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REGULATIONS 2019
M.E. WIRELESS TECHNOLOGIES
CHOICE BASED CREDIT SYSTEM

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

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1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. Provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve problems in Signal Processing, Wireless Communication and Networking.
II. Serve in research establishments and contribute towards the development of sophisticated Wireless Technologies systems.
III. Provide consultancy and offer networking solutions for next generation networks.
IV. Prepare students to excel in research or to succeed in Wireless Communication and Networking domain through global, rigorous post graduate education.
V. Become entrepreneurs and contribute towards indigenous product development to 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. The mastery should be at a level higher than the requirements in the appropriate bachelor program
4.	Engineering Design	An ability to apply various advanced tools and techniques to develop efficient signal processing, wireless communication and networking systems
5.	The engineer and society	Apply technical knowledge towards the development of socially relevant products
6.	Environment and sustainability	Ensure development of eco friendly indigenous products.

3. PROGRAMME SPECIFIC OUTCOMES (PSOs):

I. Foundation of wireless communication systems: Ability to understand the basics principles involved in the operation of wireless communication systems and thereby provide solutions due to channel impairments in real time implementation
II. Foundation of networking systems: Ability to understand the various technologies behind the recent wireless communication standards and work towards to provide improved solutions.
III. Foundations of Mathematical concepts: Ability to apply mathematical knowledge to develop new protocols, algorithms, interfaces to address networking issues and to develop new protocols, and algorithms for cyber security 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.	✓		✓	✓	✓	✓
II.	✓			✓	✓	✓
III.	✓	✓		✓	✓	✓
IV.	✓			✓	✓	✓
V.	✓			✓	✓	✓

L – Low M- Medium H-High

YEAR	SEMESTER	COURSE	PROGRAM OUTCOMES					
			PO1	PO2	PO3	PO4	PO5	PO6
First	I	Applied Mathematics for Network Engineers	L		H	H	L	L
		Wireless Broadband Networks	H	M	H	H	L	L
		Wireless Communication Techniques	H	M	H	H	L	L
		RF Engineering	H	M	H	H	L	L
		Wireless Sensor Network Design	H	M	H	H	L	L
		Research Methodology and IPR	H	H				H
		Audit Course-I						
		RF System Design Laboratory	M	H	H	H	L	L
		Wireless Sensor Network Design Laboratory	M	H	H	H	L	L
	II	Access Technologies	H	M	H	H	L	L
		Free Space Optical Communication	H	M	H	H	L	L
		Principles of Network Security	H	M	H	H	L	L
		Program Elective Course-I						
		Program Elective Course –II						
		Audit Course-II						
		Wireless Technology Laboratory	M	M	H	H	L	L
		Antenna Design and Testing Laboratory	M	M	H	H	L	L
		Mini Project with Seminar	M	H	H	H	L	L
Second	III	Professional Elective Course – III						
		Professional Elective Course – IV						
		Professional Elective Course – V						
		Open Elective						
		Dissertation - I	M	H	H	H	L	L
	IV	Dissertation - II	M	H	H	H	L	L

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PROGRAM ELECTIVE COURSE	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
Multirate Signal Processing for Communication	H	M	H	H	L	L
Electromagnetic Interference/Electromagnetic Compatibility	H	M	M	H	L	L
Space Time Wireless Communication	H	M	M	H	L	L
Cognitive Radio Networks	H	M	M	H	L	L
Adaptive Signal Processing Techniques	H	M	H	H	L	L
Radio Frequency Integrated Circuit Design	M	M	M	H	H	H
VLSI Design Techniques	M	M	M	H	H	H
Spread Spectrum Techniques	M	M	M	H	L	L
Pattern Recognition and Machine Learning	M	M	M	H	L	L
Micro Electro Mechanical System for Wireless Communication	M	M	M	H	M	M
Global Positioning Systems	M	M	M	H	L	L
Information Theory and Coding	H	M	H	H	L	L
Modeling and Simulation of Wireless Communication Systems	H	M	M	H	L	L
Multimedia Compression Techniques	M	M	M	H	L	L
Real Time Embedded System	M	M	M	H	L	L
Ultra Wideband Communication	M	M	M	H	L	L
Network Routing Protocols	M	M	H	H	L	L
Computational Intelligence	M	M	M	H	L	L
Game Theory for Wireless Communication and	H	M	M	H	L	L
Wireless Transceiver Design	M	M	M	H	H	L
Advanced Antenna Systems	M	M	M	H	L	L
Advanced Wireless Communication Techniques	M	M	M	H	L	L
IoT Fundamentals	M	M	M	H	H	L
Optical and Wireline Technology	M	M	M	H	L	L
Communication Satellite Systems	M	M	M	H	L	L

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CHOICE BASED CREDIT SYSTEM
I – IV CURRICULA AND SYLLABI

SEMESTER – I

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA5155	Applied Mathematics for Network Engineers	FC	3	1	0	4	4
2.	WT5101	Wireless Broadband Networks	PCC	3	0	0	3	3
3.	WT5102	Wireless Communication Techniques	PCC	3	0	0	3	3
4.	NE5151	RF Engineering	PCC	3	0	0	3	3
5.	WT5151	Wireless Sensor Network Design	PCC	3	0	0	3	3
6.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
7.		Audit Course-I*	AC	2	0	0	2	0
PRACTICAL								
8.	NE5161	RF System Design Laboratory	PCC	0	0	4	4	2
9.	WT5111	Wireless Sensor Network Design Laboratory	PEC	0	0	4	4	2
			TOTAL	**19**	**1**	**8**	**28**	**22**

* Audit course is optional

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SEMESTER – II

S.NO.	CODE NO.	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	WT5201	Access Technologies	PCC	3	0	0	3	3
2.	WT5202	Free Space Optical Communication	PCC	3	0	0	3	3
3.	WT5203	Principles of Network Security	PCC	3	0	0	3	3
4.		Program Elective I	PEC	3	0	0	3	3
5.		Program Elective II	PEC	3	0	0	3	3
6.		Audit Course-II*	AC	2	0	0	2	0
PRACTICAL								
7.	WT5261	Wireless Technology Laboratory	PCC	0	0	4	4	2
8.	WT5211	Antenna Design and Testing Laboratory	PEC	0	0	4	4	2
9.	WT5212	Mini Project with Seminar	EEC	0	0	4	4	2
			TOTAL	**17**	**0**	**12**	**29**	**21**

* Audit course is optional

SEMESTER – III

S.NO.	CODE NO.	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Program Elective III	PEC	3	0	0	3	3
2.		Program Elective IV	PEC	3	0	0	3	3
3.		Program Elective V	PEC	3	0	0	3	3
4.		Open Elective	OEC	3	0	0	3	3
PRACTICAL								
5.	WT5311	Dissertation - I	EEC	0	0	12	12	6
			TOTAL	**12**	**0**	**12**	**24**	**18**

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SEMESTER – IV

S.No.	Code No.	Course Title	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
PRACTICAL								
1.	WT5411	Dissertation - II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 73

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CHOICE BASED CREDIT SYSTEM
I TO VI SEMESTERS CURRICULA AND SYLLABI

SEMESTER – I

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA5155	Applied Mathematics for Network Engineers	FC	3	1	0	4	4
2.	WT5102	Wireless Communication Techniques	PCC	3	0	0	3	3
3.	NE5151	RF Engineering	PCC	3	0	0	3	3
4.		Audit Course-I*	AC	2	0	0	2	0
PRACTICAL								
5.	NE5161	RF System Design Laboratory	PCC	0	0	4	4	2
			TOTAL	**11**	**1**	**4**	**15**	**12**

* Audit course is optional

SEMESTER – II

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	WT5201	Access Technologies	PCC	3	0	0	3	3
2.	WT5202	Free Space Optical Communication	PCC	3	0	0	3	3
3.	WT5203	Principles of Network Security	PCC	3	0	0	3	3
4.		Audit Course-II*	AC	2	0	0	2	0
PRACTICAL								
5.	WT5261	Wireless Technology Laboratory	PCC	0	0	4	4	2
			TOTAL	**11**	**0**	**4**	**15**	**11**

* Audit course is optional

SEMESTER – III

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	WT5301	Wireless Broadband Networks	PCC	3	0	0	3	3
2.	WT5151	Wireless Sensor Network Design	PCC	3	0	0	3	3
3.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
PRACTICAL								
4.	WT5111	Wireless Sensor Network Design Laboratory	PEC	0	0	4	4	2
			TOTAL	**8**		**4**	**12**	**10**

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SEMESTER – IV

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Program Elective I	PEC	3	0	0	3	3
2.		Program Elective II	PEC	3	0	0	3	3
3.		Program Elective III	PEC	3	0	0	3	3
PRACTICAL								
4.	WT5211	Antenna Design and Testing Laboratory	PEC	0	0	4	4	2
5.	WT5212	Mini Project with Seminar	EEC	0	0	4	4	2
			TOTAL	**9**	**0**	**8**	**17**	**13**

SEMESTER – V

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Program Elective IV	PEC	3	0	0	3	3
2.		Program Elective V	PEC	3	0	0	3	3
3.		Open Elective	OEC	3	0	0	3	3
PRACTICAL								
4.	WT5311	Dissertation - I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER – VI

S.NO.	CODE NO.	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICAL								
1.	WT5411	Dissertation - II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 73

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PROFESSIONAL CORE (PCC)

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	WT5101	Wireless Broadband Networks	PCC	3	0	0	3	3
2.	WT5102	Wireless Communication Techniques	PCC	3	0	0	3	3
3.	NE5151	RF Engineering	PCC	3	0	0	3	3
4.	WT5151	Wireless Sensor Network Design	PCC	3	0	0	3	3
5.	WT5201	Access Technologies	PCC	3	0	0	3	3
6.	WT5202	Free Space Optical Communication	PCC	3	0	0	3	3
7.	WT5203	Principles of Network Security	PCC	3	0	0	3	3
8.	NE5161	RF System Design Laboratory	PCC	0	0	4	4	2
9.	WT5111	Wireless Sensor Network Design Laboratory	PEC	0	0	4	4	2
10.	WT5261	Wireless Technology Laboratory	PCC	0	0	4	4	2
11.	WT5211	Antenna Design and Testing Laboratory	PEC	0	0	4	4	2

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	WT5311	Dissertation- I	EEC	0	0	12	12	6
2.	WT5411	Dissertation- II	EEC	0	0	24	24	12
3.	WT5212	Mini Project with Seminar	EEC	0	0	4	4	2

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2

FOUNDATION COURSES (FC)

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S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA5155	Applied Mathematics for Network Engineers	FC	3	1	0	4	4

OPEN ELECTIVE COURSES (OEC)

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	OE5091	Business Data Analytics	OEC	3	0	0	3	3
2.	OE5092	Industrial Safety	OEC	3	0	0	3	3
3.	OE5093	Operations Research	OEC	3	0	0	3	3
4.	OE5094	Cost Management of Engineering Projects	OEC	3	0	0	3	3
5.	OE5095	Composite Materials	OEC	3	0	0	3	3
6.	OE5096	Waste to Energy	OEC	3	0	0	3	3

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

SL. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1.	AX5091	English for Research Paper Writing	2	0	0	0
2.	AX5092	Disaster Management	2	0	0	0
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0
4.	AX5094	Value Education	2	0	0	0
5.	AX5095	Constitution of India	2	0	0	0
6.	AX5096	Pedagogy Studies	2	0	0	0
7.	AX5097	Stress Management by Yoga	2	0	0	0
8.	AX5098	Personality Development Through Life Enlightenment Skills	2	0	0	0
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0
TOTAL CREDITS						**0**

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PROGRAM ELECTIVE COURSES (PEC)

