OFDM, synchronization modules, and channel equalizers. CO4. Analyse the performance of optimization algorithms for Noise/echo cancellation. CO5. Evaluate wireless channel characteristics.
Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%
Assessment Methodology: Evaluation of Student's work, Observation, Record, Activities etc.(75%), Model Practical Exam (25%)
REFERENCES:

1.	John G. Proakis and Masoud Salehi, "Digital Communications", McGraw-Hill Education, 2022, Sixth Edition.
2.	Theodore S. Rappaport, "Wireless Communications: Principles and Practice", Pearson Education, 2023, Third Edition (Global Release).
3.	Todd K. Moon, "Error Correction Coding: Mathematical Methods and Algorithms", Wiley-Interscience, 2020, Second Edition.
E resources/E materials:	
1.	https://onlinecourses.nptel.ac.in/noc25_ee172/preview
2.	https://nptel.ac.in/courses/108105151
3.	https://www.mathworks.com/help/dsp/adaptive-filters.html

Mapping of Course Outcomes with Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	2	2	2	1
CO2	2	2	2	2	2	1
CO3	2	2	1	2	3	2
CO4	2	2	1	2	3	2
CO5	1	2	2	2	2	2
CO	2	2	2	2	2	2

OPEN ELECTIVE I

CU26901	Wireless Sensor Networks and WBAN	L	T	P	TW/SL	Total	C	SDG
		45	0	0	45	90	3	3,7,9, 11, 13

COURSE OBJECTIVES:

- To understand the fundamentals and applications of wireless sensor networks.
- To analyze sensor node architecture and energy efficiency.
- To apply MAC and routing protocols for effective communication.
- To explore network infrastructure and data management techniques.
- To examine WBAN architecture and performance for healthcare systems.

COURSE CONTENT:

Unit 1	Overview of Wireless Sensor Networks	9	0	0	9	9		3,7,9, 11, 13

Challenges for Wireless Sensor Networks-Characteristics requirements-required mechanisms, Difference between mobile ad-hoc and sensor networks, Applications of sensor networks- case study, Enabling Technologies for Wireless Sensor Networks

Activity: 1. Analysis and Case Study of Wireless Sensor Network Applications and Enabling Technologies

2. Think–Pair–Share Activity: Compare Wireless Sensor Networks and Mobile Ad-hoc Networks

Unit 2	Node Architecture and Optimizations	9	0	0	9	9		3,7,9, 11, 13

Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes, Operating Systems and Execution Environments, Network Architecture - Sensor Network Scenarios, Optimization Goals and Figures of Merit.

Activity: 1. Evaluation of Sensor Node Architecture, Energy Consumption, and Network Design Scenarios

2. Discuss optimization goals in WSN such as low power consumption

Unit 3	MAC and Routing Protocols	9	0	0	9	9		3,7,9, 11, 13

MAC Protocols for Wireless Sensor Networks, IEEE 802.15.4, ZigBee, Low Duty Cycle Protocols and Wakeup Concepts - S-MAC, The Mediation Device Protocol, Routing Protocols- Energy Efficient Routing, Geographic Routing.

Activity:1. Analysis and Simulation of MAC Protocols and Energy-Efficient Routing in Wireless Sensor Networks

