ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.E. COMMUNICATION AND NETWORKING
REGULATIONS 2023

VISION OF DEPARTMENT OF ELECTRONICS ENGINEERING:

The Department of Electronics Engineering is committed to produce globally competitive and socially sensitized graduates in Electronics & Communication Engineering. We seek to instill the spirit of creativity and leadership skills enabling the students to make a global impact towards the availability of technology to mankind from all walks of life.

MISSION OF DEPARTMENT OF ELECTRONICS ENGINEERING

- To impart high quality technical education to students from socially and economically diverse backgrounds
- Give solid foundation on Mathematical skills and allied fields of Electronics & Communication
- To produce students with technical competence to design sophisticated systems in Electronics & Communication
- To make high quality research contribution in the field of Electronics, Communication, Networking, VLSI & Signal Processing
- To collaborate with industries in Electronics & Communication in the indigenous product development
- To inculcate qualities of leadership and entrepreneurship in students
- To facilitate adequate exposure to the faculty enabling them to be synchronized with the Cutting edge technology

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.E. COMMUNICATION AND NETWORKING
REGULATIONS 2023

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. Acquire core competence and excel in communication and networking based industries.

II. Serve in research establishments and contribute towards the development of sophisticated communication, signal processing and networking systems.

III. Become entrepreneurs and contribute towards indigenous product development which could compete in global market.

2. PROGRAMME OUTCOMES (POs):

PO#	GRADUATE ATTRIBUTE	PROGRAMME OUTCOME
1.	Research aptitude	An ability to independently carry out research /investigation and development work to solve practical problems
2.	Technical documentation	An ability to write and present a substantial technical report/document
3.	Technical competence	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.
4.	Engineering Design	Ability to design and conduct experiments, perform analysis, signal processing and networking systems by applying the knowledge of computing, mathematics, science and electronic engineering.
5.	Conduct investigations of complex problems	Interpret the problems of communication and investigate solutions and work towards improved solutions.
6.	Life-long Learning	Continuously update knowledge with modern tools and technical developments and ensure professional development.

3. PROGRAMME SPECIFIC OUTCOMES (PSOs):

By the completion of Communication and Networking programme, students will have the following programme specific outcomes.

I. Foundation of communication and signal processing systems: Ability to understand the basics principles of communication, signal processing and understand their implementation issues.

II. Foundation of networking systems: Ability to understand the various technologies behind the recent communication standards and work towards improved solutions.

III. Foundations of Mathematical concepts: Ability to apply mathematical knowledge to solve complex signal processing algorithms and networking issues.

IV. Applications of Communication and networking and Research ability: Ability to use knowledge in various domains to identify research gaps and provide innovative solutions.

4. PEO/PO Mapping:

PEOs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
I.	3	1	3	3	3	3
II.	3	2	3	3	3	3
III.	3	2	3	3	2	3
IV.	3	1	3	2	2	2

1- Low, 2 - Medium, 3 - High

SEM	SUBJECTS	PROGRAMME OUTCOMES (PO)					
		PO1	PO2	PO3	PO4	PO5	PO6
I	Applied Mathematics for Network Engineers	3	1.4	2	1.8	1	1
	Research Methodology and IPR	2.2	1.8	1	3	2	1.2
	Wireless Broadband Networks	2.8	1	2	1.6	1	1.4
	Digital Communication Techniques	3	2	3	3	2	1
	RF Engineering	3	1	3	2.2	1.6	1.6
	Cognitive Radio Communication and Networks	3	1	2	1.6	2.4	2.4
	RF System Design Laboratory	3	3	3	3	1.2	1.4
II	Adaptive Signal Processing Techniques	3	1	2	2	1	1.4
	Network Security	2.8	2	3	2	1.8	1
	Wireless Mobile communication	2	2	2	2	2	1
	Advanced Optical Communication Systems	2.2	1	2.2	2.2	2.2	2.2
	Professional Elective I						
	Professional Elective II						
	Networking Laboratory	3	3	2	2	1.4	1
	Wireless Technology Laboratory	3	3	2.6	2	1	1
III	Professional Elective III						
	Professional Elective IV						
	Professional Elective V						
	Project Work I	3	3	3	3	3	3
IV	Project Work II	3	3	3	3	3	3

PROFESSIONAL ELECTIVES (PEC)							
		PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
1.	IoT and Applications	3	1	3	1.6	1.6	1.2
2.	Digital Image and Video Processing	3	1	3	1.6	1.6	2.2
3.	Real Time Systems	1.8	2.6	3	1.8	1.8	1
4.	Advanced Computer Networks	3	1	3	3	3	2.8
5.	Antenna theory and design	3	1	3	2.2	3	1.8
6.	Signal Integrity For High-Speed Electronic Systems	3	1	1.6	1.8	1	1
7.	Ad hoc and sensor networks	3	3	1	1.2	1.2	1.2
8.	Game theory for Communication and Networking	3	1	3	2.8	2.8	2.2
9.	Applied Electromagnetics	2.8	1	2.8	2.8	2.8	2.8
10.	Wireless Personal Area Communication Networks	3	3	1.4	1.6	1.6	1.6
11.	Free Space Optical Communication	2.8	1	2.8	2.8	2.8	2.8
12.	Microwaves and Radar	3	1	1.6	2.4	1.4	1.4
13.	Computational Electromagnetics	2.8	1	2.8	2.8	2.8	2.8
14.	Wireless Transceiver Design	3	1	3	2.2	1.6	1.4
15.	Computational Intelligence	3	2	3	1.6	2	2
16.	Optical Networks	2.6	1	3	2.8	1	2.6
17.	Software Defined Network	3	1	3	2.4	2.4	2
18.	Microwave Photonics	2.8	1	2.8	2.8	2.8	2.8
19.	Electromagnetic Interference and Electromagnetic Compatibility	2.8	1	2.8	2.8	2.8	2.8
20.	Machine learning for next generation communication networks	3	1	3	3	3	1.4
21.	Ultra Wideband Communication	3	1	3	2.2	2.2	1.4

22.	Advanced Wireless Communication Techniques	2.4	1	2	1.8	1.2	1.4
23.	Radio Over Fiber for 5G Networks	3	1	3	2.2	2.2	1.8
24.	Information Theory and Coding	3	1	2.6	1.6	1.6	1.8
25.	Spread Spectrum Techniques and Applications	2.2	1	2	2	1.8	1.2
26.	Space Time wireless Communication	2.6	1	2.4	2.6	1.8	1.8
27.	Satellite Communication	2	1	2	2	2	1
28.	RF IC Design	3	1	3	2	2	1
29.	Antenna for 5G and 6G Communication	3	1	3	1.6	2.2	1.4
30.	Network Routing Protocols	3	1	2	1.6	1.6	1.2

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.E. COMMUNICATION AND NETWORKING
REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM
CURRICULUM AND SYLLABI
SEMESTER I

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3157	Applied Mathematics for Network Engineers	FC	4	0	0	4	4
2.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
3.	WT3151	Wireless Broadband Networks	PCC	3	0	0	3	3
4.	NE3101	Digital Communication Techniques	PCC	3	0	2	5	4
5.	NE3152	RF Engineering	PCC	3	0	0	3	3
6.	NE3151	Cognitive Radio Communication and Networks	PCC	3	0	0	3	3
PRACTICALS								
7.	NE3161	RF System Design Laboratory	PCC	0	0	4	4	2
			TOTAL	**18**	**1**	**6**	**25**	**22**

SEMESTER II

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	C		
THEORY								
1.	NE3251	Adaptive Signal Processing Techniques	PCC	3	0	0	3	3
2.	NE3201	Network Security	PCC	3	0	2	5	4
3.	NE3202	Wireless Mobile Communication	PCC	3	0	2	5	4
4.	NE3203	Advanced Optical Communication Systems	PCC	3	0	0	3	3
5.		Professional Elective I	PEC	3	0	0	3	3
6.		Professional Elective II	PEC	3	0	0	3	3
PRACTICALS								
7.	NE3211	Networking Laboratory	PCC	0	0	4	4	2
8.	WT3261	Wireless Technology Laboratory	PCC	0	0	4	4	2
			TOTAL	**18**	**0**	**12**	**30**	**24**

SEMESTER III

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective III	PEC	3	0	0	3	3
2.		Professional Elective IV	PEC	3	0	0	3	3
3.		Professional Elective V	PEC	3	0	0	3	3
PRACTICALS								
4.	NE3311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	NE3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 73

FOUNDATION COURSES (FC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	MA3157	Applied Mathematics for Network Engineers	4	0	0	4	1

PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	WT3151	Wireless Broadband Networks	3	0	0	3	1
2.	NE3101	Digital Communication Techniques	3	0	2	4	1
3.	NE3152	RF Engineering	3	0	0	3	1
4.	NE3151	Cognitive Radio communication and Networks	3	0	0	3	1
5.	NE3161	RF System Design Laboratory	0	0	4	2	1
6.	NE3251	Adaptive Signal Processing Techniques	3	0	0	3	2
7.	NE3201	Network Security	3	0	2	4	2
8.	NE3202	Wireless Mobile Communication	3	0	2	4	2
9.	NE3203	Advanced Optical Communication Systems	3	0	0	3	2
10.	NE3211	Networking Laboratory	0	0	4	2	2
11.	WT3261	Wireless Technology Laboratory	0	0	4	2	2
		TOTAL CREDITS				**32**	

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	RM3151	Research Methodology and IPR	2	1	0	3	1
					TOTAL CREDITS	**3**	

PROFESSIONAL ELECTIVES

S. No.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	NE3057	IoT and Applications	PEC	3	0	0	3	3
2.	NE3053	Digital Image and Video Processing	PEC	3	0	0	3	3
3.	VE3051	Real Time Systems	PEC	3	0	0	3	3
4.	NE3001	Advanced Computer Networks	PEC	3	0	0	3	3
5.	NE3002	Antenna Theory and Design	PEC	3	0	0	3	3
6.	WT3058	Signal Integrity for High Speed Electronic Systems	PEC	3	0	0	3	3
7.	NE3003	Ad Hoc and Sensor Networks	PEC	3	0	0	3	3
8.	NE3055	Game Theory for Communication and Networking	PEC	3	0	0	3	3
9.	NE3004	Applied Electromagnetics	PEC	3	0	0	3	3
10.	NE3059	Wireless Personal Area Communication Networks	PEC	3	0	0	3	3
11.	WT3251	Free Space Optical Communication	PEC	3	0	0	3	3
12.	NE3005	Microwaves and Radar	PEC	3	0	0	3	3
13.	NE3006	Computational Electromagnetics	PEC	3	0	0	3	3
14.	WT3060	Wireless Transceiver Design	PEC	3	0	0	3	3
15.	NE3052	Computational Intelligence	PEC	3	0	0	3	3
16.	NE3007	Optical Networks	PEC	3	0	0	3	3
17.	NE3058	Software Defined Network	PEC	3	0	0	3	3
18.	NE3008	Microwave Photonics	PEC	3	0	0	3	3
19.	NE3054	Electromagnetic Interference and Electromagnetic Compatibility	PEC	3	0	0	3	3
20.	NE3009	Machine Learning for Next Generation Communication Networks	PEC	3	0	0	3	3
21.	WT3057	Ultra Wideband Communication	PEC	3	0	0	3	3
22.	WT3051	Advanced Wireless Communication Techniques	PEC	3	0	0	3	3
23.	WT3054	Radio Over Fiber for 5G Networks	PEC	3	0	0	3	3
24.	NE3056	Information Theory and Coding	PEC	3	0	0	3	3
25.	WT3056	Spread Spectrum Techniques and Applications	PEC	3	0	0	3	3

26.	WT3059	Space Time Wireless Communication	PEC	3	0	0	3	3
27.	NE3010	Satellite Communication	PEC	3	0	0	3	3
28.	WT3055	RF IC Design	PEC	3	0	0	3	3
29.	NE3051	Antenna for 5G and 6G Communication	PEC	3	0	0	3	3
30.	WT3052	Network Routing Protocols	PEC	3	0	0	3	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	NE3311	Project Work I	0	0	12	6	3
2.	NE3411	Project Work II	0	0	24	12	4
TOTAL CREDITS						**18**	

SUMMARY

	Name of the Programme: M.E Communication and Networking					
	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1.	FC	4				4
2.	PCC	15	18			33
3.	PEC		6	9		15
4.	RMC	3				3
5.	EEC			6	12	18
6.	**TOTAL CREDIT**	**22**	**24**	**15**	**12**	**73**

MA3157 APPLIED MATHEMATICS FOR NETWORK ENGINEERS L T P C
4 0 0 4

UNIT I LINEAR ALGEBRA 12

Vector spaces – norms – Inner Products – Eigen values using QR transformations – QR factorization - generalized eigenvectors – Canonical forms – singular value decomposition and applications - pseudo inverse – least square approximations --Toeplitz matrices and some applications.

UNIT II SPECIAL FUNCTIONS 12

Bessel's equation – Bessel function – Recurrence relations - Generating function and orthogonal property for Bessel functions of first kind – Fourier-Bessel expansion.

UNIT III GRAPH ALGORITHMS 12

Graphs – Sub graphs – Complements – Graph isomorphism – Eulerian graphs –Hamiltonian graphs - Planar graphs– Kruskals algorithm – Dijkstras shortest path algorithm, Prims algorithm– Transport Networks.

UNIT IV ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, inverse power method.

UNIT V RANDOM PROCESSES 12

Classification – Auto correlation - Cross correlation - Stationary random process – Markov process –- Markov chain - Poisson process – Gaussian process

TOTAL: 60 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Work with vector spaces and linear transformations and their applications.
CO 2. Use the ideas of Special Functions in solving special types of problems.
CO 3. Apply Graph Theory algorithms in networks.
CO 4. Use various methods of solving systems of Algebraic Equations and eigenvalue problems.
CO 5. Apply the ideas of random processes.

REFERENCES:

1. Balakrishnan R., Ranganathan K., “A textbook of Graph theory”, Springer, 2nd Edition, New York, 2012.
2. Erwin Kreyszig. “Advanced Engineering Mathematics”, John Wiley & Sons, 10th Edition, New York, 2010.
3. Glyn James, “Advanced Modern Engineering Mathematics”, Pearson/Prentice Hall, 5th Edition, Horlow, 2018.
4. Oliver C. Ibe, “Fundamentals of Applied Probability and Random Processes”, Academic Press, (An imprint of Elsevier), Boston, 2014.
5. Peter V.O'Neil, “Advanced Engineering Mathematics”, Cengage Learning, 8th Edition, Singapore, 2017.
6. Ralph P. Grimaldi, "Discrete and combinatorial Mathematics", Pearson Education, 5th Edition, New Jersey, 2004.

7. Richard Bronson and Gabriel B. Costa, “Linear Algebra”, Academic Press, 3rd Edition, Amsterdam, 2013.
8. Richard Bronson, “Matrix Operation”, Schaum’s outline series, McGraw Hill, 2nd Edition, New York, 2011.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
AVG	3	3	3	3	2	2

RM3151 RESEARCH METHODOLOGY AND IPR L T P C
2 1 0 3

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

WT3151	WIRELESS BROADBAND NETWORKS	L	T	P	C
		3	0	0	3

UNIT I WIRELESS PROTOCOLS 9

Mobile network layer- Fundamentals of Mobile IP, data forwarding procedures in mobile IP, IPv4, IPv6, IP mobility management, IP addressing - DHCP, Mobile transport layer-Traditional TCP, congestion control, slow start, fast recovery/fast retransmission, classical TCP improvements Indirect TCP, snooping TCP, Mobile TCP

UNIT II 3G EVOLUTION 9

IMT-2000 - W-CDMA, CDMA 2000 - radio & network components, network structure, packet - data transport process flow, Channel Allocation, core network, interference-mitigation techniques, UMTS-services, air interface, network architecture of 3GPP, UTRAN – architecture, High Speed Packet Data-HSDPA, HSUPA.

UNIT III 4G EVOLUTION 9

Introduction to LTE-A – Requirements and Challenges, network architectures – EPC, E- UTRAN architecture - mobility management, resource management, services, channel -logical and transport channel mapping, MAC control element, PDU packet formats, scheduling services, random access procedure.

UNIT IV LAYER-LEVEL FUNCTIONS 9

Characteristics of wireless channels - downlink physical layer, uplink physical layer, MAC scheme-frame structure, resource structure, mapping, synchronization, reference signals and channel estimation, interference cancellation – CoMP, Carrier aggregation.