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	WT5001	Multirate signal processing for communication	PEC	3	0	0	3	3
2.	NE5072	Electromagnetic Interference and Electromagnetic Compatibility	PEC	3	0	0	3	3
3.	WT5002	Space Time Wireless Communication	PEC	3	0	0	3	3
4.	CU5071	Cognitive Radio Networks	PEC	3	0	0	3	3
5.	NE5251	Adaptive signal Processing Techniques	PEC	3	0	0	3	3
6.	WT5003	Radio Frequency Integrated Circuit Design	PEC	3	0	0	3	3
7.	NE5080	VLSI Design Techniques	PEC	3	0	0	3	3
8.	WT5004	Spread spectrum techniques	PEC	3	0	0	3	3
9.	NE5078	Pattern Recognition and machine learning	PEC	3	0	0	3	3
10.	WT5005	Micro Electro Mechanical System for Wireless Communication	PEC	3	0	0	3	3
11.	WT5006	Global Positioning Systems	PEC	3	0	0	3	3
12.	NE5075	Information Theory and Coding	PEC	3	0	0	3	3
13.	WT5007	Modeling and Simulation of Wireless Communication Systems	PEC	3	0	0	3	3
14.	WT5008	Multimedia Compression Techniques	PEC	3	0	0	3	3
15.	VE5151	Real Time Embedded System	PEC	3	0	0	3	3
16.	WT5009	Ultra Wideband Communication	PEC	3	0	0	3	3
17.	WT5010	Network Routing Protocols	PEC	3	0	0	3	3
18.	NE5071	Computational Intelligence	PEC	3	0	0	3	3
19.	NE5073	Game Theory for Wireless Communication and Networking	PEC	3	0	0	3	3
20.	WT5011	Wireless Transceiver Design	PEC	3	0	0	3	3
21.	WT5012	Advanced Antenna Systems	PEC	3	0	0	3	3
22.	WT5013	Advanced Wireless Communication	PEC	3	0	0	3	3

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		Techniques						
23.	NE5076	IoT Fundamentals	PEC	3	0	0	3	3
24.	WT5014	Optical and Wireline Technology	PEC	3	0	0	3	3
25.	WT5015	Communication Satellite Systems	PEC	3	0	0	3	3

MA5155 APPLIED MATHEMATICS FOR NETWORK ENGINEERS L T P C
3 1 0 4

OBJECTIVES:

- To encourage students to develop a working knowledge of the central ideas of Linear Algebra.
- To develop the ability to use the concepts of Special Functions for solving problems related to Networks.
- To analyze the Graph algorithms and understand their applications in Networks.
- To impart knowledge on Numerical Methods that will come in handy to solve numerically the problems that arise in engineering. This will also serve as a precursor for future research.
- To acquire skills in analyzing Queuing Models.

UNIT I LINEAR ALGEBRA 12

Vector spaces – norms – Inner Products – Eigenvalues 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 OUTCOME:

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

CO1: Work with vector spaces and linear transformations and their applications.
CO2: Use the ideas of Special Functions in solving special types of problems.
CO3: Apply Graph Theory algorithms in networks.
CO4: Use various methods of solving systems of Algebraic Equations and eigenvalue problems.
CO5: Apply the ideas of random processes.

REFERENCES:

1. Balakrishnan R., Ranganathan K., “A textbook of Graph theory”, Springer, New York, 2nd Edition, 2012.
2. Erwin Kreyszig. “Advanced Engineering Mathematics”, John Wiley & Sons, New York, 10th Edition, 2010.
3. Glyn James, “Advanced Modern Engineering Mathematics”, Pearson/Prentice Hall, Horlow, 5th Edition, 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, Singapore, 8th Edition, 2017.
6. Ralph P. Grimaldi, "Discrete and combinatorial Mathematics", Pearson Education, New Jersey, 5th Edition, 2004.

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

WT5101 **WIRELESS BROADBAND NETWORKS** **L T P C**
3 0 0 3

OBJECTIVES :

- To study the various network layer and transport layer protocols for wireless networks
- To study the architecture and interference mitigation techniques in 3G standards
- To learn about 4G technologies and LTE-A in mobile cellular network.
- To learn about the layer level functionalities in interconnecting networks.
- To study the emerging techniques in 5G network.

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, downlink/uplink data transfer, MAC control element, PDU packet formats, scheduling services, random access procedure.

UNITIV 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, SC-FDMA, interference cancellation – CoMP, Carrier aggregation, Services - multimedia broadcast/multicast, location-based services.

UNIT V 5G 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- capacity limits and achievable gains with densification - Mobile data demand, Demand Vs Capacity, Small cell challenges, conclusion and future directions.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the student would be able to

CO1: Design and implement the various protocols in wireless networks.
CO2: Analyze the architecture of 3G network standards.
CO3: Analyze the difference of LTE-A network design from 4G standard.
CO4: Design the interconnecting network functionalities by layer level functions.
CO5: Explore the current generation (5G) network architecture.

REFERENCES:

1. Kaveh Pahlavan, “Principles of wireless networks”, Prentice-Hall of India, 2008.
2. Vijay K.Garg, “Wireless Network Evolution - 2G & 3G”. Prentice Hall; August 11,
3. Clint Smith,P.E, Dannel Collins, “3G Wireless Networks” Tata McGraw-Hill, 2nd Edition, 2011.
4. Sassan Ahmadi, “LTE-Advanced – A practical systems approach to understanding the 3GPP LTE Releases 10 and 11 radio access technologies”, Elsevier, 2014.
5. Jonathan Rodriguez, "Fundamentals of 5G Mobile networks", John Wiley, 2015.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

WT5102 **WIRELESS COMMUNICATION TECHNIQUES** **L T P C**
3 0 0 3

OBJECTIVES:

- To understand the basic concepts in cellular communication
- To understand the characteristics of wireless channels.
- To know the Impact of digital modulation techniques in fading
- To get exposed to diversity techniques in wireless communication.
- To acquire knowledge in multicarrier systems

UNIT I CELLULAR CONCEPTS **9**

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**

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**

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

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– Transmit & Receive Diversity-MIMO Systems.

UNIT V MULTICARRIER MODULATION 9

Data Transmission using Multiple Carriers – Multicarrier Modulation with Overlapping Sub channels – Mitigation of Subcarrier Fading – Discrete Implementation of Multicarrier Modulation – Peak to average Power Ratio- Frequency and Timing offset.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: To be able to design solutions for cellular communication
CO2: To be able to compute the capacity of wireless channels
CO3: To be able to analyze the performance of the digital modulation techniques in fading channels.
CO4: To apply various diversity techniques in wireless communication.
CO5: To design 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. Keith Q. T. Zhang, “ Wireless Communications: Principles, Theory and Methodology” John Wiley & Sons, 1st Edition, 2016.
5. Ramjee Prasad, "OFDM for Wireless Communication Systems", Artech House,2004.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

NE5151 RF ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- To model high frequency circuit using scattering matrixes
- To acquire knowledge on the RF filter design
- To design microwave amplifier
- To get familiar with design of RF oscillator
- To learn about the high frequency antennas

Attested

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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, 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.

UNIT IV MICROWAVE TRANSISTOR 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

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.

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. Matthew M.Radmanesh, "RF and Microwave Design Essentials", Author House, Bloomington, 2007.
2. Reinhold Ludwig and Gene Bogdanov, "RF Circuit Design – Theory and Applications", Pearson, 2nd Edition, 2012.
3. E.da Silva, "High Frequency and Microwave Engineering", Butterworth Heinmann Publications, Oxford, 2001.
4. David.M.Pozar, "Microwave Engineering", John Wiley and Sons, 4th Edition, 2012.
5. Kraus.J.D, Marhefka.R.J. Khan.A.S. "Antennas and Wave Propagation", Tata Mc Graw Hill, New Delhi, 5th Edition, 2017

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

WT5151 **WIRELESS SENSOR NETWORK DESIGN** **L T P C**
3 0 0 3

OBJECTIVES :

- To understand the fundamentals of wireless sensor network
- To gain knowledge on the MAC and Routing Protocols of WSN
- To get exposed to 6LOWPAN technology
- To acquire knowledge on the protocols required for developing real time applications using WSN and 6LOWPAN.
- To gain knowledge about operating system related to WSN and 6LOWPAN

UNIT I INTRODUCTION **9**

Principle of Wireless Sensor Network -Introduction to wireless sensor networks- Challenges, Comparison with ad hoc network, Node architecture and Network architecture, design principles, Service interfaces, Gateway, Short range radio communication standards-IEEE 802.15.4, Zigbee and Bluetooth. Physical layer and transceiver design considerations.

UNIT II MAC AND ROUTING PROTOCOLS **9**

MAC protocols – fundamentals, low duty cycle protocols and wakeup concepts, contention and Schedule-based protocols - SMAC, BMAC,TRAMA, Routing protocols – Requirements, Classification -SPIN, Directed Diffusion, COUGAR, ACQUIRE, LEACH, PEGASIS.

UNIT III 6LOWPAN **9**

6LoWPAN Architecture - protocol stack, Adaptation Layer, Link layers – Addressing, Routing - Mesh-Under - Route-Over, Header Compression - Stateless header compression - Context-based header compression, Fragmentation and Reassembly , Mobility – types, Mobile IPv6, Proxy Home Agent, Proxy MIPv6, NEMO –Routing – MANET, ROLL, Border routing.

UNIT IV APPLICATION **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, Simple network management protocol (SNMP), Real-time transport and sessions, Industry- Specific protocols.

UNIT V TOOLS **9**

TinyOS – Introduction, NesC, Interfaces, modules, configuration, Programming in TinyOS using NesC, TOSSIM, Contiki – Structure, Communication Stack, Simulation environment – Cooja simulator, Programming

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: To be able to design solutions for WSNs applications
CO2: To be able to develop efficient MAC and Routing Protocols
CO3: To be able to design solutions for 6LOWPAN applications
CO4: To be able to develop efficient layered Protocols in 6LOWPAN
CO5: To be able to use Tiny OS and Contiki OS in WSNs and 6LOWPAN applications

REFERENCES:

1. Holger Karl , Andreas willig, “Protocol and Architecture for Wireless Sensor Networks”, John Wiley Publication, 2006.
2. Anna Forster, “Introduction to Wireless Sensor Networks”, Wiley, 2017.
3. Zach Shelby Sensinode and Carsten Bormann, “ 6LoWPAN: The Wireless Embedded Internet” John Wiley and Sons, Ltd, Publication, 2009.
4. Philip Levis, “TinyOS Programming”, 2006 – www.tinyos.net.
5. The Contiki Operating System. http://www.sics.se/contiki.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

RM5151 RESEARCH METHODOLOGY AND IPR LT P C
2 0 0 2

OBJECTIVES:

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT I RESEARCH PROBLEM FORMULATION 6

Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations

UNIT II LITERATURE REVIEW 6

Effective literature studies approaches, analysis, plagiarism, and research ethics.

UNIT III TECHNICALWRITING /PRESENTATION 6

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology.Patent information and databases.Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc.

Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 30 PERIODS

COURSE OUTCOMES:

CO1: Ability to formulate research problem
CO2: Ability to carry out research analysis
CO3: Ability to follow research ethics
CO4: Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
CO5: Ability to understand about IPR and filing patents in R & D.

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓											
CO3	✓							✓				
CO4	✓				✓							
CO5	✓					✓						✓

REFERENCES:

1. Asimov, “Introduction to Design”, Prentice Hall, 1962.
2. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
3. Mayall, “Industrial Design”, McGraw Hill, 1992.
4. Niebel, “Product Design”, McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners” 2010

NE5161 RF SYSTEM DESIGN LABORATORY L T P C
0 0 4 2

OBJECTIVES :

- To enable the student to design and develop RF components and systems
- To enable the student to learn RF measurements
- To design and develop RF filters
- To design and develop antennas for RF applications
- To design and characterize the RF systems

LIST OF EXPERIMENTS

1. Measurement of transmission line parameters using network analyzer (a) Inductor (b) Capacitor
2. Measurement of transmission line parameters using network analyzer (a) Reflection coefficient (b) VSWR
3. Design of Microstrip transmission line (a) λ/2 line (b) λ/4 line (c) λ/8 line
4. Design and characterization of RF filters
5. Design of impedance matching network
6. Measurement of RF signals and their spectrum
7. Design and characterization of antennas
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

CO1: Measure the RF network parameters
CO2: Design and develop RF filters
CO3: Design and develop antennas for RF applications
CO4: Construct new circuit and systems for high frequency applications
CO5: Test RF components and systems.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓	
CO3	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓		
CO5	✓	✓	✓	✓	✓	

WT5111 WIRELESS SENSOR NETWORK DESIGN LABORATORY L T P C
0 0 4 2

OBJECTIVES :

- To understand the working mechanism of Routing and Mac protocol of WSN
- To gain knowledge on 6LOWPAN routing protocol and its impact on topology control
- To understand characteristics features of zigbee and Bluetooth
- To learn to interface sensors and other peripheral interfaces
- To impart programming skill in networking simulation tools related to WSN and 6LOWPAN.

