UNIVERSITY DEPARTMENTS
ANNA UNIVERSITY, CHENNAI
REGULATIONS - 2019
M.E. COMMUNICATION SYSTEMS
CHOICE BASED CREDIT SYSTEM

VISION

The Department of ECE shall strive continuously to create highly motivated, technologically competent engineers, be a benchmark and a trend setter in Electronics and Communication Engineering by imparting quality education with interwoven input from academic institutions, research organizations and industries, keeping in phase with rapidly changing technologies imbibing ethical values.

MISSION

- Imparting quality technical education through flexible student centric curriculum evolved continuously for students of ECE with diverse backgrounds.
- Providing good academic ambience by adopting best teaching and learning practices.
- Providing congenial ambience in inculcating critical thinking with a quest for creativity, innovation, research and development activities.
- Enhancing collaborative activities with academia, research institutions and industries by nurturing ethical entrepreneurship and leadership qualities.
- Nurturing continuous learning in the stat-of-the-art technologies and global outreach programmes resulting in competent world class engineers.

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1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. To educate graduates who will develop as ethical, productive and contributing members of society.

II. To provide a solid foundation in signal processing, communication signal design, electromagnetics and radiation systems,, wireless and optical communications and networking, security and privacy issues and newly evolving concepts.

III. To develop the ability to use their communication engineering foundation for success in technical careers in industry, academia, government or other organizations and carrying out doctoral and post-doctoral research in specific area of study.

IV. To inculcate an appreciation for, and an ability to engage in, life-long learning process and use lifelong learning skills to take advantage of professional development opportunities.

V. Prepare students to excel in research and to apply evolving techniques, tools and practices to create solutions and technologies to meet the needs of society and engage in solving technical and societal problems.

2. PROGRAMME OUTCOMES (POs):

PO#	Graduate Attribute	Programme Outcome
1.	Research aptitude	An ability to independently carry out research /investigation , identify problems and develop solutions 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, communication circuits 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.

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3. PROGRAMME SPECIFIC OUTCOMES (PSOs):

I. Foundation on Communication System basics : To enable the student to understand the basic principles involved in the design and operation of communication systems based on a solid foundation in signal processing, baseband and band pass communication signal design, radiation systems, electromagnetic, wireless and optical media challenges for transmission and networking and high frequency processing circuits.

II. Foundation on Mathematical concepts : To impart the ability to apply mathematical knowledge to develop new baseband and bandpass techniques, design baseband and bandpass communication circuits and networking protocols, and design and analyse algorithms and circuits for secure communication systems.

III. Foundation on Research Methodology : To facilitate the students to engage with industry and other organizations, to solve engineering problems and to address the technological challenges of the future communication needs.

4. PEO/PO Mapping:

PEOs	Programme Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
I.	√				√	√
II.	√	√	√	√		
III.	√	√	√	√	√	√
IV.	√	√		√	√	
V.	√			√	√	√

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Year	Sem.	Course	Programme Outcomes					
			PO1	PO2	PO3	PO4	PO5	PO6
I	I	Signal Processing and Baseband Techniques	√		√	√	√	√
		Digital Modulation and Coding Techniques	√		√	√	√	
		Advanced Wireless Communication	√		√	√	√	√
		Advanced Radiation Systems	√		√	√	√	
		Research Methodology and IPR						
		Audit course I						
		Signal Processing and Communication Laboratory	√	√	√	√		
		RF and Optical Communication Laboratory	√	√	√	√		
	II	Wireless Communication Networks	√		√	√	√	√
		Radio Frequency Transceiver Design	√		√	√	√	√
		Microwave Integrated Circuits	√		√	√	√	√
		Program Elective I						
		Program Elective II						
		Audit Course II						
		Communication Networking and High Speed Switching Laboratory	√	√	√	√	√	
		Mini Project with Seminar	√	√	√	√	√	√
II	III	Optical Communication and Networking	√		√	√	√	√
		Program Elective III						
		Program Elective IV						
		Open Elective						
		Dissertation-I	√	√	√	√	√	√
	IV	Dissertation-II	√	√	√	√	√	√

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.E. COMMUNICATION SYSTEMS
REGULATIONS – 2019
CHOICE BASED CREDIT SYSTEM
I - IV SEMESTER CURRICULA AND SYLLABI

SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIOD PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1	CU5101	Signal Processing and Baseband Techniques	PCC	3	1	0	4	4
2	CU5102	Digital Modulation and Coding Techniques	PCC	3	1	0	4	4
3	CU5103	Advanced Wireless Communication	PCC	3	0	0	3	3
4	CU5104	Advanced Radiation Systems	PCC	3	0	0	3	3
5	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
6		Audit Course I*	AC	2	0	0	2	0
PRACTICAL								
7	CU5111	Signal Processing and Communication Laboratory	PCC	0	0	4	2	2
8	CU5112	RF and Optical Communication Laboratory	PCC	0	0	4	2	2
			TOTAL	**16**	**2**	**8**	**22**	**20**

* Audit Course is optional

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	CONTACT PERIODS	CREDITS
THEORY								
1	CU5201	Wireless Communication Networks	PCC	3	0	0	3	3
2	CU5202	Radio Frequency Transceiver Design	PCC	3	0	0	3	3
3	CU5203	Microwave Integrated Circuits	PCC	3	0	2	5	4
4		Program Elective I	PE	3	0	0	3	3
5		Program Elective II	PE	3	0	0	3	3
6		Audit Course II*	AC	2	0	0	2	0
PRACTICAL								
8	CU5211	Communication Networking and High Speed Switching Laboratory	PCC	0	0	4	2	2
9	CU5212	Mini Project with Seminar	EEC	0	1	2	3	2
			TOTAL	**17**	**1**	**8**	**24**	**20**

* Audit Course is optional

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SEMESTER III

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	CONTACT PERIODS	CREDITS
THEORY								
1	CU5301	Optical Communication and Networking	PCC	3	0	0	3	3
2		Program Elective III	PE	3	0	0	3	3
3		Program Elective IV	PE	3	0	0	3	3
4		Open Elective	OE	3	0	0	3	3
PRACTICAL								
4	CU5311	Dissertation 1	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**24**	**18**

SEMESTER IV

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	CONTACT PERIODS	CREDITS
	PRACTICAL							
1	CU5411	Dissertation 2	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 70

PROGRAM CORE COURSES (PCC)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	CONTACT PERIODS	CREDITS
1.	CU5101	Signal Processing and Baseband Techniques	PCC	3	1	0	4	4
2.	CU5102	Digital Modulation and Coding Techniques	PCC	3	1	0	4	4
3.	CU5103	Advanced Wireless Communication	PCC	3	0	0	3	3
4.	CU5104	Advanced Radiation Systems	PCC	3	0	0	3	3
5.	CU5111	Signal Processing and Communication Laboratory	PCC	0	0	4	2	2
6.	CU5112	RF and Optical Communication Laboratory	PCC	0	0	4	2	2
7.	CU5201	Wireless Communication Networks	PCC	3	0	0	3	3
8.	CU5202	Radio Frequency Transceiver Design	PCC	3	0	0	3	3
9.	CU5203	Microwave Integrated Circuits	PCC	3	0	2	5	4
10.	CU5211	Communication Networking and High Speed Switching Laboratory	PCC	0	0	4	2	2

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PROGRAM ELECTIVE COURSE (PEC)

Sl. No.	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	CONTACT PERIODS	Credits
1	MA5159	Advanced Applied Mathematics	PE	3	1	0	4	4
2	CU5001	Telecommunication System Modeling and Simulation	PE	3	0	0	3	3
3	CU5002	RADAR Signal Processing	PE	3	0	0	3	3
4	CU5003	Massive MIMO and mmWave Systems	PE	3	0	0	3	3
5	CU5004	Machine Learning in Communication Networks	PE	3	0	0	3	3
6	CU5005	Multimedia Communications	PE	3	0	0	3	3
7	CU5006	Wireless Sensor Networks and Wban	PE	3	0	0	3	3
8	CU5007	Cryptography and Network Security	PE	3	0	0	3	3
9	CU5071	Cognitive Radio Networks	PE	3	0	0	3	3
10	CU5008	Satellite Communication and Navigation Systems	PE	3	0	0	3	3
11	AP5077	Signal Integrity for High Speed Design	PE	3	0	0	3	3
12	CU5009	Electromagnetic Interference and Compatibility in System Design	PE	3	0	0	3	3
13	CU5010	Micro-Electro Mechanical Systems	PE	3	0	0	3	3
14	CU5011	High Speed Switching and Networking	PE	3	0	0	3	3
15	CU5012	Communication Network Design	PE	3	0	0	3	3
16	CU5013	Convex Optimization	PE	3	0	0	3	3
17	CU5014	Detection and Estimation	PE	3	0	0	3	3
18	CU5015	Speech Processing	PE	3	0	0	3	3
19	CU5016	Co-operative Communication	PE	3	0	0	3	3

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OPEN ELECTIVE COURSES (OEC)

*(out of 6 courses one course must be selected)

SI. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			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
			Lecture	Tutorial	Practical	
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

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

Sl. No	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	CONTACT PERIODS	CREDITS
1.	CU5212	Mini Project with Seminar	EEC	0	1	2	3	2
2.	CU5311	Dissertation I	EEC	0	0	12	12	6
3.	CU5411	Dissertation II	EEC	0	0	24	24	12

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CU5101 SIGNAL PROCESSING AND BASE BAND TECHNIQUES L T P C
3 1 0 4

OBJECTIVES:

- Expertise the students to understand the basic principles of random signal processing and enlighten them on spectral estimation, equalization, detection and synchronization of communication signal. This course also explores the integration principles of communication system working with different sampling rates.

UNIT I DISCRETE RANDOM SIGNAL PROCESSING 9+3

Discrete Random Processes- Ensemble Averages, Stationary processes, Bias and Estimation, Autocovariance, Autocorrelation, Parseval's theorem, Wiener-Khintchine relation, White noise, Power Spectral Density, Spectral factorization, Filtering Random Processes, Special types of Random Processes : ARMA, AR, MA models, Yule-Walker equations.

UNIT II SPECTRAL ESTIMATION 9+3

Estimation of spectra from finite duration signals, 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 ADAPTIVE FILTERS 9+3

FIR adaptive filters – Steepest descent method- LMS algorithm, RLS adaptive algorithm, Kalman filter – Application: channel equalization, noise cancellation, prediction.

UNIT IV MULTIRATE SIGNAL PROCESSING 9+3

Decimation, Interpolation, Sampling rate conversion by rational factor, polyphase filter structures, Application: sub-band coding technique with quadrature mirror filter.

UNIT V DETECTION, ESTIMATION AND SYNCHRONIZATION 9+3

Detection rules : MAP, ML rules, detection of M-ary signals, MMSE estimation: Signal amplitude estimation, carrier frequency and phase estimation, symbol timing estimator, joint estimation of carrier phase and symbol timing.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1: Reinforcing the basic random process theory used for signal processing
CO2: Learning the techniques to estimate the spectrum of random signals in the presence of noise
CO3: Exploring the techniques to equalize the signal distorted by the transmission channel
CO4: Understanding the principles of system design that works with subsystems working with different sampling rates
CO5: Studying the techniques to recover the desired signal parameters and information from the signal corrupted by noisy channel

REFERENCES:

1. Monson H. Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley and Sons, Inc, Singapore, 2002.
2. John J. Proakis, Dimitris G. Manolakis, "Digital Signal Processing", Pearson Education, 2002.
3. Bernard Sklar and Pabitra Kumar Roy, "Digital Communications: Fundamentals & Applications", Pearson Education India, 2nd Edition, 2009.
4. John G. Proakis., " Digital Communication" , Mc Graw Hill Publication, 4th Edition, 2001.
5. John G. Proakis, Masoud Salehi, "Communication Systems Engineering", Prentice Hall, 1994.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		1	2		
2	1		1	1		
3	1		3	3		
4	1		3	3		
5	1		2	2	1	1

CU5102 DIGITAL MODULATION AND CODING TECHNIQUES L T P C
3 1 0 4

OBJECTIVES:

- To understand the role of the communication medium in the design approaches for coding and modulation techniques.
- To know the trade-offs involved in the design of basic and advanced coding and modulation techniques.
- To learn the advanced baseband signal conditioning methods evolved for exploiting the channel and user application characteristics
- To familiarize on the system design approaches.