UNIT V 5G AND 6G EVOLUTION 9

5G Roadmap - Pillars of 5G - 5G Architecture, The 5G internet - IoT and context awareness - Networking reconfiguration and virtualization support - Mobility QoS control - emerging approach for resource over provisioning, small cells for 5G mobile networks - Mobile data demand, Demand Vs Capacity, Small cell challenges, conclusion and future directions. Introduction to 6G.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Design and implement the various protocols in wireless networks.
- **CO 2.** Analyze the architecture of 3G network standards.
- **CO 3.** Analyze the difference of LTE-A network design from 4G standard.
- **CO 4.** Design the interconnecting network functionalities by layer level functions.
- **CO 5.** Explore the current generation (5G) network architecture.

REFERENCES:

1. Erik Dahlman, Stefan Parkvall and Johan Skold ,"5G NR: The Next Generation Wireless Access Technology"Academic Press, 2020.
2. Jonathan Rodriguez, "Fundamentals of 5G Mobile networks", John Wiley, 2015.
3. Sassan Ahmadi, "LTE-Advanced – A practical systems approach to understanding the 3GPP LTE Releases 10 and 11 radio access technologies", Elsevier, 2014.
4. Abd-Elhamid M. Taha and Hossam S. Hassanein, Najah Abu Ali ,"LTE, LTE-Advanced and WiMAX", John Wiley, 2012
5. Vijay K.Garg, "Wireless Network Evolution - 2G & 3G". Prentice Hall; August 2011,
6. Clint Smith,P.E, Dannel Collins, "3G Wireless Networks" Tata McGrawHill, 2nd Edition, 2011.
7. Kareh Pahalavan, "Principles of Wireless Networks" Prentice-Hall of India, 2008.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	2	1	1	2
CO2	3	3	2	1	1	2
CO3	3	3	2	1	1	1
CO4	3	3	2	1	1	1
CO5	2	2	2	1	1	1
AVG	2.8	2.8	2	1	1	1.4

NE3101 DIGITAL COMMUNICATION TECHNIQUES L T P C

3 0 2 4

UNIT I SIGNALING SCHEMES 9+6

Base band signaling: Line Coding schemes & their Power spectra. Band pass Signaling: Geometric Representation of signals – BER and PSDs of Binary ASK, PSK, FSK, QPSK. Principles of QAM, CPFSK, OQPSK, MSK, GMSK -Link Budget.

- Analyze the PSD of various Line Codes - polar, uni-polar and bi-polar
- Communication link simulation using SDR platform
- BER performance analysis of digital modulation techniques using SDR platform

UNIT II MULTICARRIER MODULATION 9+6

OFDM: Generation of sub-carriers using the IFFT - Guard Time and Cyclic Extension - Windowing - Peak to Average Power reduction schemes. Case study on IEEE 802.11a WLAN and Mobile WiMAX. Principles of Multicarrier CDMA (MC-CDMA), Filter Bank Multicarrier (FBMC).

- OFDM transceiver design using simulink / SDR

UNIT III ERROR CONTROL TECHNIQUES 9+6

Channel coding - bandwidth expansion - coding gain - Linear Block Codes- Error correction vs detection. Encoding and Decoding of convolutional codes and cyclic codes - Principles of Turbo and LDPC codes.

- Performance analysis of convolutional and cyclic error control codes

UNIT IV COMPRESSION TECHNIQUES 10+6

Review of PCM, DPCM & DM- ADPCM – LPC – Vector Quantization – Transform coding techniques – Sub-band Coding – Huffman coding – LZW – Run Length coding – Intra-frame and inter-frame compression in video

- Performance analysis of image compression using lossy and lossless technique

UNIT V SPREAD SPECTRUM TECHNIQIUES 8+6

Spread Spectrum - PN Sequences, Direct Sequence Spread Spectrum (DSSS)- Frequency Hop Spread Spectrum (FHSS) - Slow FHSS & Fast FHSS, BER Analysis, Processing gain and Jamming Margin - Applications.

- Design and analyse the performance of Spread Spectrum : DSSS and FHSS

TOTAL: 75 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. analyze the different digital modulation techniques in the design of communication systems.

CO 2. understand the optimal resource utilization in the multiuser environment.

CO 3. design the various errors control coding schemes and carry out their implementations.

CO 4. design compression techniques as applicable to the specific application

CO 5. acquire knowledge about generation of pn sequence codes and its implementation in spread spectrum techniques

REFERENCES:

1. B.Sklar, “Digital Communications, Fundamentals and Applications”, 2nd Edition, Pearson Education 2001.
2. Simon Haykin, Michael Moher and David Koilpillai, Modern Wireless communications, Pearson, 2011.
3. B.P.Lathi, “Modern Digital and Analog Communication Systems”, 3rd Edition, Oxford University Press, 2011.
4. J.G.Proakis, M.Salehi, “Fundamentals of Communication Systems”, Pearson Education 2014.
5. Robert C. Dixon, "Spread Spectrum Systems with Commercial Applications", 3rd Edition, John Wiley & Sons, Ins, 1994.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	3	3	2	1
CO2	3	2	3	3	2	1
CO3	3	2	3	3	2	1
CO4	3	2	3	3	2	1
CO5	3	2	3	3	2	1
AVG	**3**	**2**	**3**	**3**	**2**	**1**

NE3152 **RF ENGINEERING** **L T P C**
3 0 0 3

UNIT I NETWORKS AND MATRICES 9

Scattering and chain scattering matrices, Generalized scattering matrix, Analysis of two port networks, Interconnection of networks. Positive real concepts, scattering matrix, representation of microwave components (directional coupler, circulators, hybrids and isolators).

UNIT II HIGH FREQUENCY CIRCUIT DESIGN 9

Tuned Circuits, Filter design- Butterworth filter, Chebyshev filter, impedance matching. High frequency amplifier, BJT and FET amplifier, Broadband Amplifiers RF Oscillators, Colpitts, Hartley Oscillators, PLL. High Frequency Integrated Circuits.

UNIT III MICROWAVE AMPLIFIER DESIGN 9

Types of amplifiers, Power gain equations. Introduction to narrow band amplifiers basic concepts, IMD3, IIP3 and SFDR, Maximum gain design, Low noise design. High power design, Negative resistance, reflection amplifiers – various kinds – stability considerations, Microwave transistor amplifier design – input and output matching networks – constant noise figure circuits, IC based Microwave amplifier design.

UNIT IV MICROWAVE OSCILLATOR DESIGN 9

One port and two port negative resistance oscillators. Oscillator configurations, Oscillator design using large signal measurements, Introduction to Microwave CAD packages, Microwave integrated circuits, MIC design for lumped elements, IC based Oscillator Design.

UNIT V RF AND MICROWAVE ANTENNAS 9

Radiation from surface current and line current distribution, Basic Antenna parameters, Feeding structure-Patch Antenna, Ring Antenna, Micro strip dipole, Micro strip arrays, Traveling wave Antenna, Antenna System for Mobile Radio-Antenna Measurements and Instrumentation. Propagation characteristics of RF and Microwave signals, Introduction to EBG structures, Antenna for 5G/6G Mobile Networks.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the student should be able to:

CO1: Apply scattering parameters in RF circuit and systems
CO2: Develop filters for high frequency applications
CO3: Design amplifiers for RF transceivers
CO4: Understand the RF oscillator design techniques
CO5: Develop antennas for high frequency applications.

REFERENCES:

1. Charles E. Free, Colin S. Aitchison, “RF and Microwave Circuit Design: Theory and Applications” John Wiley & Sons Ltd, 2021.
2. Kraus.J.D, Marhefka.R.J. Khan.A.S. “Antennas and Wave Propagation”, Tata Mc Graw Hill, New Delhi, 5 th Edition, 2017
3. Reinhold Ludwig and Gene Bogdanov, "RF Circuit Design – Theory and Applications", Pearson, 2 nd Edition, 2012.
4. David. M. Pozar, "Microwave Engineering", John Wiley and Sons, 4 th Edition, 2012.
5. E.da Silva, "High Frequency and Microwave Engineering", Butterworth Heinmann

Publications, Oxford, 2001.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	1	3
CO2	3	1	3	1	1	2
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1
AVG	3	1	3	2.2	1.6	1.6

NE3151 COGNITIVE RADIO COMMUNICATION AND NETWORKS L T P C
3 0 0 3

UNIT I SOFTWARE DEFINED RADIO 9

Introduction to SDR, Brief history of SDR, Networking and SDR, RF Architecture for SDR, Processing architectures for SDR, Software environments for SDR, Benefits of Using SDR, Problems Faced by SDR.

UNIT II COGNITIVE RADIO COMMUNICATION & NETWORKS 9

Cognitive Radio Communications: Cognitive Radios and Dynamic Spectrum Access, Analytical Approach and Algorithms for Dynamic Spectrum Access, Mathematical Models Toward Networking Cognitive Radios. Cognitive Radio Networks: CRN Architecture, Terminal Architecture of CRN, QoS Provisional Diversity Radio Access Networks. Radio XML coding for CRN

UNIT III SPECTRUM SENSING AND MANAGEMENT 9

Spectrum Sensing to Detect Specific Primary System : Conventional Spectrum Sensing, Power Control, Power Scaling, Cooperative Spectrum Sensing. Spectrum Sensing for Cognitive OFDMA Systems- Cognitive Cycle, Discrimination of States of the Primary System, Spectrum Sensing techniques - Energy detector, Matched filter, Feature detector. Spectrum Sensing for Cognitive Multi-Radio Networks : Multiple System Sensing, Radio Resource Sensing. Spectrum Management of CRN: Sharing, Pricing, Mobility Management of Heterogeneous Wireless Networks

UNIT IV USER COOPERATIVE COMMUNICATIONS 9

User Cooperation and Cognitive Systems , Relay Channels: General Three-Node Relay Channel, Wireless Relay Channel , User Cooperation in Wireless Networks: Two-User Cooperative Network, Cooperative Wireless Network , Multihop Relay Channel

UNIT V APPLICATIONS OF COGNITIVE RADIO 9

Regulatory scenario for TV space, Dynamic spectrum access models. Overview of IEEE 802.22 standard - Applications, Reference architecture. IEEE 802.22 Physical layer, Medium access control layer, Spectrum sensing algorithms. Applications of Cognitive radio in IoT - Applications of Cognitive radio in 5G networks.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Understand the basics of Software Defined Radio

CO 2. Understand the fundamental concepts and architecture of cognitive radio communication and networks.

CO 3. Evaluate different spectrum sensing mechanisms and management in cognitive radio communication and networks

CO 4. Implementation of radio domain competence and formalizing radio knowledge using radio XML (RXML)

CO 5. Explore various applications of cognitive radio systems in WRAN, IoT, 5G networks.

REFERENCES:

1. Travis F. Collins Robin Getz Di Pu Alexander M. Wyglinski ,"Software-Defined Radio for Engineers", Artech House Publishers; Unabridged edition, 2018.
2. Kwang-Cheng Chen, Ramjee Prasad, “Cognitive radio networks”, John Wiley & Sons Ltd., 2009.
3. Alexander M. Wyglinski, Maziar Nekovee , Thomas Hou, " Cognitive Radio Communications and Networks: Principles and Practice", Academic Press Inc; Illustrated edition, 2009.
4. Huseyin Arslan, “Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems”, Springer, 2007.
5. Joseph Mitola III, " Cognitive Radio Architecture: The Engineering Foundations of Radio XML", John Wiley & Sons, Inc., Hoboken, New Jersey, 2006.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	2	2	2	2
CO2	3	1	2	2	2	2
CO3	3	1	2	1	3	3
CO4	3	1	2	1	3	3
CO5	3	1	2	2	3	3
AVG	3	1	2	1.6	2.4	2.4

NE3161 **RF SYSTEM DESIGN LABORATORY** **L T P C**
0 0 4 2

LIST OF EXPERIMENTS:

1. Measurement of transmission line parameters using network analyzer
   (a) Reflection coefficient (b) VSWR
2. Design of Microstrip transmission line
   (a) λ/2 line (b) λ/4 line (c) λ/8 line
3. Design and characterization of RF filters
4. Design of impedance matching network
5. Measurement of RF signals and their spectrum at 5G sub-GHz band
6. Design and characterization of antennas
7. Design and Characterization of antenna for 5G/6G mobile networks
8. Design and characterization of LNA
9. Design and characterization of Mixer
10. Design and characterization of VCO

TOTAL: 60 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Measure the RF network parameters

CO 2. Design and develop RF filters

CO 3. Design and develop antennas for RF applications

CO 4. Construct new circuit and systems for high frequency applications

CO 5. Test RF components and systems

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	3	3	1	2
CO2	3	3	3	3	2	1
CO3	3	3	3	3	1	2
CO4	3	3	3	3	1	1
CO5	3	3	3	3	1	1
AVG	3	3	3	3	1.2	1.4

NE3251 ADAPTIVE SIGNAL PROCESSING TECHNIQUES L T P C
3 0 0 3

UNIT I DISCRETE RANDOM SIGNAL PROCESSING 9

Discrete Random Processes, Random variables, Parseval's theorem, Wiener-Khintchine relation, Power Spectral Density, Spectral factorization, Filtering Random Processes, Special types of Random Processes.

UNIT II SPECTRAL ESTIMATION 9

Introduction, Nonparametric methods – Periodogram, Modified periodogram, Bartlett, Welch and Blackman-Tukey methods, Parametric methods – ARMA, AR and MA model based spectral estimation, Solution using Levinson-Durbin algorithm.

UNIT III WEINER AND ADAPTIVE FILTERS 9

Weiner Filter: FIR wiener filter, IIR wiener filter, Adaptive Filter: FIR adaptive filters – Steepest descent method- LMS algorithm, RLS adaptive algorithm, Applications.

UNIT IV DETECTION AND ESTIMATION 9

Bayes detection techniques, MAP, ML – detection of M-ary signals, Neyman Peason, minimax decision criteria. Kalman filter- Discrete Kalman filter, The Extended Kalman filter, Application.

UNIT V SYNCHRONIZATION 9

Signal parameter estimation, carrier phase estimation, symbol timing estimator, joint estimation of carrier phase and symbol timing.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On successful completion of this course, students will be able to

CO1 Analyze the basic principles of discrete random signal processing.

CO2 Analyze the principles of spectral estimation.

CO3 Analyze and design the Weiner and adaptive filters.

CO4 Analyze the different signal detection and estimation methods.

CO5 Design the synchronization methods for proper functioning of the system

REFERENCES:

1. John G. Proakis., "Digital Communication", McGraw Hill Publication, 5th edition,2014.
2. Simon Haykin, “Adaptive Filter Theory”, Pearson Education, 5th edition,2013.
3. Paulo S. R. Diniz, “Adaptive Filtering Algorithms and Practical Implementation”, Springer,4th edition,2013.
4. Monson H. Hayes, “Statistical Digital Signal Processing and Modeling”, John Wiley andSons, Inc, Singapore ,2009.

5. Kay Steven M, “Fundamentals of Statistical Processing: Estimation Theory Volume 1 and 2 (Estimation & detection Theory”, Pearson,1993 .

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	2	2	1	1
CO2	3	1	2	2	1	1
CO3	3	1	2	2	1	1
CO4	3	1	2	2	1	2
CO5	3	1	2	2	1	2
AVG	3	1	2	2	1	1.4

NE3201 NETWORK SECURITY L T P C
3 0 2 4

UNIT I MATHEMATICS OF CRYPTOGRAPHY 9+6

Introduction: Security Goals, Need for security, Types of attacks, Security Services and Mechanisms. Mathematics of symmetric cryptography: Modular arithmetic, Matrices, Linear congruence, Algebraic structures, GF(2^n) Fields. Mathematics of Asymmetric cryptography: Primes, Fermat's and Euler's Theorem, Primality Testing, Factorization, Chinese Remainder Theorem, Quadratic, Exponentiation & Logarithm.

- Computation of Modular arithmetic, Matrices, Extended Euclidean algorithm, Exponentiation and Logarithm using Matlab
- Analyse the complexity of testing a large Prime number
- Analyse the complexity to factor a larger number using Factorization mets

UNIT II MODERN SYMMETRIC AND ASYMMETRIC CIPHERS 9+6

Classical Techniques: Substitution Ciphers, Transposition Ciphers. Modern symmetric ciphers: Stream cipher – RC4. Block cipher – DES, AES – Uses of Modes of operation. Modern Asymmetric block ciphers – RSA, Rabin, ElGamal.