2. Prepare flowcharts illustrating MAC address assignment and routing processes in WSNs.

Unit 4	Infrastructure Establishment and Data Management	9	0	0	9	9		3,7,9, 11, 13

Topology Control, Clustering, Time Synchronization, Localization and Positioning-Data management in WSN. **Activity:** 1. Case Study Analyze a real-world WSN application focusing on localization,								
Unit 5	**Wireless Body Area Network**	**9**	**0**	**0**	**9**	**9**		**3,7,9, 11, 13**
WBAN Standard-Architecture-WBAN layers- Network and MAC Protocol Design for WBAN-Energy Management in WBAN-Performance Analysis of WBAN. **Activity:** 1. Quiz on WBAN standards, MAC protocols, energy management, and PHY layer concepts.								
COURSE OUTCOMES:								
At the end of the course, the students will be able to: CO1: Differentiate wireless sensor networks from mobile ad-hoc networks based on characteristics and challenges. CO2: Estimate energy consumption of sensor nodes using architectural parameters. CO3: Implement MAC and routing protocols for efficient communication in wireless sensor networks. CO4: Assess data aggregation and query processing methods for scalability and efficiency. CO5: Interpret WBAN performance metrics such as latency, reliability, and energy usage.								
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%								
Assessment Methodology: Internal Examinations (60%), Activities (40%)								
REFERENCES:								
1.	Dr. Sneh Garg , Dr. Puja Shrivastava, Dr. Monika Anand," Next Generation Wireless Sensor Networks: Self-Management, AI, and Multi Objective Optimization, Technical Book", GEH PRESS, 2026							
2.	Bhanu Chander, Anoop Benet Nirmala, Koppala Guruvaiah. G," Intelligent Wireless Sensor Networks and the Internet of Things", CRC Press 2025							
3.	Deepak Gupta Victor Hugo C, De Albuquerque Ashish Khanna, " Smart Sensors for Industrial Internet of Things Challenges, Solutions and Applications", Springer 2021							
4.	D.M.G. Preethichandra; Lasitha Piyathilaka; Umer Izhar; Rohan Samarasinghe; Liyanage C. De Silva," Wireless Body Area Networks and Their Applications – A Review" 2023							
5.	Ramona Trestian," Mobile and Wireless Communications with Practical Use-Case Scenarios", CRC Press 2022.							
E resources/E materials:								
1.	https://nptel.ac.in/courses/106105160							
2.	https://alison.com/topic/learn/93597/learning-outcomes							

Mapping of Course Outcomes with Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	1	1
CO2	1	1	1	2	1	1
CO3	1	1	1	2	1	1
CO4	1	1	1	2	1	1
CO5	1	1	1	2	1	1
CO	1	1	2	2	1	1

CU26902	Security for Wireless Communication Networks	L	T	P	TW/SL	Total	C	SDG
		45	0	0	45	90	3	4,9,16

COURSE OBJECTIVES:

- To analyze security goals, services, and mechanisms in communication systems.
- To analyze cryptographic techniques including symmetric and asymmetric algorithms.
- To study integrity, authentication, and key management mechanisms.
- To explore security protocols used in IP, email, and web communications.
- To investigate security challenges in modern wireless networks including 4G/5G systems and side-channel attacks.

COURSE CONTENT:

Unit 1	Security Techniques	9	0	0	9	18		4,16

Security goals: Confidentiality, Integrity, Availability, Security services and mechanisms, Cryptographic attacks: Passive and Active attacks, Techniques: Cryptography and Steganography, Traditional symmetric key ciphers, Mathematics of cryptography

Activities: 1. Study and analysis of security goals, cryptographic attacks, and fundamental cryptographic techniques.

Unit 2	Symmetric & Asymmetric Key Algorithms	9	0	0	9	18		9,16

Block ciphers and stream ciphers, Data Encryption Standard (DES) – overview, Advanced Encryption Standard (AES), RC4 stream cipher, Principles of asymmetric key cryptography, Public key algorithms and applications

Activities: 1. Exploration and comparative study of symmetric and asymmetric encryption algorithms.

Unit 3	Integrity, Authentication and Key Management	9	0	0	9	18		9,16

Message integrity and authentication, Hash functions and properties, Digital signatures and Digital Signature Standards (DSS), Entity authentication techniques, Biometrics in authentication, Key management and key distribution techniques.
Activities: 1. Case study on message integrity, authentication methods, and key management schemes

Unit 4	**Security Protocols**	**9**	**0**	**0**	**9**	**18**		**9,16**

IP Security (IPSec): Architecture and protocols, Email security: PGP and S/MIME, Web security: SSL, TLS, and SET
Activities: 1. Analysis and implementation study of security protocols for IP, email, and web communications.

Unit 5	**Wireless Network Security**	**9**	**0**	**0**	**9**	**18**		**9,16**

Security in broadband wireless networks, Security challenges in 4G and 5G networks, Threat models in wireless communication, Introduction to side-channel attacks, Countermeasures for side-channel attacks.
Activities: 1. Investigation of wireless network security challenges in 4G/5G and their countermeasures.