UNIT I REVIEW OF DIGITAL MODULATION TECHNIQUES 9+3

Base band and band pass communication; Signal space representation, Linear and nonlinear modulation techniques, M-ary modulation techniques; Spectral characteristics of digital modulation, Spread spectrum modulation techniques.

UNIT II RECEIVERS FOR AWGN AND FADING CHANNELS 9+3

Optimum receivers for AWGN channel –Correlation demodulator, matched filter, maximum likelihood sequence detector, envelope detectors for M-ary signals; Characterization of fading multipath channels, RAKE demodulator, Multiuser detection techniques.

UNIT III MULTICARRIER SYSTEMS 9+3

OFDM- Generation of sub-carriers using the IFFT; Guard Time and Cyclic Extension; Windowing; Peak to Average Power reduction schemes; Overview of GFDM, FBMC, UFMC, Multicarrier CDMA

UNIT IV TRELLIS CODED MODULATION 9+3

Coded Modulation for bandwidth-constrained channels-Trellis coded modulation; Set Partitioning, Four –state Trellis-coded modulation with 8-PSK signal constellation, Eight-state Trellis code for coded 8-PSK modulation, Eight-state Trellis for rectangular QAM signal constellations, Decoding methods and implementation issues.

UNIT V TURBO CODING 9+3

Introduction-Turbo Encoder, Turbo Decoder, Iterative Turbo Decoding Principles; Modifications of the MAP Algorithm-The Soft-Output Viterbi Algorithm(SOVA); Turbo Coding for AWGN channels, Turbo Coding for Rayleigh Channels, LDPC Codes.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1: Demonstrate an understanding of the trade-offs involved in the design of modulation signals.
CO2: Ability to identify best receiver configuration based on the channel and signal characteristics.
CO3: Understand the issues involved in the design of multi-carrier modulation signals
CO4: Ability to design coded modulation as per the bandwidth and power efficiency requirements
CO5: Ability to code and decode using advanced coding strategies for AWGN and fading chnnael conditions and understand the mathematics behind their implementation.

REFERENCES:

1. Bernard Sklar., "Digital Communications" , Pearson Education, 2nd Edition, 2001.
2. John G. Proakis., "Digital Communication", Mc Graw Hill Publication, 4th Edition, 2001
3. Theodore S.Rappaport., _Wireless Communications',Pearson Education, 2nd Edition, 2002.
4. Richard Van Nee & Ramjee Prasad., _OFDM for Multimedia Communications' Artech House
5. Publication, 2001.
6. Heinrich Meyer, Mare Moeneclacy, Stefan.A.Fechtel, " Digital communication receivers ", Vol I & Vol II, John Wiley, New York, 1997.
7. Sergio Verdu, "Multiuser Detection", Cambridge University Press, 1998.
8. Andrea Goldsmith , "Wireless Communication", Cambridge Univ. Press, 2006.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	2		2	2		
2	1		2	2		
3	2		3	3		
4	2		3	3		
5	2		2	2	1	

CU5103 ADVANCED WIRELESS COMMUNICATION L T P C
3 0 0 3

OBJECTIVES:

- To learn the concepts of wireless communication.
- To know about the various propagation methods, Channel models, capacity calculations multiple antennas and multiple user techniques used in the mobile communication.

UNIT I WIRELESS CHANNEL PROPAGATION AND MODEL 9

Propagation of EM signals in wireless channel – Reflection, diffraction and Scattering-free space, two ray. Small scale fading- channel classification- channel models – COST -231 Hata model, Longley-Rice Model, NLOS Multipath Fading Models: Rayleigh, Rician, Nakagami, Composite Fading –shadowing Distributions, Link power budget Analysis.

UNIT II CAPACITY OF WIRELESS CHANNELS 9

Capacity in AWGN, capacity of flat fading channel, capacity of frequency selective fading channels.

UNIT III DIVERSITY 9

Realization of independent fading paths, Receiver Diversity: Selection combining, Threshold Combining, Maximum-ratio Combining, Equal gain Combining. Transmitter Diversity: Channel known at transmitter, Channel unknown at the transmitter.

UNIT IV MIMO COMMUNICATIONS 9

Narrowband MIMO model, Parallel decomposition of the MIMO channel, MIMO channel capacity, MIMO Diversity Gain: Beam forming, Diversity-Multiplexing trade-offs, Space time Modulation and coding : STBC,STTC, Spatial Multiplexing and BLAST Architectures.

UNIT V MULTI USER SYSTEMS 9

Review of Multiple Access Techniques, Scheduling, power control, Uplink and Downlink channel capacity, multiuser diversity, MIMO-MU systems.

TOTAL: 45 PERIODS

COURSE OUTCOME:

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

CO1: Analyze the wireless channel characteristics and identify appropriate channel models

CO2:Understand the mathematics behind the capacity calculation under different channel conditions

CO3: Understand the implication of diversity combining methods and the knowledge of channel

CO4: Understand the concepts in MIMO Communications

CO5: Understand mulitiple access techniques and their use in different multi-user scenarios.

REFERENCES

1. Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2007.
2. Harry R. Anderson, “Fixed Broadband Wireless System Design”, John Wiley, India, 2003.
3. Andreas.F. Molisch, “Wireless Communications”, John Wiley, India, 2006.
4. Simon Haykin & Michael Moher, “Modern Wireless Communications”, Pearson Education, 2007.
5. Rappaport. T.S., “Wireless communications”, Pearson Education, 2003.
6. Gordon L. Stuber, “Principles of Mobile Communication”, Springer International Ltd., 2001.
7. Upena Dalal, “Wireless Communication”, Oxford Higher Education, 2009.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		2	2		
2	1		2	2		
3	1		2	2		
4	1		2	3		
5	1		3	3	1	1

CU5104 ADVANCED RADIATION SYSTEMS L T P C
3 0 0 3

OBJECTIVES:

- To enhance the students knowledge in the area of various antenna design and to make them understand their radiation mechanism.
- To impart knowledge about the state of art in antenna technology.

UNIT I ANTENNA FUNDAMENTALS & WIRE ANTENNAS 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

UNIT II ANTENNA ARRAYS 9

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

UNIT III APERTURES ANTENNAS 9

Field equivalence principle, Radiation from Rectangular and Circular apertures, Babinets principle, Slot antenna; Horn antenna; Reflector antenna, aperture blockage, and design consideration. Radiation Mechanism and Excitation techniques, Microstrip dipole; Patch, Rectangular patch, Circular patch – Microstrip array and feed network; Lens Antennas

UNIT IV MODERN ANTENNAS & MEASUREMENT TECHNIQUES 9

Base station antennas, PIFA – Antennas for WBAN – RFID Antennas – Automotive antennas, MIMO Antennas, Diversity techniques – Antenna impedance and radiation measurements

UNIT V NEXT GENERATION ANTENNA DESIGN 9

UWB antenna arrays – Vivaldi antenna arrays – Artificial magnetic conductors/High impedance surfaces – Antennas in medicine – Plasma antennas – Antennas for millimeter wave communication - optimization techniques – Numerical methods

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the fundamentals behind the different techniques in antenna technology.

CO2:Understand the challenges associated in designing antennas based on different technologies

CO3: Understand the capability and assess the performance of various antennas.

CO4: Identify the antennas specific to the applications , design and characterize.

CO5: Understand the need for optimizing in antenna design and the methodologies for the same.

REFERENCES:

1. Balanis.A, "Antenna Theory Analysis and Design", John Wiley and Sons, New York, 3rd Edition,1982.
2. Frank B. Gross, "Frontiers in Antennas", 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, "Antennas", John Wiley and sons, New York, 2nd Edition, 1997.
5. I.J. Bahl and P. Bhartia, "Microstrip Antennas", Artech House,Inc.,1980
6. W.L.Stutzman and G.A.Thiele, "Antenna Theory and Design", John Wiley& Sons Inc., 2nd Edition, 1998.
7. Jim R. James,P.S.Hall ,"Handbook of Microstrip Antennas" IEE Electromagnetic wave series 28, Volume 2,1989.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		2	2		
2			1	1		
3	1		2	2		
4	1		3	3	2	
5	2		2	3		

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,“Research Methodology: A Step by Step Guide for beginners” 2nd Edition, 2010.

CU5111 SIGNAL PROCESSING AND COMMUNICATION LABORATORY L T P C
0 0 4 2

OBJECTIVES:

- To enable the student to verify the basic principles of random signal processing, spectral estimation methods, wireless and AWGN channel characterization, application of adaptive filter algorithms for communication system design, coding and modulation design, synchronization aspects and the overall baseband system design.
- To design and conduct experiments, as well as to analyze and interpret data to produce meaningful conclusions and match with theoretical concepts.
- To enable the student to appreciate the practical aspects of baseband system design and understand the associated challenges.

LIST OF EXPERIMENT:

1. Spectral Characterisation of communication signals (using Spectrum Analyzer)
2. Design and Analysis of Spectrum Estimators (Bartlett , Welch)
3. Design and analysis of digital modulation techniques on an SDR platform
4. Carrier and Symbol timing Synchronization using SDR platform
5. CDMA signal generation and RAKE receiver design using DSP/MATLAB/ SIMULINK
6. Design and performance analysis of error control encoder and decoder (Block and Convolutional Codes)
7. Simulation of Turbo coding and SOVA
8. Sub-band coding system simulation
9. Wireless Channel equalizer design using DSP (ZF / LMS / RLS)
10. Wireless Channel Estimation and Diversity Combining

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1: The student would be able to design and conduct experiments to demonstrate the trade-offs involved in the design of basic and advanced coding and modulation techniques and the advanced baseband signal conditioning methods.

CO2: The student would be capable of applying communication engineering principles and design tools and will be well practiced in design skills.

CO3: The student would be able to comprehensively record and report the measured data, write reports, communicate research ideas and do oral presentations effectively.

CO4: The student would be capable of analyzing and interpreting the experimental measurement data and produce meaningful conclusions

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COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		1	2		
2	1		2	2		
3	1	3	1	1		
4	1		3	3		

CU5112 RF AND OPTICAL COMMUNICATION LABORATORY L T P C
0 0 4 2

OBJECTIVES:

- To verify the basic principles and design aspects involved in high frequency bandpass communication system components design
- To know the performance parameters for the components and the overall system.
- To appreciate the practical aspects of bandpass system design
- To understand the associated link power and risetime budgeting challenges.
- To design and conduct experiments, as well as to analyze and interpret data to produce meaningful conclusions and match with theoretical concepts.

LIST OF EXPERIMENTS:

1. Measurement of Transmission line and antenna parameters
2. Design and characterization of Antennas
3. Pathloss Measurement and Characterization of Wireless Channels
4. LNA / Mixer / VCO design and characterization
5. OFDM transceiver design using MATLAB/SIMULINK/SYSTEMView or equivalent
6. Simulation/Demonstration of MIMO systems
7. Determination of Maximum bit rate of a digital fiber optic link
8. Signal transmission and reception using WDM and spectral characterization
9. Characterization of Fiber Bragg Grating Filter (Reflectivity, Insertion loss & Crosstalk)
10. Link power and risetime budget estimation (Simulations)

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1: Given the user requirements and the type of channel over which the system has to function the student would be in a position to apply the knowledge to identify a suitable architecture and systematically design an RF system.