- Implementation of Classical Cipher Techniques - Substitution & Transposition Ciphers
- Implementation of AES Block cipher
- Implementation of RSA cipher

UNIT III MESSAGE INTEGRITY AND AUTHENTICATION TECHNIQUES 9+6

Message Integrity: MAC. Cryptographic Hash Functions: SHA 512. Digital Signature Schemes – RSA, Elgamal. Entity Authentication: Passwords, Challenge Response, Zero-knowledge. Key management system: Symmetric Key Distribution – Kerberos – Public key distribution

- Implementation of SHA 512 algorithm to calculate message digest for an arbitrary message
- Implementation of Digital Signature authentication mechanism
- Implementation of Diffie-Hellman key exchange mechanism and test the performance using MITM attack

UNIT IV SECURITY PROTOCOLS AND PRACTICES 10+6

Electronic Mail Security: PGP, S/MIME. Internet Protocols: TLS, SSL, SET, SSL versus SET, 3-D Secure, Electronic money. Security in GSM and 3G. Overview of Block chain and Distributed Ledger Technology.

- Analysis the security vulnerabilities of E-Mail Application
- Analysis the security vulnerabilities of E-commerce services.

- Steps to ensure security of any one web browser (Mozilla Firefox/Google Chrome)

UNIT V SYSTEM SECURITY 8+6

Intruders- Intrusion Detection, Malicious software - Types, viruses, countermeasures, worms. Firewalls - Need for firewalls, characteristics, types.

- Study of the features of firewall in providing network security and examine the effect of firewall filtering on application response time

TOTAL: 75 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Apply number theory in symmetric and asymmetric encryption techniques.
CO 2. Design cryptographic algorithms and carry out their implementation.
CO 3. Understand the role played by authentication in security.
CO 4. Analyze the application of cryptography algorithms used in email, E-Commerce and mobile technology.
CO 5. Illustrate the importance of firewall security for network.

REFERENCES:

1. Behrouz A. Forouzan and Debdeep Mukhopadhyay, Cryptography and Network Security, third edition, Tata McGraw Hill, 2016
2. Atul Kahate, Cryptography and Network Security, Third Edition, McGraw Hill, July 2017
3. William Stallings “Cryptography and Network Security: Principles and Practice”, 7thd Edition, Pearson Education, 2017
4. Jonathan Katz and Yehuda Lindell, “Introduction to Modern Cryptography”,Chapman and Hall/CRC Press Second Edition,2015.
5. David M. Durton, “Elementary Number Theory”, Tata Mcgraw Hill, Sixth Edition, 2009

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	2	3	2	1	1
CO2	3	2	3	2	2	1
CO3	3	2	3	2	2	1
CO4	3	2	3	2	2	1
CO5	3	2	3	2	2	1
AVG	**2.8**	**2**	**3**	**2**	**1.8**	**1**

NE3202 WIRELESS MOBILE COMMUNICATION L T P C
3 0 2 4

UNIT I CELLULAR CONCEPTS 9+6

Frequency Reuse – Channel Assignment Strategies – Hand off Strategies – Interference and system capacity- Co-Channel Interference- Adjacent Channel Interference – Trunking and Grade of service – Improving coverage & capacity in cellular systems-Cell Splitting- Sectoring-Repeaters for Range Extension-Microcell Zone Concept.

UNIT II THE WIRELESS CHANNEL 9+6

Overview of wireless systems – Physical modeling for wireless channels – Time and Frequency coherence – Statistical channel models – Capacity of wireless Channel- Capacity of Flat Fading Channel – Channel Side Information at Receiver – Channel Side Information at Transmitter and Receiver –Capacity comparisons – Capacity of Frequency Selective Fading channels.

UNIT III PERFORMANCE OF DIGITAL MODULATION OVER WIRELESS CHANNELS 9+6

Performance of flat fading and frequency selective fading – Impact on digital modulation techniques – Outage Probability– Average Probability of Error – Combined Outage and Average Error Probability – Doppler Spread – Inter symbol Interference

UNIT IV DIVERSITY TECHNIQUES 9+6

Realization of Independent Fading Paths – Receiver Diversity – Selection Combing – Threshold Combing – Maximal-Ratio Combing – Equal - Gain Combing – Capacity with Receiver diversity – Transmitter Diversity – Channel known at Transmitter – Channel unknown at Transmitter – The Alamouti Scheme–MIMO Systems-Smart antenna systems, Beamforming.

UNIT V MULTICARRIER MODULATION 9+6

Data Transmission using Multiple Carriers – Multicarrier Modulation with Overlapping Subchannels – Mitigation of Subcarrier Fading – Discrete Implementation of Multicarrier Modulation –Peak to average Power Ratio- Frequency and Timing offset. Wireless LAN, WiMAX, GSM, WCDMA, 3GPP LTE and 5G standards

LIST OF EXPERIMENTS:

1. Study of Co channel and adjacent channel interference
2. Study of different path loss models
3. Study of CDMA
4. Performance of Flat fading and frequency selective fading channels
5. Effect of digital modulation in different models
6. Doppler spread effect
7. Study of MIMO channel capacity, PAPR
8. Study of Almouti scheme
9. Case study of multicarrier modulation system

TOTAL: 75 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Identify the solutions for cellular communication
CO 2. Compute the capacity of wireless channels
CO 3. Analyze the performance of the digital modulation techniques in fading channels.
CO 4. Estimate various diversity techniques in wireless communication.
CO 5. Apply multicarrier systems in wireless communication

REFERENCES:

1. Theodore.S. Rappaport, “Wireless Communications: Principles and Practice", 2nd Edition, Pearson Education, India, 2009.
2. Andrea Goldsmith, “Wireless Communications”, Cambridge University Press, 2005.
3. David Tse and Pramod Viswanath, “Fundamentals of Wireless Communication”, Wiley Series in Telecommunications, Cambridge University Press, 2005.
4. Andrea Molisch, Wireless Communications, John Wiley & Sons, 2005.
5. Keith Q. T. Zhang, “ Wireless Communications: Principles, Theory and Metology” 1st Edition, John Wiley & Sons, 2016.
6. Ramjee Prasad, "OFDM for Wireless Communication Systems", Artech House,2004.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	2	1	1	1	1
CO2	2	2	2	2	2	1
CO3	3	2	3	3	3	1
CO4	2	2	2	2	2	1
CO5	3	2	3	3	3	1
AVG	**2**	**2**	**2**	**2**	**2**	**1**

NE3203 ADVANCED OPTICAL COMMUNICATION SYSTEMS L T P C
3 0 0 3

UNIT I REVIEW OF OPTICAL COMMUNICATIONS SYSTEMS 9

Optical fibers, dispersion, link budget, Time Division Multiplexing, Sub Carrier Multiplexing and code division multiplexing. Systems: Passive optical Network, Hybrid fiber coax architectures, Radio over fiber technologies, free space optics

UNIT II MODERN OPTICAL COMPONENTS 9

VCSEL, QW lasers, Multi section DFB lasers, Tunable lasers, Electro absorption modulator, Integrated transmitters and receivers, optical switches and routers, WDM components, Optical schemes for microwave generation, PCF and PCF components

UNIT III NON LINEAR FIBER OPTICS AND AMPLIFIERS 9

Nonlinear optics – basics, Brilluion, Raman effects, Four wave mixing, optical phase conjugation, Solitons, Communication using solitons, WDM solitons. Optical Amplifiers-SOA, EDFA, DRFA. Fiber lasers

UNIT IV DISPERSION COMPENSATION SCHEMES 9

Pre, post and mixed compensation schemes, Optical filters for compensation, Delay line filters, Dispersion slope compensation, Dispersion and Nonlinearity, Dispersion maps, multi channel compensation schemes.

UNIT V OPTICAL NETWORKS 9

Optical Network Concepts, Network Topologies, SONET/SDH, IP over DWDM, Optical Ethernet. Modulators for Gigabit networks, Limitations of direct modulation, External modulators - types, Generation and detection of advanced Modulation Techniques.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Distinguish different optical communication systems
- **CO 2.** Outline the various optical components and its performances
- **CO 3.** Examine the nonlinear effects in optical fiber links and schemes to mitigate them
- **CO 4.** Have a thorough knowledge on dispersion and identify its mitigation techniques
- **CO 5.** An understanding about optical networks and performance of various modulation and detection shemes

REFERENCES:

1. G.P.Agarwal,“Fiber optic communication system”,John Wiley &sons,New York, 5th Edition, 2021.
2. Gred Keiser, Optical fiber communications” 5ed Tata Mc Graw Hill,New Delhi,2017.

3. G.P.Agrawal,“Lightwave technology: Components and devices”, John Wiley and Sons, NewJersy, 2004
4. G.P Agrawal,” Nonlinear fiber optics”, 5th edition Academic press, Elsevier, Oxford,.2013.
5. Shiva kumar, M.Jamal Deen, Fiber optic communications:”Fundamentals and applications”, John Wiley,2014

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	1	1	1	1	1
CO2	2	1	2	2	2	2
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	2	1	2	2	2	2
AVG	**2.2**	**1**	**2.2**	**2.2**	**2.2**	**2.2**

NE3211 NETWORKING LABORATORY

(Experiments using NS2/ QUALNET/NS3/ MATLAB/packet tracer equivalent) **L T P C**

0 0 4 2

LIST OF EXPERIMENTS:

1. Configuration of LAN, VLAN & WLAN.
2. Implementation of IP Sub-netting.
3. To study ICMP, TCP and HTTP packets using wireshark.
4. Analyze MAC protocols for wired and wireless networks : ALOHA, CSMA, CSMA CD/CA etc
5. Analyze LLC Protocols for wired and wireless networks: Stop & Wait & Sliding window
6. Implement routing protocols AODV/ DSR and analyze its performance using simulator
7. Scheduling & queuing method on the network performance - FIFO, Priority Based, WFQ etc
8. Security algorithms analysis: Symmetric key ciphers - AES and Asymmetric key ciphers - RSA.
9. Analyze the low power communication standards in terms of throughput and energy efficiency - Zigbee, 6LOWPAN, LORA
10. Throughput, End-End delay comparison study of 802.11a,b,802.16
11. Write python script to create topology in Mininet and configure OpenFlow switches with POX controller to communicate between nodes.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Configure functionalities of router and switches.

CO 2. Understand the need for various flow control, routing, scheduling and queuingalgorithms for the wired and wireless networks

CO 3. Understand the importance of Network security mechanisms.

CO 4. Compare and contrast various wireless technologies.

CO 5. Assess the importance of low power communication standards protocols for wirelessdevices.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	2	2	2	1
CO2	3	2	2	2	2	1
CO3	3	2	2	2	1	1

CO4	3	2	2	2	1	1
CO5	3	2	2	2	1	1
AVG	**3**	**2**	**2**	**2**	**1.4**	**1**

WT3261 WIRELESS TECHNOLOGY LABORATORY L T P C
0 0 4 2

LIST OF EXPERIMENTS:

1. Configure wireless router and wireless devices and create a wireless network. environment to verify transmission of data between device to wireless network.
2. Protocol analysis on the created wireless network (IEEE 802.11).
3. Packet analysis on the deployed wireless network (IEEE 802.11).
4. Network analysis of (IEEE 802.11) wireless network and observe hacking and attack information from the wireless network protocols.
5. Perform and measure the interactions between client and server communication on deployed network.
6. Validation of two server and two device configuration and communication under two different network.
7. Setting up a network and its configurations to measure a network service such as voice service over network.
8. Perform MITM attack to wireless network and observation of users information from an compromised user.
9. Create a hacking platform of an user OS and find possible attacks.
10. Hacking of an web page by an OS platform and observation of an compromised user details.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Understand the functioning of various protocols in wireless environment.
CO2: Perform real-time experimentation using the existing infrastructure.
CO3: Get exposed to open source networking tools.
CO4: Gain knowledge in constructing WLAN, and VLAN
CO5: Design a network and verify new service

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO1	4	4	4	1	1	1
CO2	4	4	4	1	1	1
CO3	4	4	4	1	1	1
CO4	4	4	4	1	1	1
CO5	3	3	1	1	1	1
AVG	3	2	2.6	1	1	1

NE3057 **IoT AND APPLICATIONS** **L T P C**
3 0 0 3

UNIT I INTRODUCTION AND APPLICATIONS 9

Introduction to IoT – Definition, Characteristics, functional requirements, motivation, Physical design - things in IoT, IoT protocols, Logical Design - functional blocks, communication models, Communication APIs, Applications – Home Automation, Cities, Environment, Energy, Agriculture, Health, Industry

UNIT II IoT DESIGN & SYSTEM MANAGEMENT 9

IoT &M2M – Machine to Machine, Difference between IoT & M2M, Software Defined Network, Network function virtualization, IoT system management – SNMP, NETCONF, YANG, IoT Design methodology.

UNIT III IoT PROTOCOLS & SYSTEM 9

Protocols – HTTP, UPnP, CoAP, MQTT, XMPP. IoT systems logical design using python - python data types & data structures, control flow, functions or modules .Modules & package of python, python packages of interest for IoT-JSON, XML, HTTP & URL Lib, SMTP Lib. Exemplary Device: Raspberry Pi - Linux on Raspberry – Programming Raspberry Pi with Python.

UNIT IV IoT CLOUD & DATA ANALYTICS 9

Introduction to Cloud storage Models – WAMP – Xively Cloud for IoT – Python Web Application Framework- Django – Designing a RESTful based Web API. Data Analytics for IoT – Apache Hadoop, Apache Oozie

UNIT V IoT SECURITY 9

IoT attacks - Phase attacks, Attacks as per architecture, Attacks based on components. Security Protocols - Time-Based Secure Key Generation and Renewal – Security access algorithms for unidirectional data transmissions, Security access algorithms for bidirectional data transmissions

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Interpret the vision of IoT from a global context.
- **CO 2.** Compare and Contrast the use of Devices, Gateways and Data Management in IoT.
- **CO 3.** Design a portable IoT using any Single Board Computer and relevant protocols
- **CO 4.** Analyze applications of IoT in real time scenario
- **CO 5.** Deploy an IoT application and connect to the cloud.

REFERENCES:

1. Qusay F, Hassan, Atta Ur Rehman Khan and Sajjad A.Madani, “Internet of Things – Challenges, Advances and Applications” , CRC Press, Taylor & Francis Group, 2019
2. Olivier Hersent, David Boswarthick, and Omar Elloumi, “The Internet of Things – Key Applications and Protocols”, City Press, Delhi, 2017.
3. Fei Hu, “Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations,” 1st Edition, CRC Press, 2016.
4. Arshdeep Bahga, Vijay Madisetti, "Internet of Things - A hand on approach” ,Universities Press (India) Private Limited, 2014.
5. William Stallings, Lawrie Brown, “Computer Security: Principles and Practice”, Pearson, 3 rd Edition, 2014.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	1	2
CO2	3	1	3	1	1	1
CO3	3	1	3	2	2	1
CO4	3	1	3	2	2	1
CO5	3	1	3	2	2	1
AVG	3	1	3	1.6	1.6	1.2

NE3053 DIGITAL IMAGE AND VIDEO PROCESSING L T P C
3 0 0 3

UNIT I IMAGE ENHANCEMENT 9

Digital image fundamentals - Image sampling - Quantization - Spatial domain filtering- intensity transformations - Contrast stretching - Histogram equalization - Smoothing filters, Sharpening filters –Noise distributions-Mean filters-Order statistics filters

UNIT II IMAGE TRANSFORMS 9

1DDFT-2D Transforms- DFT-DCT- Walsh- Hadamard- Slant- Haar-KLT –SVD Wavelet transform

UNIT III IMAGE RESTORATION AND SEGMENTATION 9

Image restoration – degradation model-Unconstrained and Constrained restoration – Inverse filtering –Wiener filtering- Image segmentation- Thresholding- Edge detection- Edge linking- Region based methods-Texture Descriptors- Boundary Descriptors-Graph based segmentation - Hybrid methods

UNIT IV IMAGE COMPRESSION 9

Need for data compression -Redundancy-Image Compression Schemes-Run Length coding-Huffman - Arithmetic coding - LZW technique - Vector Quantization -JPEG—MPEG

UNIT V VIDEO PROCESSING 9

Sampling and Interpolation of video- Back ground Subtraction – Frame difference- Static and dynamic background modeling -Video analytics - Video object Segmentation - Object Detection – Face Recognition –Motion Estimation-Shadow removal.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Implement image enhancement algorithms
- **CO 2.** Apply image transform for different imaging modalities
- **CO 3.** Perform different segmentation and restoration processes
- **CO 4.** Implement different compression techniques
- **CO 5.** Develop algorithms for computer vision problems

REFERENCES:

1. Rafael C. Gonzalez, Richard E. Woods, “Digital Image Processing”, Pearson Education, Inc.,4th Edition,2017
2. AnilK. Jain,"Fundamentals of Digital Image Processing”,Prentice Hall of India, 2015.