COURSE OUTCOMES:

At the end of the course, the students will be able to:
CO1: Examine security goals, cryptographic attacks, security services, and fundamental cryptographic techniques including symmetric ciphers and mathematical foundations of cryptography.
CO2: Compare symmetric and asymmetric key algorithms such as AES, RC4, and public key cryptosystems with respect to security, performance, and application requirements.
CO3: Implement integrity, authentication, and key management mechanisms for secure wireless communication systems.
CO4: Assess security protocols used in IP, email, and web-based communication networks.
CO5: Develop and simulate security protocols and wireless network security mechanisms for 4G/5G networks, including side-channel attack countermeasures.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Internal Examinations (60%), Activities (40%).

REFERENCES:

1.	William Stallings, Cryptography and Network Security: Principles and Practice, Ninth Edition, Pearson, 2023.
2.	Behrouz A. Forouzan and Debdeep Mukhopadhyay, Cryptography and Network Security, Fourth Edition, McGraw Hill, 2022.

3.	Atul Kahate, Cryptography and Network Security, Fifth Edition, McGraw Hill, 2021.
4.	Charlie Kaufman, Radia Perlman and Mike Speciner, Network Security: Private Communication in a Public World, Third Edition, Wiley, 2021.
5.	William Stallings, Wireless Communications and Networks, Third Edition, Pearson, 2022.
E resources/E materials:	
Course Type: NPTEL**Course, Title:** Cryptography and Network Security, **Web Link:** https://nptel.ac.in/courses/106105031	
Course Type: NPTEL, **Course Title:** Computer Networks and Internet Protocol, **Web Link:** https://nptel.ac.in/courses/106105183	
Course Type: Online Course (Coursera),**Title:** Cryptography I (Stanford University), **Web Link:** https://www.coursera.org/learn/crypto	
Course Type: OpenCourseWare (MIT OpenCourseWare),**Title:** Computer Systems Security, **Web Link:** https://ocw.mit.edu/courses/6-858-computer-systems-security-fall-2014/	

Mapping of Course Outcomes with Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	2	1	1	1
CO2	3	1	2	1	1	1
CO3	3	1	2	1	1	1
CO4	3	1	2	1	1	1
CO5	3	1	2	1	1	1
CO	3	1	2	1	1	1

PROFESSIONAL ELECTIVES

CU26001	Radiation Systems	L	T	P	TW/SL	Total	C	SDG
		45	0	0	45	90	3	3,4,7,9,11,13,17

COURSE OBJECTIVES:

- To understand the basic principles, types and radiation mechanisms of antennas.
- To learn the design and analysis of antenna arrays and beam forming techniques.
- To study aperture, horn, slot, and reflector antennas and their performance.
- To explore modern antennas such as micro strip, fractal, MIMO and wearable antennas.
- To understand antenna measurement techniques and evaluate antenna performance parameters.

COURSE CONTENT:

Unit 1	Antenna Fundamentals and Wire Antennas	9	0	0	9	18		4,9

Radiation mechanisms, Maxwell's equations, antenna parameters, dipole, monopole, loop analysis, current distribution, radiation integrals. Numerical methods -MoM, FEM, FDTD, simulation tools.

Activities:

Write a report on real-world antenna installations

Unit 2	Antenna Arrays and Beamforming	9	0	0	9	18		4,9,11

Linear arrays –uniform, end fire and broad side arrays, planar arrays; Linear array synthesis techniques – Binomial and Chebyshev distributions; Beamforming; phased arrays, smart antennas, Mutual Coupling in Finite Arrays.

Activities:

1. MATLAB/Python simulation of linear and planar array patterns
2. Comparison chart activity of beamforming methods.

Unit 3	Aperture and Reflector Antennas	9	0	0	9	18		4,7

Field equivalence principle, Aperture radiation, Radiation from Rectangular and Circular apertures, Babinet’s principle, Slot antenna; Horn antenna; Reflector antenna-types and design. GTD, performance metrics.

Activities:

1. Design exercise: horn/reflector using standard formulas
2. Concept map of diffraction and equivalence principles

Unit 4	Modern and Specific Antennas	9	0	0	9	18		4,9,3,17

Microstrip, fractal, reconfigurable, MIMO, mm Wave, THz, wearable and implantable antennas, feeding and tuning methods.