LIST OF EXPERIMENTS

1. Routing protocol of WSN
2. Characteristics Analysis of ZIGBEE
3. Characteristics Analysis of Bluetooth
4. MAC protocol of WSN
5. Study of 6LOWPAN OS and Simulator
6. RPL analysis
7. Topology Analysis of 6LOWPAN
8. RFID based application using zigbee/Bluetooth/6lowpan
9. Proximity based application using zigbee/Bluetooth/6lowpan
10. MINI PROJECT

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1: To be able to understand the working mechanism of Routing and Mac protocol of WSN
CO2: To be able to design 6LOWPAN routing protocol
CO3: To be able to rectify the problems involved in zigbee and Bluetooth based applications
CO4: To be able to design real time applications in WSN, 6LOWPAN
CO5: To be able to develop protocols and interfaces required for WSN and 6LOWPAN applications.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓	
CO3	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓		
CO5	✓	✓	✓	✓	✓	

Attested

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WT5201 **ACCESS TECHNOLOGIES** **L T P C**
3 0 0 3

OBJECTIVES :

- To understand the fundamental concepts related to access technologies.
- To understand the current and emerging wired and wireless access technologies.
- To understand the knowledge about the cable modems.
- To study and exposure to different systems standards for next generation access technologies.
- To study about the broadband wireless technologies

UNIT I REVIEW OF ACCESS TECHNOLOGIES 9

Phone-Line modem, cable-access, ISDN, Emerging Broad band Technologies, Cable DSL, Fiber and Wireless, Standards for access network.

UNIT II DIGITAL SUBSCRIBER LINES 9

Asymmetric Digital subscriber lines (ADSL) – Rate Adaptive subscriber line (RADSL)-ISDN Digital subscriber line (IDSL) - High bit rate DSL (HDSL)-Single line DSL (SDSL) - very high bit rate DSL (VDSL) - Standards for XDSL & Comparison.

UNIT III CABLE MODEM 9

Cable Modem, DOCSIS – Physical Cabling, Dual Modem Operation, Hub Restriction, Upstream Operation – Downstream operation – Access control – framing Security sub layer – Data link layer – LLC & Higher layers – ATM centric VS IP – centric cable modem.

UNIT IV FIBER ACCESS TECHNOLOGIES 9

Optical Fiber in access networks, Architecture and Technologies- Hybrid fiber – Coax (HFC) system, Switched Digital Video (SDV) – Passive optical networks (PON) – FTTX (FTTH, FTTB, FTTC, FTT cab) comparison.

UNIT V BROADBAND WIRELESS 9

Fixed Wireless, Direct Broadcast Satellite (DBS), Multi channel multi point distribution services (MMDS), Local multi point distribution services (LMDS), and Wideband integrated Digital Interactive Services (WIDIS).

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: To be able to explore the fundamental concepts and emerging broadband technologies
CO2: To be able to design the systems meeting out the requirements of the recent standards.
CO3: To be able to design the cable modem in next generation Access technologies.
CO4: To be able to analyze the systems standards for next generation access technologies.
CO5: To be able to explore the various services of wireless broadband technologies.

REFERENCES:

1. Niel Ransom and Albert A. Azzam, “Broadband Access Technologies: ADSL, VDSL Cable Modem, Fiber and LMDS", McGraw Hill, 1999.
2. Glen Carty, "Broadband Networking",Mc Graw Hill,2002.
3. Steven Gorshe, Arvind Raghavan, Thomas Starr, Stefano Galli, "Broadband Access: Wireline and Wireless - Alternatives for Internet Services", John Wiley & Sons, 2014.
4. Gilbert Held, “Next Generation Modems: A Professional Guide to DSL and Cable Modems”, John Wiley & Sons, 2000.
5. Walter J Woralski, “ADSL and DSL Technologies”, McGraw Hill Computer Communication Series, Second Edition Oct 2001.

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	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

WT5202 FREE SPACE OPTICAL COMMUNICATION L T P C
3 0 0 3

OBJECTIVES :

- To understand the concept of free space optical communication
- To know the challenges involved in designing a FSO system
- To understand the importance of FSO System
- To provide an adequate exposure to emerging FSO technology
- To study about the principles of FSO network

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 waves - Alternate Bandwidth Technologies - Fiber versus FSO - The Role of FSO in the Network - Factors affecting FSO

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 MODELS 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 - Free space optical links

UNIT IV OPTICAL BEAM PROPAGATION 9

Various mechanism of propagation - Propagation channel - Modeling - Additional power required to reach a given bit error rate - Optical noise - BER performance of FSO System - Link Performance Improvement Techniques - Link Feasibility Study - Concept of quality of service and availability - Regulation of FSO equipment - Safety and Confidentiality

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 - Free space optics and Laser safety.

TOTAL: 45 PERIODS

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COURSE OUTCOMES:

CO1: To be able to design and analyze the free space optical communication systems.
CO2: To be able to identify and select suitable components for building a FSO system
CO3: Complete understanding of FSO channels with their mathematical representation
CO4: To be able to understand the networking principles of FSO technology
CO5: To be able to understand the beam propagation mechanism.

REFERENCES:

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

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

WT5203 PRINCIPLES OF NETWORK SECURITY L T P C
3 0 0 3

OBJECTIVES :

- To learn the mathematics behind cryptography.
- To understand the network security mechanisms and security algorithms for wireless networks.
- To study the fundamental security protocols involved in wireless network security.
- To understand the fundamentals of WiFi and mobile Telecommunication networks
- To study different system and mobile IP security

UNIT I INTRODUCTION 9

Security Services and Mechanism, Mathematics of cryptography - integer arithmetic, modular arithmetic, Matrices, Linear congruence, algebraic structures ,GF(2n), primes, Euler's phi & totient functions, Fermat's and Euler's theorem, primality testing, factorization, CRT, quadratic congruence, exponentiation and logarithm.

UNIT II CRYPTOGRAPHIC ALGORITHMS 9

Classical Cryptographic Techniques – Substitution Ciphers - Transposition Ciphers. Symmetric Encryption Principles- Feistel Cipher Structure. Block cipher: DES,AES. Stream cipher: RC4. Cipher Block Modes of Operation. Asymmetric ciphers - RSA, ElGamal. Message Integrity, Entity Authentication - Passwords, Challenge Response. Digital Signatures- RSA, ELGamal

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UNIT III SECURITY PROTOCOLS 9

Security Protocols: Security at the Application Layer- PGP and S/MIME, Security at Transport Layer- SSL and TLS, Security at Network Layer-IPSec.

UNIT IV WIRELESS SECURITY 9

Wi-Fi Security: Attacks on wireless networks, Security in the IEEE 802.11 standard, Security in 802.11i - security architecture, security policy negotiation. Authentication in wireless networks - RADIUS. Layer 3 security mechanisms - PKI, level 3 VPN. Security in Mobile Telecommunication networks - signaling, vulnerabilities of SS7, possible attacks on SS7, Security in GSM - security flaws.

UNIT V SYSTEM & IP BASED NETWORK SECURITY 9

Viruses and related threats, viruses counter measures. Firewalls: Characteristics, Types of Firewalls. Intrusion Detection System, Password Management. Security issues related to mobility - vulnerabilities of mobile IP networks, Discovery mechanisms, Authenticity of mobile location, Data protection. Mobility with MIPv6 and MIPv4

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students will be able to

CO1: To be able to formulate mathematical models for security algorithms
CO2: To be able to design security algorithms
CO3: To be able to develop new security protocols
CO4: Analyze security threats in both Wi-Fi and mobile telecommunication network
CO5: Analyze security threats in mobile internet

REFERENCES:

1. Behrouz A. Ferouzan, Debdeep Mukhopadhyay —Cryptography & Network Security, Tata McGraw Hill, 3rd Edition, 2015.
2. William Stallings, “Cryptography & Network Security – Principles and Practices”, Prentice Hall, 5th Edition, 2013.
3. Hakima Chaouchi , maryline Laurent - Maknavicius, " Wireless and Mobile network security" Wiley, 2009.
4. Wolfgang Osterhage, “Wireless Security”, CRC Press, 2011.
5. Michael E.Whitman and Herbert J.Mattord, “Principles of Information Security,” Cengage Learning, 4th Edition, 2011.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

Attested

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WT5261 **WIRELESS TECHNOLOGY LABORATORY** **L T P C**
0 0 4 2

OBJECTIVES :

- To understand the functioning of various protocols in Wired Environment.
- To understand the functioning of various protocols in Wireless Environment.
- To perform real time experimentation using the existing infrastructure.
- To get exposed to open source networking tools.
- To gain knowledge in constructing LAN, WLAN, and VLAN

LIST OF EXPERIMENTS

1. Wired and Wireless network scenario creation.
2. Study of Routing Protocols
3. Analysis of Network Security Algorithms
4. Study of ZigBee Energy Model and MAC protocols
5. Queuing mechanism.
6. QoS analysis of Multimedia traffic.
7. Call establishment in cellular network
8. Handover in cellular network
9. Throughput performance for various terrain models, transmission modes, loading conditions, traffic profiles in LTE network.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1: Ability to design MAC and routing protocols in Wired Environment
CO2: Ability to design MAC and routing protocols in Wireless Environment
CO3: Acquire the technical competence to meet out the industry expectation in the wired technologies
CO4: Ability to meet out requirements of industries related to wireless technologies
CO5: Acquire the ability to design WLAN/ LAN systems meeting out real time requirements.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓	
CO3	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓		
CO5	✓	✓	✓	✓	✓	

WT5211 **ANTENNA DESIGN AND TESTING LABORATORY** **L T P C**
0 0 4 2

OBJECTIVES :

- To measure antenna parameters
- To design and develop Yagi antenna
- To design and develop Microstrip antenna
- To design and develop antennas for WiFi and mobile applications
- To design and characterize the Microwave antenna

LIST OF EXPERIMENTS

1. Measurement of return loss of different antenna using network analyzer
2. Design and development of Yagi antenna by using software
3. Design and development of microstrip patch antenna
4. Characteristics of Horn antenna
5. Radiation pattern and gain measurement of antenna
6. Design and characterization of reflector antenna
7. Design and development of wire antenna
8. Design and characterization of WiFi and Cell phone antenna
9. Mini Project

TOTAL: 60 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Measure the antenna parameters
CO2: Design and develop Yagi antenna
CO3: Design and develop antennas for mobile applications
CO4: Construct antennas for high frequency applications
CO5: Test and characterize the antennas.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓	
CO3	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓		
CO5	✓	✓	✓	✓	✓	

WT5001 MULTIRATE SIGNAL PROCESSING FOR COMMUNICATION L T P C
3 0 0 3

OBJECTIVES :

- To understand discrete signals and basic signal processing - filters.
- To understand and implement multistage filters.
- To get exposed to various filter bank techniques.
- To get knowledge about uniform filter banks.
- To understand the various applications of Multirate signal processing.

UNIT I DECIMATION AND INTERPOLATION 9

Introduction – Representation of discrete signals – Down Sampling - Up Sampling - Decimation with transversal filters – Interpolation with transversal filters.

UNIT II DECIMATION WITH POLYPHASE FILTERS 9

Interpolation with polyphase filters – Decimation and Interpolation with Rational sampling factors - Multistage implementations of decimators and interpolators.

UNIT III TWO CHANNEL FILTER BANKS 9

Analysis and synthesis filter banks – Quadrature mirror filter banks – Filter banks with perfect reconstruction – Paraunitary filter banks – Biorthogonal and linear phase filter banks – Transmuliplexer filter banks

UNIT IV UNIFORM M-CHANNEL FIILTER BANKS 9

Filter banks with tree structure – Filter banks with parallel structure – complex modulated filter banks –cosine modulated filter banks – Transmultiplexer filter banks.

UNIT V APPLICATIONS 9

Digital Audio Systems – Sub band coding of speech and image signals – Analog Voice privacy System – Timing recovery in a digital demodulator – FM Receiver and Demodulator.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: To be able to understand the concepts of signal processing filters.
CO2: To be able to implement polyphase filters.
CO3: To be able to design various filter banks.
CO4: Student will in position to design complex M channel filter banks.
CO5: To be able to design speech/ audio systems related applications.