3. Richard Szeliski, "Computer Vision - Algorithms and Applications", Springer Verlag London Limited,2011.
4. Alan Bovik, “Handbook of Image and Video Processing”,2nd Edition, 2005.
5. Milan Sonka, Vaclav Hlavac and Roger Boyle, “Image Processing, Analysis & Machine Vision”,Brookes/Cole,Vikas Publishing House, 2nd edition,1999.
6. Sid Ahmed, M.A., “ Image Processing Theory, Algorithms and Architectures”,Mc Graw Hill,1995.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	2	1	3
CO2	3	1	3	2	2	1
CO3	3	1	3	1	2	1
CO4	3	1	3	2	2	3
CO5	3	1	3	1	1	3
AVG	3	1	3	1.6	1.6	2.2

VE3051 REAL TIME SYSTEMS L T P C
3 0 0 3

UNIT I EMBEDDED DESIGN PROCESS AND HARDWARE COMPONENTS 9

Complex Systems and RISC processors - Embedded System Design Process - Formalism for System Design - CPU - CPU Bus- CPU performance-CPU Power Consumption - Memory System Mechanism–Configuring and Programming Input and Output Peripherals - Supervisor Mode, Exceptions and Traps -Coprocessors.

UNIT II SOFTWARE TOOLS AND EMBEDDED C PROGRAMMING 9

Compilation process - Native vs Cross-Compilers - Run-time libraries - Writing a library - Using Standard and alternative libraries - Porting Kernels –Techniques for Emulation and Debugging – Embedded C Program Structure– Data types - Operators, expressions and control statements – Functions and Procedures -Structures and union.

UNIT III ARM PROCESSOR 9

ARM features and architecture–Development Tools–ARM Instruction set-Thumb Instruction set– Architectural Support for System Development and operating systems

UNIT IV REAL TIME OPERATING SYSTEM 9

Concurrent Software – Foreground/Background systems, Multithreaded Programming, Shared resources and Critical sections – Scheduling – Cyclic, Round-Robin, Priority based, Deadline driven and Rate Monotonic schedules – Memory Management – Shared Memory -Commercial operating systems.

UNIT V EMBEDDED SYSTEM DESIGN, MODELING AND VERIFICATION 9

Finite State Machines - Moore Machine - Mealy Machine - Nondeterministic Finite Automation - Programming - UML State Machines - Petri Net Definition -Properties - Timed Petri Nets - Model Checking-Temporal Logic- NuSMV Model Checking Tool-Real Time Computation Tree Logic-Practical Issues.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: To be able to explain about different hardware components and software development tools.

CO2:To be able to describe the features, architecture and instruction set of ARM processor.

CO3: To be able to detail the concept and usage of RTOS in Embedded applications.

CO4:To be able to apply the embedded system design process while building real-time applications.

CO5:To be able to design a real time embedded system.

REFERENCES:

1. Daniel W. Lewis,"Fundamentals of Embedded Software with the ARM Cortex-M3",Pearson education limited, 2nd Edition,2015.
2. Wayne Wolf,"Computers as Components-Principles of Embedded Computing System Design",Morgan Kaufmann Publishers, 2nd Edition, June2008.
3. Andrew N.Sloss, Dominic Symes, Chris Wright," ARM System Developer's Guide-Designing and Optimizing System Software", MorganKaufmann Publishers,2004.
4. Steve Heath, "Embedded Systems Design", Newnes Publications,2nd Edition,2003.
5. Steve Furber, “ARM system on chip architecture”, Pearson education limited, 2000.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	3	3	1	1	1
CO2	1	3	3	1	1	1
CO3	1	3	3	1	1	1
CO4	3	2	3	3	3	1
CO5	3	2	3	3	3	1
AVG	1.8	2.6	3	1.8	1.8	1

NE3001 ADVANCED COMPUTER NETWORKS L T P C

3 0 0 3

UNIT I INTRODUCTION TO NETWORK LAYER 9

Network layer: Services, Packet Switching, Performance. Internet Protocols: IPv4 packet format, IP addressing, sub-netting and super-netting, Classless Inter Domain Routing (CIDR), Variable Length Subnet Mask (VLSM), ICMPv4 - Types, Message format, Error reporting, Query, Debugging tools. Mobile IP - Addressing, Agents, Three phases, Inefficiency in mobile IP.

UNIT II NEXT GENERATION IP 9

Internet Protocol: IPv6 features, packet format, addressing, options. Transition from IPv4 to IPv6 - Dual stack, Tunneling, Header transition. ICMPv6 - Error reporting, Query. Address Translation Protocols - ARP, RARP, DHCP, NAT.

UNIT III FORWARDING AND ROUTING OF IP PACKETS 9

Delivery: Connection types, Direct versus Indirect, forwarding: Techniques, Forwarding with classful addressing, Forwarding with classless addressing. Routing and protocols: Intra and Inter domain routing - Unicast Routing: Distance Vector Routing - RIP, Link State Routing - OSPF, Path-vector routing - BGP, Multicast Routing: Multicast Distance Vector (DVMRP), Multicast Link State Routing (MOSPF), Protocol Independent Multicast (PIM)

UNIT IV TRANSPORT LAYER 9

Introduction to Transport Layer Protocols: UDP - Operation, use of UDP, UDP package. TCP - Services, TCP Connection, State Transition Diagram, Flow control, Error control, TCP congestion control, TCP timers, TCP options. SCTP - Services, Features, Packet format, SCTP association, State Transition Diagram, Flow control, Error control. Quality of Service - QoS Architecture, Traffic Policing, Traffic shaping, Traffic Scheduling.

UNIT V SOFTWARE DEFINED NETWORK 9

Overview, History and evolution of SDN, Traditional Switch Architecture - Traffic problems, Comparison between SDN and traditional networks. Architecture of SDN - Data Plane, Control plane and Application Plane. SDN challenges and Opportunities

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Configure network protocols at different layers of TCP/IP protocol suit.
- **CO 2.** Analyze different functionalities of routing protocols and student can able to choose routing protocol in the given network situation.
- **CO 3.** Understand the significance of transport layer protocols.
- **CO 4.** Implement IP addressing for the given network.
- **CO 5.** Understand the concepts of Software Defined Networks

REFERENCES:

1. Behrouz A. Forouzan, Data Communications and Networking with TCP/IP Protocol Suite. Sixth Edition, McGraw Hill, 2021.
2. James.F.Kurose and Keith.W.Ross, Computer Networking – A Top – Down Approach, Sixth Edition, Pearson, 2017.
3. Douglas E. Comer, Internetworking with TCP/IP Volume I sixth edition, Pearson Education India, 2015
4. High Performance Switches and Routers, H. Jonathan Chao, Bin Liu, 2007, John Wiley& Sons, Inc. ISBN-10: 0-470-05367-4
5. Goransson P, Black C, Culver T. Software Defined Networks: a Comprehensive Approach. Morgan Kaufmann; 2014.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	3	3	1
CO2	3	1	3	3	3	1
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3
AVG	3	1	3	3	3	2.8

NE3002 ANTENNA THEORY AND DESIGN L T P C

3 0 0 3

UNIT I ANTENNA PARAMETERS 9

Introduction –Types of Antennas – Radiation Mechanism – Current distribution on wire antennas – Maxwell's equations - Antenna fundamental parameters - Radiation integrals - Radiation from surface and line current distributions – dipole, monopole, loop antenna; Mobile phone antennabase

station, hand set antenna; design of dipole, monopole, loop antenna, Friis transmission equation, path loss calculation.

UNIT II ANTENNA ARRAYS 9

One Dimensional Arrays: Linear array –uniform array, end fire and broad side array, gain, beam width, side lobe level; Linear array synthesis techniques – Binomial and Chebyshev distributions; Two dimensional uniform arrays; smartantennas, switched beam and adaptive arrays, design of uniform array, broad side and end fire array.

UNIT III APERTURE ANTENNAS 9

Field equivalence principle, Radiation from Rectangular and Circular apertures, Uniform aperture distribution on an infinite ground plane; Babinets principle, Slot antenna; design, Horn antenna; Reflector antenna, aperture blockage, and design consideration.

UNIT IV MICROSTRIP ANTENNA 9

Radiation Mechanism and Excitation techniques :Microstrip dipole; Patch, Rectangular patch, Circular patch, and Ring antenna – radiation analysis from cavity model; input impedance of rectangular and circular patch antenna; Microstrip array and feed network; Reconfiguration Mechanisms; Computer Aided Design of Microstrip Antennas, Microstrip Reflect array Antennas, Microstrip antenna for 5G mobile networks

UNIT V MODERN ANTENNA DESIGN 9

Mobile antennas, limits of antenna design, antenna matching, single and dual band matching, PIFA – single and multi band PIFA, Vivaldi Antennas - UWB Antennas - Antennas in Medicine – Leaky Wave Antennas – Plasma Antennas – Wearable Antennas – RFID Antennas - Automotive antennas, Reconfigurable antennas - Meta materials.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Understand the basic antenna theory
- **CO 2.** Identify the concepts of antenna arrays
- **CO 3.** Apply the theory of aperture for antenna design
- **CO 4.** Design microstrip antennas
- **CO 5.** Develop antennas for various applications

REFERENCES:

1. Krauss.J.D, Ronald J Marhefka and Ahmed S khan, “Antennas and Wave Propagation”, Fifth edition, Tata Mc Graw Hill, New Delhi, 2017.
2. Balanis.A, “Antenna Theory Analysis and Design”, John Wiley and Sons, New Jersey, 4 th Edition, 2016.
3. W.L.Stutzman and G.A.Thiele, “Antenna Theory and Design”, John Wiley & Sons Inc., 3 rd Edition, 2013
4. Frank B. Gross, “Frontiers in Antennas- Next Generation Design and Engineering”, Mc Graw Hill, 2011.
5. S. Drabowitch, A. Papiernik, H.D.Griffiths, J.Encinas, B.L.Smith, “Modern Antennas”, Springer Publications, 2 nd Edition, 2007.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	3	3
CO2	3	1	3	1	3	3
CO3	3	1	3	3	3	1
CO4	3	1	3	3	3	1
CO5	3	1	3	3	3	1
AVG	3	1	3	2.2	3	1.8

WT3058 SIGNAL INTEGRITY FOR HIGH-SPEED ELECTRONIC SYSTEMS L T P C
3 0 0 3

UNIT I FUNDAMENTALS OF ELECTROMAGNETICS 9

The Basics - Maxwell's Equations, Common Vector Operators - Wave Propagations Electrostatics - Magneto statics - Power flow and the Poynting Vector - Reflections of Electromagnetic Waves.

UNIT II CROSS TALK AND NON IDEAL CONDUCTOR MODELS 9

Mutual Inductance and Capacitance - Coupled Wave Equations - Coupled Line Analysis - Modal Analysis - Crosstalk Minimization - Signals Propagation in Unbounded Conductive Media - Classic Conductor Model for Transmission models.

UNIT III DIELECTRIC MATERIALS 9

Polarization of Dielectrics - Classification of Dielectric Materials - Frequency Dependent Dielectric Behavior - Fiber Weave Effect - Environmental Variation in Dielectric Behavior Transmission Line Parameters for Lossy Dielectrics and Realistic Conductors.

UNIT IV DIFFERENTIAL SIGNALING 9

Removal of Common Mode Noise - Differential Crosstalk - Virtual Reference Plane - Propagation of Modal Voltages - Common Terminology - Drawbacks of Differential Signaling.

UNIT V CHANNEL AND I/O CIRCUITS MODELLING 9

Creating a Physical Transmission Line Model - Non idea Return Paths - I/O Design Considerations - Push-Pull Transmitters - CMOS Receivers - ESD Protection Circuits - On Chip Termination - Bergeron Diagrams.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Understand the fundamental concepts of signal integrity in high speed PCBs.
- **CO 2.** Identify and resolve crosstalk.
- **CO 3.** Interpret the frequency dependence of dielectrics
- **CO 4.** Analyze the design considerations in I/O circuits.
- **CO 5.** Comprehend transmission line model

REFERENCES:

1. Stephen H. Hall, Howard L. Heck, "Advanced Signal Integrity for High-Speed Digital Designs", Second Edition, John Wiley and Sons, 2009.
2. Mike Peng Li, "Jitter, Noise, and Signal Integrity at High-Speed", First Edition, Prentice Hall, 2007.
3. Douglas Brooks, Signal Integrity Issues and Printed Circuit Board Design, First Edition, Prentice Hall PTR, 2003.

4. James Edgar Buchanan, “Signal and power integrity in digital systems: TTL, CMOS, and BiCMOS”, Second Edition, McGraw-Hill, 1996.
5. H. W. Johnson and M. Graham, “High-Speed Digital Design: A Handbook of Black Magic”, Second Edition, Prentice Hall, 1993.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	1	1	1
CO2	3	1	1	1	1	1
CO3	3	1	2	1	1	1
CO4	3	1	3	3	1	1
CO5	3	1	1	3	1	1
Avg	3	1	1.6	1.8	1	1

NE3003 AD HOC AND SENSOR NETWORKS L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Introduction to Ad hoc Networks, Characteristic features, Need for Ubiquitous Computing network, Applications of Ad hoc, Challenges for Wireless Sensor Networks-Characteristics requirements-required mechanisms, Difference between mobile ad-hoc and sensor networks, Applications of sensor networks-Single Node Architecture- Hardware Components, Energy Consumption of Sensor Nodes.

UNIT II MAC AND ROUTING PROTOCOLS 9

Physical Layer and Transceiver Design Considerations, MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols And Wakeup Concepts- Need for Different routing Protocols, Proactive Vs Reactive Routing. Unicasting: Dynamic Source Routing, Ad Hoc On-Demand Distance Vector Routing, On-Demand Multicast Routing Protocol.

UNIT III 6LoWPAN 9

6LoWPAN Architecture - protocol stack, Adaptation Layer, Link layers – Addressing. Routing - Mesh-Under - Route-Over, Header Compression - Stateless header compression. Fragmentation and Reassembly.

UNIT IV 6LoWPAN APPLICATION LAYER 9

Design Issues, Protocol Paradigms -End-to-end, Real-time streaming and sessions, Publish/subscribe, Web service paradigms, Common Protocols -Web service protocols, MQ telemetry transport for sensor networks (MQTT-S), ZigBee compact application protocol (CAP),Service discovery. , Industry- Specific protocols.

UNIT V IoT NODES 9

LoRA Transmission range, LoRA communication, LoRA devices, LoRAWAN communication, gateway, and service provider, gateway, end devices. TTN -The Things Network Infrastructure, LoRAWAN gateway- Heltec HT-M00 dual channel, Dragino LPs8. LoRA Transceivers -micro chip RN 2483, Lora WAN nodes --commercial end devices, Boards, NIC of networks - IEEE 802.3, IEEE 802.15.4, LoRAWAN.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. gain knowledge on ad hoc and sensor networks Develop efficient MAC and Routing

Protocols

CO 2. Design new MAC and Routing protocols for Sensor

CO 3. Learn about the 6LoWPAN network layer and its application layer protocols

CO4. Attain the capability to learn new network nodes LoRAWAN

REFERENCES:

1. Charles E. Perkins — Ad hoc Networking‖, Addison-Wesley, 2000
2. Tracy Camp, Jeff Boleng, Vanessa Davies, — A survey on Mobility Models for Ad hoc Network Research.‖ Wireless Communications and Mobile Computing: Special Issue on Mobile Ad hoc Networking: Research, Trends and Applications, Vol.2. No. 5. pp 483-502, 2002.
3. Hongmei Deng, Wei Li and Dharma P. Agrawal — Routing security in wireless ad hoc networks‖., IEEE Communication magazine, Oct. 2002.
4. Holger Karl & Andreas Willig, " Protocols And Architectures for Wireless Sensor Networks" , John Wiley, 2005.
5. Feng Zhao & Leonidas J. Guibas, —Wireless Sensor Networks - An Information Processing Approach", Elsevier, 2007.
6. Kazem Sohraby, Daniel Minoli, & Taieb Znati, —Wireless Sensor Networks-Technology, Protocols, And Applications‖, John Wiley, 2015.
7. Zach Shelby, Carsten Bormann, —6LoWPAN: The Wireless Embedded Internet‖ John Wiley & Sons, November 2009, ISBN: 978-0-470-74799-5.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	1	1		1
CO2	3	3	1	1	1	1
CO3	3	3	1	1	1	1
CO4	3	3	1	3	3	3
CO5	3	3	1	1	1	1
AVG	3	3	1	1.2	1.2	1.2

NE3055 GAME THEORY FOR COMMUNICATION AND NETWORKING L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Introduction to theory of games- conflict, strategy, utility theory, games in extensive and normal forms, Examples.