Activities:

1. Mini project: Microstrip or fractal antenna design using CST/HFSS
2. Invited expert talk on recent trends in antenna design

Unit 5	**Antenna Measurements**	**9**	**0**	**0**	**9**	**18**		**4,3,13,17**

Antenna test environments, anechoic/reverb chambers, gain, pattern, impedance, polarization.

Activities:

1. Lab visit or virtual demo of anechoic chamber setup
2. Report writing on modern antenna testing.

COURSE OUTCOMES:

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

CO1: Identify fundamental antenna concepts, radiation mechanisms and numerical analysis methods.
CO2: Apply array design and synthesis techniques to realize beamforming and smart antenna systems.
CO3: Make use of aperture and reflector antenna theories to design and evaluate practical antennas.
CO4: Analyze modern and specialized antennas and their feeding/tuning techniques.
CO5: Examine how modern simulation tools and measurement techniques influence the design accuracy and performance analysis of antennas.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Internal Examinations (60%), Activities (40%).

REFERENCES:

1.	M. I. Skolnik," Advanced Antenna Systems for 5G Network Deployments", CRC Press, 2020.
2.	Zhijun Zhang, "Antenna Design for 5G and Beyond", Academic Press, 2021.
3.	L. Lu et al, "Massive MIMO for Wireless Communications", Cambridge University Press, 2020.
4.	David B. Davidson, "Computational Electromagnetics for RF and Microwave Engineering", Cambridge University Press, 2021.
5.	Robert J. Mailloux," Phased Array Antennas for Radar, Communications and Remote Sensing", Institution of Engineering and Technology, 2021.
6.	K. Wu et al., "Millimeter Wave Antennas for 5G Networks", Springer, 2020.

E resources/E materials:

1.	https://web.njit.edu/~gary/320/antennas.pdf
2.	https://www.mathworks.com/help/antenna/
3.	https://library.nrao.edu/public/memos/aro/ARO_21.pdf

4.	https://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=6287639
5.	NPTEL: Antenna measurement modules https://nptel.ac.in/courses/108/101/108101092/

Mapping of Course Outcomes with Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	-	2	1	-	-
CO2	2	-	3	3	2	-
CO3	3	-	3	3	2	1
CO4	2	-	3	3	2	2
CO5	3	2	3	2	3	3
CO	2	2	3	2	2	2

CU26002	**Telecommunication System Modeling and Simulation**	**L**	**T**	**P**	**TW/SL**	**Total**	**C**	**SDG**
		45	**0**	**0**	**45**	**90**	**3**	**4,9,11,12**

COURSE OBJECTIVES:

- To understand the fundamentals of simulation methodology and performance estimation in communication systems.
- To study random signal generation and processing techniques for communication system modeling.
- To understand Monte Carlo simulation methods and their application in wireless system performance evaluation.
- To study modeling and simulation of nonlinear and time-varying communication systems.
- To understand efficient simulation techniques such as importance sampling for communication systems.

COURSE CONTENT:

Unit 1	**Simulation Methodology**	**9**	**0**	**0**	**9**	**18**		**4,9,11**

Aspects of methodology, Performance Estimation, Simulation sampling frequency, Low pass equivalent simulation models for bandpass signals, Multicarrier signals, Non-linear and time-varying systems, Post processing – Basic graphical techniques and estimations.
Activity: Simulating a Multicarrier Communication System and Analyzing Performance.

Unit 2	**Random Signal Generation & Processing**	**9**	**0**	**0**	**9**	**18**		**4, 9**