CO2: The student would be able to design and conduct experiments to demonstrate the trade-offs involved in the design of bandpass systems.

CO3: The student would be capable of applying communication engineering principles and design tools and will be well practiced in design skills.

CO4: The student would be able to comprehensively record and report the measured data, and would be capable of analyzing and interpreting the experimental measurement data and produce meaningful conclusions.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		1	1		
2	1		2	2		
3	1		2	2	1	1
4		3	3	3		

CU5201 WIRELESS COMMUNICATION NETWORKS L T P C
3 0 0 3

OBJECTIVES:

- To introduce students with concepts, design issues in 5G networks.
- To study about architectures and protocols and the state-of-the–art developments in next generation wireless network technologies.

UNIT I 5G CHANNEL MODEL 9

Modeling requirements and scenarios, Channel model requirements and Measurements, Propagation scenarios, METIS channel models, Map-based model, stochastic model, Comparison of Models

UNIT II MULTI-CARRIER WAVEFORMS FOR 5G 9

Filter-bank based multi-carrier (FBMC)- Principles, Transceiver block diagram, Frame structure, Resource structure, allocation, mapping. Universal filtered multi carrier (UFMC)- Principles, Transceiver structure, Frame and Resource structure, allocation, mapping. Generalized frequency division multicarrier (GFDM) – Principles, Transceiver Block diagram, Frame structure, Resource structure, allocation, mapping, MIMO-GFDM

UNIT III MULTIPLE ACCESS TECHNIQUES IN 5G 9

Challenges in OFDM- NOMA – Principle- Superposition Coding, Successive Interference Cancellation, Power Domain NOMA, Sparse Code NOMA- types, Power Domain Sparse Code NOMA, Cooperative NOMA- Benefits and Challenges

UNIT IV MASSIVE MIMO 9

Introduction-pilot design and channel estimation- uplink data transmission and downlink data transmission for Single cell systems and multi cell systems – capacity analysis.

UNIT V COOPERATIVE COMMUNICATION 9

Machine Type Communication (MTC), Device to Device Communication (D2D), 5G Narrowband IoT, Cloud Computing architecture and Protocols**, Relaying:** Cooperative NOMA- Benefits and Challenges, Half duplex relaying, Full duplex relaying, Amplify and forward relaying, Decode and forward relaying, Decode and forward relaying with PLNC, BER Analysis, Capacity Analysis.

TOTAL : 45 PERIODS

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COURSE OUTCOMES:

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

CO1: Able to analyze the performance of different channel models adopted in 5G wireless systems

CO2: Able to design a transceiver for Multicarrier waveforms.

CO3: Able to analyze multiple access techniques in 5G networks

CO4: Able to design a pilot, estimate channels and analyze capacity for single cell and multicell Massive MIMO.

CO5: Able to analyze different types of cooperative communications.

REFERENCES

1. Afif Osseiran, Jose.F.Monserrat and Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2016.
2. Robert W. Heath Jr., Nuria González-Prelcic, SundeepRangan, WonilRoh,and Akbar M. Sayeed, "An Overview of Signal Processing Techniques for Millimeter Wave MIMO Systems", IEEE Journal of Selected Topics in Signal Processing, Vol. 10, No. 3, April 2016.
3. MinChulJu and Il-Min Kim, "Error Performance Analysis of BPSK Modulation in Physical-Layer Network-Coded Bidirectional Relay Networks", IEEE Transactions on Communications, Vol. 58, No. 10, October 2010.
4. Shengli Zhang, Soung-Chang Liew, Patrick P.Lam, "Physical Layer Network Coding", Mobicom _06, Proceeding of the 12th International Conference on Mobile Computing and Networking, pp.358-365, Los Angeles, CA, USA, Sep.23-29,2006.
5. Thomas L. Marzetta, Erik G. Larsson, Hong Yang, HienQuoc Ngo, "Fundamentals of Massive MIMO", Cambridge University Press, 1st Edition, 2016.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		2	2		1
2	1		2	2		1
3	1		1	1		1
4	1		3	3		1
5	1		1	1	1	1

CU5202 RADIO FREQUENCY TRANSCEIVER DESIGN L T P C
3 0 0 3

OBJECTIVE:

- To enable the student to understand the specification parameters of a radio frequency system
- To enable the student to understand the intricacies of RF system design using behaviour models of the subsystems present in the transceiver chains

UNIT I BASICS OF RADIO FREQUENCY SYSTEM DESIGN 9

Definitions and models of Linear systems and Non-linear system. Specification parameters: Gain, noise figure, SNR, Characteristic impedance, S-parameters, Impedance matching and Decibels. Elements of digital base band signaling: complex envelope of band pass signals, Average value, RMS value, Crest factor, Sampling, jitter, modulation techniques, filters, pulse shaping, EVM, BER, sensitivity, selectivity, dynamic range and, adjacent and alternate channel power leakages

UNIT II RADIO ARCHITECTURES AND DESIGN CONSIDERATIONS 9

Superheterodyne architecture, direct conversion architecture, Low IF architecture, band-pass sampling radio architecture

UNIT III AMPLIFIER MODELING AND ANALYSIS 9

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

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

UNIT IV MIXER AND OSCILLATOR MODELING AND ANALYSIS 9

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

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

UNIT V APPLICATIONS OF SYSTEMS DESIGN 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:

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

CO1: Students will be able understand the specifications of transceiver modules

CO2: Students will understand pros and cons of transceiver architectures and their associated design considerations

CO3: Students will understand the impact of noise and amplifier non-linearity of amplification modules and also will learn the resultant effect during cascade connections

CO4: Students will be get exposure to learn about spurs and generation principles during signal generation and frequency translations

CO5: The case study will reinforce the understanding of transceiver systems and aid to select specification parameters selections

REFERENCES:

1. Qizheng Gu, “RF System Design of Transceivers for Wireless Communications”, Springer, 2005.
2. Kevin McClaning, “Wireless Receiver Design for Digital Communications,”. 2/3, Yes Dee Publications, 2012.
3. M C Jeruchim, P Balapan and K S Shanmugam, “Simulation of Communication systems: Modeling, Methodology and Techniques”, Kluwer Academic/Plenum Publishers, 2nd Edition, 2000.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		1	2		
2	1		1	1		
3	1		3	3		
4	1		3	3		
5	1		2	2	1	1

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CU5203 **MICROWAVE INTEGRATED CIRCUITS** **L T P C**
3 0 2 4

OBJECTIVES

- To familiarize different transmission lines used at Microwave frequencies
- To design impedance matching networks using lumped and distributed elements
- To design and analyze different microwave components
- To use SMITH chart to analyze the region of stability and instability for designing amplifiers and oscillators
- To simulate and to test the microwave components under laboratory conditions

UNIT I PLANAR TRANSMISSION LINES AND COMPONENTS 9

Review of Transmission line theory – S parameters-Transmission line equations – reflection coefficient – VSWR – Microstrip lines: Structure, waves in microstrip, Quasi-TEM approximation, Coupled lines: Even mode and odd mode analysis – Microstrip discontinuities and components – Strip line – Slot line – Coplanar waveguide – Filters – Power dividers and Couplers

UNIT II IMPEDANCE MATCHING NETWORKS 9

Circuit Representation of two port RF/Microwave Networks: Low Frequency Parameters, High Frequency Parameters, Transmission Matrix, ZY Smith Chart, Design of Matching Circuits using Lumped Elements, Matching Network Design using Distributed Elements

UNIT III MICROWAVE AMPLIFIER AND OSCILLATOR DESIGN 9

Characteristics of microwave transistors – Stability considerations in active networks – Gain Consideration in Amplifiers – Noise Consideration in active networks – Broadband Amplifier design – Oscillators: Oscillator versus Amplifier Design – Oscillation conditions – Design and stability considerations of Microwave Transistor Oscillators.

UNIT IV MIXERS AND CONTROL CIRCUITS 9

Mixer Types – Conversion Loss – SSB and DSB Mixers – Design of Mixers: Single Ended Mixers – Single Balanced Mixers – Sub Harmonic Diode Mixers, Microwave Diodes, Phase Shifters – PIN Diode Attenuators

UNIT V MICROWAVE IC DESIGN AND MEASUREMENT TECHNIQUES 9

Microwave Integrated Circuits – MIC Materials- Hybrid versus Monolithic MICs – Multichip Module Technology – Fabrication Techniques, Miniaturization techniques, Introduction to SOC, SOP, Test fixture measurements, probe station measurements, thermal and cryogenic measurements, experimental field probing techniques.

Sl. No.	Details of Experiment		Details of the Equipment	
	Name	Duration	Name	Quantity
1	Study of transmission line parameters – Impedance analysis	1	Transmission line Trainer kit, VNA	1 set
2	Design of impedance matching networks	2	EM Software, MIC Trainer kit, VNA	1 set
3	Design of low pass and high pass filter	4	EM software, MIC Trainer kit, VNA	1 set
4	Design of bandpass and bandstop filters	4	EM software, MIC Trainer kit, VNA	1 set
5	Design of branch line couplers	2	EM software, MIC Trainer kit, VNA	1 set
6	Design of phase shifters	2	EM software, MIC Trainer kit, VNA	1 set
7	Design of Mixers	2	EM software, MIC Trainer kit, VNA	1 set
8	Design of Power dividers	2	EM software, MIC Trainer kit, VNA	1 set

THEORY: 45 HOURS LABORATORY: 30 HOURS = 75 PERIODS

COURSE OUTCOMES:

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

CO1: Design impedance matching circuits using LC components and stubs.
CO2: Design and analyze microwave components.
CO3: Perform stability analysis and be able to design amplifiers and oscillators at microwave frequencies.
CO4: Perform simulations, fabricate and test microwave devices.

REFERENCES:

1. Jia Sheng Hong, M. J. Lancaster, "Microstrip Filters for RF/Microwave Applications", John Wiley & Sons, 2001
2. David M. Pozar, "Microwave Engineering", II Edition, John Wiley & Sons, 1998
3. Guillermo Gonzalez, "Microwave Transistor Amplifiers – Analysis and Design", II Edition, Prentice Hall, New Jersy
4. Thomas H.Lee, "Planar Microwave Engineering", Cambridge University Press, 2004
5. Matthew M. Radmanesh, "Radio Frequency and Microwave Electronics", Pearson Education, II Edition 2002
6. Ravender Goyal, "Monolithic MIC; Technology & Design", Artech House, 1989.
7. Gupta K.C. and Amarjit Singh, "Microwave Integrated Circuits", John Wiley, New York, 1975.
8. Hoffman R.K. "Handbook of Microwave Integrated Circuits", Artech House, Boston, 1987.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		1	1		
2	1		2	2		
3	1		2	3	1	1
4			2	3		

CU5211 COMMUNICATION NETWORKING AND HIGH SPEED SWITCHING LABORATORY **L T P C 0 0 4 2**

OBJECTIVES:

- To understand the basics of communication protocol design for different functionalities
- To design and conduct experiments, as well as to analyze and interpret data to produce meaningful conclusions and match with theoretical concepts.