UNIT II NON CO-OPERATIVE GAMES 9

Basics of Non-Cooperative games, Non-Cooperative games in strategic form – Matrix games, Nash Equilibrium, Mixed Strategies. Dynamic Non-Cooperative games – Non-Cooperative game inextensive form, repeated games, and stochastic games.

UNIT III COOPERATIVE GAMES 9

Basics of Cooperative games, bargaining theory – Introduction, Nash bargaining solution, Coalitiongame theory – shape value, Dynamic Coalition formation algorithms.

UNIT IV BAYESIAN GAMES 9

Overview of Bayesian Games, Bayesian Games in extensive form, Cournot duopoly model with incomplete information, Super-Modular games, learning in games: Fictitious play, and Regret minimization, Vickrey-Clarke-Groves Auction, Optimal Auction.

UNIT V GAME THEORY APPLICATIONS IN COMMUNICATION & NETWORKING 9

Cellular & Broadband wireless access networks – Routing & Resource allocation, Power allocation, Network selection in Multi-technology, Game theoretic solutions for cooperation in ad hoc networks. Power Allocation Games and Learning in MIMO Multiuser Channels

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Explain the Game Theory models

CO 2. Classify and design strategies under Game Theory perspective

CO 3. Analyze the interaction of competitors in an imperfect market and its consequences in the short and long run.

CO 4. Make use of game theory concepts in communication and networking

CO 5. Interpret uncertainty and asymmetric information in the communication and networking field.

REFERENCES:

1. Dixit, A. K., & Skeath, S. Games of Strategy: Fourth International Student Edition. WW Norton & Company, 2015.
2. Zhu Han, Dusit Niyato, Walid Saad, Tamer Basar, Are Hjorungnes, “Game Theory in Wireless and Communication Networks: Theory, Models, and Applications”, University PressCambridge, 1st Edition, 2012.
3. Samson Lasaulce and Hamidou Tembine “Game Theory and Learning for Wireless Networks” Fundamentals and Applications, 2011.
4. Vijay Krishna, "Auction Theory", Academic Press, 2010.
5. Martin J. Osborne, “An Introduction to Game Theory”, Oxford Press, 2006.
6. Allan MacKenzie, Luiz DaSilva, "Game Theory for Wireless Engineers, Synthesis Lectureson Communication", Morgan and Claypool Publishers, 2006.
7. Drew Fudenberg and Jean Tirole, "Game Theory", MIT Press, 1991.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	2	2	1
CO2	3	1	3	3	3	1
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3
Avg	3	1	3	2.8	2.8	2.2

NE3004 APPLIED ELECTROMAGNETICS L T P C

3 0 0 3

UNIT I FUNDAMENTALS OF ELECTROMAGNETIC THEORY 9

Electric and magnetic fields; Maxwell’s equations in integral and Differential forms, Boundary conditions; Poynting's vector and energy storage; Static fields and circuit elements; Quasi- static

fields and frequency behavior of circuit elements.

UNIT II ELECTROMAGNETIC INTERFERENCE 9

Electromagnetic Environment, Practical concerns, Frequency spectrum conservation, Sources of EMI: Lightning, ESD, EMP, EMI from apparatus and circuits. Modeling of Interferences, Test sites and measurements, Simulation of EMI.

UNIT III ELECTROMAGNETIC COMPATIBILITY 9

Capacitive and inductive couplings; Crosstalk on transmission lines; Common impedance coupling; Methods of solution of EMC problems;EMI filters, Grounding and Shielding; Cables and connectors, EMC standards.

UNIT IV ELECTROMAGNETIC WAVE PROPAGATION 9

EM Waves and Radiation. Overview of propagation effects; Ground wave, Skywave, Tropospheric, Ionospheric propagation effects; Propagation models for satellite and Mobile links. EM Simulation of propagation models

UNIT V ELECTROMAGNETICS FOR LIGHT WAVE & RADAR SYSTEMS 9

Reflection, refraction, Interference and diffraction of plane waves; Dielectric slab waveguide; Pulsebroadening in a dispersive medium. RADAR, LIDAR range equations, Radar cross section (RCS).Introduction to electromagneticfieldcomputationandsimulation.

TOTAL:45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Understand the importance of EM theory for communication
- **CO 2.** Identify EMI in circuits and systems
- **CO 3.** Use appropriate EM compatibility schemes in electronic systems
- **CO 4.** Model wireless channels for communications
- **CO 5.** Apply knowledge light wave and RADAR system design.

REFERENCES:

1. N.N.Rao,"Fundamentals of Electromagnetics for Engineering",Pearson Education, 2008.
2. Abdollah Gasemi, AliAbedi, Farshid Gashemi,"Propagation Engineering in Wireless Communication".Springer Verlag, Newyork, 2016.
3. Clayton R. Paul, Robert C. Scully, Mark A. Steffka, Introduction to Electromagnetic Compatibility, 3rd Edition, John Wiley and sons, Inc, 2022
4. G.Keiser,"Fiber Optic Communications", Springer, MA, 2021
5. A.K,Sen and A.B.Bhattacharya,"Radar Systems and radio aids to navigation", Mercury Learning and Information LLC,Dulles,2019.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	2	2	2
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3
AVG	2.8	1	2.8	2.8	2.8	2.8

NE3059 WIRELESS PERSONAL AREA COMMUNICATION NETWORKS L T P C
3 0 0 3

UNIT I NETWORK INTERCONNECTION 9

Inter connection of networks- Interconnection issues, Interconnection devices: - Repeaters, Routers and Gateways. Internet protocols; IPV4, IPV6. Wireless Network Interconnection - Challenges and Issues address mobility, inefficiency of layers for wireless network inter connection - network layer, transport layer and application layer. Mobile IP – simultaneous binding, route optimization, mobile IP variations, handoffs. TCP in wireless domain – TCP over wireless, TCPs -traditional, snoop, indirect, transaction- oriented, impact of mobility.

UNIT II PAN 9

Introduction to PAN - Bluetooth, Zigebee, Wireless Sensor Networks. WSN - MAC protocols – low duty cycle protocols and wakeup concepts, contention -based and Schedule-based protocols. WSN Routing protocols – Requirements, Classification -SPIN, LEACH, PEGASIS. Node and Network architecture, design principles.

UNIT III 6LoWPAN PROTOCOLS 9

6LoWPAN Architecture - protocol stack, Link layers – Addressing, BOOTSTRAPPING, MESH topologies, Adaptation Layer - functions, assumptions in link layers, Header Compression - Stateless header compression - Context based header compression, Fragmentation and Reassembly, Forwarding and Routing - L2 forwarding - Mesh-Under - L3 Routing - Route-Over, Mobility and Routing - mobility types, solutions for mobility, mobile IPv6, Proxy Home Agent, Proxy MIPv6, Role of neighbor discovery.

UNIT IV INTERNET WORKING 9

3G Evolutions - Radio and Network Components -Characteristics of wireless channels - downlink physical layer, uplink physical layer, MAC scheme - frame structure, resource structure, mapping, synchronization, reference signals and channel estimation, SC-FDMA, interference cancellation – CoMP, Carrier aggregation, Services - multimedia broadcast/multicast, location-based services.

UNIT V OS FOR NETWORKS 9

IEEE 802.3 standard - Implementation, NIC card, protocols verifications - TinyOS – Introduction, NesC, Interfaces, modules, configuration, Programming in TinyOS using NesC, TOSSIM, CONTIKI OS – Structure, Communication Stack, Simulation environment – COOJA simulator, Programming.

TOTAL:45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1:Understand the network interconnection and heterogeneous network connection using internet protocol.

CO2: Find new design of the protocols for wireless network and wireless sensor network.

CO3: Develop protocols for resource constrained and low range networks.

CO4: Characterize and modeling the wireless channel

CO5: Implement network protocols on operating systems.

REFERENCES:

1. Jochen H.Schiller, “Mobile Communications”, 2/e, Pearson, 2014
2. Vijay K.Garg, “Wireless Network Evolution- 2G & 3G” Pearson, 2013.
3. Clint Smith,P.E, Dannel Collins, “3G Wireless Networks” 2nd edition, Tata McGraw-Hill, 2008.
4. Kaveh Pahlavan, “Principles of wireless networks”, Prentice-Hall of India, 2008.

5. Subir Kumar Sarkar, T G Basavaraju, C Puttamadappa, “Ad Hoc Mobile Wireless Networks”, Auerbach Publications, 2008
6. Holger Karl, Andreas Willig, “Protocols and Architectures for Wireless Sensor Networks”, John Wiley & Sons, Inc., 2005.
7. C.Siva Ram Murthy and B.S.Manoj, “Ad Hoc Wireless Networks – Architectures and Protocols”, Pearson Education, 2004.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	1	2	2	2
CO2	3	3	2	2	2	2
CO3	3	3	2	2	2	2
CO4	3	3	1	1	1	1
CO5	3	3	1	1	1	1
AVG	3	3	1.4	1.6	1.6	1.6

WT3251 FREE SPACE OPTICAL COMMUNICATION L T P C
3 0 0 3

UNIT I FUNDAMENTALS OF FSO TECHNOLOGY 9

Introduction -History of Optical Telecommunications-Maxwell's Equations-Electromagnetic wave propagation in an isotropic, linear homogenous medium - Propagation of a wave in a non-homogenous medium- Coherent and incoherent communication -Indoor and Outdoor FSO links, FSO versus RF and optical fiber.

UNIT II OPTICAL COMPONENTS AND SUBSYSTEMS 9

Radiometry: basic concepts - Optical spectral windows, materials and eye-safety - Transmitters - LED-Laser Diodes – Modulation Schemes – Receivers – Types of Detectors – Receiver Configuration - Optical Post and Preamplifiers -Link Design Trade-off - Acquisition, Tracking and Pointing

UNIT III FREE SPACE OPTICAL CHANNEL 9

Atmospheric Channel - Losses - Absorption and Scattering Losses - Free Space Loss – Beam Divergence Loss - Pointing Loss - Loss due to Weather Conditions - Atmospheric Turbulence – Atmospheric Turbulent Channel Model – Techniques for Turbulence Mitigation-Visibility-Atmospheric attenuation-Meteorological disturbances–channel-Modeling

UNITIV FSO LINK PERFORMANCE 9

FSO Link budget, case studies, Additional power required to reach a given bit error rate – Optical noise-BER performance of FSO System – Link Performance Improvement Techniques - Concept of quality of service and availability-Regulation of FSO equipment

UNIT V INTEGRATION OF FSO IN OPTICAL NETWORKS 9

Revolution of Optical Networking - Next Generation Optical Networking - Classifying the Global Optical Network - Driving FSO from the EDGE - FSO in Metropolitan Optical Networks – FSO Market-Installation of Free space Optical Systems – Regulation of FSO equipment Free space optics and Laser safety.

TOTAL:45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Design and analyze the free space optical communication systems.

CO 2. Identify and select suitable components for building a FSO system
CO 3. Understand FSO channels with their mathematical representation models.
CO 4. Understand the beam propagation mechanism.FSO link performance
CO 5. Understand the networking principles aspects of FSO technology

REFERENCES:

1. Hemani Kaushal, V.K Jain, Subrat Kar, "Free Space Optical Communication", Springer (India) Pvt. Ltd., 2017.
2. Hamid Hemmati," Near earth laser communications"CRC press, Boca Raton,FL,2009.
3. Arun K. Majumdar, Jennifer C. Ricklin, "Free-Space Laser Communications : Principles and Advances", Springer Science + Business Media, LLC, 2008.
4. Olivier Bouchet, HerveSizun, Christian Boisrobert, Frederique de Fornel, Pierre-Noel Favennec, "Free-Space Optics : Propagation and Communication", ISTE Ltd, 2006.
5. Heinz Willebrand, Baksheesh S. Ghuman, "Free-Space Optics : Enabling Optical Connectivity in Today's Networks", Sams Publishing, 2002.
6. Morris Katzman, "Laser Satellite Communication", Prentice Hall Inc, Newyork, 1991.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	2	2	2	2
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3
AVG	2.8	1	2.8	2.8	2.8	2.8

NE3005 MICROWAVES AND RADAR L T P C
3 0 0 3

UNIT I MICROWAVE SOURCES 9

Passive waveguide components, Microstrip line structure and components, Simple theory and operating characteristics of Reflex klystrons, Two cavity Klystrons, Magnetrons, and TWTS - solid state source - TEDS, IMPATTS, TRAPATT, GaAs FETs and Tunnel diode.

UNIT II RADAR PRINCIPLES 9

Introduction to Radar – Radar range equation – Receiver noise and signal to noise ratio- Radar cross section (RCS) – Radar system – Radar Antennas

UNIT III TYPES OF RADARS 9

CW and FMCW radars-Tracking radars-MTI radar -Principles of coherent MTI radars - Digital MTI, Synthetic Aperture radar, Principles of Pulsed Doppler Radar, Low-, High-, and medium-PRF Mode.

UNIT IV RADAR SIGNAL PROCESSING 9

Radar requirements – Matched filters -Radar ambiguity function – Optimum waveforms for detection in clutter – Classes of waveforms – Digital representation of signals -Pulse compression

UNIT V TRACKING RADAR 9

Tracking with radar — Mono pulse Tracking — conical scan and sequential lobing–limitations

to tracking Accuracy - Kalman Tracker -Fundamentals of Airborne radar-Radar Chipset.

TOTAL:45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Understand the concepts of radar
- **CO 2.** Derive radar equations
- **CO 3.** Design a radar system.
- **CO 4.** Design and implement radar tracking algorithms.
- **CO 5.** Review the types of microwave sources

REFERENCES:

1. Skolnik,M.I. Introduction to Radar System (SecondEdition) McGrawHill, 2017.
2. Filipo Neri,"Introduction to Electronic Defense Systems", 2nd Edition, Scitech, 2006.
3. Fred E.Nathanson—Radar design Principles—Signal processing and the environment, Prentice Hall, 2007
4. GuyV.Morris,LindaL. Harkness, Airborne Pulsed Dopplerradar, Second Edition, Artech House Publishers, 1996.
5. Liao,Y.Microwave Devices and Circuits, Prentice Hall,1990.
6. Michael.O.Kolawole,"RadarSystems,Peak Detection and Tracking",Elsevier, Burlington, 2002.
7. ToomayJ.C.andPaul.J.Hannen,"Principles of Radar, 3rdEdition, PHI, 2010.
8. Blackman S.S., —Multiple target tracking with radar applications, Artech House1986.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	2	2	1	1
CO2	3	1	1	3	1	2
CO3	3	1	1	3	3	2
CO4	3	1	3	3	3	2
CO5	3	1	1	1	1	1
AVG	3	1	1.6	2.4	1.4	1.4

NE3006 COMPUTATIONAL ELECTROMAGNETICS L T P C

3 0 0 3

UNIT I INTRODUCTION 9

Review of Electromagnetic Theory – Electromagnetic fields – Magneto static fields - Maxwells equations – Electro thermal formulation – Classification of EM problems.

UNIT II ANALYTICALTECHNIQUES 9

Limitation of the conventional design procedure – Need for field analysis based design –problem definition – Direct Integration Method – Variable Separable Method– Method of Images – Conformal Mapping.

UNIT III NUMERICAL TECHNIQUES 9

Finite Difference Method (FDM) – Finite Element Method (FEM) – Variational Method – Method of Moments – Transmission Line Matrix Method –Finite Difference Time Domain (FDTD).