REFERENCES:

1. Fliege N J, "Multirate Digital Signal Processing", John Wiley and sons, 2000.
2. Proakis J G and Manolakis D G, "Digital Signal Processing Principles, Algorithms and Applications", Prentice Hall of India, 3rd Edition, 2015.
3. Li Tan , “Digital Signal Processing Fundamentals and Applications”, 2nd Edition, 2008,
4. Sanjit K Mitra , “Digital Signal Processing: A Computer-Based Approach”, 3rd Edition, 2008
5. Fredric J Harris “Multirate Signal Processing for Communication Systems” Pearson Education, 3rd Edition, 2009.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

NE5072 ELECTROMAGNETIC INTERFERENCE AND ELECTROMAGNETIC COMPATIBILITY

L T P C
3 0 0 3

OBJECTIVES :

- To develop an understanding of basics of Electromagnetic interference in Electronic systems
- To acquire knowledge on the EMI coupling mechanisms
- To impart concepts of EMI control schemes
- To get acquainted with design PCB incorporating EMC principles
- To know about the current EMC standards and measurement techniques

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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 to cable 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; Cross talk control; Power distribution decoupling; Zoning; Grounding; VIAs 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 standardsMIL461E/462.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Understand EMI and susceptibility
CO2: Identify EMI coupling mechanisms
CO3: Use appropriate EMI control schemes in electronic systems
CO4: Design PCBs with EMC
CO5: Conduct EMI measurements according to standards.

REFERENCES:

1. David A Weston," Electromagnetic Compatibility – Methods, Analysis, circuits and measurements" CRC press, Boca raton 2017
2. Tim Williams, "EMC for product designers" , Newness, 5th Edition, 2017.
3. Patrick G. Andre and Kenneth Wyatt," EMI Troubleshooting Cookbook for Product Designers (Electromagnetics and Radar),SciTech publishing, 2014
4. C.R.Paul, "Introduction to Electromagnetic Compatibility", John Wiley and Sons, Inc, 2nd Edition, 2010.
5. Henry W.Ott.," Electromagnetic Compatibility Engineering, Revised edition, Wiley Black well Newyork, 2009.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

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WT5002 **SPACE TIME WIRELESS COMMUNICATION** **L T P C**
3 0 0 3

OBJECTIVES :

- To acquire the knowledge on Space time wireless technology using multiple antennas.
- To understand Space time wireless propagation and space time channel.
- To understand diversity and capacity performance of space time wireless communication.
- To exploit the channel knowledge at the transmitter.
- To realize space time multiuser communication and system design.

UNIT I MULTIPLE ANTENNA PROPAGATION AND ST CHANNEL CHARACTERIZATION **9**

Wireless channel, Scattering model in macrocells, 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 for MIMO-OFDM,SISO-SS modulation, MIMO-SS modulation, Signaling and receivers for MIMO-S S.MIMO-MAC,MIMO-BC, Outage performance for MIMO-MU,MIMO-MU with OFDM.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: To be able to apply the knowledge of wireless technology using multiple antennas.
CO2: To be able to analyze space time wireless propagation and space time channel.
CO3: To be able to evaluate the performance of space time wireless communication.
CO4: To be able to utilize the channel knowledge at the transmitter.
CO5: To be able to understand space time multiuser communication.

REFERENCES:

1. A. Paulraj, Rohit Nabar, Dhananjay Gore., “Introduction to Space Time Wireless Communication Systems”, Cambridge University Press, 2003.
2. Claude Oestges, Bruno Clerckx., "MIMO Wireless Communications: From Real-World Propagation to Space-Time Code Design" , Academic Press, 2010.
3. Erik G. Larsson, Petre Stoica ., "Space-Time Block Coding for Wireless Communications", Cambridge University Press, 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. Tolga M. Duman, Ali Ghrayeb., "Coding for MIMO Communication Systems", John Wiley & Sons, 2008.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

CU5071 COGNITIVE RADIO NETWORKS L T P C
3 0 0 3

COURSE OBJECTIVES:

- To enable the student to understand the evolving paradigm of cognitive radio communication and the enabling technologies for its implementation.
- To enable the student to understand the essential functionalities and requirements in designing software defined radios and their usage for cognitive communication.
- To expose the student to the evolving next generation wireless networks and their associated challenges.

UNIT I SOFTWARE DEFINED RADIO AND ITS ARCHITECTURE 9

Definitions and potential benefits, software radio architecture evolution, technology tradeoffs and architecture implications. Essential functions of the software radio, basic SDR, hardware architecture, Computational processing resources, software architecture, top level component interfaces, interface topologies among plug and play modules.

UNIT II COGNITIVE RADIOS AND ITS ARCHITECTURE 9

Marking radio self-aware, cognitive techniques – position awareness, environment awareness in cognitive radios, optimization of radio resources, Artificial Intelligence Techniques, Cognitive Radio – functions, components and design rules, Cognition cycle – orient, plan, decide and act phases, Inference Hierarchy, Architecture maps, Building the Cognitive Radio Architecture on Software defined Radio Architechture.

UNIT III SPECTRUM SENSING AND IDENTIFICATION 9

Primary Signal Detection: Energy Detector, Cyclostationary Feature Detector,Matched Filter ,Cooperative Sensing , Definition and Implications of Spectrum Opportunity, Spectrum Opportunity Detection , Fundamental Trade-offs: Performance versus Constraint , MAC Layer Performance Measures, Global Interference Model, Local Interference Model, Fundamental Trade-offs: Sensing Accuracy versus Sensing Overhead.

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 INFORMATION THEORETICAL LIMITS ON CR NETWORKS 9

Types of Cognitive Behavior, Interference-Avoiding Behavior: Spectrum Interweave, Interference-Controlled Behavior: Spectrum Underlay, Underlay in Small Networks: Achievable Rates, Underlay in Large Networks: Scaling Laws, Interference-Mitigating Behavior: Spectrum Overlay, Opportunistic Interference Cancellation, Asymmetrically Cooperating Cognitive Radio Channels.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1: The student would be able to appreciate the motivation and the necessity for cognitive radio communication strategies.

CO2: The student would be able to evolve new techniques and demonstrate their feasibility using mathematical validations and simulation tools.

CO3: The student would be able to demonstrate the impact of the evolved solutions in future wireless network design.

REFERENCES:

1. Alexander M. Wyglinski, Maziar Nekovee, And Y. Thomas Hou, "Cognitive Radio Communications and Networks - Principles And Practice", Elsevier Inc. , 2010.
2. Kwang-Cheng Chen and Ramjee Prasad, "Cognitive Radio Networks", John Wiley & Sons, Ltd, 2009.
3. Khattab, Ahmed, Perkins, Dmitri, Bayoumi, Magdy, "Cognitive Radio Networks - From Theory to Practice", Springer Series: Analog Circuits and Signal Processing, 2009.
4. J. Mitola, "Cognitive Radio: An Integrated Agent Architecture for software defined radio", Doctor of Technology thesis, Royal Inst. Technology, Sweden 2000.
5. Simon Haykin, "Cognitive Radio: Brain –empowered wireless communications", IEEE Journal on selected areas in communications, Feb 2005.
6. Ian F. Akyildiz, Won – Yeol Lee, Mehmet C. Vuran, Shantidev Mohanty, "NeXt generation / dynamic spectrum access / cognitive radio wireless networks: A Survey Elsevier Computer Networks", May 2006.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	

NE5251 ADAPTIVE SIGNAL PROCESSING TECHNIQUES L T P C
3 0 0 3

OBJECTIVES:

- To understand the basic principles of discrete random signal processing
- To understand the principles of spectral estimation
- To learn about the weiner and adaptive filters
- To understand the different signal detection and estimation methods
- To acquire skills to design synchronization methods for proper functioning of the system

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.

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UNIT IV DETECTION AND ESTIMATION 9

Bayes detection techniques, MAP, ML,– detection of M-ary signals, NeymanPeason, 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 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. Monson H. Hayes, “Statistical Digital Signal Processing and Modeling”, John Wiley and Sons, Inc, Singapore, 2009.
2. John G. Proakis., "Digital Communication", McGraw Hill Publication, 4th Edition, 2001.
3. Simon Haykin, “Adaptive Filter Theory”, Pearson Education, 4th Edition, 2003.
4. Bernard Sklar and Pabitra Kumar Roy, “Digital Communications: Fundamentals and Applications”, Pearson Education India, 2nd Edition, 2009
5. Paulo S. R. Diniz, “Adaptive Filtering Algorithms and Practical Implementation”, Springer, 2011.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

WT5003 RADIO FREQUENCY INTEGRATED CIRCUIT DESIGN L T P C
3 0 0 3

OBJECTIVES :

- To introduce the Integrated circuit design for Amplifiers at radio frequency.
- To get exposed to microwave oscillator design.
- To imparts the concepts of RF IC
- To analyze and focus on circuits for radio frontends for mobile phone handsets.
- To understand noise amplifiers, mixers, power amplifiers, frequency synthesizers (phase locked loops) and modern radio architectures.

UNIT - I AMPLIFIERS 9

FET and bipolar transistor models **–** Two port power gains – stability – Amplifier design using S parameters – LNA – Differential amplifiers – DC biasing – Power amplifiers – general issues – efficiency, linearity, load pull, class A, AB and C Designs – Higher class power amplifiers – linearization – distributed power amplifier.

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UNIT - II RF OSCILLATORS 9

Microwave oscillators – LC – Colpitts – negative resistance – differential oscillators – frequency synthesis methods – phase locked loop analysis – oscillator phase noise.

UNIT – III RADIO FREQUENCY IC 9

Introduction to RFIC – Analog and microwave design versus RFIC design – noise performance estimate – RF technology – receiver with single IF stage metallization – sheet resistance – skin effect – parasitic capacitance and inductance – current handling – metal capacitors – spiral inductors – quality factor – layouts in IC – mutual inductance – multilevel – measurement – packaging.

UNIT – IV MICROWAVE POINT TO POINT SYSTEM DESIGN 9

Microwave transmission – link design – theoretical and practical aspects – fading design – protected and non protected microwave systems – link design – path calculation - spread spectrum microwave system – compatibility – safety coordinate systems – Datum"s & GPS – Receiver design – receiver architecture – dynamic range – frequency conversion and filtering – examples of practical receivers – FM broad cast, Digital cellular – Millimeter wave point to point, Direct conversion GSM receiver

UNIT – V TRANSMISSION LINE EQUIPMENT 9

Digital microwave radio – fiber optic equipment – wire line equipment – cabling, grounding – Power battery backup – GPS antenna – reliability issues – cell site selection – microwave repeater site selection – microwave site and path survey – microwave antenna mounting – measurement of RF fields – source emissions – power level and radiation pattern – microwave installation measurements and testing.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Design amplifier by using RF IC
CO2: Develop RF oscillator for high frequency applications
CO3: Apply RF technology in the high frequency IC design
CO4: Understand the RF point to point system design
CO5: Apply IC design techniques in the transmission line equipment

REFERENCES:

1. David Pozar, "Microwave and RF Design of Wireless Systems", John Wiley, 2nd Edition 2012.
2. John Rogers and Calvin Plett, "Radio Frequency Integrated Circuit Design", Artech House, 2nd Edition ,2002.
3. Thomas H Lee, "The Design of CMOS Radio Frequency Integrated Circuits" Cambridge University press, 2nd Edition, 2003.
4. Hooman Darabi, "Radio Frequency Integrated Circuits and Systems", Cambridge University press, 1st Edition, 2015.
5. Sorin Voinigescu, "High Frequency Integrated Circuits", Cambridge University press, 1st Edition, 2013.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

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NE5080 **VLSI DESIGN TECHNIQUES** **L T P C**
3 0 0 3

OBJECTIVES :

- To learn the fundamentals of VLSI design
- To understand the IC Manufacturing Process
- To familiarize with VLSI combinational logic circuits design
- To familiarize with VLSI sequential logic circuits design
- To learn the various arithmetic circuits and testing methodologies

UNIT - I MOS TRANSISTOR PRINCIPLES 9

MOS Technology and VLSI, CMOS Fabrication process and Electrical properties of CMOS circuits – secondary effects – device modeling – process variations – static and dynamic behavior of CMOS inverter – power and energy – scaling principles – stick diagram.

UNIT - II COMBINATIONAL LOGIC CIRCUITS 9

Static CMOS logic design - Complementary CMOS – Ratioed logic – Pass transistor Logic. Dynamic CMOS logic – principles – speed and power dissipation – signal integrity issues – cascading dynamic gates.