LIST OF EXPERIMENTS:

Simulation and performance evaluation using
(QUALNET /GLOMOSIM / NS2/ MATLAB/ PYTHON/ Equivalent) of :

1. MAC protocols for wired and wireless networks
2. Routing protocols for wired and wireless networks
3. Analysis of Scheduling policies and Queuing methods on the network performance
4. Cellular network modeling and performance analysis in terms of Blocking Probability and Spectral Efficiency

5. Wireless Sensor Network implementation and analysis in terms of Throughput and Energy Efficiency
6. Algorithms to implement packet forwarding/ packet classification/packet switching in IP routers/Ethernet switches
7. Packet Scheduling and Buffer Management – Output-buffered Switches/ Shared-memory Switches/ Input-buffered Switches / Clos-network Switches/ Multi-Stage Buffered Switches.
8. Analysis of optical switching technologies using Optical Simulation tool
9. Implementation and analysis of data security and network security algorithms
10. Analysis of Side-Channel Attacks in IoT Devices

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1: Given the user requirements the student would be in a position to apply the knowledge to identify a suitable architecture and systematically design a communication network.

CO2: The student would be able to design and conduct experiments to demonstrate the trade-offs involved in the design of high speed communication networks.

CO3: The student would be capable of applying communication engineering principles and design tools and will be well practiced in design skills.

CO4: The student would be able to comprehensively record and report the measured data, and would be capable of analyzing and interpreting the experimental measurement data and produce meaningful conclusions.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		1	1		
2			2	2	1	
3			2	2		
4		3	1	1		

CU5301 OPTICAL COMMUNICATION AND NETWORKING L T P C
3 0 0 3

OBJECTIVES:

- To enable the student to understand the basic principles of operation of optical system components, the different network architectures and issues associated with network design.
- To enable the student to understand the differences in the design of data plane and the control plane and the routing, switching and the resource allocation methods and the network management and protection methods in vogue.

UNIT I OPTICAL SYSTEM COMPONENTS AND NETWORK DESIGN 9

Optical System Components – MZIM, Multiplexers; filters; switches; wavelength converters; optical amplifiers – EDFA, Raman Amplifiers and hybrid; Transmission system Engineering – System Model, Aimer penalty – transmitter, receiver, cross talk, dispersion compensation, wavelength stabilization, FWM.

UNIT II COHERENT SYSTEMS 9

Basic principles of Coherent detections – Practical constraints – Injection laser line width state of polarization, local oscillator power, fiber limitations; Modulation formats – ASK, FSK, PSK, DPSK and polatization shift keying (POL SK); Demodulation schemes – Homodyne, Heterodyne – Synchronous and Non synchronous detection; Comparison; Carrier recovery in Coherent detection.

UNIT III OPTICAL NETWORK ARCHITECTURES 9

Introduction to Optical Networks; First Generation optical networks –SONET / SDH Network, Second Generation (WDM) Optical Networks, Need for Multilayered Architecture-, Layers and Sub-layers, Spectrum partitioning, Optical Network Nodes, Network Access Stations, Overlay Processor, Logical network overlays.

UNIT IV NETWORK CONNECTIONS 9

Connection Management and Control; Static Networks, Wavelength Routed Networks; Linear Light wave networks; Logically Routed Networks; Routing and Wavelength Assignment , Traffic Grooming in Optical Networks.

UNIT V OPTICAL NETWORK SURVIVABILITY 9

Protection and Restoration Objectives, Fault Protection and Restoration Techniques in the Logical Layer – Point-to-Point Systems, SONET Self-Healing Rings, Interconnection Techniques, Architectures with Arbitrary Mesh Topologies ,Optical-Layer Protection: Point-to-Point and Ring Architectures, Mesh Architectures

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Able to demonstrate an understanding of the differences and challenges involved in the design of optical systems and networks.

CO2: In a position to apply his knowledge for designing a fiber optic system addressing the channel impairments.

CO3: Familiar with the architectures and the protocol stack in use.in optical networks and would be able to identify a suitable backbone infrastructure for our present and future communication needs.

CO4: Able to understand how connections are managed in the network and the pros and cons of the different approaches

CO5: Able to appreciate the need for network survivability and the methodologies used.

REFERENCES:

1. Max Ming-Kang Liu, —Principles and Applications of Optical Communication‖, Tata McGraw Hill Education Pvt., Ltd., New Delhi.
2. Thomas E. Stern, Georgios Ellinas, Krishna Bala, —Multiwavelength Optical Networks – Architecture, Design and control —, Cambridge University Press, 2nd Edition, 2009.
3. Rajiv Ramaswami and Kumar N. Sivarajan, —Optical Networks : A Practical Perspective‖, Harcourt Asia Pte Ltd., Second Edition 2006.
4. P.E. Green, Jr., —Fiber Optic Networks‖, Prentice Hall, NJ, 1993.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		1	1		
2	1		2	2		
3	2		3	2	1	
4	1		2	3		
5			2	2	1	1

MA5159 **ADVANCED APPLIED MATHEMATICS** **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 enable students to understand the concepts of probability and random variables.
- To make students understand the notion of a Markov chain, and how simple ideas of conditional probability and matrices can be used to give a thorough and effective account of discrete-time Markov chains.
- To familiarize the students with the formulation and construction of a mathematical model for a linear programming problem in real life situation.
- To introduce the Fourier Transform as an extension of Fourier techniques on periodic functions and to solve partial differential equations.

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 ONE DIMENSIONAL RANDOM VARIABLES 12

Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable.

UNIT III RANDOM PROCESSES 12

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

UNIT IV LINEAR PROGRAMMING 12

Formulation – Graphical solution – Simplex method – Two phase method - Transportation and Assignment Models

UNIT V FOURIER TRANSFORM FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Fourier transforms: Definitions, properties-Transform of elementary functions, Dirac Delta functions – Convolution theorem – Parseval‘s identity – Solutions to partial differential equations: Heat equations, Wave equations, Laplace and Poisson‘s equations.

TOTAL: 45+15=60 PERIODS

OUTCOMES:

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

CO1: Apply the concepts of linear algebra to solve practical problems.
CO2: Use the ideas of probability and random variables in solving engineering problems.
CO3: Classify various random processes and solve problems involving stochastic processes.
CO4: Formulate and construct mathematical models for linear programming problems and solve the transportation and assignment problems.
CO5: Apply the Fourier transform methods of solving standard partial differential equations.

REFERENCES:

1. Andrews, L.C. and Philips.R.L., “Mathematical Techniques for engineering and scientists”, Prentice Hall of India, New Delhi, 2006.
2. Bronson, R., “Matrix Operation”, Schaum‘s outline series, Tata McGraw Hill, New York, 2011.
3. O‘Neil P.V., “Advanced Engineering Mathematics”, Cengage Learning, India, 8th Edition, 2017.
4. Oliver C. Ibe, “Fundamentals of Applied Probability and Random Processes”, Academic Press, Boston, 2014.

5. Sankara Rao, K., “Introduction to partial differential equations”, Prentice Hall of India, Pvt., Ltd, New Delhi, 3rd Edition, 2010.
6. Taha H.A., “Operations Research: An introduction”, Ninth Edition, Pearson Education, Asia, New Delhi, 10th Edition, 2017.

CU5001 TELECOMMUNICATION SYSTEM MODELING AND SIMULATION L T P C
3 0 0 3

OBJECTIVES:

- To enable the student to understand the various aspects of simulation methodology and performance, appreciate the significance of selecting sampling frequency and modelling different types of signals and processing them.
- To expose the student to the different simulation techniques, their pros and cons and enable him to understand and interpret results using case studies.

UNIT I SIMULATION METHODOLOGY 8

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

UNIT II RANDOM SIGNAL GENERATION & PROCESSING 8

Uniform random number generation, Mapping uniform random variables to an arbitrary pdf, Correlated and Uncorrelated Gaussian random number generation, PN sequence generation, Random signal processing, Testing of random number generators.

UNIT III MONTE CARLO SIMULATION 9

Fundamental concepts, Application to communication systems, Monte Carlo integration, Semianalytic techniques, Case study: Performance estimation of a wireless system.

UNIT IV ADVANCED MODELS & SIMULATION TECHNIQUES 10

Modeling and simulation of non-linearities : Types, Memoryless non-linearities, Non-linearities with memory, Modeling and simulation of Time varying systems : Random process models, Tapped delay line model, Modelling and simulation of waveform channels, Discrete memoryless channel models, Markov model for discrete channels with memory.

UNIT V EFFICIENT SIMULATION TECHNIQUES 10

Tail extrapolation, pdf estimators, Importance Sampling methods, Case study: Simulation of a Cellular Radio System.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be able to

CO1: Understand the different signal generation and processing methods
CO2: Mathematically model a physical phenomena
CO3: Simulate a phenomena so as to depict the characteristics that may be observed in a real experiment.
CO4: Apply knowledge of the different simulation techniques for designing a communication system or channel
CO5: Ability to validate a simulated system performance so as to match a realistic scenario.

REFERENCES

1. William.H.Tranter, K. Sam Shanmugam, Theodore. S. Rappaport, Kurt L. Kosbar, Principles of Communication Systems Simulation, Pearson Education (Singapore) Pvt. Ltd, 2004.
2. M.C. Jeruchim, P.Balaban and K. Sam Shanmugam, Simulation of Communication Systems: Modeling, Methodology and Techniques, Plenum Press, New York, 2001.
3. Averill.M.Law and W. David Kelton, Simulation Modeling and Analysis, McGraw Hill Inc., 2000.
4. Geoffrey Gorden, System Simulation, Prentice Hall of India, 2nd Edition, 1992.
5. Jerry Banks and John S. Carson, Discrete Event System Simulation, Prentice Hall of India, 1984.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		2	2		
2	1		3	2		
3			3	3		
4			3	3		
5	2		2	2		

CU5002 RADAR SIGNAL PROCESSING L T P C

3 0 0 3

OBJECTIVES:

- To enable the student to understand the basic principles of radar operation and the different types of radars and their applications.
- To enable the student to understand the different systems involved in radar configuration, the signal processing aspects to accurately detect and interpret signals and the antenna systems for signal capture.
- The student should also become familiar with conventional applications of radar and with new techniques currently being researched and implemented.

UNIT I RANGE EQUATION AND TYPES OF RADAR 9

Basic Radar, Radar equation, Radar parameters, Block diagram, Radar frequencies. Types of Radar: CW, Doppler, MTI, FMCW, Pulsed, Tracking Radar. DSP in Radar (MTD1),Radar measurements.

UNIT II RADAR SYSTEM CONCEPTS 9

Scattering and RCS, RCS models, propagation, antennas, receivers, Different type of Noise, Noise figure, False alarm & Missed detection, Radar cross section, Transmit/Receive and Anti-Transmit/Receive Switches

UNIT III SIGNAL PROCESSING – I 9

Radar Signal Processing Fundamentals –Detection and likelihood ratio, binary detection, matched filtering, radar ambiguity functions, pulse compression and radar waveforms, radar resolution, Detection of radar signals in Noise and clutter, detection of non fluctuating target in noise, Matched filter response to delayed Doppler shifted signals,

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UNIT IV SIGNAL PROCESSING – II **9**

Doppler Processing, Linear FM Pulse Compression, Waveform diversity, Passive System: Digital compression, SAW pulse compression. Signal processing in Antenna arrays.

UNIT V APPLICATIONS OF RADAR SIGNAL PROCESSING **9**

Pulse-Doppler radar, CFAR detection, synthetic aperture radar (SAR), inverse synthetic aperture radar (ISAR), moving target indication (MTI), displaced-phase-center-antenna technique (DPCA), adaptive radar, superresolution (MUSIC), space-time adaptive processing (STAP).

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Able to demonstrate an understanding of the basic principles of radar operation and the types

CO2: Able to appreciate the impact of the different performance measures in a radar system.

CO3: Able to identify and apply different signal processing tools in the design of radar systems

CO4: Able to design radar systems to meet user specified operational goals.

CO5: Able to model radar returns in various operational environments and analyze performance.