Uniform random number generation, Mapping uniform random variables to an arbitrary pdf, Correlated and Uncorrelated Gaussian random number generation, PN sequence generation, Random signal processing, Testing of random number generators. **Activity**: Generating and Processing Random Signals.								
Unit 3	**Monte Carlo Simulation**	**9**	**0**	**0**	**9**	**18**		**9,11**
Simulation concepts, Application to communication systems, Monte Carlo integration, Semianalytic techniques, Case study: Performance estimation of a wireless system. **Activity**: Monte Carlo Simulation for Wireless System Performance Estimation.								
Unit 4	**Advanced Models & Simulation Techniques**	**9**	**0**	**0**	**9**	**18**		**9,11,12**
Modeling and simulation of nonlinearities: Types, Memoryless non-linearities, Non-linearities with memory, Modeling and simulation of Time varying systems: Random process models, Tapped delay line model, Modelling and simulation of waveform channels, Discrete memoryless channel models, Markov model for discrete channels with memory. **Activity:** Modeling and Simulating Non-linear and Time-Varying Communication Systems.								
Unit 5	**Efficient Simulation Techniques**	**9**	**0**	**0**	**9**	**18**		**9,12**
Tail extrapolation, pdf estimators, Importance Sampling methods, Case study: Simulation of a Cellular Radio System. **Activity**: Efficient Simulation of a Cellular Radio System Using Importance Sampling.								
COURSE OUTCOMES:								
At the end of the course, the students will be able to: CO1: Utilize simulation methodologies and performance estimation techniques. CO2: Implement random signal generation and processing methods in communication system modeling. CO3: Use Monte Carlo simulation methods for performance evaluation of wireless systems. CO4: Execute modeling techniques for nonlinear and time-varying communication systems. CO5: Examine efficient simulation techniques such as importance sampling in communication								
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%								
Assessment Methodology: Internal Examinations (60%), Activities(40%).								
REFERENCES:								
1.	A. L. Imoize, O. O. Oyerinde, A. E. Ibhaze and M. A. Adebisi, “Computational Modeling and Simulation of Advanced Wireless Communication Systems”, CRC Press, 2024.							
2.	Averill M. Law,” Simulation Modeling and Analysis”, McGraw-Hill, sixth Edition, 2024.							

3.	Giuseppe Caso and Luca De Nardis, "Simulation and Modeling for Wireless Communications", Wiley, 2022.
4.	Wan Lei, Anthony C. K. Soong, Jianhua Zhang, Mohammed Mahtab Alam and Howard Wang, "5G System Design: An End-to-End Perspective", Springer, second Edition, 2021.
5.	Jerry Banks, John S. Carson, Barry L. Nelson, David M. Nicol**,** Discrete-Event System Simulation, Pearson, fifth Edition, 2019.
E resources/E materials:	
1.	NPTEL – Simulation of Communication Systems Using MATLAB
2.	MATLAB Communications Toolbox - https://www.mathworks.com/help/comm/
3.	CppSim Communication System Tutorials - https://cppsim.org/tutorials.html

Mapping of Course Outcomes with Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	3	3	3	1
CO2	2	1	3	3	3	1
CO3	2	1	3	3	3	1
CO4	2	1	3	3	3	1
CO5	2	1	3	3	3	1
CO	2	1	3	3	3	1

CU26003	**Satellite Based Systems**	**L**	**T**	**P**	**TW/SL**	**Total**	**C**	**SDG**
		45	**0**	**0**	**45**	**90**	**3**	**4, 9,11,13, 15**

COURSE OBJECTIVES:

- To introduce the fundamental concepts of satellite communication and various satellite navigation systems.
- To provide knowledge of Global Navigation Satellite Systems, GPS, inertial navigation, and differential positioning techniques.
- To explain remote sensing principles, satellite imaging systems, sensors, and their applications in safety of life services.

- To familiarize students with satellite-based broadcasting systems and multimedia communication services.
- To enable students to design, analyze, and simulate image processing applications and IPv6-based satellite communication networks using open source tools.

COURSE CONTENT:

Unit 1	**Satellite and GPS**	**9**	**0**	**0**	**9**	**18**		**4, 9,11**

Satellite communication: Space segment, Ground segment, Types of orbit, Types of service, Global Navigation Satellite Systems- Basic concepts of GPS and its segments, GPS constellation, GPS measurement characteristics, selective availability, Anti spoofing .

Activities (Flipped classroom and Quiz):

1. Flipped classroom followed by a quiz where students learn Satellite and GPS through preclass study.

Unit 2	**Inertial Navigation and Differential GPS**	**9**	**0**	**0**	**9**	**18**		**4, 9,11**

Inertial Navigation-Inertial Sensors-Navigation coordinates system implementations-System level Error Models, Differential GPS: LADGPS-WADGPS-WAAS - GEO Uplink Subsystem (GUS) - GEO Uplink Subsystem (GUS), Clock Steering Algorithms - GEO Orbit Determination-Problems.