UNIT IV FIELD COMPUTATION FOR BASIC STRUCTURES 9

Computation of Electric and Magnetic field intensities – Capacitance and Inductance –

Semiconductor Structures – Resonant Circuit Method – Frequency Band Gap for surface wave propagation – Soft and Hard surfaces.

UNIT V CASESTUDIES 9

EBG structure analysis – EBG patch antenna – Surface wave antenna – PBG structures – Physical origin of PBG – Modes – PBG application in Waveguide, Cavity, Narrow Band Filter.

TOTAL:45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Understand EM problems
- **CO 2.** Solve EM problems using analytical techniques
- **CO 3.** Numerical methods for EM problems
- **CO 4.** Use field computation methods
- **CO 5.** Design and analyze antenna and other high frequency structures

REFERENCES:

1. Nathan Ida, Joao P.A.Bastos, "Electromagnetics & Calculation of Fields", Springer-Verlag, London, 2013.
2. Fanyang& Yahya RahmatSamii, "Electromagnetic Band Gap Structures in Antenna Engineering", The Cambridge RF& Microwave Engineering Series,2014.
3. Mathew N.O. Sadiku,"Numerical Techniques in Electromagnetics with MATLAB", 4thed , CRC Press,Bocaraton,2019.
4. Jian Ning Jin," Theory and Computation of Electromagnetic Fields", 2 ed, Wiley, IEEE press, New jersey, 2015.
5. KiyotoshiYasumoto"Electromagnetic theory and applications of Photonic Crystals", CRC Press, Bocaraton, 2018.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	2	2	2	2
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3
AVG	2.8	1	2.8	2.8	2.8	2.8

WT3060 WIRELESS TRANSCEIVER DESIGN L T P C

3 0 0 3

UNIT I FUNDAMENTALS OF SYSTEM DESIGN 9

Linear systems and transformation, Non-linear system representation, Noise and Random process, elements of Digital base band system: Sampling, jitter, modulation techniques, pulse shaping, error probability detection

UNIT II RADIO ARCHITECTURES AND DESIGN CONSIDERATIONS 9

Super heterodyne architecture, direct conversion architecture, Low IF architecture, band-pass sampling radio architecture

UNIT III RECEIVER SYSTEM ANALYSIS AND DESIGN 9

Sensitivity and noise figure of receiver, intermodulation characteristics, single tone desensitization, adjacent channel selectivity and blocking characteristics, receiver dynamic range and AGC system, system design and performance evaluation

UNIT IV TRANSMITTER SYSTEM ANALYSIS AND DESIGN 9

Transmission power and spectrum, modulation accuracy, adjacent and alternate channel power, noise emission

UNIT V CASE STUDY 9

Multimode and multiband super heterodyne transceiver: selection of frequency plan, receiver system and transmitter system design - Direct conversion transceiver: receiver system and transmitter system design.

TOTAL:45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Apply knowledge in transceiver design
- **CO 2.** Understand the receiver architecture
- **CO 3.** Analyze the system parameters in receiver
- **CO 4.** Understand the transmitter system design
- **CO 5.** Apply design techniques in the RF transceivers

REFERENCES:

1. Ariel Luzzatto, MottiHaridim. "Wireless Transceiver Design: Mastering the Design of Modern Wireless Equipment and Systems" Wiley, 2nd Edition, 2016.
2. Qizheng Gu, "RF System Design of Transceivers for Wireless Communications",Springer, 2005.
3. Kai Chang , RF and Microwave Wireless Systems, John Wiley, 2004.
4. K P Pun, J E D Franca and C A Leme, "Circuit Design For Wireless Communications – Improved Techniques for Image Rejection in Wideband Quadrature Receivers", Springer, 2003.
5. Crols, Jan, Steyaert, Michiel, " CMOS Wireless Transceiver Design" , Springer, 1 st Edition, 2003

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	1	2
CO2	3	1	3	1	1	2
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1
AVG	3	1	3	2.2	1.6	1.4

NE3052 COMPUTATIONAL INTELLIGENCE L T P C

3 0 0 3

UNIT I NEURAL NETWORKS 9

Biological Neurons Networks - Artificial Neural Networks - Supervised - Unsupervised learning - Reinforcement Learning -Hebb learning- Perceptron- Back Propagation networks -Radial Basis Function Networks-Adaptive Resonance architectures -Support Vector Machines

UNIT II FUZZY LOGIC 9

Fuzzy Sets - Operations on Fuzzy Sets - Fuzzy Relations - Membership Functions - Fuzzy Rules and Fuzzy Reasoning-Fuzzy Inference Systems-Fuzzy Expert Systems-Fuzzy Decision Making

UNIT III NEURO-FUZZY MODELING 9

Adaptive Neuro- Fuzzy Inference Systems-Coactive Neuro- Fuzzy Modeling-Classification and Regression Trees-Data Clustering Algorithms-Hybrid learning algorithms-Applications of Neuro-fuzzy concepts

UNIT IV DEEP LEARNING NETWORKS 9

Introduction to Deep neural networks – Convolution neural networks – Deep Belief Networks-Recurrent neural networks – Case studies

UNIT V EVOLUTIONARY ALGORITHMS 9

Heuristics search and optimization techniques- Introduction to Genetic Algorithms – Social Algorithms– Ant colony Optimization- Particle swarm Optimization - Case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Design systems based on neural network architectures
- **CO 2.** Perform basic operations in fuzzy and design fuzzy systems
- **CO 3.** Implement neuro - fuzzy models for various applications
- **CO 4.** Design and implement deep learning architectures
- **CO 5.** Design optimization-based algorithm for various application

REFERENCES:

1. Lan Good fellow, Yoshua Bengio and Aaron Courville, “DeepLearning” The MIT Press, Cambridge,2016.
2. Jyh-ShingRogerJang,Chuen-TsaiSun,EijiMizutani,“Neuro-uzzy and Soft Computing”, Pearson Edn., 2015.
3. George J.Klir and BoYuan, “FuzzySetsand Fuzzy Logic-Theory and Applications”, Prentice Hall, 2011.
4. David E. Goldberg, “Genetic Algorithms in Search, Optimization and Machine Learning”, Pearson Education, 2008.
5. James A. Freeman and David M. Skapura, “Neural Networks Algorithms, Applications, and Programming Techniques”, Pearson Edn., 2003.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	3	1	1	1
CO2	3	2	3	1	1	1
CO3	3	2	3	2	2	2
CO4	3	2	3	2	3	3
CO5	3	2	3	2	3	3
AVG	3	2	3	1.6	2	2

NE3007 **OPTICAL NETWORKS** **L T P C**
3 0 0 3

UNIT I OPTICAL SYSTEM COMPONENTS 9

Light propagation in optical fibers-Loss& Bandwidth, System limitations, Non-Linear effect, Solitons, Optical Network\ Components- Couplers, Isolators & Circulators, Multiplexers & Filters Optical Amplifiers, Switches Wavelength Converters.

UNIT II OPTICAL NETWORK ARCHITECTURES 9

Introduction to Optical Networks**;** WDM networks, SONET/SDH, Metropolitan-Area Networks, Layered Architecture; Broadcast and Select Networks-Topologies for Broadcast Networks, Media-Access Control Protocols, Wavelength Routing Architecture. WOBAN and OTDM networks. Introduction to ASON.

UNIT III WAVELENGTH ROUTING NETWORKS 9

The Optical layer, Node Designs, Optical layer cost tradeoff, Routing and Wavelength Assignment algorithms, Virtual Topology design, Architectural variations.

UNIT IV PACKET SWITCHING AND ACCESS NETWORKS 9

Photonic Packet Switching — OTDM, Multiplexing and De multiplexing, Synchronization, Broadcast OTDM networks, Switch based networks; Access Networks- Network Architecture overview, Future Access Networks, Optical Access Network Architectures.

UNIT V NETWORK DESIGN AND MANAGEMENT 9

Transmission system Engineering-system model, Power penalty-transmitter, receiver, Optical amplifiers, crosstalk, dispersion, wavelength stabilization; overall design consideration; Control and Management-Network management functions, Configuration management, Performance management, Fault management. Optical safety, Service interface

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Apply design state-of-the-art optical networks.
- **CO 2.** Implement to optical network protocols.
- **CO 3.** Design high speed networks using optical fibers
- **CO 4.** Simulate access network
- **CO 5.** Design the optical network infrastructure and network management methods.

REFERENCES:

1. Rajiv Ramaswamiand Kumar N.Sivarajan,“Optical Networks:A Practical Perspective”, Harcourt Asia Pvt Ltd., Second Edition 2004.
2. C.SivaRam Moorthy and Mohan Gurusamy, “WDM Optical Networks: Concept Design and Algorithms”, PHI, 1st Edition, 2002.
3. P.E.Green,jr.,"FiberOpticalNetworks",PrenticeHall,NewJersey,1993.
4. Optical Networks: Third GenerationTransportSystems,PrenticeHall,2002.
5. Martin Maier,"Optical Switching Networks", Cambridge India,2014.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	3	1	1
CO2	2	1	3	2	1	3
CO3	3	1	3	3	1	3

CO4	2	1	3	3	1	3
CO5	3	1	3	3	1	3
AVG	2.6	1	3	2.8	1	2.6

NE3058 SOFTWARE DEFINED NETWORK L T P C
3 0 0 3

UNIT I INTRODUCTION 9

History of Software Defined Networks (SDN) – Modern Data Center – Traditional Switch Architecture – Evolution of SDN – How SDN Works – Centralized and Distributed Control and Date Planes.

UNIT II OPEN FLOW & SDN CONTROLLERS 9

Open Flow Specification – Drawbacks of Open SDN, SDN via APIs, SDN via Hypervisor- Based Overlays – SDN via Opening up the Device – SDN Controllers – General Concepts

UNIT III SOFTWARE DEFINED NETWORKING 9

Introduction- Deep Dive (North bound and South bound interface), active network, data and control plane separation abstraction, SDN Open flow prospects and challenges

UNIT IV NETWORK FUNCTION VIRTUALIZATION 9

Introduction – NFC concepts, Frame work and Architecture – key challenges – high performance packet processing, comparison of NFC and SDN

UNIT V DATA CENTER NETWORKING 9

Introduction – characteristics and Challenges – protocols innovation – network telemetry- server less computing, content distribution in IP networks- Information centric networking

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

- **CO 1.** Understand the evolution of software defined networks
- **CO 2.** Realize the various components of SDN and their uses
- **CO 3.** Realize the role of the Software Defined Networking
- **CO 4.** Realize the role of Network function virtualization
- **CO 5.** Realize the role of Data center Networking

REFERENCES:

1. Information-Centric Networking (ICN): Content Centric Networking (CCNx) and Named Data Networking (NDN) Terminology, B. Wissingh, C. Wood, A. Afanasyev, L. Zhang, D. Oran and C. Tschudin, RFC 8793, June 2020
2. Chayapathi R, Hassan SF, Shah P. Network Functions Virtualization (NFV) with a Touch of SDN: Netw Fun Vir (NFV ePub_1. Addison- Wesley Professional; 2016
3. Marschke D, Doyle J, Moyer P. Software Defined Networking (SDN): Anatomy of OpenFlow Volume 1. 2015.
4. Paul Goransson and Chuck Black, —Software Defined Networks: A Comprehensive Approach, First Edition, Morgan Kaufmann, 2014.
5. Cloud Networking: Understanding Cloud-based Data Centre Networks, Gary Lee Morgan Kaufmann Publisher, 2014, ISBN-139780128007280

6. Thomas D. Nadeau, Ken Gray, —SDN: Software Defined Networks, O'Reilly Media, 2013.
7. Information-Centric Networks: A New Paradigm for the Internet (Focus Series in Networks and Telecommunications), Gabriel M. de Brito, Pedro B. Velloso, Igor M. Moraes, Wiley-ISTE; 1st edition, 2013, ISBN: 9781848214491
8. Software-Defined Networks: A Systems Approach, Peterson, Cascone, O'Connor, Vachuska, and Davie, Online Free Reference Book available at https://sdn.systemsapproach.org/index.html

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	2	2	1
CO2	3	1	3	2	2	1
CO3	3	1	3	2	2	2
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3
AVG	3	1	3	2.4	2.4	2

NE3008 MICROWAVE PHOTONICS L T P C
3 0 0 3

UNIT I RADIO OVER FIBER (ROF) LINK 9

Introduction to microwave photonics, Radio over fiber, figure of merit and performance of microwave photonics, gain and frequency response, noise figure, distortion in RF links, directly modulated optical links, RF subcarrier link for local access networks.

UNIT II MODULATION TECHNIQUES FOR MICROWAVE PHOTONICS 9

Laser diode fundamentals, rate equation analysis, small signal analysis, microwave loss, modulation effect on ink performance, frequency modulation, intensity modulation, External modulation, $LiNbO_3$ and polymer based electrooptic modulator, broadband travelling wave modulator, Electro absorption modulator

UNIT III OPTO-ELECTRONIC OSCILLATOR AND MICROWAVE GENERATION 9

Basics of opto-electronic oscillators, signal generation for RF photonic systems, multi loop optoelectronic oscillator, photonic link technique for microwave frequency conversion, benefits of frequency converting, optical local oscillator, microwave frequency conversion in photonic links

UNIT IV ROF FOR CELLULAR SYSTEMS 9

Analysis of analog fiber optic link, fiber optic remote antenna feeding links, comparison of fiber optic and coaxial remote antenna feeding links, ROF for micro cellular system, fiber optic microcell repeater, performance evaluation, WCDMA for 3G cellular systems, WCDMA based ROF system performance, ROF for micro cellular communication networks

UNIT V ROF FOR RADAR AND CATV APPLICATIONS 9

ROF for mobile communications, antenna remoting applications, phased array antennas, wideband photonic phased array antenna, photonic beam steering, ROF for CATV applications, mobile CATV, ROF application for multiservice wireless communication systems, fixed and integrated multi service mobile communication

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Understand the properties of Radio over fiber link.

CO 2. Identify suitable optical modulation techniques for various applications.

CO 3. Understand optical methods for microwave generations.

CO 4. Design RoF based cellular systems.

CO 5. Apply ROF techniques for Radar and CATV applications.

REFERENCES:

1. ChiH.Lee,"Microwave Photonics",2ed, CRCpress,Bocaraton,2017
2. Xavier Fernando,"Radio over fiber for wireless communication", John Wiley and Sons, NewYork, 2014.
3. Nathan J.Gomes, PauloP.Monterio and Atilio Gameiro"Next Generation Wireless Communication using Radio Over Fiber" John Wiley and Sons, NewYork,2012
4. StacrosIezekiel,"Microwave Photonics, Devices and Applications", JohnWiley and Sons, NewYork 2009.
5. HamedAl-Rawesshidy and ShozoKomaki, "Radio Over Fiber Technology for Mobile Communication Networks",ArtechHouse,London, 2002.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	2	2	2	2
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3
AVG	2.8	1	2.8	2.8	2.8	2.8

NE3054 ELECTROMAGNETIC INTERFERENCE AND ELECTROMAGNETIC COMPATIBILITY

L T P C
3 0 0 3

UNIT I EMI/EMC CONCEPTS **9**

EMI/EMC Concepts - EMI-EMC definitions and Units of parameters; Sources and victim of EMI; Conducted and Radiated EMI Emission and Susceptibility; Transient EMI, ESD; Radiation Hazards.

UNIT II EMI COUPLING PRINCIPLES **9**

EMI Coupling Principles - Conducted, radiated and transient coupling; Common ground impedance coupling; Common mode and ground loop coupling ; Differential mode coupling ;Near field cable tocable coupling, cross talk ; Field to cable coupling ; Power mains and Power supply coupling.

UNIT III EMI CONTROL TECHNIQUES **9**

EMI Control Techniques Shielding, Filtering, Grounding, Bonding, Isolation transformer, Transient suppressors, Cable routing, Signal control.

UNIT IV EMC DESIGN OF PCBs **9**

EMC Design of PCBs -Component selection and mounting; PCB trace impedance; Routing; Crosstalk control; Power distribution decoupling; Zoning; Grounding; VIA s connection;

Terminations.