REFERENCES

1. M.I.Skolnik , “Introduction to Radar Systems”, Tata McGraw Hill 2006.
2. Mark A. Richards, “Fundamentals of Radar Signal Processing”, McGraw-Hill, 2005.
3. Peyton Z. Peebles, Jr., “Radar Principles”, Wiley India Pvt Ltd, 2007.
4. Nadav Levanon , “Radar Principles”, Wiley – Technology and Engineering Publication, 1988.
5. Nathansan, “Radar design principles-Signal processing and environment”, PHI, 2nd Edition, 2007.
6. Roger J.Sullivan, “Radar foundations for Imaging and advanced concepts”, PHI,2004.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		2			
2	2		2			
3	1		3	3		
4	2		3	3	1	
5	2		2	1		1

CU5003 MASSIVE MIMO AND mmWAVE SYSTEMS **L T P C**
3 0 0 3

OBJECTIVES:

- To understand the principles and challenges involved in the design of Massive MIMO systems
- To understand the propagation aspects of Millimeter wave signals and the fundamentals of Millimeter wave devices and circuits.
- To understand the various components of Millimeter wave MIMO systems.

UNIT I INTRODUCTION 9

Massive MIMO: principles, characteristics and transmission/detection techniques; Channel hardening in large dimensions,- Channel Models – Effect of spatial correlation – Channel Estimation – Pilot contamination in massive MIMO – Implementation challenges and Standardization.

UNIT II PRECODING IN LARGE MIMO SYSTEMS 9

SVD precoding, Precoding in a multiuser MIMO downlink –Linear precoding- Linear precoding , Non-linear precoding, Precoding in large multiuser MISO systems, Multicell precoding.

UNIT III mmWAVE PROPAGATION 9

Millimeter wave characteristics- millimeter wave wireless, implementation challenges, Radio wave propagation for mm wave: Large scale propagation channel effects, small scale channel effects, Outdoor and Indoor channel models, Emerging applications of millimeter wave communications.

UNIT IV mmWAVE COMMUNICATION SYSTEMS 9

Modulations for millimeter wave communications: OOK, PSK, FSK, QAM, OFDM, Millimeter wave link budget, Transceiver architecture, Transceiver without mixer, Receiver without Oscillator, millimeter wave calibration, production and manufacture, Millimeter wave design considerations.

UNIT V mmWAVE MIMO SYSTEMS 9

Massive MIMO Communications, Spatial diversity of Antenna Arrays, Multiple Antennas, Multiple Transceivers, Noise coupling in MIMO system, Potential benefits for mm wave systems, Spatial, Temporal and Frequency diversity, Dynamic spatial, frequency and modulation allocation, Beamforming for MmWave communications: Analog beamforming, digital beamforming and hybrid Beamforming.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Ability to appreciate Massive MIMO: characteristics and implementation challenges
CO2: Understand the need and impact of different precoding approaches
CO3: Ability to characterize propagation issues at Millimeter wave frequencies
CO4: Ability to estimate link budget and identity Millimeter wave devices and circuits specifications
CO5: Understand and appreciate the various implementation aspects of mmWave MIMO systems.

REFERENCES:

1. Chockalingam and B. Sundar Rajan, " Large MIMO Systems ", Cambridge University Press, 2014.
2. Ezio Biglieri, Robert Calderbank, Anthony Constantinides, Andrea Goldsmith, Arogyaswami Paulraj, Vincent Poor, "MIMO Wireless Communications", Cambridge University Press, 2006.
3. I. Robertson, N. Somjit and M. Chongcheawchamnan, "Microwave and Millimetre-Wave Design for Wireless Communications", 2016.
4. T.S. Rappaport, R.W. Heath Jr., R.C. Daniels and J.N. Murdock, "Millimeter Wave Wireless Communications: Systems and Circuits", 2015.
5. K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, 2011.
6. Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock,"Millimeter Wave Wireless Communication", Prentice Hall, 2014.
7. Xiang, W; Zheng, K; Shen, X.S; "5G Mobile Communications", Springer, 2016

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		1	2		
2	1		1	1		
3	1		2	2		
4	1		2	2		
5	1		3	3	1	1

CU5004 MACHINE LEARNING IN COMMUNICATION NETWORKS L T P C
3 0 0 3

OBJECTIVES:

- To enable the student to understand the concept of machine learning and its application in wireless communication and bio-medical.
- To expose the student to be familiar with a set of well-known supervised, semi-supervised and unsupervised learning algorithms

UNIT I MATHEMATICAL BACKROUND 9

Linear Algebra – Arithmetic of matrices, Norms, Eigen decomposition, Singular value decomposition, Pseudo inverse, Principal Component analysis. Probability theory – probability distribution, conditional probability, Chain rule, Bayes rule, Information theory, Structured Probabilistic models.

UNIT II MACHINE LEARNING BASICS 9

Supervised and Unsupervised learning, Capacity, Overfitting and Underfitting, Cross Validation, Linear regression, Logistic Regression, Regularization, Naive Bayes, Support Vector Machines (SVM), Decision tree, Random forest, K-Means Clustering, k nearest neighbor.

UNIT III NEURAL NETWORKS 9

Feedforward Networks , Backpropagation, Convolutional Neural Networks-LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet, Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks. Recurrent Neural Network(RNN) – Backpropagation through time (BPTT), Vanishing and Exploding Gradients.

UNIT IV ML IN WIRELESS AND SECURITY 10

Water-filling power allocation, Optimization for MIMO Systems, OFDM Systems and MIMO-OFDM systems. Optimization in beamformer design – Robust receive beamforming, Transmit downlink beamforming. Application: Radar for target detection, Array Processing, MUSIC, ML in Side channel analysis.

UNIT V ML IN BIO-MEDICAL 10

Machine Learning in Medical Imaging. Deep Learning for Health Informatics. Deep Learning Automated ECG Noise Detection and Classification System for Unsupervised Healthcare Monitoring. Techniques for Electronic Health Record (EHR) Analysis.

TOTAL : 45 PERIODS

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COURSE OUTCOMES:

At the end of the course the student would be

CO1: Demonstrate understanding of the mathematical principles underlying machine learning.
CO2: Familiar with the different machine learning techniques and their use cases.
CO3: In a position to formulate machine learning problems corresponding to different applications.
CO4: Able to recognize the characteristics of machine learning techniques that are useful to solve real-world problems.
CO5: In a position to read current research papers, understand the issues and the machine learning based solution approaches.

REFERENCES

1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, "Deep learning",Cambridge,MA", MIT Press, 2017.
2. Tom M. Mitchell, "Machine Learning", McGraw Hill, 1997.
3. Ethem Alpaydın, "Introduction to machine learning", MIT Press, 3rd Edition, 2014.
4. M. N. Wernick, Y. Yang, J. G. Brankov, G. Yourganov and S. C. Strother, "Machine Learning in Medical Imaging", IEEE Signal Processing Magazine, vol. 27, no. 4, pp. 25-38, July 2010.
5. Ravì et al., "Deep Learning for Health Informatics," IEEE Journal of Biomedical and Health Informatics, vol. 21, no. 1, pp. 4-21, Jan. 2017.
6. U. Satija, B. Ramkumar and M. S. Manikandan, "Automated ECG Noise Detection and Classification", IEEE Journal of Biomedical and Health Informatics PP(99), March 2017
7. "System for Unsupervised Healthcare Monitoring," IEEE Journal of Biomedical and Health Informatics, vol. 22, no. 3, pp. 722-732, May 2018.
8. B. Shickel, P. J. Tighe, A. Bihorac and P. Rashidi, "Deep EHR: A Survey of Recent Advances in Deep Learning Techniques for Electronic Health Record (EHR) Analysis," IEEE Journal of Biomedical and Health Informatics, vol. 22, no. 5, pp. 1589-1604, Sept. 2018.
9. A. Heuser, S. Picek, S. Guilley and N. Mentens, "Lightweight Ciphers and their Side-channel Resilience," IEEE Transactions on Computers, ~~DOI 10.1109/TC.~~2017~~.2757921~~.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		1			
2	1		2			
3			3	3	1	
4	1		3	3		1
5			2		1	

CU5005 **MULTIMEDIA COMMUNICATIONS**

L T P C
3 0 0 3

OBJECTIVES:

- To enable the student to understand the basic characteristics of multimedia components and the different methods for compressing audio, video, text and images.
- To expose the students to the challenges of IP based transport and the solution approaches considering the example case of VoIP technology.
- To enable the student to understand the different networking aspects with reference to multimedia transmission.

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UNIT I MULTIMEDIA COMPONENTS 9

Introduction – Multimedia skills – Multimedia components and their characteristics – Text, sound, images, graphics, animation, video, hardware.

UNIT II AUDIO AND VIDEO COMPRESSION 9

Audio compression–DPCM-Adaptive PCM –adaptive predictive coding-linear Predictive coding-code excited LPC-perpetual coding Video compression –principles-H.261-H.263-MPEG 1, 2, 4, Watermarking

UNIT III TEXT AND IMAGE COMPRESSION 9

Compression principles-source encoders and destination encoders-lossless and lossy compression-entropy encoding –source encoding –text compression –static Huffman coding dynamic coding –arithmetic coding –Lempel ziv-welsh Compression-image compression .

UNIT IV VoIP TECHNOLOGY 9

Basics of IP transport, VoIP challenges, H.323/ SIP –Network Architecture, Protocols, Call establishment and release, VoIP and SS7, Quality of Service- CODEC Methods-VOIP applicability.

UNIT V MULTIMEDIA NETWORKING 9

Multimedia networking –Applications-streamed stored and audio-making the best Effort service-protocols for real time interactive Applications-distributing multimedia-beyond best effort service-secluding and policing Mechanisms-integrated services-differentiated Services-RSVP, Encryption and Decryption,

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Able to demonstrate an understanding of the different multimedia components and their characteristics.

CO2: Familiar with the challenges involved in multimedia signal processing and the techniques used.

CO3: Able to demonstrate an understanding of the multimedia transmission technologies.

CO4: Able to demonstrate an understanding of the multimedia networking aspects.

CO5: In a position to apply his knowledge for identifying a suitable strategy for compression and communication based on the signal characterization and its needs.

REFERENCES:

1. Fred Halshall, “Multimedia communication – applications, networks, protocols and standards”, Pearson education, 2007.
2. Tay Vaughan, ―Multimedia: making it work‖, TMH, 7th Edition, 2007.
3. Kurose and W.Ross, “Computer Networking ―a Top down approach”, Pearson education, 3rd Edition, 2005.
4. Marcus goncalves, “Voice over IP Networks”, McGraw Hill,
5. K R. Rao,Z S Bojkovic, D A Milovanovic, “Multimedia Communication Systems: Techniques, Standards, and Networks”, Pearson Education, 2007.
6. R. Steimnetz, K. Nahrstedt, “Multimedia Computing, Communications and Applications‖, Pearson Education”, 1st Edition, 1995.
7. Ranjan Parekh, “Principles of Multimedia”, TMH, 2006.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1			2			
2	2		3	3		
3			2	1		
4			2	1		
5	2		2	3	1	

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CU5006 WIRELESS SENSOR NETWOKS AND WBAN L T P C
3 0 0 3

OBJECTIVES:

- To introduce the characteristic features of wireless sensor networks and their applications to the students.
- To expose the students to the sensor node essentials and the architectural details, the medium access and routing issues and the energy constrained operational scenario.
- To facilitate the students to understand the characteristics requirements of sensor network, the medium access and routing issues and protocols.
- To enable the students to understand the challenges in synchronization and localization of sensor nodes, and data management for effective and sustained communication.
- To introduce the students to understand the role of body area network, architectural framework, various network and medium access protocols, antennas designs, Ultra Wide Band for body area network.