Activity (Seminar Presentation):

1. Technical seminar presentation on different GPS systems.

Unit 3	**Remote Sensing Systems and Techniques**	**9**	**0**	**0**	**9**	**18**		**4,13,15**

Commercial Imaging-Digital Globe-GeoEye-Meteorology-Meteosat-Land Observation-Landsat, Remote Sensing Data, Sensor, Optical Sensors: Cameras, Non-Optical Sensors- Image Processing-Image Interpretation- System Characteristics.

Activity :

1. Satellite image analysis and interpretation using Landsat/Meteosat data.

Unit 4	**Broadcast Systems**	**9**	**0**	**0**	**9**	**18**		**4,9**

Satellite Radio Systems-XM Satellite Radio Inc. -Sirius Satellite Radio-world space- Direct Multimedia Broadcast- MBCO and TU Multimedia-European Initiatives-Direct to Home Television-Implementation Issues -DTH Services ,Representative DTH Systems - Military Multimedia Broadcasts - US Global Broadcast Service (GBS)- Business TV(BTV), GRAMSAT, Specialized services - E-mail, Video conferencing, Internet.

Activity (Seminar Presentation):

1. Technical seminar presentation on Broadcast Systems.

Unit 5	**Satellite Communication in IPV6 Environment**	**9**	**0**	**0**	**9**	**18**		**4, 9,11**

IPv6 and its benefits for Satellite Networks - Migration and Coexistence- Implementation scenarios and support- Preparations for IPv6 in Satellite communication- Satellite specific protocol issues in IPv6 - Impact of IPv6 on Satellite network architecture and services, Detailed transitional plan- IPv6 demonstration over satellites - Key results and recommendations.

Activity (Model Making):

1. Design and simulation of IPv6 based networks using network simulator tools.

COURSE OUTCOMES:

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

CO1: Utilize Satellite Navigation and Global Positioning System concepts.

CO2: Apply inertial navigation and DGPS methods to find accurate position.

CO3: Interpret remote sensing methods to analyze satellite images.

CO4: Evaluate satellite broadcasting methods in communication systems like DTH and radio.

CO5: Assess IPv6-based satellite communication networks and their performance.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Internal Examinations (60%), Activities (40%).

REFERENCES:

1.	Gerard Maral, Michel Bousquet, and Zhili Sun, "Satellite Communications Systems: Systems, Techniques and Technology", Sixth Edition, John Wiley & Sons, 2020.
2.	Timothy Pratt and Jeremy E. Allnutt, "Satellite Communications", Third Edition., John Wiley & Sons, 2019.
3.	Gerard Maral, Michel Bousquet, Zhili Sun, "Satellite Communications Systems: Systems, Techniques and Technology", Sixth Edition.2020.
4.	Shkelzen Cakaj, "Ground Station Design and Analysis for LEO Satellites: Analytical, Experimental and Simulation Approach", Wiley, 2022.
5.	Teresa M. Braun and Walter R. Braun, "Satellite Communications Payload and System", Second Edition, Wiley, 2021.
6.	Minoli, D. "Satellite systems engineering in an IPv6 environment", CRC Press, 2019.
7.	Ramjee Prasad, "Satellite Communications and Networks", River Publishers, 2021.
8.	Jianjun Zhang and Jing Li, "Laser Inter-Satellite Links Technology", Wiley, 2022.

E resources/E materials:

1.	https://archive.nptel.ac.in/courses/117/105/117105131.
2.	https://link.springer.com/article/10.1007/BF03655018.

Mapping of Course Outcomes with Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2	1	-
CO2	3	1	2	3	2	-
CO3	2	1	2	3	2	-
CO4	2	2	1	3	2	1
CO5	2	2	1	3	2	1
CO	2	1	2	3	2	1

CU26004	Wavelets and Sub-band Coding	L	T	P	TW/SL	Total	C	SDG
		45	0	0	45	90	3	4,9,11,12,17

COURSE OBJECTIVES:

- To apply signal decomposition techniques for analyzing signals.
- To use two-channel filter banks for signal decomposition.
- To implement multiresolution analysis for signal representation.
- To execute Continuous Wavelet Transform (CWT) for time-frequency signal analysis.
- To implement linear transform techniques for signal compression.