UNIT – III SEQUENTIAL LOGIC CIRCUITS AND MEMORY ARRAY STRUCTURES 9

Static and Dynamic Latches and Registers, Timing Issues, Pipelines, Clocking strategies, Memory core and peripheral circuitry, memory reliability and power dissipation. Case Studies: PLA, SRAM and NAND flash memories.

UNIT – IV DESIGNING ARITHMETIC BUILDING BLOCKS & TESTING 9

Data paths - Architectures for Adders - Multipliers and Shifters, Test procedures - Design for testability – Scan based test – built in self test – test pattern generation – fault models and fault simulation.

UNIT – V IMPLEMENTATION STRATEGIES 9

Full custom and semicustom design – cell based design – array based implementation - Programmable ASIC logic cells - Actel ACT - Xilinx LCA - Altera FLEX and MAX.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course students will be
CO1: Able to familiarize the basics of VLSI design.
CO2: Able to design combinational logic circuits.
CO3: Able to design sequential logic and memory circuits.
CO4: Able to analyze the various design techniques involved in arithmetic building blocks.
CO5: Able to analyze the implementation strategies in circuit design.

REFERENCES:

1. N.Weste, D.M.Harris, “CMOS VLSI Design: Circuits and System Perspective”, Pearson, 4th Edition,2015.
2. N.Weste, K.Eshraghian, “Principles of CMOS VLSI DESIGN”, A system Perspective, second edition,Addision Wesley, 2010.
3. A.Pucknell, Kamran Eshraghian, “BASIC VLSI DESIGN”, Prentice Hall of India, 3rd Edition, 2007.
4. M.J. Smith, “Application specific integrated circuits”, Addisson Wesley, 2009.
5. R.Jacob Baker, Harry W.LI., David E.Boyee, “CMOS Circuit Design, Layout and Simulation”, Prentice Hall of India, 2005.

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	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

WT5004 **SPREAD SPECTRUM TECHNIQUES** **L T P C**
3 0 0 3

OBJECTIVES :

- To introduce the concept of spread spectrum modulation.
- To understand the generation of PN sequence and their properties.
- To understand the performance of spread spectrum in jamming environment.
- To understand the way in which spread spectrum is applied to CDMA and GPS systems.
- To get expose to the applications of spread spectrum.

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

OUTCOMES:

- To be able to arrive at detailed specifications of the spread spectrum systems.
- To be able to realize the generation of PN sequence.
- To be able to analyze synchronization issues in spread spectrum.
- To design systems based on spread spectrum to mitigate the jamming.
- To be able to design GPS system.

Attested

REFERENCES:

1. Rodger E. Ziemer, "Fundamentals of Spread Spectrum Modulation", Morgan & Claypool, Publishers series, 2007.
2. Robert C. Dixon, "Spread Spectrum Systems with Commercial Applications", 3rd Edition, John Wiley & Sons, Ins, 1994.
3. R. L. Peterson, R. E. Ziemer, and D. E. Borth, "Introduction to Spread Spectrum Communications", Upper Saddle River, NJ: Prentice Hall, 1995.
4. M.K. Simon, J.K. Omura, R.A. Scholtz, and B.K. Levitt, "Spread Spectrum Communications Handbook", Electronic Edition, McGraw-Hill, 2002.
5. Don Torrieri, "Principles of Spread-Spectrum Communication Systems", Springer Science, Business Media, Inc Boston, 2005.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

NE5078 PATTERN RECOGNITION AND MACHINE LEARNING L T P C
3 0 0 3

OBJECTIVES:

- To understand the basics of data processing and dimensionality reduction techniques
- To understand different learning models for classification
- To understand the principles and applications of ANN architectures
- To study the different Deep convolutional networks
- To learn deep generative models

UNIT - I BASICS OF PROBABILITY AND RANDOM PROCESS 9

Probability Theory - Conditional and Joint Probability - Stationary and non-stationary process - Expectation - Auto correlation - Cross Correlation - Eigen values - Eigen vectors - Singular values - Singular vectors - Decision Theory - Information Theory

UNIT - II DIMENSIONALITY REDUCTION 9

Introduction - Features, feature vectors - Feature selection and ranking - Discriminant functions - Fisher's Discriminant analysis - Principal Component Analysis - Kernel PCA - Independent component analysis

UNIT – III LEARNING MODELS 9

Linear models for Classification and Regression - Classifiers based on Bayes Decision theory – Naïve Bayes - Nearest neighbor rules - Mixture models - Mixture of Gaussian - Hidden Markov Model

UNIT – IV ARTIFICIAL NEURAL NEWORKS 9

Supervised Learning - Unsupervised Learning- Reinforcement Learning – Feed Forward and Feedback architectures - Multilayer Perceptron - Backpropagation Algorithm- Radial Basis Function networks - Support vector Machines

UNIT – V DEEP LEARNING NETWORKS **9**

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Employ different feature extraction and dimensionality reduction techniques
CO2: Design different learning models
CO3: Implement different neural network architectures
CO4: Realize basic Deep neural network architectures
CO5: Test and implement deep generative models for various data processing applications

EFERENCES:

1. Christopher M. Bishop, " Pattern Recognition and Machine Learning", Springer, 2011
2. R.O. Duda, P.E. Hart and D.G. Stork, "Pattern Classification" John Wiley, 2002
3. EthemAlpaydm, "Introduction to Machine Learning", The MIT Press, Cambridge, 2nd Edition, 2010.
4. Kevin P. Murphy, "Machine Learning - A Probabilistic Perspective", The MIT Press, Cambridge, 2012.
5. Josh Patterson and Adam Gibson, "Deep Learning - A Practitioner's Approach", O'Reilly Media, Inc, 2017.
6. Richard Szeliski, "Computer Vision - Algorithms and Applications", Springer Verlag London Limited, 2011.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

WT5005 MICRO ELECTRO MECHANICAL SYSTEM FOR WIRELESS COMMUNICATION **L T P C 3 0 0 3**

OBJECTIVES :

- To introduce the importance of micro electro mechanical systems for wireless scenario.
- To know the fabrication techniques of MEMS components.
- To make the student familiar with the mechanical and the electrostatic design and the associated systems.
- To know the integration issues in a single platform of electrical and mechanical system.
- To understand the critical physical dimensions of MEMS devices

UNIT - I FUNDAMENTALS & SWITCHES **9**

Micromachining- Bulk micromachining, Surface Micromachining, LIGA Process, RF MEMS relays and switches. Switch parameters. Actuation mechanisms. Bistable relays and micro actuators. Dynamics of switching operation.

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UNIT - II TUNNABLE MEMS 9

MEMS inductors and capacitors. Micromachined inductor. Effect of inductor layout. Modeling and design issues of planar inductor. Gap tuning and area tuning capacitors. Dielectric tunable capacitors.

UNIT – III FILTERS 9

Micromachined RF filters. Modeling of mechanical filters. Electrostatic comb drive. Micromechanical filters using comb drives. Electrostatic coupled beam structures.

UNIT – IV MEMS DEVICES 9

MEMS phase shifters. Types. Limitations. Switched delay lines. Micro machined transmission lines. Co planar lines. Micro machined directional coupler and mixer.

UNIT – V MICROMACHINED ANTENNA 9

Micro machined antennas. Microstrip antennas – design parameters. Micromachining to improve performance. Reconfigurable antennas.

TOTAL: 45 PERIODS

OUTCOMES:

- The student would be able to understand the fabrication techniques in MEMS technology.
- The student would be able to analyze different type of MEMS based devices, circuits and subsystems.
- The student would be able to demonstrate an understanding of the different aspects of microsystem design.
- The student would be capable of applying his knowledge and design tools and will be well practiced in design skills.
- The student would be able to solve the integration issues in mechanical and electrical microsystem components.

REFERENCES:

1. Varadan, V. K., Jose, K. A., Vinoy, Kalarickaparambil Joseph, "RF MEMS and their Applications", Chichester, England ; Hoboken, NJ : John Wiley, 2014.
2. H.J.D.Santos, RF MEMS Circuit Design for Wireless Communications, Artech House, 2002.
3. G.M.Rebeiz , RF MEMS Theory , Design and Technology, wiley , 2013.
4. Stephen D. Senturia, "Microsystem Design", Kluwer Academic Publishers, 1st Ed., 2001.
5. Marc Madou, "Fundamentals of Microfabrication" , CRC Press, 1st Ed.2007.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

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WT5006 **GLOBAL POSITIONING SYSTEMS** **L T P C**
3 0 0 3

OBJECTIVES :

- To introduce the relevance of this course to the existing technology
- To understand the basic concepts and design factors of GPS
- To enable the student to understand the necessity for GPS, the essential elements involved and the transmission methodologies
- To enable the student to understand the fundamentals of coordinate systems, different interferences and attenuation mechanisms affecting the satellite motion
- To get exposed to the environmental factors involved in the design of GPS and the different application scenarios.

UNIT - I GPS FUNDAMENTALS **9**

History of GPS – BC-4 System – HIRAN – NNSS – NAVSTAR GLONASS and GNSS Systems – GPS Constellation – Space Segment – Control Segment – User Segment – Single and Dual Frequency – Point – Relative – Differential GPS – Static and Kinematic Positioning – 2D and 3D – reporting Anti Spoofing (AS); Selective Availability (SA) – DOP Factors.

UNIT - II CO-ORDINATE SYSTEM AND SATELLITE MOTION **9**

Coordinate Systems – Geo Centric Coordinate System – Conventional Terrestrial Reference System – Orbit Description – Keplerian Orbit – Kepler Elements – Satellite Visibility – Topocentric Motion – Disturbed Satellite Motion – Perturbed Motion – Disturbing Accelerations - Perturbed Orbit – Time Systems – Astronomical Time System – Atomic Time – GPS Time – Need for Coordination – Link to Earth Rotation – Time and Earth Motion Services.

UNIT – III TRACKING TECHNIQUES **9**

C/A code; P-code; Y-code; L1, L2 Carrier frequencies – Code Pseudo Ranges – Carries Phases – Pseudo Ranges – Satellite Signal Signature – Navigation Messages and Formats – Un differenced and Differenced Range Models – Delta Ranges – Signal Processing and Processing Techniques – Tracking Networks – Ephemerides – Data Combination: Narrow Lane; Wide Lane – OTF Ambiguity.

UNIT – IV ATMOSPHERIC EFFECTS **9**

Propagation Media – Multipath – Antenna Phase Centre – Atmosphere in brief – Elements of Wave Propagation – Ionospheric Effects on GPS Observations – Code Delay – Phase Advances – Integer Bias – Clock Error – Cycle Slip – Noise-Bias – Blunders – Tropospheric Effects on GPS Oberservables – Multipath Effect – Antenna Phase Centre Problems and Correction.

UNIT – V APPLICATION **9**

Iner Disciplinary Applications – Crystal Dynamics – Gravity Field Mapping – Atmospheric Occulation – Surveying – Geophysics – Air borne GPS – Ground Transportation – Space borne GPS – Metrological and Climate Research using GPS.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be able to:

CO1: Design GPS and ability to comprehend and appreciate the significance and role of this course in the present contemporary world

CO2: Explain the necessity for GPS, the essential elements involved and the transmission methodologies

CO3: Analyze the fundamentals of coordinate systems, different interferences and attenuation mechanisms affecting the satellite motion

CO4: Demonstrate an understanding the necessity for GPS, the essential elements involved and the transmission methodologies

CO5: Demonstrate an understanding the environmental factors involved in the design of GPS and the different application scenarios and their implementation.

REFERENCES:

1. B.Hoffman - Wellenhof, H.Lichtenegger and J.Collins, "GPS: Theory and Practice", Springer, Wein, New york, 5th revised Edition, 2003
2. A.Leick, "GPS Satellites Surveying", John Wiley & Sons, NewYork, 4th Edition, 2015
3. A.Kleusberg and P.Teunisen(Eds), “GPS for Geodesy”, Springer-Verlag, Berlin,1996
4. L.Adams, "The GPS - A Shared National Asset”, Chair, National Academy Press, Washington, DC, 1995
5. Guochang, Xu, “GPS Theory, Algorithms and Applications”, Springer, 2nd Edition Springer-Verlag Berlin Heidelberg, 3rd edition, 2016.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

NE5075 INFORMATION THEORY AND CODING L T P C
3 0 0 3

OBJECTIVES :

- To understand the concepts of Information theory and Coding.
- To analyze the various techniques to improve the capacity of the channel.
- To understand the fundamental limits prescribed by the information theory.
- To get exposed to the gaussian channel
- To learn the various coding schemes in detail.