UNIT I OVERVIEW OF WIRELESS SENSOR NETWORKS 9

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

UNIT II ARCHITECTURES 9

Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes, Operating Systems and Execution Environments, Network Architecture - Sensor Network Scenarios, Optimization Goals and Figures of Merit, Gateway Concepts. Physical Layer and Transceiver Design Considerations

UNIT III MAC AND ROUTING 9

MAC Protocols for Wireless Sensor Networks, IEEE 802.15.4, ZigBee, Low Duty Cycle Protocols and Wakeup Concepts - S-MAC, The Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols- Energy-Efficient Routing, Geographic Routing.

UNIT IV INFRASTRUCTURE ESTABLISHMENT AND DATA MANAGEMENT 9

Topology Control, Clustering, Time Synchronization, Localization and Positioning-Data management in WSN, Storage and indexing in sensor networks, Query processing in sensor, Data aggregation.

UNIT V WIRELESS BODY AREA NETWORK 9

Introduction to WBAN Standard-Architecture-WBAN layers- Network and MAC Protocol Design for WBAN-Energy Management in WBAN-Performance Analysis of WBAN- Miniaturized Antennas-Implanted Antennas- PHY layer for UWB WBAN.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Able to demonstrate an understanding of the different components of WSN and WBAN

CO2: Able to demonstrate an understanding of the different implementation challenges and the solution approaches

CO3: Able to design and implement protocols suitable to sensor communication scenario using design tools and characterize them

CO4: Able to appreciate the need for designing energy efficient sensor nodes and protocols for prolonging network lifetime.

CO5: Able to understand the practical design issues and find out different implementation tools for improving the overall performance of body area network.

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REFERENCES

1. Holger Karl & Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", JohnWiley, 2005.
2. Ian F. Akyildiz, Mehmet Can Vuran, “Wireless Sensor Networks” John Wiley, 2010
3. Yingshu Li, My T. Thai, Weili Wu, “Wireless Sensor Networks and Applications” Springer 2008.
4. Huan-Bang Li, KamyaYekehYazdandoost Bin-Zhen, “Wireless Body Area Networks”, River Publishers, 2010.
5. Kasun Maduranga Silva Thotahewa(Author), Jean-Michel Redoute(Author), Mehmet Rasit Yuce, “Ultra Wideband Wireless Body Area Networks”, Springer, 2016.

COS	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1			1	2		
2			2	2		
3	1		3	3	1	1
4	1		2	2		
5	1		2	3	1	1

CU5007 CRYPTOGRAPHY AND NETWORK SECURITY L T P C
3 0 0 3

OBJECTIVES:

- To make the student understand the importance and goals of communication network and information security and introduce them to the different types of attacks.
- To expose the student to the different approaches to handling security and the algorithms in use for maintaining data integrity and authenticity.
- To enable the student to appreciate the practical aspects of security features design and their implementation in wired and wireless internetworking domains.

UNIT I INTRODUCTION ON SECURITY 9

Security Goals, Cryptographic attacks, Security services and mechanisms Techniques: Cryptography and Steganography, Traditional Symmetric-Key Ciphers: Substitution Ciphers and Transposition Ciphers, Mathematics for Cryptography.

UNIT II SYMMETRIC & ASYMMETRIC KEY ALGORITHMS 9

Introduction to Block Ciphers and Stream Ciphers, Data Encryption Standards (DES), Advanced Encryption Standard (AES), RC4, Principle of asymmetric key algorithms, RSA Cryptosystem.

UNIT III INTEGRITY, AUTHENTICATION AND KEY MANAGEMENT 9

Message Integrity, Hash functions: **SHA 512, Whirlpool**, Digital signatures: Digital signature standards. Authentication: Entity Authentication: Biometrics, Key management Techniques.

UNIT IV NETWORK SECURITY, FIREWALLS AND WEB SECURITY 9

Introduction on Firewalls, Types of Firewalls, IP Security, E-mail security: PGP- S/MIME, Web security: SSL-TLS, SET.

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UNIT V WIRELESS NETWORK SECURITY 9

Security Attack issues specific to Wireless systems: Worm hole, Tunneling, DoS. Security for WLAN, Security for Broadband networks: Security challenges in 4G and 5G deployments, Introduction to side channel attacks and their counter measures.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Able to demonstrate an understanding of the ways in which communication network security may get compromised and the basic principles of security algorithm design.

CO2: Familiar with the different types of security attacks, approaches to handling security and the algorithms in use for maintaining data integrity and authenticity

CO3: Able to implement and analyse the different algorithms and compare their performances.

CO4: Able to appreciate the practical aspects of security features design and their implementation in wired and wireless internetworking domains

CO5: In a position to apply his knowledge for designing or modifying existing algorithms and implementing them atleast by simulation.

REFERENCES:

1. Behrouz A. Forouzan ,"Cryptography and Network security", McGraw- Hill, 2011
2. William Stallings, "Cryptography and Network security: principles and practice", Prentice Hall of India, New Delhi, 2nd Edition, 2002
3. Atul Kahate , "Cryptography and Network security", Tata McGraw-Hill, 2nd Edition, 2008.
4. R.K.Nichols and P.C. Lekkas , "Wireless Security: Models , threats and Solutions", McGraw- Hill, 2001.
5. H. Yang et al., "Security in Mobile Ad Hoc Networks: Challenges and Solution", IEEE Wireless Communications, Feb. 2004.
6. "Securing Ad Hoc Networks", IEEE Network Magazine, vol. 13, no. 6, pp. 24-30, December 1999.
7. "Security of Wireless Ad Hoc Networks," http://www.cs.umd.edu/~aram/wireless/survey.pdf
8. David Boel et.al, "Securing Wireless Sensor Networks – Security Architecture", Journal of networks , Vol.3. No. 1. pp. 65 -76, Jan 2008.
9. Perrig, A., Stankovic, J., Wagner, D., "Security in Wireless Sensor Networks", Communications of the ACM, 47(6), 53-57, 2004.
10. Introduction to side channel attacks – http://gauss.ececs.uc.edu/Courses/c653/lectures/SideC/intro.pdf.

COS	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		1			
2	1		2			
3	2		3	1		
4			2		1	
5	2		3	3		

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:

At the end of the course the student would be

CO1: Able to appreciate the motivation and the necessity for cognitive radio communication strategies.
CO2: Demonstrate understanding of the enabling technologies for its implementation
CO3: Demonstrate understanding of the essential functionalities and requirements in designing software defined radios and their usage for cognitive communication.
CO4: Able to evolve new techniques and demonstrate their feasibility using mathematical validations and simulation tools.
CO5: 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.

COS	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		1	1		
2			2			
3			2	3		1
4	1		2	2		
5	1		3	2		

CU5008 SATELLITE COMMUNICATIONS AND NAVIGATION SYSTEMS L T P C
3 0 0 3

OBJECTIVES:

- To enable the student to understand the necessity for satellite based communication, the essential elements involved and the transmission methodologies.
- To enable the student to understand the different interferences and attenuation mechanisms affecting the satellite link design.
- To expose the student to the advances in satellite based navigation, GPS and the different application scenarios.

UNIT I ELEMENTS OF SATELLITE COMMUNICATION 9

Satellite Systems, Orbital description and Orbital mechanics of LEO, MEO and GSO, Placement of a Satellite in a GSO, Antennas and earth coverage, Altitude and eclipses, Satellite drift and station keeping, Satellite – description of different Communication subsystems, Bandwidth allocation.

UNIT II SATELLITE SPACE SEGMENT AND ACCESS 9

Introduction; attitude and orbit control system; telemetry, tracking and command; power systems, communication subsystems, antenna subsystem, equipment reliability and space qualification, Multiple Access: Demand assigned FDMA - spade system - TDMA - satellite switched TDMA – CDMA.

UNIT III SATELLITE LINK DESIGN 9

Basic link analysis, Interference analysis, Rain induced attenuation and interference, Ionospheric characteristics, Link Design: System noise temperature and G/T ratio, Downlink and uplink design, C/N, Link Design with and without frequency reuse, link margins, Error control for digital satellite link.

UNIT IV SATELLITE BASED BROADBAND COMMUNICATION 9

VSAT Network for Voice and Data – TDM/TDMA, SCPC/DAMA, Elements of VSAT Network, Mobile and Personal Communication Services, Satellite based Internet Systems, Multimedia Broadband Satellite Systems, UAVs

UNIT V SATELLITE NAVIGATION AND GLOBAL POSITIONING SYSTEM 9

Radio and Satellite Navigation, GPS Position Location Principles of GPS Receivers and Codes, Satellite Signal Acquisition, GPS Receiver Operation and Differential GPS, INS, Indian Remote Sensing and ISRO GPS Systems

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Able to demonstrate an understanding of the basic principles of satellite based communication the essential elements involved and the transmission methodologies.

CO2: Familiar with satellite orbits, placement and control, satellite link design and the communication system components.

CO3: Able to demonstrate an understanding of the different interferences and attenuation mechanisms affecting the satellite link design.

CO4: The student would be able to demonstrate an understanding of the different communication, sensing and navigational applications of satellite.

CO5: Familiar with the implementation aspects of existing satellite based systems.

REFERENCES:

1. Wilbur L. Pritchard, Hendri G. Suyderhoud and Robert A. Nelson, “Satellite Communication Systems Engineering”, Prentice Hall/ Pearson, 2007.
2. Timothy Pratt and Charles W.Bostain, “Satellite Communications”, John Wiley and Sons, 2nd Edition, 2012.
3. D.Roddy, “Satellite Communication”, McGraw Hill, 4th Edition (Reprint), 2009.
4. Tri T Ha, “Digital Satellite Communication”, McGraw Hill, 2nd Edition,1990.
5. B.N.Agarwal, “Design of Geosynchronous Spacecraft”, Prentice Hall, 1993.
6. Brian Ackroyd, “World Satellite Communication and Earth Station Design”, BSP Professional Books, 1990.

COS	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1			1			
2	1		3	2		
3	1		2	2		
4			2			
5			2	2	1	1

AP5077 SIGNAL INTEGRITY FOR HIGH SPEED DESIGN L T P C
3 0 0 3

OBJECTIVES:

- To identify sources affecting the speed of digital circuits.
- To introduce methods to improve the signal transmission characteristics

UNIT I SIGNAL PROPAGATION ON TRANSMISSION LINES 9

Transmission line equations, wave solution, wave *vs*. circuits, initial wave, delay time, Characteristic impedance , wave propagation, reflection, and bounce diagrams Reactive terminations – L, C , static field maps of micro strip and strip line cross-sections, per unit length parameters, PCB layer stackups and layer/Cu thicknesses, cross-sectional analysis tools, Zo and Td equations for microstrip and stripline Reflection and terminations for logic gates, fan-out, logic switching , input impedance into a transmission-line section, reflection coefficient, skin-effect, dispersion.

UNIT II MULTI-CONDUCTOR TRANSMISSION LINES AND CROSS-TALK 9

Multi-conductor transmission-lines, coupling physics, per unit length parameters ,Near and far-end cross-talk, minimizing cross-talk (stripline and microstrip) Differential signalling, termination, balanced circuits ,S-parameters, Lossy and Lossless models.

UNIT III NON-IDEAL EFFECTS 9

Non-ideal signal return paths – gaps, BGA fields, via transitions , Parasitic inductance and capacitance , Transmission line losses – Rs, tanδ , routing parasitic, Common-mode current, differential-mode current , Connectors.

UNIT IV POWER CONSIDERATIONS AND SYSTEM DESIGN 9

SSN/SSO , DC power bus design , layer stack up, SMT decoupling ,, Logic families, power consumption, and system power delivery , Logic families and speed Package types and parasitic ,SPICE, IBIS models ,Bit streams, PRBS and filtering functions of link-path components , Eye diagrams , jitter , inter-symbol interference Bit-error rate ,Timing analysis.