COURSE CONTENT:

Unit 1	Signal Decompositions techniques	9	0	0	9	18		4,9

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

Activities:1. Case study: Analyze a speech signal using time-frequency representation.
2. Quiz: Basics of inner product, orthonormal basis, and signal representation.

Unit 2	Discrete-Time Bases and Filter Banks	9	0	0	9	18		4,9

Series Expansions of Discrete - Time Signals - Two-Channel Filter Banks – Tree Structured Filter Banks - Multichannel Filter Banks - Pyramids and Over complete Expansions - Multidimensional Filter Banks - Tran multiplexers and Adaptive Filtering in Subbands.

Activities:1. Case study: Implement tree-structured filter banks for multi-level signal decomposition.
2. Think pair share: Discuss challenges in designing multichannel filter banks.

Unit 3	Multiresolution Analysis and Construction of Wavelets	9	0	0	9	18		4,9,11

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.

Activities: 1. Case study: Construct wavelets using Fourier techniques and analyze frequency localization.

2. Concept map activity: Wavelet framework (scaling function, wavelet function, decomposition levels).

Unit 4	**Continuous Wavelet and Frames**	**9**	**0**	**0**	**9**	**18**		**4,9,17**

Continuous Wavelet Transform: Analysis and Synthesis, Properties, Morlet Wavelet - Continuous Short-Time Fourier Transform: Properties - Frames of Wavelet and Short Time Fourier Transforms: Discretization of Continuous-Time Wavelet and Short-Time Fourier Transforms, Reconstruction in Frames, Frames of Wavelets and STFT

Activities:1. Case study: Analyze Continuous Wavelet Transform for time-frequency analysis of a signal using Morlet wavelet.

2. Research paper writing: Applications of Continuous Wavelet Transform and STFT in real-world signal processing.

Unit 5	**Signal Compression and Sub Band Coding**	**9**	**0**	**0**	**9**	**18**		**4,9,12**

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

Activities:1. Case study: Implement transform coding for image compression and evaluate performance.

2. Research paper writing: Recent advancements in transform-based compression techniques.

COURSE OUTCOMES:

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

CO1: Identify Fourier and time-frequency techniques for signal analysis.

CO2: Apply filter bank techniques for signal decomposition and subband processing.

CO3: Implement multiresolution analysis and wavelet construction techniques

CO4: Analyze Continuous Wavelet Transform, STFT, and frame-based signal representations.

CO5: Examine signal compression techniques including audio, image, and video compression methods.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Internal Examinations (60%), Activities (40%)

REFERENCES:

1.	Cajetan M. Akujuobi, “Wavelets and Wavelet Transform Systems and Their Applications: A Digital Signal Processing Approach”, Springer, 2022.

2.	Sabrine Arfaoui, Anouar Ben Mabrouk, and Carlo Cattani, “Wavelet Analysis”, CRC Press, 2023.
3.	M S Sinith, Gayathri A, and Chithra K R, “Wavelets and Multi-Resolution Analysis: A Signal Processing Approach”, Springer, 2025.
4.	Firdous A. Shah and Azhar Y. Tantary, “Wavelet Transforms: Kith and Kin”, CRC Press, 2022.
5.	William A. Pearlman, “Mathematical Transformations and Wavelet Filters for Source Coding and Signal Processing Systems”, Springer, 2023.
E resources/E materials:	
1.	https://nptel.ac.in/courses/117101123
2.	https://archive.nptel.ac.in/courses/108/101/108101093/
3.	https://www.math.purdue.edu/~lucier/692/DJL-image-compression.pdf

Mapping of Course Outcomes with Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	2	1	1
CO2	1	1	2	2	1	1
CO3	1	1	2	2	1	1
CO4	1	2	2	2	1	1
CO5	1	1	2	2	1	1
CO	1	1	2	2	1	1