UNIT V EMI MEASUREMENT AND STANDARDS 9

EMI Measurements and Standards- Open area test site; TEM cell; EMI test shielded chamber and shielded ferrite lined anechoic chamber; Tx /Rx Antennas, Sensors, Injectors / Couplers, and coupling factors; EMI Rx and spectrum analyzer; Civilian standards-CISPR, FCC, IEC, EN; Military standards MIL461E/462.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Understand EMI and susceptibility
CO 2. Identify EMI coupling mechanisms
CO 3. Use appropriate EMI control schemes in electronic systems
CO 4. Design PCBs with EMC
CO 5. Conduct EMI measurements according to standards.

REFERENCES:

1. C.R.Paul,"Introduction to Electromagnetic Compatibility", John Wiley and Sons, Inc, 3rd Edition,2022
2. David A Weston," Electromagnetic Compatibility —Methods, Analysis ,circuits and measurements" CRC press, Bocaraton 2017
3. TimWilliams,"EMC for product designers", Newness, 5 th Edition, 2017.
4. Patrick G.Andre and Kenneth Wyatt, "EMI Troubleshooting Cookbook for Product Designers SciTech publishing, 2014
5. Henry W.Ott., "Electromagnetic Compatibility Engineering, Revised edition, Wiley Blackwell Newyork, 2009.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	2	2	2	2
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3
AVG	2.8	1	2.8	2.8	2.8	2.8

NE3009 MACHINE LEARNING FOR NEXT GENERATION COMMUNICATION NETWORKS

L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Machine learning, Terminologies in machine learning, Types of machine learning: supervised, unsupervised, semi-supervised learning. Review of probability.

UNIT II DISCRIMINATIVE MODELS: 9

Least Square Regression, Gradient Descent Algorithm, Univariate and Multivariate Linear Regression, Prediction Model, probabilistic interpretation, Regularization, Logistic regression, multi class classification, Support Vector Machines- Large margin classifiers, Nonlinear SVM, kernel functions, SMO algorithm.

UNIT III GENERATIVE MODELS 9

k-Nearest Neighbour Classification, Bayesian concept learning, Likelihood, Posterior predictive distribution, beta-binomial model, Naive Bayes classifiers, classifying documents using bag of words.Bayesian Statistics and Frequentist statistics. Directed graphical models (Bayes nets), Conditional independence, Inference.

UNIT IV MACHINE LEARNING FOR SPECTRUM ACCESS AND SHARING 9

Online Learning Algorithms for Opportunistic Spectrum Access, Random and Deterministic Approaches, the Adaptive Sequencing Rules Approach, Structure of Transmission Epochs, Learning Algorithms for Channel Allocation, Machine learning for spectrum sharing in millimeter wave cellular networks.

UNIT V MACHINE LEARNING IN ENERGY EFFICIENCY OPTIMIZATION 9

Self-Organizing Wireless Networks, Positioning of Unmanned Aerial Vehicles, Traffic Prediction, Mobility Prediction, Threshold-Based Optimization Energy-Efficient Routing Technique in Heterogeneous Wireless Sensor Network.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Apply relevant machine learning approaches to build supervised and unsupervised models to solve problems

CO 2. Use probability and statistics concepts to prepare the training, testing and validation datasets for model-building

CO 3. Apply advanced techniques to model the relationship between a dependent variable and one or more independent variables

CO 4. Design machine learning algorithms for spectrum, access and sharing

CO 5. Apply machine learning algorithms for optimizing energy efficiency

REFERENCES:

1. Alex Smola and SVN. Viswanathan, “Introduction to Machine Learning”, Cambridge University Press, 2008
2. Fa-Long Luo," Machine Learning for Future Wireless Communications", John Wiley and Sons, 2020
3. Ruisi He, Z Ding, “Applications of Machine Learning in Wireless Communications”, IET Telecommunication series 81.
4. K. K. Singh, A. Singh, K. Cengiz, Dac-Nhuong Le, “Machine Learning and Cognitive Computing for Mobile Communications and Wireless Networks”, Wiley 2020
5. Mitchell, Tom. *Machine Learning*. New York, NY: McGraw-Hill, 1997. ISBN: 9780070428072.
6. E. Alpaydin, “Introduction to Machine Learning”, PHI, 2005.
7. Tom Mitchell, “Machine Learning”, McGraw Hill, 1997
8. Kevin P. Murphy, “Machine Learning, a probabilistic perspective”, The MIT Press Cambridge, Massachusetts, 2012.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	3	3	1
CO2	3	1	3	3	3	1
CO3	3	1	3	3	3	1
CO4	3	1	3	3	3	1
CO5	3	1	3	3	3	3
AVG	3	1	3	3	3	1.4

WT3057 ULTRA WIDEBAND COMMUNICATION L T P C
3 0 0 3

UNIT I INTRODUCTION TO ULTRA-WIDEBAND 9

Introduction, UWB Modulation Options - UWB Signaling Techniques - Data Mapping – Spectral Characteristics-Data Mapping and Transceiver Complexity – Modulation Performances in Practical Conditions.

UNIT II ULTRA-WIDEBAND PULSE SHAPER DESIGN 9

Transmit Spectrum and Pulse Shaper - FIR Digital Pulse Design - Optimal UWB Single Pulse Design –Optimal UWB Orthogonal Pulse Design.

UNIT III ULTRA-WIDEBAND CHANNEL MODELING 9

Principles and Background of UWB Multipath Propagation Channel Modeling -Channel Sounding Techniques-UWB Statistical-Based Channel Modeling-Impact of UWB Channel on System Design – Potential Benefits of MIMO.

UNIT IV UWB TRANCEIVER DESIGN CONSIDERATIONS 9

System Model - UWB Receiver Related Issues - TH-IR-UWB Receiver Options. Multiple-Access Interference Mitigation at the Receiver Side-Multiple – Access Interference Mitigation at the Transmitter Side, Effect of NBI in UWB Systems-Avoiding NBI - Canceling NBI.

UNIT V MULTIBAND OFDM SYSTEM 9

Multiband Pulsed – OFDM UWB system. Medium Access Protocols-Network Applications. Multiple Accesses in UWB Sensor Systems – UWB Sensor Network Case Study – System Description-UWEN–Implementation – Location System – Position Calculation Methods. The 802.15.4 MAC Standard-Advanced MAC Design for Low – Bit-Rate UWB Networks.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Develop a comprehensive overview of UWB system design.
CO 2. Understand the distinct UWB channel
CO 3. Design UWB pulse shaper
CO 4. Understand difference between UWB and legacy systems
CO 5. Understand the future directions of UWB technology

REFERENCES:

1. MarianVerhelst and Wim Dehaene Energy Scalable Radio Design: for Pulsed UWB Communication and Ranging (Analog Circuits and Signal Processing) , Springer, 2011.
2. Homayoun Nikcobar and Ramjee Prasad" Introduction to Ultra Wideband for Wireless Communications" Springer, 2009.
3. HuseyinArsian, ZinNing Chen, "Ultra-Wide band Wireless Communication" Wiley, 2006.
4. Jeffrey H.Reed, "An Introduction to Ultra Wideband Communication Systems" Prentice HallPTR, 2005.
5. Kayimierysiwiak and Debra mekown, "Ultra-Wideband Radio Technology", John Willey & Sons, 2004.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	1	3
CO2	3	1	3	1	1	1
CO3	3	1	3	3	3	1
CO4	3	1	3	3	3	1
CO5	3	1	3	3	3	1
AVG	3	1	3	2.2	2.2	1.4

WT3051 ADVANCED WIRELESS COMMUNICATION TECHNIQUES L T P C
3 0 0 3

UNIT I COOPERATIVE COMMUNICATIONS 9

Network architectures and research issues in cooperative cellular wireless networks; Cooperative communications in OFDM and MIMO cellular relay networks: issues and approaches; Fundamental trade-offs on the design of green radio networks.

UNIT II COOPERATIVE TECHNIQUES 9

Cooperative techniques for energy efficiency, Cooperative base station techniques for cellular wireless networks; Turbo base stations; Antenna architectures for cooperation; Cooperative communications in 3GPP LTE-Advanced, Partial information relaying.

UNIT III RELAY-BASED COOPERATIVE CELLULAR NETWORK 9

Distributed space-time block codes; Collaborative relaying in downlink cellular systems; Radio resource optimization; Adaptive resource allocation; Cross-layer scheduling design for cooperative wireless two-way relay networks.

UNIT IV GREEN RADIO NETWORKS 9

Base Station Power-Management Techniques- Opportunistic spectrum and load management, Energy-saving techniques in cellular wireless base stations, Cooperative multi cell processing techniques for energy-efficient cellular wireless communications.

UNIT V ACCESS TECHNIQUES FOR GREEN RADIO NETWORKS 9

Cross-layer design of adaptive packet scheduling for green radio networks; Energy-efficient relaying for cooperative cellular wireless networks; Energy performance in TDD-CDMA multihop cellular networks ; Resource allocation for green communication in relay-based cellular networks.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Appreciate the necessity and the design aspects of cooperative communication
- **CO 2.** Appreciate the necessity and the design aspects of cooperative base station techniques.
- **CO 3.** Evolve new techniques in relay-based cooperative networks
- **CO 4.** Appreciate green radio networks
- **CO 5.** Identify the impact of the access techniques for green radio networks

REFERENCES:

1. Muhammad Ismail, Muhammad Zeeshan Shakir, Khalis A. Qaraqe, Erchin Serpedin, "Green Heterogeneous Wireless Networks", Wiley- IEEE Press, 2016.

2. Ekram Hossain, Vijay K. Bhargava (Editor), Gerhard P. Fettweis (Editor), “Green Radio Communication Networks”, Cambridge University Press, 2012.
3. F. Richard Yu, Yu, Zhang and Victor C. M. Leung “Green Communications and Networking”, CRC press, 2012.
4. Jinsong Wu, Sundeep Rangan and Honggang Zhang, “Green Communications: Theoretical Fundamentals, Algorithms and Applications”, CRC Press, 2012.
5. Ekram Hossain, Dong In Kim, Vijay K. Bhargava , “Cooperative Cellular Wireless Networks”, Cambridge University Press, 2011.
6. Ramjee Prasad and Shingo Ohmori, Dina Simunic, “Towards Green ICT”, River Publishers,2010.
7. Ahmed K. Sadek, Andres Kwasinski, K.J. Ray Liu, Weifeng Su,"Cooperative Communications and Networking", Cambridge University Press, Illustrated edition, 2008.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	2	1	1	1
CO2	2	1	2	1	1	1
CO3	3	1	2	3	1	1
CO4	2	1	2	2	1	2
CO5	2	1	2	2	2	2
AVG	2.4	1	2	1.8	1.2	1.4

WT3054 RADIO OVER FIBER FOR 5G NETWORKS L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Introduction to Radio over fiber (RoF), figure of merit and performance of RoF link, gain and frequency response, noise figure, distortion in RF links, directly modulated optical links, RF subcarrier link for local access networks, 5G oriented optical networks.

UNIT II RADIO OVER FIBER LINKS 9

Fi-Wi link, Importance of Fi-Wi link elements, power link budget, signal to noise ratio, relative intensity noise, improved expression for relative intensity noise, subcarrier multiplexed RoF link, down link and uplink, externally modulated RoF links.

UNIT III ANALYSIS OF FIBER-WIRELESS CHANNEL 9

RoF channel modelling, nonlinearity, DSP modelling of RoF link nonlinearity, adaptive compensation techniques, joint estimation of Fi-Wi channel, joint equalization of Fi-Wi channel, performance evaluation, multiuser CDMA systems, Fi-Wi for 5G wireless networks.

UNIT IV OPTICAL TECHNOLOGIES FOR 5G NETWORKS 9

Analysis of analog fiber optic link, digital RoF links, convergence of optical and wireless technologies in 5G, common fiber system- RoF and PON, GPON and EPON architecture, D-RoF transmission in PON systems, mobile front haul for D-RoF transmission.

UNIT V BROADBAND RoF FOR WIRELESS NETWORKS 9

Broadband optical millimeter wave generation, broad band millimeter wave detection in RoF, Digital signal processing for RoF systems, broadband mm wave delivery, long distance mm wave transmission in RoF, RF transparent photonic demodulation techniques.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Understand the properties of Radio over fiber link.

CO 2. Identify suitable optical technology for wireless networks

CO 3. Understand Fiber Wireless channel modeling and estimation

CO 4. Design RoF based cellular systems.

CO 5. Generate and detect millimeter wave in RoF technology

REFERENCES:

1. Alan E Willner, Optical Fiber Telecommunication VII, Academic Press, 2020.
2. Hamed Al-Rawesshidy and Shozo Komaki, "Radio Over Fiber Technology for Mobile Communication Networks", Artech House, London, 2002.
3. Fei Hu, Opportunities in 5G Networks, A Research and Development Perspective, Taylor and Francis,2016.
4. Xavier Fernando," Radio over fiber for wireless communication", John Wiley and Sons, New York ,2014
5. Nathan J. Gomes, Paulo P.Monterio and Atilio Gameiro "Next Generation Wireless Communication using Radio Over Fiber" John Wiley and Sons, New York,2012.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	1	3
CO2	3	1	3	1	2	2
CO3	3	1	3	3	2	2
CO4	3	1	3	3	3	1
CO5	3	1	3	3	3	1
AVG	3	1	3	2.2	2.2	1.8

NE3056 INFORMATION THEORY AND CODING L T P C

3 0 0 3

UNIT I QUANTITATIVE STUDY OF INFORMATION 9

Entropy, Relative Entropy, Mutual information, Chain rule, Relationship Bounds on entropy, Fisher information, Cramer Rao inequality, Entropy rates of a Stochastic process.

UNIT II CAPACITY OF NOISELESS CHANNEL 9

Fundamental theorem for a noiseless channel, Data compression, Kraft inequality, Shannon-Fanocodes, Huffman codes, Asymptotic equipartition, Rate distortion theory.

UNIT III CHANNEL CAPACITY 9

Properties of channel capacity, jointly typical sequences, Channel Coding Theorem, converse to channel coding theorem, Joint source channel coding theorem.

UNIT IV DIFFERENTIAL ENTROPY AND GAUSSIAN CHANNEL 9

AEP for continuous random variables, relationship between continuous and discrete entropy, properties of differential entropy, Gaussian channel definitions, converse to coding theorem for Gaussian channel, channels with colored noise, Gaussian channels with feedback.

UNIT V CHANNEL CODING TECHNIQUES 9

Galois Fields, Fundamental Theorem of Galois Theory (FTGT), Reed-Solomon Codes, TurboCodes, LDPC Codes, TCM, Polar code.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Quantify information.
CO 2. Implement various coding schemes.
CO 3. Design efficient channel.
CO 4. Apply coding techniques to information sources like video, audio and so on.
CO 5. Implement the information theory and coding technique for effective communication

REFERENCES:

1. P.S. Satyanarayana , " Concepts of Information Theory and coding, Med tech 2nd edition 2016.
2. Varun Goyal, Gaurav Gupta, " Information Theory and coding, S.K. Kataria & Sons, 2014
3. Edition (2011).
4. Monica Borda, Fundamentals in Information Theory and Coding Springer 2011
5. Thomas Cover, Joy Thomas, "Elements of Information Theory ", 2nd edition, Wiley,2006
6. David J.C. MacKay, "Information Theory, Interference & Learning Algorithms", 2nd
7. edition, Cambridge University Press 2003.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	2	1	1
CO2	3	1	3	2	2	2
CO3	3	1	3	2	2	2
CO4	3	1	2	1	2	2
CO5	3	1	2	1	1	2
AVG	3	1	2.6	1.6	1.6	1.8

WT3056 SPREAD SPECTRUM TECHNIQUES AND APPLICATIONS L T P C
3 0 0 3

UNIT I SPREADING CODES 9

Finite-Field Arithmetic- Sequence Generator Fundamentals-State - Machine Representation of Shift-Register Generators-Generation &Properties of m-Sequences Gold Codes - Kasami Sequences (Small Set) - Quaternary Sequences - Complementary Code Keying - Walsh–Hadamard Sequences.

UNIT II SPREAD SPECTRUM SYSTEMS 9

Direct Sequence Spread Spectrum (DSSS) - Processing Gain- Frequency Hop Spread Spectrum (FHSS)- Coherent & Noncoherent Slow FHSS – Coherent & Noncoherent Fast FHSS- Hybrid DS/FH Spread Spectrum.

UNIT III SYNCHRONIZATION IN SPREAD SPECTRUM 9

Sources of synchronization Uncertainty, Carrier Synchronization - Code Synchronization & Acquisition - Matched Filter Acquisition, Serial Search Acquisition, Sequential Acquisition, Code Tracking- Delay Lock Tracking loop, Noncoherent Tracking loop.