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-Fano codes, Huffman codes , Asymptotic equi partition, 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, Turbo Codes, LDPC Codes, TCM.

Attested

TOTAL: 45 PERIODS

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COURSE OUTCOMES:

CO1: The student will be in a position to quantify information.
CO2: To be able to implement various coding schemes.
CO3: To be able to design efficient channel.
CO4: To be able to apply coding techniques to information sources like video, audio and so on.
CO5: To able to implement the information theory and coding technique for effective communication

REFERENCES:

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

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

WT5007 MODELING AND SIMULATION OF WIRELESS COMMUNICATION SYSTEMS **L T P C 3 0 0 3**

OBJECTIVES :

- To understand the requirement of simulation and modeling.
- To understand random signals and process
- To get exposed to simulation methods for wireless systems
- To know modeling procedures for various channels.
- To understand the versatility of simulation and apply simulation intelligently.

UNIT I INTRODUCTION **9**

Role of Simulation: Examples of complexity- multi disciplinary aspects of simulation - models - deterministic and stochastic simulations; simulation sampling frequency-low pass simulation models for band pass – low pass complex envelope for band pass signals -linear band pass systems- multi carrier signals-non linear and time - varying systems.

UNIT II GENERATING AND PROCESSING RANDOM SIGNALS **9**

Stationary and Ergodic Processes: Uniform random number generators - mapping uniform RVs to an arbitrary PDF - generating uncorrelated Gaussian random numbers - generating correlated Gaussian random numbers - PN sequence generators; Establishing a PDF and a PSD Post Processing: Basic graphical techniques - estimation - coding.

UNIT III METHODOLOGY FOR SIMULATING A WIRELESS SYSTEM **9**

Monte Carlo Simulation Fundamental Concepts: Applications and integration - two Monte Carlo examples; Semi Analytic Techniques System: Level simplifications and sampling rate considerations - overall methodology; Modeling and Simulation of Nonlinearities: Introduction - modeling and simulation of memory less nonlinearities - modeling and simulation of nonlinearities with memory - techniques for solving nonlinear differential equations.

UNIT IV MODELING AND SIMULATION OF TIME-VARYING SYSTEMS 9

Introduction: Models for LTV systems - random process models - simulation models for LTV systems; Wired and guided wave - radio channels - multipath fading channels - modeling multipath fading channels; Random process models - simulation methodology; Discrete Channel Models: Discrete memory less channel models - Markov models for discrete channels with memory-example HMMs - Gilbert and Fritchman models - estimation of Markov model parameters.

UNIT V EFFICIENT SIMULATION TECHNIQUES 9

Tail Extrapolation: PDF estimators- importance sampling; Case study of a cellular radio system; Cellular radio system - simulation methodology - modeling co-channel interference - two example simulations; A code-division multiple access system - FDM system with a nonlinear satellite transponder - preprocessors for CDMA application.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: To be able to design various models for wireless communication.
CO2: To be able to simulate various channels.
CO3: To apply simulations for various wireless communication technologies.
CO4: Choose appropriate simulation techniques to reduce run time.
CO5: To differentiate between wireless and wired systems with respect to simulation requirements.

REFERENCES:

1. William H. Tranter, K. Sam Shanmugan, Theodore S. Rappaport and Kurt L. Kosbar “Principles of Communication Systems Simulation with Wireless Applications”, Prentice Hall, Upper Saddle River, 2004.
2. M. C. Jeruchim, Philip Balaban and K.Sam shanmugam. “Simulation of Communication Systems”, Plenum Press, second edition , 2012.
3. M. Law and W. David Kelton , “Simulation Modelling and Analysis”, McGraw Hill, fifth edition, 2014.
4. K. Hayes, “Modelling and Analysis of Computer Communication Networks”,Plenum Press, 1984.
5. Banks, J. S. Carson, Nelson and D. M. Nicol, “Discrete Event System Simulation”, fifth Edition, Pearson, 2009.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

WT5008 **MULTIMEDIA COMPRESSION TECHNIQUES** **L T P C**
3 0 0 3

OBJECTIVES :

- To understand the basic concepts of various compression algorithms related to multimedia which includes Text, speech, audio, image and Video.
- To understand the principles of underlying technologies and study its performance parameters.
- To study and compare different coding schemes.
- To learn about the importance of compression methods and its applications
- To study and understand the design issues involved in emerging compression standards.

UNIT - I FUNDAMENTALS OF COMPRESSION 9

Introduction To multimedia – Graphics, Image and Video representations – Fundamental concepts of video, digital audio – Storage requirements of multimedia applications – Need for compression – Taxonomy of compression Algorithms - Elements of Information Theory – Error Free Compression –Lossy Compression

UNIT - II TEXT COMPRESSION 9

Huffman coding – Adaptive Huffman coding – Arithmetic coding – Shannon-Fano coding – Dictionary techniques – LZW family algorithms.

UNIT – III IMAGE COMPRESSION 9

Image Compression: Fundamentals –– Compression Standards – JPEG Standard – Sub-band coding – Wavelet Based compression – Implementation using Filters – EZW, SPIHT coders – JPEG 2000 standards – JBIG and JBIG2 standards.

UNIT – IV AUDIO COMPRESSION 9

Audio compression Techniques – law, A-Law companding – Frequency domain and filtering – Basic sub-band coding – Application to speech coding – G.722 – MPEG audio – progressive encoding – Silence compression, Speech compression – Formant and CELP vocoders.

UNIT – V VIDEO COMPRESSION 9

Video compression techniques and Standards – MPEG video coding: MPEG-1 and MPEG-2 video coding: MPEG-3 and MPEG-4 – Motion estimation and compensation techniques – H.261 Standard – DVI technology – DVI real time compression – Current Trends in Compression standards.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon Completion of the course, the students should be able to

CO1: Analyze the pros and cons of different coding schemes

CO2: Design and implement text and image compression approaches.

CO3: Examine audio and video compression in real time environment

CO4: Design compression algorithms using MATLAB or equivalent open source software.

Co5: Analyze and apply the concepts of compression algorithms in multimedia applications

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REFERENCES:

1. Khalid Sayood: Introduction to Data Compression", Morgan Kauffman Harcourt India, 5th Edition, 2017.
2. David Solomon, "Data Compression – The Complete Reference", Springer Verlog, New York, 2010.
3. Yun Q.Shi, Huifang Sun, "Image and Video Compression for Multimedia Engineering, Algorithms and Fundamentals", CRC Press, 2008.
4. Mark S. Drew, Ze-Nian Li, "Fundamentals of Multimedia", PHI, 2014.
5. Peter Symes : Digital Video Compression, McGraw Hill Pub., 2004.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

VE5151 REAL TIME EMBEDDED SYSTEM L T P C
3 0 0 3

OBJECTIVES :

- To have a detailed knowledge about the process involved in the design and development of real-time embedded system.
- To develop a programmable embedded platform from scratch on ARM Processor.
- To develop an integrated approach in low-power systems with hardware, software, sensors, actuators and controllers.
- To improve the knowledge base of students in Real time operating system, Systems modeling and Verification.
- To study about the different methods involved in software development, Emulation and Debugging.

UNIT - I INTRODUCTION 9

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

UNIT - II ARM PROCESSOR 9

Fundamentals - ARM Instruction set - Thumb Instruction set - Writing and Optimizing ARM assembly codes - Efficient C programming - Optimized Primitives - Digital Signal Processing - Exception and Interrupt Handling - Firmware.

UNIT – III REAL TIME OPERATING SYSTEM 9

Operating System Internals - Multitasking Operating Systems - Scheduler Algorithms - Priority Inversion - Tasks, threads and Processes - Exception - Memory model - Memory management address translation - Commercial operating systems - Resource protection - Linux - Disk partitioning.

UNIT – IV EMBEDDED SYSTEM 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.

UNIT – V SOFTWARE DEVELOPMENT, EMULATION AND DEBUGGING TECHNIQUES **9**

Compilation process - Native vs Cross-Compilers - Run-time libraries - Writing a library - Using Standard and alternative libraries - Porting Kernels - C extensions - Downloading - Debugging techniques - Emulation techniques

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: To be able to design and program for real time embedded system application.
CO2: To be able to model and design on embedded platform.
CO3: To be able to design a system in different hardware and software platforms.
CO4: To be able to port an operating system in Embedded Systems.
CO5: Complete understanding of real-time embedded platform.

REFERENCES:

1. Wayne Wolf, "Computers as Components - Principles of Embedded Computing System Design", Morgan Kaufmann Publishers, 2nd Edition,June 2008.
2. Andrew N. Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide - Designing and Optimizing System Software", Morgan Kaufmann Publishers, 2004.
3. Steve Heath, "Embedded Systems Design", Newnes Publications, 2nd Edition, 2003.
4. Doug Abbott, "Linux for Embedded and Real-time Applications", Newnes Publication, 2003.
5. Phillip A. Laplante, "Real-Time System Design and Analysis", A John Wiley & Sons, Inc, 3rd Edition, 2004.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

WT5009 ULTRA WIDEBAND COMMUNICATION **L T P C**
3 0 0 3

OBJECTIVES :

- To understand the basics principles behind the UWB concepts.
- To learn the design of pulse shaper as a digital filter
- To understand the unique UWB channel
- To understand when to use and when not to use UWB technology
- To enable the student to understand the design and implementation of UWB transceiver

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.

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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 Access 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:

CO1: The student should be able to develop a comprehensive overview of UWB system design.
CO2: The student would be able to understand the distinct UWB channel
CO3: The student should be able to design UWB pulse shaper
CO4: The student should be able to understand difference between UWB and legacy systems
CO5: The student should be able to understand the future directions of UWB technology

REFERENCES:

1) HuseyinArsian, ZinNing Chen, “Ultra-Wide band Wireless Communication” Wiley, 2006.
2) HomayounNikcobar and RamjeePrasas” Introduction to Ultra Wideband for Wireless Communications” Springer, 2009.
3) Jeffrey H.Reed, “An Introduction to Ultra Wideband Communication Systems” Prentice Hall PTR, 2005.
4) Kayimierysiwiak and Debra mekown, “Ultra-Wideband Radio Technology”, John Willey & Sons, 2004.
5) Marian VerhelstandWimDehaeneEnergy Scalable Radio Design: for Pulsed UWB Communication and Ranging (Analog Circuits and Signal Processing) , Springer, 2011.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

WT5010 **NETWORK ROUTING PROTOCOLS** **L T P C**
3 0 0 3

OBJECTIVES :

- To understand the basics and foundations of routing algorithms
- To design basic routing protocols and routing protocols for internet.
- To design multicast routing protocols for next generation networks.
- To understand the reservation oriented network routing and PSTN routing.
- To analyze the routing protocols of GSTN and VoIP technologies.

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:

CO1: To be able to understand the various network routing algorithms.
CO2: To be able to differentiate and design routing protocols of internet.
CO3: To be able to design routing protocols for multicast transmission.
CO4: To be able to understand routing protocols in reservation oriented networks
CO5: To be able to 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. William Stallings, ”High speed networks and Internets Performance and Quality of Service‟, Pearson Education Asia. Reprint India, 2nd Edition, 2002.
3. M. Steen Strub, “Routing in Communication network, Prentice –Hall International, New york, 1995.
4. S. Keshav, „An engineering approach to computer networking‟ Addison Wesley 1999.
5. Jochen H.Schiller, “Mobile Communication”, Pearson Ed, 2nd Edition, 2014.