CU26005	Application Specific Integrated Circuits	L	T	P	TW/SL	Total	C	SDG
		45	0	0	45	90	3	3, 4, 8, 9
COURSE OBJECTIVES:								
● Prepare the student to be an entry-level industrial standard ASIC or FPGA designer. ● To analyze the issues and tools related to ASIC/FPGA design and implementation. ● To understand basics of System on Chip and Platform based design.								
COURSE CONTENT:								
Unit 1	**Introduction to ASICS, CMOS Logic and ASIC Library Design**	**9**	**0**	**0**	**9**	**18**		**3, 4, 8, 9**

Types of ASICs - Design flow - CMOS transistors - Combinational Logic Cell – Sequential logic cell-Data path logic cell - Transistors as Resistors - Transistor Parasitic Capacitance- Logical effort. **Activities:** 1.Quiz 2. Assignment on calculations of logical effort of gates.								
Unit 2	**Programmable ASICS, Programmable ASIC Logic Cells and Programmable ASIC I/O Cells**	**9**	**0**	**0**	**9**	**18**		**3, 4, 8, 9**
Anti-fuse - static RAM - EPROM and EEPROM technology - Actel ACT - Xilinx LCA –Altera FLEX - Altera MAX DC & AC inputs and outputs - Clock & Power inputs - Xilinx I/O blocks. **Activities:** 1.Quiz 2.Assignment on programming techniques for ASICs.								
Unit 3	**Programmable ASIC Architecture**	**9**	**0**	**0**	**9**	**18**		**3, 4, 8, 9**
Architecture and configuration of Spartan / Cyclone and Virtex / Stratix FPGAs — Micro-Blaze / Nios based embedded systems – Signal probing techniques. **Activities:** 1.Quiz 2.Assignment on ASIC and Embedded systems.								
Unit 4	**Logic Synthesis, System Partitioning, Placement and Routing**	**9**	**0**	**0**	**9**	**18**		**3, 4, 8, 9**
Logic synthesis - System partitioning- ASIC floor planning- placement and routing – power and clocking strategies. **Activities:** 1.Write simple Verilog/VHDL modules and synthesize them using EDA tools.								
Unit 5	**High Performance Algorithms for ASICs/ SOCs- SOC case studies**	**9**	**0**	**0**	**9**	**18**		**3, 4, 8, 9**
DAA and computation of FFT and DCT. High performance filters using delta-sigma modulators.Case studies: Digital camera, SDRAM, High speed data standards. **Activities:** 1.ASIC Implementation of sequential circuits and verify design rule compliance.								
COURSE OUTCOMES:								
At the end of the course, the students will be able to: CO1: Articulate ASIC types, design flow, and timing analysis. CO2: Illustrate programmable ASIC logic and I/O cells. CO3: Compare the architectures of FPGAs and embedded systems and its signal probing methods. CO4: Demonstrate logic synthesis, system partitioning, placement and routing using EDA tools. CO5: Investigate new developments in SOC and low power design.								
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%								
Assessment Methodology: Internal Examinations (60%), Activities(40%).								

REFERENCES:	
1.	Vaibbhav Taraate, “ASIC Design and Synthesis: RTL Design using Verilog”, Springer, 2021.
2.	Kevin Hubbard, “Mastering FPGA Chip Design: For Speed, Area, Power, and Reliability”, Elektor International Media, 2025.
3.	Shirshendu Roy, “Advanced Digital System Design A Practical Guide to Verilog Based FPGA and ASIC Implementation”, Springer, 2024.
4.	Sheetal Umesh Bhandari, Anuradha D. Thakare, “Artificial Intelligence Applications and Reconfigurable Architectures”, Wiley, 2023.
E resources/E materials:	
1.	https://vlsitalks.com/
2.	https://www.wevolver.com/article/the-ultimate-guide-to-asic-design-from-concept-to-production
3.	https://anysilicon.com/asic-design-from-spec-to-chips/

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Programme Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	2	1	2	2
CO2	1	1	2	1	2	2
CO3	1	1	2	1	2	2
CO4	1	1	2	1	2	2
CO5	1	1	2	1	2	2
CO	1	1	2	1	2	2