UNIT IV SPREAD SPECTRUM IN CELLULAR COMMUNICATION 9

Cellular Network and Power Control- DS-CDMA Cellular Networks, FH-CDMA Cellular Networks, Performance in Jamming Environment – Low Probability of Intercept methods- Optimum Intercept Receives for Spread - Spectrum Signals.

UNIT V APPLICATIONS OF SPREAD SPECTRUM METHODS 9

Space Systems, Avionics Systems, Test Systems and equipment, Message Protection, GPS System-Principles-Differential GPS.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Realize the generation of PN sequence.
- **CO 2.** Appreciate spread spectrum systems.
- **CO 3.** Analyze synchronization issues in spread spectrum.
- **CO 4.** Design systems based on spread spectrum to mitigate the jamming.
- **CO 5.** Design GPS system

REFERENCES:

1. Jerry D. Gibson, "Mobile Communications Handbook", 3rd Edition, CRC Press, 2017.
2. Don Torrieri, "Principles of Spread-Spectrum Communication Systems",3rd edition, Springer International Publishing Switzerland, 2015.
3. Roger L. Peterson, Rodger E. Ziemer, Davis E. Borth, " Introduction to Spread Spectrum Communications", 1st edition, Pearson Education India, 2013
4. Rodger E. Ziemer, "Fundamentals of Spread Spectrum Modulation", Morgan & Claypool, Publishers series, 2007.
5. M.K. Simon, J.K. Omura, R.A. Scholtz, and B.K. Levitt, "Spread Spectrum Communications Handbook", Electronic Edition, McGraw-Hill, 2002.
6. Andrew J. Viterbi, "CDMA: Principles of Spread Spectrum Communication", Addison-Wesley Wireless Communications Series, 1995.
7. Robert C. Dixon, "Spread Spectrum Systems with Commercial Applications", 3rd Edition, John Wiley & Sons, Ins, 1994.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	2	1	1	1
CO2	2	1	2	2	1	1
CO3	2	1	2	2	2	1
CO4	3	1	2	3	2	1
CO5	2	1	2	2	3	2
AVG	2.2	1	2	2	1.8	1.2

WT3059 SPACE TIME WIRELESS COMMUNICATION L T P C
3 0 0 3

UNIT I MULTIPLE ANTENNA PROPAGATION AND ST CHANNEL CHARACTERIZATION 9

Wireless channel, Scattering model in macro cells, Channel as a ST random field, Scattering functions, Polarization and field diverse channels, Antenna array topology, Degenerate channels, reciprocity and its implications, Physical scattering model, sampled signal model, ST multiuser and ST interference channels

UNIT II CAPACITY OF MULTIPLE ANTENNA CHANNELS 9

Capacity of frequency flat deterministic MIMO channel: Channel unknown to the transmitter, Channel known to the transmitter, capacity of random MIMO channels, Influence of ricean fading, fading correlation, XPD and degeneracy on MIMO capacity, Capacity of frequency selective MIMO channels.

UNIT III SPATIAL DIVERSITY 9

Diversity gain, Receive antenna diversity, Transmit antenna diversity, Diversity order and channel variability, Diversity performance in extended channels, Combined space and path diversity, Indirect transmit diversity, Diversity of a space-time- frequency selective fading channel.

UNIT IV MULTIPLE ANTENNA CODING AND RECEIVERS 9

Coding and interleaving architecture, ST coding for frequency flat channels, ST coding for frequency selective channels, Receivers (SISO,SIMO,MIMO),Iterative MIMO receivers, Exploiting channel knowledge at the transmitter: linear pre-filtering, optimal pre-filtering for maximum rate,optimal pre-filtering for error rate minimization, selection at the transmitter, Exploiting imperfect channel knowledge.

UNIT V OFDM, SPREAD SPECTRUM AND MIMO MULTIUSER DETECTION 9

SISO – OFDM modulation, MIMO-OFDM modulation, Signaling and receivers MIMO-FDM, SISO-SS modulation, MIMO-SS modulation, Signaling and receivers for MIMO-SS.MIMO-MAC,MIMO-BC, Outage performance for MIMO-MU,MIMO – MU with OFDM

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Apply the knowledge of wireless technology using multiple antennas.
CO 2. Analyze space time wireless propagation and space time channel.
CO 3. Evaluate the performance of space time wireless communication.
CO 4. Utilize the channel knowledge at the transmitter.
CO 5. Understand pace time multiuser communication.

REFERENCES:

1. Claude Oestges, Bruno Clerckx., "MIMO Wireless Communications: From Real-World Propagation to Space-Time Code Design" , Academic Press, 2010.
2. Erik G. Larsson, Petre Stoica ., "Space-Time Block Coding for Wireless Communications",Cambridge University Press, 2008.
3. Tolga M. Duman, Ali Ghrayeb., "Coding for MIMO Communication Systems", John Wiley & Sons, 2008.
4. H. Bölcskei, D. Gesbert, Constantinos, B. Papadias A.-J. van der Veen., "Space-Time Wireless Systems: From Array Processing to MIMO Communications ", Cambridge University Press, 2006.
5. A. Paulraj, Rohit Nabar, Dhananjay Gore., “Introduction to Space Time Wireless Communication Systems”, Cambridge University Press, 2003

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	3	3	2	2
CO2	3	1	2	3	2	2
CO3	3	1	2	2	1	1
CO4	3	1	3	3	2	2

CO5	2	1	2	2	2	2
AVG	2.6	1	2.4	2.6	1.8	1.8

NE3010 SATELLITE COMMUNICATION L T P C
3 0 0 3

UNIT I ELEMENTS OF SATELLITE COMMUNICATION 9

Satellite Frequency Bands, Satellite Systems, Frequency Reuse by Orthogonal Polarizations, Kepler's Laws, Orbital Period and Velocity, Effects of Orbital Inclination, look angle calculation, Coverage angle and Slant range, Eclipse, Placement of a Satellite in a Geostationary Orbit.

UNIT II SATELLITE SUBSYSTEM 9

Satellite Subsystems—Altitude Control Subsystem, Telemetry, Command, and Ranging Subsystem, Communication Subsystem, Electrical Power Subsystem.

UNIT III EARTH STATION 9

Earth Station Antenna-Antenna Types, Effective Isotropic Radiated Power, Antenna Gain -to-Noise Temperature Ratio, G/T measurement, High Power Amplifier, Low-Noise Amplifier, Up convertor, Down Convertor, Monitoring and Control, Reliability, Multiple Access

UNIT IV SPACE LINK 9

Basic Link Design: EIRP, Transmission Losses, Link-Power Budget Equation, System Noise, Carrier-to-Noise Ratio, The Uplink & Downlink, System Design for link with and without frequency reuse, Effects of Rain, Intermodulation Noise

UNIT V SATELLITE APPLICATIONS 9

Communication Satellites, Remote Sensing Satellites, Weather Satellites, Navigation Satellites, Scientific Satellites, Military Satellites.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Relate the elements of satellite communication system.
- **CO 2.** Understand the various satellite subsystems.
- **CO 3.** Review the design of earth station.
- **CO 4.** Evaluate the satellite link budget.
- **CO 5.** State the various satellite applications.

REFERENCES:

1.W. L. Pritchart, H. G. Suyderhoud and R. A. Nelson, "Satellite Communication Systems Engineering, " 2nd Ed., Pearson Education, 2012.

2. Tri. T. Ha, "Digital Satellite Communications", McGraw Hill, Second Edition, 2009.

3. Dennis Roddy, "Satellite Communications", McGrawHill, 4th Edition, 2008.

4. Louis J.Ippolito, "Satellite Communications Systems Engineering", John Wiley & Sons, 2017

5. M. Richharia, "Satellite Systems for Personal applications", John Wiley, 2010.

T.Pratt, C. Bostian and J.Allnutt; "Satellite Communications", John Wiley & Sons, Second Edition, 2008.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	1	1	1	1	1
CO2	2	1	2	2	2	1
CO3	3	1	3	3	3	1
CO4	3	1	3	3	3	1
CO5	1	1	1	1	1	1
AVG	2	1	2	2	2	1

WT3055 **RF IC DESIGN** **L T P C**
3 0 0 3

UNIT I COMPONENTS FOR RF IC 9

Capacitance, Inductance, Circuit representations, Distributed and Lumped circuits, LC and RLC circuits, Antennas, Integrated capacitors, Integrated inductors, plane waves, Antennas.

UNIT II LOW NOISE AMPLIFIERS 9

Types of Noise, Two port Equivalent Noise, Noise figure, Minimum NF,Noise figure of cascade of stages, CS and CG LNA, series and shunt feedback LNA, Feed forward LNAs, LNA power noise optimization, LNA design case study

UNIT III POWER AMPLIFIER DESIGN 9

Small and Large signal Non linearities, Class A, B, C, D, E and F amplifiers, Class D Digital power amplifiers, Linearization Techniques, RF power amplifier design example.

UNIT IV PLL AND FREQUENCY SYNTHESIZERS AND OSCILLATORS 9

PLL basics, Type I – PLL, Type – II PLL, Integer N frequency synthesizers, Fractional N frequency Synthesizers, Frequency divides, Digital PLLs. Ring oscillators, Quadrature Oscillators, Crystal and FBAR Oscillators

UNIT V SYSTEM ARCHITECUTRE 9

Analog Linear modulation, on linear Modulation, Modern radio modulation, SSB receivers, Receiver architectures, Blocker tolerant receivers, Receiver filtering and AGC design, Transmitter architectures, Transceiver design considerations.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Analyze the RF integrated circuits
CO 2. Design low noise amplifiers
CO 3. Design power amplifiers
CO 4. Design PLL and frequency synthesizers
CO 5. Develop RF transceivers and its building blocks

REFERENCES:

1. Hooman Darabi," Radio Frequency Integrated Circuits and Systems", Cambridge University Press, Cambridge, 2020.
2. Cam Nguyen," Radio frequency integrated circuit Engineering", John Wiley, New Jersy,2015.
3. Matthew M.Radmanesh "RF and Microwave Design Essentials", AuthorHouse, Bloomington,2007.

4. Thomas Lee, “The Design of Radio Frequency CMOS Integrated Circuits”, Cambridge UniversityPress, 2nd Edition, Cambridge, 2004.
5. John W.M.Rogers and Calvin Plett, "Radio Frequency Integrated Circuit Design", 2nd Edition, Artech House, Norwood, 2010.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	2	2	1
CO2	3	1	3	2	2	1
CO3	3	1	3	2	2	1
CO4	3	1	3	2	2	1
CO5	3	1	3	2	2	1
AVG	3	1	3	2	2	1

NE3051 ANTENNA FOR 5G AND 6G COMMUNICATION L T P C
3 0 0 3

UNIT I INTRODUCTION 9

5G Mobile Communication, spectrum, 5G antenna design considerations, Antenna integration with RFIC, Sub-6GHz 5G antennas, mm wave 5G antennas, Frequency reconfigurable multi band antenna, 6G spectrum, 6G antenna specifications, mm wave antennas, THz antennas, Lens antennas.

UNIT II ANTENNA FOR 5G MOBILE TERMINAL 9

Antenna for cellular communications, antenna for mobile terminal, requirements for mobile antenna, Wide band antenna for 5G mobile terminal, CPW feed antenna, CPW feed antenna with reflector, Wide band high gain antenna for mm wave 5G, Flexible antenna for 5G, Patch antenna, slot antenna and Vivaldi antenna.

UNIT III ANTENNA FOR 5G BASE STATIONS 9

Antenna for 5G base stations, mm wave tapered slot antenna, dielectric and metamaterial loaded tapered slot antenna, diversity antenna with radome, 3D radome for patch antenna, high aperture efficiency antenna, shared aperture antenna for base station, pattern diversity

UNIT IV ANTENNA ARRAY FOR 5G AND 6G 9

5G requirement of antenna arrays, array characteristics, integration and Antenna-in Package, 6G antenna requirements, digital beamforming, hybrid beam forming, mm wave beam forming networks.

UNIT V ANTENNA ARRAY- TYPES AND TECHNIQUES 9

Decoupling methods- Electromagnetic Band Gap, Defected Ground Surface, neutralization lines, metamaterial, Polarization decoupling. Type of antenna arrays-differential feed, linear and circularly polarized differential antennas, conformal transmit arrays, multi beam transmit array.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1. Apply knowledge in 5G antenna design
CO 2. Understand the design requirements of 5G and 6G antennas
CO 3. Analyze the characteristics of antenna array

CO 4. Understand the beam forming technique

CO 5. Apply design techniques in the 5G and 6G mobile and base station antennas

REFERENCES:

1. ShibanKishenKoul and G S Karthikaya, Millimater Wave antennas for 5G mobile terminals and base stations, CRC Press, 2021.
2. Yingjie Jay Guo, Richard W. Ziolkowski, Advanced Antenna Array Engineering for 6G and Beyond Wireless Communications, Wiley-IEEE press, 2022.
3. Qammer H. Abbasi, SyedaFizzahJilani,AkramAlomainy, Muhammad Ali Imran, Antenna and Propagation for 5G and beyond, IET,2020.
4. Paul RP Hoole, Smart Antennas and Electromagnetic Signal Processing in Advanced Wireless Technology, River Publishers, 2020.
5. Mohammed Ali, Reconfigurable Antenna Design and Analysis, Artech House, 2021

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	1	3
CO2	3	1	3	1	1	1
CO3	3	1	3	2	3	1
CO4	3	1	3	2	3	1
CO5	3	1	3	2	3	1
AVG	3	1	3	1.6	2.2	1.4

WT3052 NETWORK ROUTING PROTOCOLS L T P C
3 0 0 3

UNIT I INTRODUCTION TO ROUTING ALGORITHMS 9

Routing: Basics and Foundations – Addressing and Internet service an overview, IPv4 addressing, IPV6 addressing, Router architecture. Routing Algorithms: Bellman ford, distance vector approach, Dijikstra algorithm, shortest path computations with candidate path caching, widest path algorithm, Spanning tree, K-shortest path algorithms.

UNIT II ROUTING PROTOCOL 9

Routing protocols – routing algorithm, routing table, routing information representation and protocol messages, DSR, LSR, path vector routing protocol. Internet Routing Protocol – basics, static routes, RIP, IGRP, EIGRP, OSPF.

UNIT III MULTICAST ROUTING 9

Multicast IP addressing, IGMP, MLD, RPF, DVMRP, Multicast OSPF, protocol independent multicast. Inter domain multicast routing – BGMP, Multiprotocol Extension of BGMP.

UNIT IV ROUTING IN RESERVATION ORIENTED NETWORKS 9

Circuit switching, hierarchical call routing, dynamic routing, DNHR, DCR, DAR, RTNR, classification of dynamic call routing, QoS routing – attributes, adaptive shortest path and widest path routing, routing protocols for QoS routing.

UNIT V ROUTING IN GSTN AND VOIP 9

Signaling System: SS7 – protocol stack, call processing, call routing with single service provider and multiple service provider. VoIP – GSTN call routing using internet, managed IP approach. IP –

GSTN internetworking for VoIP, IMS, All IP environments for VoIP services.

TOTAL:45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

- **CO 1.** Understand the various network routing algorithms.
- **CO 2.** Differentiate and design routing protocols of internet.
- **CO 3.** Design routing protocols for multicast transmission.
- **CO 4.** Understand routing protocols in reservation oriented networks
- **CO 5.** Analyze routing protocols of mobile network and VoIP network.

REFERENCES:

1. Deep Medhi, Karthik Ramasamy, “Network Routing: Algorithms, Protocols and Architecture”, Morgan Kaufmann publishers, 2nd Edition, 2018.
2. JochenH.Schiller, “Mobile Communication”, Pearson Ed, 2nd Edition, 2014.
3. William Stallings,”High speed networks and Internets Performance and Quality of Service‟, Pearson Education Asia. Reprint India, 2nd Edition, 2002.
4. S. Keshav, An engineering approach to computer networking‟ Addison Wesley 1999.
5. M. Steen Strub, “Routing in Communication network, Prentice –Hall International, New york, 1995.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	2	1	1	2
CO2	3	1	2	1	1	1
CO3	3	1	2	2	2	1
CO4	3	1	2	2	2	1
CO5	3	1	2	2	2	1
AVG	3	1	2	1.6	1.6	1.2