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	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

NE5071 COMPUTATIONAL INTELLIGENCE L T P C
3 0 0 3

OBJECTIVES :

- To expose neural network learning techniques and architectures
- To study and understand fuzzy concepts and models
- To expose the students to hybrid neuro -fuzzy techniques
- To learn the basic concepts in Deep Learning networks
- To understand different optimization techniques and apply the same in different scenarios

UNIT I NEURALNETWORKS 9

Biological Neurons Networks - Artificial Neural Networks - Supervised -.unsupervised learning - Reinforcement Learning - Activation functions - Perceptrons - 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

UNIT V EVOLUTIONARYALGORITHMS 9

Heuristic search and optimization techniques -Random search - Introduction to Genetic Algorithms - Social Algorithms

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: To be able to design systems based on neural network architectures
CO2: To be able to perform basic operations in fuzzy
CO3: To be able to implement fuzzy models and work on fuzzy tool box
CO4: To be able to design and implement deep learning architectures
CO5: To be able to design optimization based algorithm for a given application

Attested

REFERENCES:

1. Jyh-Shing Roger Jang, Chuen-Tsai Sun, Eiji Mizutani, “Neuro - Fuzzy and Soft Computing”, Pearson Edn., 2015.
2. George J. Klir and Bo Yuan, “Fuzzy Sets and Fuzzy Logic -Theory and Applications”, Prentice Hall, 2011.
3. James A. Freeman and David M. Skapura, “Neural Networks Algorithms, Applications, and Programming Techniques”, Pearson Edn., 2003.
4. David E. Goldberg, “Genetic Algorithms in Search, Optimization and Machine Learning”, Pearson Education, 2008.
5. Ian Goodfellow, Yoshua Bengio and Aaron Courville, “Deep Learning” The MIT Press, Cambridge, 2016.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

NE5073 GAME THEORY FOR WIRELESS COMMUNICATION AND NETWORKING **L T P C 3 0 0 3**

OBJECTIVES :

- To give an overview of a broad range of models that is studied in game theory
- To attain understanding on concepts related to non- cooperative games
- To understand a range of mathematical models of conflict and co-operation between two or more agents
- To attain understanding on concepts related to Bayesian games
- To discuss the application of game theory in wireless communication and networking

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 in extensive form, repeated games, and stochastic games.

UNIT III COOPERATIVE GAMES **9**

Basics of Cooperative games, bargaining theory – Introduction, Nash bargaining solution, Coalition game 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.

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UNIT V APPLICATIONS TO NETWORKING 9

Cellular & Broadband wireless access networks – Routing & Resource allocation, Power allocation, Network selection in Multi-technology, WLAN – MAC Protocol design, Random Access Control, Rate Selection for VOIP services, throughput efficiency, competition and implication on network performance – Game theoretic solutions for cooperation in ad hoc networks.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: To be able to understand new concept in game theory
CO2: To be able to design non cooperative game theory based models
CO3: To be able to design cooperative game theory based models
CO4: To be able to design Bayesian game theory based models
CO5: To be able to apply game theory to solve network related issues.

REFERENCES:

1. Martin J. Osborne, “An Introduction to Game Theory”, Oxford Press 2006.
2. Zhu Han, Dusit Niyato, Walid Saad, Tamer Basar, Are Hjorungnes, “Game Theory in Wireless and Communication Networks: Theory, Models, and Applications”, University Press Cambridge, 1st Edition, 2012.
3. Allan MacKenzie, Luiz DaSilva, "Game Theory for Wireless Engineers, Synthesis Lectures on Communication", Morgan and Claypool Publishers, 2006.
4. Drew Fudenberg and Jean Tirole, "Game Theory", MIT Press, 1991.
5. Vijay Krishna, "Auction Theory", Academic Press, 2010.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

WT5011 WIRELESS TRANSCEIVER DESIGN L T P C
3 0 0 3

OBJECTIVES :

- To understand the basics of system
- To acquire knowledge on the receiver architecture
- To analyze the receiver characteristics
- To get familiar with transmitter system design
- To learn about the high frequency transceivers

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 superheterodyne 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

CO1: Apply knowledge in transceiver design
CO2: Understand the receiver architecture
CO3: Analyze the system parameters in receiver
CO4: Understand the transmitter system design
CO5: Apply design techniques in the RF transceivers

REFERENCES:

1. Kai Chang , RF and Microwave Wireless Systems, John Wiley, 2004.
2. 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.
3. Qizheng Gu, "RF System Design of Transceivers for Wireless Communications",Springer, 2005.
4. Ariel Luzzatto, Motti Haridim. "Wireless Transceiver Design: Mastering the Design of Modern Wireless Equipment and Systems" Wiley, 2nd Edition, 2016.
5. Crols, Jan, Steyaert, Michiel, " CMOS Wireless Transceiver Design" , Springer, 1st Edition, 2003.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

WT5012 ADVANCED ANTENNA SYSTEMS L T P C
3 0 0 3

OBJECTIVES :

- To acquire knowledge on antenna fundamentals
- To develop an understanding of antenna array concepts
- To impart principles of radiation from apertures
- To know about the principles of microstrip antenna
- To get acquainted with recent trends in antenna design

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UNIT - I ANTENNA FUNDAMENTALS 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 antenna-base station, hand set antenna; Image; Induction ,reciprocity theorem, Balance to unbalance transformer, Review of Antenna Measurements.

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;smart antennas,switched beam and adaptive arrays, Mutual Coupling in Finite Arrays.

UNIT – III RADIATION FROM APERTURES 9

Field equivalence principle, Radiation from Rectangular and Circular apertures, Uniform aperture distribution on an infinite ground plane; Babinets principle, Slot antenna; 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 Reflectarray Antennas.

UNIT – V MODERN ANTENNAS 9

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:

At the end of the course, the student should be able to:

CO1: Understand the basic antenna theory
CO2: Identify the concepts of antenna arrays
CO3: Apply the theory of aperture for antenna design
CO4: Design microstrip antennas
CO5: Develop antennas for various applications

REFERENCES:

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

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	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

WT5013 ADVANCED WIRELESS COMMUNICATION TECHNIQUES L T P C
3 0 0 3

OBJECTIVES :

- To understand the evolving paradigm of cooperative communication
- To understand concepts related to green wireless communication
- To enable the student to understand the different power saving strategies and energy efficient signal, system and network design.
- To expose the student to the energy saving techniques adopted in existing wireless components
- To provide understanding on protocols and networks related to green future wireless communication technologies.

UNIT I COOPERATIVE COMMUNICATIONS AND GREEN CONCEPTS 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, Green modulation and coding schemes.

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 and Coordinated multi-point transmission in LTE-Advanced.

UNIT III RELAY-BASED COOPERATIVE CELLULAR NETWORKS 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 ; Network coding in relay-based 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 , Power-management for base stations in smart grid environment , 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 ; Green Radio Test-Beds and Standardization Activities.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: The student would be able to appreciate the necessity and the design aspects of cooperative communication

CO2: The student would be able to appreciate the necessity and the design aspects of green wireless communication.

CO3: The student would be able to evolve new techniques in wireless communication

CO4: The students would be able to demonstrate the feasibility of using mathematical models using simulation tools.

CO5: The student would be able to demonstrate the impact of the green engineering solutions in a global, economic, environmental and societal context.

REFERENCES:

1. Ekram Hossain, Dong In Kim, Vijay K. Bhargava , "Cooperative Cellular Wireless Networks",Cambridge University Press, 2011.
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. Ramjee Prasad and Shingo Ohmori, Dina Simunic, "Towards Green ICT", River Publishers,2010.
5. Jinsong Wu, Sundeep Rangan and Honggang Zhang, "Green Communications: Theoretical Fundamentals, Algorithms and Applications", CRC Press, 2012.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

NE5076 **IoT FUNDAMENTALS** **L T P C**
3 0 0 3

OBJECTIVES :

- To assess the vision and introduction of IoT.
- To Implement Data and Knowledge Management and use of Devices in IoT Technology.
- To Understand State of the Art - IoT Architecture.
- To build a small low-cost embedded system using Single Board Computers
- To learn the various case study of IoT systems.

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 Pi – 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 algorithmsfor unidirectionaldata transmissions, Security access algorithmsfor bidirectionaldata transmissions.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the completion of the course the student will be able to

CO1: Interpret the vision of IoT from a global context.
CO2: Compare and Contrast the use of Devices, Gateways and Data Management in IoT.
CO3: Design a portable IoT using any Single Board Computer and relevant protocols
CO4: Analyze applications of IoT in real time scenario
CO5: Deploy an IoT application and connect to the cloud.

REFERENCES:

1. Arshdeep Bahga, Vijay Madisetti, "Internet of Things - A hand on approach" ,Universities Press (India) Private Limited, 2014.
2. Pethuru Raj, Anupama C. Raman, "The Internet of Things – Enabling Technologies, Platforms and Use cases" , CRC Press, Taylor & Francis Group, 2017.
3. William Stallings, Lawrie Brown, "Computer Security: Principles and Practice", Pearson, 3rd Edition, 2014.
4. Fei Hu, "Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations," 1st Edition, CRC Press, 2016.
5. Rajkumar Buyya, "Internet of Things – Principles and Paradigms" , Published by Morgan Kaufmann, Elsevier, 2016.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

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WT5014	OPTICAL AND WIRELINE TECHNOLOGY	L T P C 3 0 0 3

OBJECTIVES :

- To know about the fundamentals of optical fiber transmission and its limitations.
- To develop an understanding of basics of optical transmitters and receivers
- To acquire knowledge on fiber loss and dispersion compensation schemes
- To impart concepts of passive optical networks
- To get acquainted with various wire line technologies

UNIT – I RAY THEORY ANALYSIS& TRANSMISSION CHARACTERISTICS 9

Fibre Optic Guides, Light wave generation systems, systems components, optical fibers, SI, GI fibre, modes, Dispersion in fibers limitations due to dispersions, fibre loss, non liner effects.

UNIT - II OPTICAL TRANSMITTERS & RECEIVERS 9

Optical Transmitters and Fibres, Basic concept, spectral distribution, semiconductor lasers, gain coefficients, modes. Transmitter design, Receive PIN and APD diodes,SNR. Switches, Coherent, homodyne and Hetro dyne keying formats, BER in synchronous and Asynchronous.

UNIT – III COMPENSATION TECHNIQUES 9

Amplifiers, Basic concepts, Semiconductor laser amplifiers Raman and Brillouin-fibre amplifiers, Erbium doped-fibre and amplifiers, pumping phenomenon Dispersion Compensation Limitations, post and pre-compensation techniques, equalizing filters, SONET/SDH.

UNIT – IV PASSIVE OPTICAL NETWORKS: ARCHITECTURES AND PROTOCOLS 9

PON Architectures, Network Dimensioning and operation, Power Budget, FTTx , Broadband PON: architecture, protocol and Service, Bandwidth allocation. Gigabit-Capable PON. Burst switching, Ethernet PON Architecture, 10GEPON PMD Architecture.

UNIT – V WIRE LINE TECHNIQUES 9

Wire line Narrowband, XDSL, Wire line broad band, Very High Bit Rate Digital Subscriber Line (VDSL), Cable MODEM Home Networks, & VDSL Transmission Protocols. DOCSIS-Standards.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Understand optical fiber characteristics
CO2: Design optical transmitters and receivers
CO3: Use appropriate compensation techniques in a optical fiber link
CO4: Identify the architectures and protocols in PON
CO5:Apply wireline techniques in the optical network design

REFERENCES:

1. G Keiser, “Optical fiber communication, system”, Tata McGraw Hill, New Delhi, 5th Edition, 2013.
2. Dave Hood, Elmar Trojer, “Gigabit capable passive optic network”, John Wiley & sons, New Jersy 2012.
3. G. P. Agarwal, “Fiber optic communication system”, John Wiley & sons, New York, 4th Edition, 2012.
4. Franz and Jain, “Optical communication system”, Narosa Publications, New Delhi, 2013.
5. Leonid G.Kazovsky, Ning Cheng, Wei-Tao Shaw, David Gutierrez, Shing-Wa Wong, “Broadband Optical Access Networks”, John Wiley and Sons, New Jersey, 2011.

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	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

WT5015 COMMUNICATION SATELLITE SYSTEMS L T P C
3 0 0 3

OBJECTIVES :

- To provide basic understanding about satellite communication technologies.
- To have an exposure to orbital mechanics, launching techniques and satellite link design.
- To know the basic satellite link parameters.
- To get exposed to modulation, antennas and mobile terminals for mobile satellite• communication system.
- To understand various applications of mobile satellite.

UNIT - I BASIC PRINCIPLES 9

General features- frequency allocation for satellite services- properties of satellite communication systems- Kepler's laws- orbital dynamics- orbital characteristics- satellite spacing and orbital capacity- GSO & LEO Satellites – Launch Vehicle Technology-GSLV.