UNIT V CLOCK DISTRIBUTION AND CLOCK OSCILLATORS 9

Timing margin, Clock slew, low impedance drivers, terminations, Delay Adjustments, canceling parasitic capacitance, Clock jitter.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Familiar with transmission line characterization due to high speed signal propagation
CO2: Able to understand the impairments, crosstalk and non-ideal effects associated with high speed design
CO3: Able to identify sources affecting the speed of digital circuits and their analysis.
CO4: Able to appreciate power and clock related challenges in high speed system design
CO5: Able to identify methods to improve the signal transmission characteristics

REFERENCES

1. H. W. Johnson and M. Graham, “High-Speed Digital Design: A Handbook of Black Magic”, Prentice Hall, 1993.
2. Douglas Brooks, “Signal Integrity Issues and Printed Circuit Board Design”, Prentice Hall PTR , 2003.
3. S. Hall, G. Hall, and J. McCall, “High-Speed Digital System Design: A Handbook of Interconnect Theory and Design Practices”, Wiley-Interscience, 2000.
4. 4. Eric Bogatin , “Signal Integrity – Simplified”, Prentice Hall PTR, 2003.

TOOLS REQUIRED

1. SPICE, source - http://www-cad.eecs.berkeley.edu/Software/software.html
2. HSPICE from synopsis, www.synopsys.com/products/ mixedsignal/hspice/hspice.html
3. SPECCTRAQUEST from Cadence, http://www.specctraquest.com

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

CU5009 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY IN SYSTEM DESIGN **L T P C 3 0 0 3**

OBJECTIVES:

- To understand the concepts related to Electromagnetic interference in PCBs
- To provide solutions for minimizing EMI in PCBs
- To learn EMI standards in the design of PCBs
- To learn various EMI coupling principles, EMI standards and measurements
- To provide knowledge on EMI control techniques and design procedures to make EMI compatible PCBs

UNIT I EMI/EMC CONCEPTS **9**

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**

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**

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

UNIT IV EMC DESIGN OF PCBS **9**

Component selection and mounting; PCB trace impedance; Routing; Cross talk control; Power distribution decoupling; Zoning; Grounding; VIAs connection; Terminations.

UNIT V EMI MEASUREMENTS AND STANDARDS **9**

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

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TOTAL: 45 PERIODS

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COURSE OUTCOMES:

At the end of the course the student would be

CO1: Familiar with the concepts related to Electromagnetic interference and Compatibility issues in PCBs

CO2: Familiar with the principles of EMI coupling and control techniques

CO3: Able to analyze Electromagnetic interference effects in the design of PCBs

CO4: Able to propose solutions for minimizing EMI in PCBs

CO5: Able to analyze Electromagnetic environment and carryout measurements as per standards

REFERENCES:

1. V.P.Kodali, "Engineering EMC Principles, Measurements and Technologies", IEEE Press, Newyork, 1996.
2. Henry W.Ott., "Noise Reduction Techniques in Electronic Systems", A Wiley Inter Science Publications, John Wiley and Sons, Newyork, 1988.
3. Bemhard Keiser, "Principles of Electromagnetic Compatibility", Artech house, Norwood, 3rd Edition, 1986.
4. C.R.Paul, "Introduction to Electromagnetic Compatibility", John Wiley and Sons, Inc, 1992.
5. Don R.J.White, "Consultant Incorporate, —Handbook of EMI/EMC", Vol I-V, 1988.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		2		1	
2			2	2		
3			3	3		
4	1		2	2		
5			2	1		1

CU5010 MICRO-ELECTRO-MECHANICAL SYSTEMS L T P C
3 0 0 3

OBJECTIVES:

- To enable the student to understand the basic principles of sensors and actuators, materials and fabrication aspects of MEMS and Microsystems.
- To make the student familiar with the mechanical and the electrostatic design and the associated system issues.
- To introduce the student to the different MEMS applications , the design basics, the design tools and the performance issues.

UNIT I INTRODUCTION TO MEMS 9

MEMS and Microsystems, Miniaturization, Typical products, Micro sensors, Micro actuation, MEMS with micro actuators, Microaccelorometers and Micro fluidics, MEMS materials, Micro fabrication

UNIT II MECHANICS FOR MEMS DESIGN 9

Elasticity, Stress, strain and material properties, Bending of thin plates, Spring configurations, torsional deflection, Mechanical vibration, Resonance, Thermo mechanics – actuators, force and response time, Fracture and thin film mechanics.

UNIT III ELECTRO STATIC DESIGN AND SYSTEM ISSUES 9

Electrostatics: basic theory, electro static instability. Surface tension, gap and finger pull up, Electro static actuators, Comb generators, gap closers, rotary motors, inch worms, Electromagnetic actuators. bistable actuators. Electronic Interfaces, Feed back systems, Noise , Circuit and system issues,

UNIT IV MEMS APPLICATION 9

Case studies – Capacitive accelerometer, Peizo electric pressure sensor, Microfluidics application, Modeling of MEMS systems, CAD for MEMS.

UNIT V INTRODUCTION TO OPTICAL AND RF MEMS 9

Optical MEMS, - System design basics – Gaussian optics, matrix operations, resolution. Case studies, MEMS scanners and retinal scanning display, Digital Micro mirror devices. RF Memes – design basics, case study – Capacitive RF MEMS switch, performance issues.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Able to demonstrate an understanding of the different aspects of microsystem design.
CO2: Familiar with Mechanical and the Electrostatic design aspects
CO3: Familiar with the different applications and their design basics
CO4: In a position to identify a suitable MEMS structure, material and fabrication procedure based on the application and functionality.
CO5:Capable of applying his knowledge and design tools and will be well practiced in design skills.

REFERENCES:

1. Stephen Santeria, “Microsystems Design”, Kluwer publishers, 2000.
2. N.P.Mahalik, “MEMS”,Tata McGraw hill, 2007.
3. Nadim Maluf, “An introduction to Micro electro mechanical system design”, Artech House, 2000.
4. Mohamed Gad-el-Hak, “The MEMS Handbook”, CRC press Baco Raton,2000.
5. Tai Ran Hsu, “MEMS & Micro systems Design and Manufacture”, Tata McGraw Hill, New Delhi, 2002.
6. Chang Liu,‖Foundations of MEMS‖, Pearson education, 2nd Edition, 2012.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		2			
2			2	2		
3			2	2		
4			2	3		
5			3	2		

CU5011 HIGH SPEED SWITCHING AND NETWORKING L T P C
3 0 0 3

OBJECTIVES:

- To enable the student to understand the basics of switching technologies and their implementation LANs, ATM networks and IP networks.
- To enable the student to understand the different switching architectures and queuing strategies and their impact on the blocking performances.
- To expose the student to the advances in packet switching architectures and IP addressing and switching solutions and approaches to exploit and integrate the best features of different architectures for high speed switching.

UNIT I LAN SWITCHING TECHNOLOGY 9

Switching Concepts, LAN Switching, switch forwarding techniques - cut through and store and forward, Layer 3 switching, Loop Resolution, Switch Flow control, virtual LANs.

UNIT II QUEUES IN HIGH SPEED SWITCHES 9

Internal Queueing -Input, output and shared queueing, multiple queueing networks – combined Input, output and shared queueing - performance analysis of Queued switches.

UNIT III PACKET SWITCHING ARCHITECTURES 9

Architectures of Internet Switches and Routers- Bufferless and buffered Crossbar switches, Multi-stage switching, Optical Packet switching; Switching fabric on a chip; Internally buffered Crossbars

UNIT IV. OPTICAL SWITCHING ARCHITECTURES 9

Need for Multilayered Architecture-, Layers and Sub-layers, Spectrum partitioning, Optical Network Nodes, Network Access Stations, Overlay Processor, Logical network overlays, Connection Management and Control

UNIT V IP SWITCHING 9

Addressing model, IP Switching types - flow driven and topology driven solutions, IP Over ATM address and next hop resolution, multicasting, Ipv6 over ATM.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Familiar with the basics of switching technologies and their implementation in LANs, ATM , IP and Optical networks.

CO2: Familiar with the different switching architectures and queuing strategies

CO3:Able to analyze switching networks based on their blocking performances and implementation complexities.

CO4: Able to identify suitable switch architectures for a specified networking scenario.

CO5: In a position to apply his knowledge of switching technologies, architectures and buffering strategies for designing high speed communication networks and analyse their performance.

REFERENCES

1. Achille Pattavina, “Switching Theory: Architectures and performance in Broadband ATM networks ",John Wiley & Sons Ltd, New York. 1998
2. Thomas E. Stern, Georgios Ellinas, Krishna Bala, “Multiwavelength Optical Networks – Architecture, Design and control” , Cambridge University Press, 2nd Edition, 2009.
3. Rich Siefert, Jim Edwards, “The All New Switch Book – The Complete Guide to LAN Switching Technology”, Wiley Publishing, Inc., 2nd Edition, 2008.
4. Elhanany M. Hamdi, “High Performance Packet Switching architectures”, Springer Publications, 2007.
5. Christopher Y Metz, “Switching protocols & Architectures”, McGraw - Hill Professional Publishing, New York, 1998.
6. Rainer Handel, Manfred N Huber, Stefan Schroder, “ATM Networks - Concepts Protocols, Applications”, Addison Wesley, New York, 3rd Edition, 1999.

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COS	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		2	2		
2			2	2		
3	1		2	2		
4			2	2		
5	1		3	3		

CU5012 COMMUNICATION NETWORK DESIGN L T P C
3 0 0 3

OBJECTIVES:

- To expose the student to the functional elements and evolution of networking, the multiplexing, switching and routing related issues and some case studies of wired and wireless network design process.
- To enable the student to analyse the various aspects of a protocol and implement it using a network simulation tool.

UNIT I INTRODUCTION 9

Importance of Quantitative Modeling in Engineering of Telecommunication Networks, The Functional Elements of Networking, Evolution of Networking in the Wired and Wireless Domain.

UNIT II MULTIPLEXING 9

Performance Measures and Engineering Issues Network performance and source characterization, Circuit multiplexed Networks, packet Multiplexing over wireless networks, Events and processes in packet multiplexer models, Deterministic traffic Models and network calculus, stochastic traffic models, LRD traffic, Link Scheduling and network capacity in wireless networks.

UNIT III SWITCHING 9

Performance Measures of packet switches and circuit switches, queuing in packet switches, delay Analysis in Output Queued Switch, Input Queued Switch and CIOQ Switch with Parallelism, Blocking in Switching Networks, Closed Networks.

UNIT IV ROUTING 9

Algorithms for Shortest Path Routing - Dijkstra‘s Algorithm, Bellman Ford Algorithm, Generalized Dijkstra‘s Algorithm, Optimal Routing, Routing Protocols-Distance Vector, Link State and Exterior gateway protocols, Formulations of the Routing Problem-minimum interference Routing, MPLS, QoS Routing, Nonadditive and Additive metrics

UNIT V CASE STUDIES 9

Design of a wireless network and a wired network, prototype implementation to be simulated in a network simulator.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Familiar with the functional elements and evolution of communication networking

CO2: Familiar with the multiplexing, switching and routing related issues, solutions and performance metrics

CO3: Able to understand the wired and wireless network design process.

CO4: Analyse the various aspects of a protocol and implement it using a network simulation tool.

CO5: Able to breakup the communication network design problem into a number of sub-problems, identify suitable protocol solutions, implement using any simulator tool and carry out performance characterization.

REFERENCES:

1. Anurag Kumar, D. Manjunath and Joy, "Communication Networking", Morgan Kaufan Publishers, 2005.
2. A.Lean Garica and Indra Widjaja, "Communications Networks", Tata Mc Graw Hill,2004.
3. Thomas G.Robertazzi, "Computer Networks and Systems", Springer, 3rd Edition, 2006.
4. Keshav.S., "An Engineering Approach to Computer Networking", Addison – Wesley, 1999.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1			2			
2			2	2		
3			2	2		
4			2	2		
5	1		3	3		

CU5013 CONVEX OPTIMIZATION L T P C

3 0 0 3

OBJECTIVES:

- To enable the student to understand the various aspects of optimization and its application in communication systems.
- To expose the student to the different convex optimization techniques, their pros and cons and enable him to understand and interpret results using case studies.

UNIT I INTRODUCTION TO OPTIMIZATION 8

Introduction to properties of Vectors, Norms, Positive Semi-Definite matrices, Gaussian Random Vectors. Extrema of functions – local and global. Optimization problem – categories, objective function, constraints, feasible region. Introduction to Convex Optimization – Convex sets, Hyperplanes/ Half-spaces, Convex/ Concave Functions,

UNIT II CONVEX PROGRAMMING 8

Uniform random, Geometric programming (GP). Linear programming (LP). Quadradic programming (QP) Quadratically constraint QP (QCQP). Second order cone programming (SOCP). Semidefinite programming (SDP).

UNIT III DUALITY 9

Fundamental concepts, Lagrange dual function and conjugate function. Lagrange dual problem. Strong duality. Karush-Kuhn-Trcker (KKT) conditions. Lagrange dual optimization. Duality of problems with generalized inequalities.

UNIT IV MULTI ANTENNA TECHNIQUIES 10

Water-filling power allocation, Optimization for MIMO Systems, OFDM Systems and MIMO-OFDM systems. Optimization in beam former design - Robust receive beam forming, Transmit downlink beam forming. Application: Radar for target detection, Array Processing, MUSIC, MIMO-Radar Schemes for Enhanced Target Detection

UNIT V COOPERATIVE COMMUNICATIONS 10

Optimal Power Allocation for cooperative Communication. Cooperative communications in OFDM and MIMO cellular relay- System model - Radio resource allocation (RRA) in OFDMA relay systems, Dynamic RRA in OFDMA, RRA in MIMO multi-hop networks. Power allocation in Multi-cell cooperative OFDM systems. Radio resource optimization in cooperative cellular wireless networks - Network with single source-destination pair, multiuser cooperation, Relay selection.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Familiar with the basic mathematics associated with Optimization

CO2: Able to understand the Convex programming approaches and the application of duality conditions

CO3: Familiar with the application methodology for real time communication applications

CO4: Able to mathematically model optimization problems and propose solution approaches

CO5: In a position to apply his knowledge of the different convex optimization techniques to solve different problems in communication system.

REFERENCES

1. Chia-Hsiang Lin, Chong-Yung Chi, and Wei-Chiang Li (Eds.), “Convex Optimization for Signal Processing and Communications: From Fundamentals to Applications”, CRC press, 2017.
2. Hossain, E., Kim, D., & Bhargava, V. (Eds.). (2011). Cooperative Cellular Wireless Networks. Cambridge: Cambridge University Press.
3. https://nptel.ac.in/courses/108104112/
4. Stephen Boyd and Lieven Vandenberghe, Convex Optimization, Cambridge University Press. [Online]. http://www.stanford.edu/~boyd/cvxbook/

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		2			
2			3	1		
3			3			
4			2	2		
5			2	2		

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CU5014 **DETECTION AND ESTIMATION** **L T P C**
3 0 0 3

OBJECTIVES:
The students should be made to:
- Understand basics of detection and estimation theory.
- Design and analyze optimum detection schemes.
- Study different estimation schemes such as ML and MMSE estimators.
- Understand the basics of linear filtering.
- Apply the estimation and detection principles in real time scenario.

UNIT I STATISTICAL DECISION THEORY 9
Review of Gaussian variables and processes; problem formulation and objective of signal detection and signal parameter estimation in discrete-time domain, Hypothesis testing- Bayes' detection, Maximum A Posteriori detection, Maximum likelihood criterion, Minimum probability of error criterion, Min-Max criterion, Neyman-pearson criterion- Multiple hypotheses. Composite hypothesis. Non-parametric detection. Wilcoxon detector, sequential detection.

UNIT II DETECTION OF DETERMINISTIC AND RANDOM SIGNALS 9
M-ary detection- correlation receiver and matched filter receiver. General binary detection with unwanted parameters. Binary detection in colored noise- karhunen-lowve expansion approach, whitening approach and detection performance. Detection and estimation in white gaussian noise. Detection and estimation in non-white gaussian noise.

UNIT III ESTIMATION OF SIGNAL PARAMETERS 9
Bayesian linear model. Bayesian estimation for deterministic parameters. General Bayesian estimators- Minimum variance unbiased estimation, minimum mean square error estimators, maximum a posteriori estimations. Cramer-Rao bound , Linear Bayesian estimations. Best linear unbiased estimations.

UNIT IV SIGNAL ESTIMATION IN DISCRETE-TIME 9
Linear transformation and orthogonality principle. Wiener filters. Discrete wiener filters. Kalman filters- dynamical signal models, Kalman-Bucy filtering, Wiener-Kolmogorov filtering.

UNIT V RECENT TECHNIQUES FOR DETECTION AND ESTIMATION PROBLEMS 9
Applications to detection, parameter estimation and classification- the periodogram and the spectrogram, correlation, Wigner-Ville distribution, spectral correlation and ambiguity function. Cyclo-stationary processing. Higher order moments and poly spectra. Coherence processing.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
On successful completion of this course, the students will be able to
CO1: Understand the qualitative problems of detection and estimation in the framework of statistical inference.
CO2: Understand different hypotheses in detection and estimation problems
CO3: Write down hypothesis tests and estimation schemes for typical problems of interest.
CO4: Gain an understanding of detection and estimation of signals in white and non-white Gaussian noise
CO5: Understand the detection of random signals

REFERENCES:

1. MouradBarkat, "Signal detection and estimation", artech house, Inc. , 2nd Edition, 2005.
2. Ralph D. Hippenstiel, "Detection theory applications and digital signal processing", CRC press, 2002
3. Steven M. Kay, "Fundamentals of statistical signal processing: Estimation theory", Prentice-Hall PTR, 1993.

4. H.Vincent Poor, “An introduction to signal detection and estimation”, Springer-Verlag, 2nd Edition,1994.
5. Harry L. Van trees, “Detection, estimation and modulation theory:Part 1”, John wiley& sons, Inc., 2001.

COS	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		2			
2			2			
3	1		1	1		
4	1		3			
5	1		3	2		

CU5015 SPEECH PROCESSING L T P C
3 0 0 3

OBJECTIVES:

- To introduce speech production mechanism and associated time and frequency parameters
- To introduce the computation of short time Fourier transform and linear prediction based parametric estimation
- To understand various speech features relevant for building speech based systems
- To understand statistical modeling approaches such as Gaussian Mixture model, hidden Markov models and their implementation issues.

UNIT I BASIC CONCEPTS 10

Speech Fundamentals: Articulatory Phonetics – Production and Classification of Speech Sounds; Acoustic Phonetics – Acoustics of speech production; discrete time model of speech, Short-Time Fourier Transform. Basics of Linear prediction, autocorrelation method, Levinson Durbin algorithm. Pitch estimation using linear prediction analysis.

UNIT II FEATURE EXTRACTION 10

Fundamentals of pattern recognition and significance of feature selection. Homomorphic filtering - Cepstrum. Feature Extraction - MFCC, LPCC and PLP. Speech distortion measures– mathematical and perceptual – Log–Spectral Distance, Cepstral Distances, Weighted Cepstral Distances Likelihood Distortions. Time alignment and normalization - dynamic time warping, multiple time alignment paths.

UNIT III SPEECH MODELING 8

Statistical modeling of speech - Gaussian mixture modeling, Hidden Markov models - Markov processes, HMMs - Probability Evaluation, optimal state sequence - Viterbi search, Baum-Welch parameter re-estimation

UNIT IV RECOGNITION ENGINES 9

Large Vocabulary Continuous Speech Recognition: Architecture of a large vocabulary continuous speech recognition system – acoustics and language models – n-gram statistics, context dependent sub-word units. Speaker recognition - speaker identification and verification - acoustic models; Applications and current status

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UNIT V SPEECH SYNTHESIS 8

Text-to-Speech Synthesis: Concatenative and waveform synthesis methods, hidden Markov model-based TTS, context dependent sub-word units for TTS, intelligibility and naturalness – role of prosody, Applications and current status.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Model speech production system and describe the fundamentals of speech.
CO2: Extract and compare different speech features
CO3: Choose an appropriate statistical speech model for a given application.
CO4: Design and implement a speech and speaker recognition system.
CO5: Build speech synthesis systems

REFERENCES:

1. Lawrence Rabiner and Biing-Hwang Juang, “Fundamentals of Speech Recognition”, Pearson Education, 2003.
2. Thomas F Quatieri, “Discrete-Time Speech Signal Processing – Principles and Practice”, Pearson 2012
3. John Makhoul, “Linear prediction: a tutorial review” –Proceedings of the IEEE, Vol. 63, No. 4, Apr. 1975, pp. 561 – 580
4. L. R. Rabiner and Schaffer, “Digital Processing of Speech signals Pearson Education”, 2004.
5. Ben Gold and Nelson Morgan, “Speech and Audio Signal Processing, Processing and Perception of Speech and Music”, Wiley- India Edition, 2006.
6. Heiga Zen, Keiichi Tokuda, Alan W. Black, "Statistical Parametric Speech Synthesis", Speech Communication, Vol. 51, Issue 11, Nov. 2009, pp. 1039 - 1064.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		2			
2	1		3			
3	1		1			
4	1		2	1		
5	1		3	2		

CU5016 COOPERATIVE COMMUNICATIONS L T P C
3 0 0 3

OBJECTIVES:

- To enable the student to appreciate the necessity of co-operative wireless communication.
- To expose the student would to new techniques and understand their feasibility.

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 multicell 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:

At the end of the course the student would be

CO1: Able to appreciate the necessity and the design aspects of cooperative and green wireless communication.

CO2: Familiar with different techniques used in cooperative cellular networks

CO3: Familiar with different techniques used in green radio networks

CO4: Able to evolve new techniques and demonstrate their feasibility using mathematical validations and simulation tools.

CO5: 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. Mazin Al Noor, “Green Radio Communication Networks Applying Radio-Over-Fibre Technology for Wireless Access”, GRIN Verlag, 2012.
5. Mohammad S. Obaidat, Alagan Anpalagan and Isaac Woungang, “Handbook of Green Information and Communication Systems”, Academic Press, 2012.
6. Ramjee Prasad and Shingo Ohmori, Dina Simunic, “Towards Green ICT”, River Publishers, 2010.
7. Jinsong Wu, Sundeep Rangan and Honggang Zhang, “Green Communications: Theoretical Fundamentals, Algorithms and Applications”, CRC Press, 2012.

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		2	1		
2			2	1		
3			2			
4	1		2	2		
5	1		3	1	1	1

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 Map Reduce
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

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

	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

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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

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

	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

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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.

UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9

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

TOTAL: 45 PERIODS

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	✓	✓	✓		✓	✓	✓				✓	✓

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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

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.

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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

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	✓	✓	✓		✓							✓

EFERENCES:

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

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										✓		✓

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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.

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

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

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	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

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.

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	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

OUTCOMES

Students will be able to

- Knowledge of self-development.
- Learn the importance of Human values.
- 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

OUTCOMES

Students will be able to:

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- of social reforms leading to revolution in India.
- 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.
- 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

OUTCOMES

Students will be able to understand:

- What pedagogical practices are being used by teachers informal and informal classrooms in developing countries?
- What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

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SUGGESTED READING

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

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

OUTCOMES

Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- 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

OUTCOMES

Students will be able to

- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and mankind to peace and prosperity
- 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.