UNIT - II SATELLITE SUBSYSTEMS AND SATELLITE LINKS 9

Attitude and orbit control system- telemetry, tracking and command- power systems communication subsystems- antenna subsystem- equipment reliability and space qualification. Free space loss-Atmospheric effects- Ionospheric scintillation-link design- Power Budget Calculation -system noise temperature – Modulation for satellite communication

UNIT – III MOBILE SATELLITE NETWORK 9

GSM signaling and S-PCN signaling protocol architecture, Mobility management-cell location, location management, handover management. Resource Management- Resource allocation strategies, Network operation and procedures

UNIT – IV ANTENNAS AND MOBILE TERMINALS 9

Antennas for MSS, Architecture of Hand held, Vehicle mounted, Ship borne, Aeronautical terminals, CODECS for Mobile Satellite Communication.

UNIT – V APPLICATIONS 9

GPS, Mobile satellite system for UMTS, GSM/EDGE, MOBILE IP, WLAN, Global Broadband services, ATM, GEO and Non GEO Mobile satellite systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: To able to understand the principles of satellite system
CO2: To be able to design satellite subsystems and satellite link.
CO3: To be able to design mobile satellite network
CO4: To be able to design new antenna architecture for satellite system
CO5: To be able to develop new applications in the field of mobile satellite

Attested

REFERENCES:

1. Wilbur L Pritchard, Henri G Suyderhoud, “Satellite Communication Systems Engineering”, 2nd Edition, Pearson 2013.
2. Dennis Roddy “Satellite Communication”, Tata McGraw-Hill, 4th Edition, 2009.
3. Timothy Pratt, Chareless Bostian, “Satellite Communications”, Wiley, 2nd Edition, 2010.
4. Tri T.Ha “Digital Satellite Communications”, Tata McGraw Hill, 1st Reprint, 2nd Edition, 2012.
5. Ray E. Sheriff and Y. Fun Hu, “Mobile Satellite communication Networks,” John Wiley & Sons, 2008.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			✓
CO2	✓		✓			
CO3	✓		✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓	✓	

OE5091 BUSINESS DATA ANALYTICS L T P C
3 0 0 3

OBJECTIVES:

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT I OVERVIEW OF BUSINESS ANALYTICS 9

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

Suggested Activities:

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT II ESSENTIALS OF BUSINESS ANALYTICS 9

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance,

Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

Suggested Activities:

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

Suggested Evaluation Methods:

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE 9

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

Suggested Activities:

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

Suggested Evaluation Methods:

- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK 9

Introducing Hadoop – RDBMS versus Hadoop – Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop – Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

Suggested Activities:

- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT V OTHER DATA ANALYTICAL FRAMEWORKS 9

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Suggested Activities:

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig

- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Identify the real world business problems and model with analytical solutions.
CO2: Solve analytical problem with relevant mathematics background knowledge.
CO3: Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
CO4: Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
CO5: Use open source frameworks for modeling and storing data.
CO6: Apply suitable visualization technique using R for visualizing voluminous data.

REFERENCES:

1. Vignesh Prajapati, “Big Data Analytics with R and Hadoop”, Packt Publishing, 2013.
2. Umesh R Hodeghatta, Umesha Nayak, “Business Analytics Using R – A Practical Approach”, Apress, 2017.
3. Anand Rajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, “Essentials of Business Analytics”, Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, “Business Analytics: The Science of Data-Driven Decision Making”, Wiley, 2017.
6. A. Ohri, “R for Business Analytics”, Springer, 2012
7. Rui Miguel Forte, “Mastering Predictive Analytics with R”, Packt Publication, 2015.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	3	1
CO2	2	1	1	2	1	1
CO3	1	1	2	3	3	1
CO4	2	2	1	2	1	1
CO5	1	1	2	2	1	1
CO6	1	1	1	3	2	1

OE5092 **INDUSTRIAL SAFETY** **LT P C**
3 0 0 3

OBJECTIVES:

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

UNIT I INTRODUCTION **9**

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

UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING **9**

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

UNIT III WEAR AND CORROSION AND THEIR PREVENTION **9**

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT IV FAULT TRACING **9**

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT V PERIODIC AND PREVENTIVE MAINTENANCE **9**

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students will be able to:

CO1: Ability to summarize basics of industrial safety

CO2: Ability to describe fundamentals of maintenance engineering

CO3: Ability to explain wear and corrosion

CO4: Ability to illustrate fault tracing

CO5: Ability to identify preventive and periodic maintenance

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P,Maintenance Engineering, S. Chand and Company,1987.
3. Hans F. Winterkorn, Foundation Engineering Handbook, Chapman & Hall London, 2013.
4. Higgins & Morrow, Maintenance Engineering Handbook, Eighth Edition,2008

OE5093 OPERATIONS RESEARCH L T P C

3 0 0 3

OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation, assignment problems
- Solve project management problems
- Solve scheduling problems

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method, Voges's approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method -CPM/PERT

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students will be able to:

CO1: To formulate linear programming problem and solve using graphical method.

CO2: To solve LPP using simplex method

CO3: To formulate and solve transportation, assignment problems

CO4: To solve project management problems

CO5: To solve scheduling problems

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

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

OE5094 COST MANAGEMENT OF ENGINEERING PROJECTS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

UNIT I INTRODUCTION TO COSTING CONCEPTS 9

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member, Importance Project site: Data required with significance, Project contracts.

UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

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UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students will be able to:

CO1 – Understand the costing concepts and their role in decision making

CO2–Understand the project management concepts and their various aspects in selection

CO3–Interpret costing concepts with project execution

CO4–Gain knowledge of costing techniques in service sector and various budgetary control techniques

CO5 - Become familiar with quantitative techniques in cost management

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓			✓	✓		✓	✓
CO2	✓	✓	✓		✓				✓		✓	✓
CO3	✓	✓	✓		✓	✓					✓	✓
CO4	✓	✓	✓		✓		✓				✓	✓
CO5	✓	✓	✓		✓	✓	✓				✓	✓

REFERENCES:

1.Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991

2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988

3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011

4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003

5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

OE5095 COMPOSITE MATERIALS L T P C

3 0 0 3

OBJECTIVES:

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identify the various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT I INTRODUCTION 9

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENTS 9

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES 9

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES 9

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

UNIT V STRENGTH 9

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students will be able to:

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓								
CO2		✓	✓	✓	✓						✓	
CO3			✓	✓	✓		✓				✓	
CO4			✓	✓	✓		✓				✓	
CO5			✓	✓	✓		✓					

REFERENCES:

1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, West Germany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.

OE5096 WASTE TO ENERGY L T P C
3 0 0 3

OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNIT I INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNIT II BIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT III BIOMASS GASIFICATION 9

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

UNIT IV BIOMASS COMBUSTION 9

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

UNIT V BIO ENERGY 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students will be able to:

CO1 – Understand the various types of wastes from which energy can be generated

CO2 – Gain knowledge on biomass pyrolysis process and its applications

CO3 – Develop knowledge on various types of biomass gasifiers and their operations

CO4 – Gain knowledge on biomass combustors and its applications on generating energy

CO5 – Understand the principles of bio-energy systems and their features

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									✓
CO2	✓		✓									✓
CO3	✓	✓	✓		✓							✓
CO4	✓	✓	✓		✓		✓					✓
CO5	✓	✓	✓		✓							✓

REFERENCES:

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

AUDIT COURSES (AC)

AX5091 ENGLISH FOR RESEARCH PAPER WRITING L T P C
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNIT I INTRODUCTION TO RESEARCH PAPER WRITING 6

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS 6

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS 6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission

TOTAL: 30 PERIODS

COURSE OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 – Learn about what to write in each section
CO3 – Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3										✓		✓
CO4										✓		✓
CO5										✓		✓

REFERENCES

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

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AX5092 **DISASTER MANAGEMENT** **L T P C**
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION **6**

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS **6**

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA **6**

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT **6**

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT **6**

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 30 PERIODS

COURSE OUTCOMES

CO1: Ability to summarize basics of disaster
CO2: Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi,2001.

AX5093 SANSKRIT FOR TECHNICAL KNOWLEDGE L T P C
2 0 0 0

OBJECTIVES

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS 6

Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES 6

Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS 6

Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE 6

Technical information about Sanskrit Literature

UNIT V TECHNICAL CONCEPTS OF ENGINEERING 6

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

TOTAL: 30 PERIODS

COURSE OUTCOMES

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3												✓
CO4												✓
CO5												✓

REFERENCES

1. "Abhyaspustakam" – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

AX5094 **VALUE EDUCATION** **L T P C**
2 0 0 0

OBJECTIVES
Students will be able to
- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

UNIT I
Values and self-development–Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non-moral valuation. Standards and principles. Value judgements

UNIT II
Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline

UNIT III
Personality and Behavior Development-Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour.
Universal brother hood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

UNIT IV
Character and Competence–Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

TOTAL: 30 PERIODS

COURSE OUTCOMES
Students will be able to
CO1: Knowledge of self-development.
CO2: Learn the importance of Human values.
CO3: Developing the overall personality.

SUGGESTED READING
1. Chakroborty, S.K.“Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

AX5095 **CONSTITUTION OF INDIA** **L T P C**
2 0 0 0

OBJECTIVES
Students will be able to:
- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals’ constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION
History, Drafting Committee, (Composition & Working)

UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION

District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1: Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.

CO2: Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.

CO3: Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.

CO4: Discuss the passage of the Hindu Code Bill of 1956.

SUGGESTED READING

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

AX5096 PEDAGOGY STUDIES L T P C
2 0 0 0

OBJECTIVES

Students will be able to:

- Review existing evidence on there view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

UNIT I INTRODUCTION AND METHODOLOGY:

Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions - Overview of methodology and Searching.

UNIT II THEMATIC OVERVIEW

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT III EVIDENCE ON THE EFFECTIVENESS OF PEDAGOGICAL PRACTICES

Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches - Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT IV PROFESSIONAL DEVELOPMENT

Professional development: alignment with classroom practices and follow up support - Peer support - Support from the head teacher and the community - Curriculum and assessment - Barriers to learning: limited resources and large class sizes

UNIT V RESEARCH GAPS AND FUTURE DIRECTIONS

Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment - Dissemination and research impact.

TOTAL: 30 PERIODS

COURSE OUTCOMES

Students will be able to understand:

CO1: What pedagogical practices are being used by teachers informal and informal classrooms in developing countries?

CO2: What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?

CO3: How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

SUGGESTED READING

1. Ackers J, HardmanF, "Classroom interaction in Kenyan primary schools", Compare, 31(2): 245-261,2001.
2. Agrawal M, "Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies", 36(3):361-379, 2004.
3. Akyeampong K, "Teacher training in Ghana-does it count? Multi-site teacher education research project (MUSTER) country report 1", London:DFID, 2003.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J, "Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development", 33(3): 272–282, 2013.
5. Alexander RJ, "Culture and pedagogy: International comparisons in primary education", Oxford and Boston: Blackwell, 2001.
6. Chavan M, Read India: Amass scale, rapid, 'learning to read' campaign, 2003.
7. www.pratham.org/images/resource%20working%20paper%202.pdf

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AX5097 **STRESS MANAGEMENT BY YOGA** **L T P C**
2 0 0 0

OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

UNIT I

Definitions of Eight parts of yoga.(Ashtanga)

UNIT II

Yam and Niyam - Do`s and Don't's in life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT III

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

TOTAL: 30 PERIODS

COURSE OUTCOMES

Students will be able to:
CO1: Develop healthy mind in a healthy body thus improving social health also
CO2: Improve efficiency

SUGGESTED READING

1. 'Yogic Asanas for Group Tarining-Part-I":Janardan Swami Yoga bhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

AX5098 **PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS** **L T P C**
2 0 0 0

OBJECTIVES

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

UNIT I

Neetisatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses-29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (dont's) - Verses-71,73,75,78 (do's)

UNIT II

Approach to day to day work and duties - Shrimad Bhagwad Geeta: Chapter 2-Verses 41, 47,48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

UNIT III

Statements of basic knowledge - Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 - Personality of role model - shrimad bhagwad geeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

TOTAL: 30 PERIODS

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COURSE OUTCOMES

Students will be able to

CO1: Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life

CO2: The person who has studied Geeta will lead the nation and mankind to peace and prosperity

CO3: Study of Neet is hatakam will help in developing versatile personality of students.

SUGGESTED READING

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari's Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda , Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.

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