RAJALAKSHMI ENGINEERING COLLEGE

(An Autonomous Institution Affiliated to Anna University, Chennai)

DEPARTMENT OF ELECTRONCS AND COMMUNICATION ENGINEERING

CURRICULUM AND SYLLABUS – REGULATIONS - 2019

M.E (COMMUNICATION SYSTEMS)

VISION

To produce globally competent Electronics and Communication Engineers with a commitment to serve the society.

MISSION

M1 To impart training with the best of teaching expertise supported by excellent laboratory infrastructure and exposure to recent trends in the industry.

M2 To ensure that the students are molded into competent Electronics and Communication engineers with the knowledge of computer applications and worthy citizens of the country.

PROGRAM OUTCOMES (POs)

Engineering Graduates will have:

PO1: Ability to apply the knowledge of science, mathematics, and engineering principles for developing problem solving attitude in the field of communication.

PO2: Ability to identify, formulate, solve engineering problems and to explore recent developments in the areas like RF& Microwave, Signal Processing, Modern communication systems and Networks.

PO3: Ability to understand and use of different recent hardware and software tools for Analysis and verification in the domain of communication and networking.

PO4: Ability to design and conduct experiments, analyze and interpret data, imbibe programming skills for development of simulation experiments.

PO5: Ability to impart knowledge to enthusiastic young minds for developing products for scientific and business applications with state of art technologies.

PO6: Ability to function as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.

CURRICULUM

SEMESTER I

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	MH19105	Applied Mathematics for Communication Engineers	FC	4	3	1	0	4
2	CU19101	Advanced Radiation Systems	PC	4	3	1	0	4
3	CU19102	Optical Networks	PC	3	3	0	0	3
4	CU19103	Advanced Digital Communication Techniques	PC	3	3	0	0	3
5	CU19141	Advanced Digital Signal Processing	PC	5	3	0	2	4
6	PG19101	Research Methodology and IPR	MC	3	3	0	0	3
7	AC19101	English for Research paper writing (Audit Course)	HS	3	3	0	0	0
PRACTICALS								
8	CU19111	Communication Systems Laboratory	PC	4	0	0	4	2
			TOTAL	**29**	**21**	**2**	**6**	**23**

SEMESTER II

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	CU19201	Wireless Communication Networks	PC	3	3	0	0	3
2	CU19202	MIC and RF System Design	PC	4	3	1	0	4
3	CU19203	Communication System Modeling and Simulation	PC	3	3	0	0	3
4		Professional Elective- I	PE	3	3	0	0	3
5		Professional Elective- II	PE	3	3	0	0	3
6		Professional Elective- III	PE	3	3	0	0	3
7	AC19201	Constitution of India (Audit Course)	MC	3	3	0	0	0
PRACTICALS								
8	CU19211	RF System Design Laboratory	PC	4	0	0	4	2
			TOTAL	**26**	**20**	**1**	**4**	**21**

SEMESTER III								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY								
1	CU19301	Wireless Ad Hoc and Sensor Networks	PC	3	3	0	0	3
2		Professional Elective -IV	PE	3	3	0	0	3
3		Open Elective	OE	3	3	0	0	3
PRACTICALS								
4	CU19311	Project Work (Phase I)	EEC	12	0	0	12	6
		TOTAL		**21**	**9**	**0**	**12**	**15**
SEMESTER IV								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY								
1	CU19411	Project Work (Phase II)	EEC	24	0	0	24	12
		TOTAL		**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS: 71

LIST OF PROFESSIONAL ELECTIVES

PROFESSIONAL ELECTIVE- I

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	CU19P11	Advanced Satellite Communication	PE	3	3	0	0	3
2	CU19P12	Real Time Embedded Systems	PE	3	3	0	0	3
3	CU19P13	MEMS and NEMS	PE	3	3	0	0	3
4	CU19P14	Multimedia Compression Techniques	PE	3	3	0	0	3
5	CU19P15	High Performance Networks	PE	3	3	0	0	3

PROFESSIONAL ELECTIVE-II

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	CU19P21	RF MEMS	PE	3	3	0	0	3
2	CU19P22	Digital Communication Receivers	PE	3	3	0	0	3
3	CU19P23	Cognitive Radio	PE	3	3	0	0	3
4	CU19P24	VLSI for Wireless Communication	PE	3	3	0	0	3
5	CU19P25	Digital Communication over Fading Channels	PE	3	3	0	0	3

PROFESSIONAL ELECTIVE-III

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	CU19P31	Speech and Audio Signal Processing	PE	3	3	0	0	3
2	CU19P32	Digital Image and Video processing	PE	3	3	0	0	3
3	CU19P33	Radar Signal Processing	PE	3	3	0	0	3
4	CU19P34	Electromagnetic Interference and Compatibility	PE	3	3	0	0	3
5	CU19P35	Soft Computing	PE	3	3	0	0	3

PROFESSIONAL ELECTIVE-IV

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	CU19P41	Detection and Estimation Theory	PE	3	3	0	0	3
2	CU19P42	Internetworking Multimedia	PE	3	3	0	0	3
3	CU19P43	Millimeter Wave Communication	PE	3	3	0	0	3
4	CU19P44	Communication Network Security	PE	3	3	0	0	3
5	CU19P45	Internet of Things	PE	3	3	0	0	3

AUDIT COURSES -I & II

SEMESTER I							
S.No	**COURSE CODE**	**COURSE TITLE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY							
1	AC19101	English for Research Paper Writing	3	3	0	0	0
SEMESTER II							
S.No	**COURSE CODE**	**COURSE TITLE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
1	AC19201	Constitution of India	3	3	0	0	0

OPEN ELECTIVES

S.No	COURSE CODE	COURSE TITLE	CONTACT PERIODS	L	T	P	C
THEORY							
1	CP19O31	Business Analytics	3	2	1	0	3
2	ED19O31	Industrial Safety	3	3	0	0	3
3	ED19O32	Operations Research	3	2	1	0	3
4	PG19O31	Cost Management of Engineering Projects	3	2	1	0	3
5	ED19O33	Composite Materials	3	3	0	0	3
6	PG19O33	Waste to Energy	3	2	1	0	3

SEMESTER WISE CREDIT DISTRIBUTION

CATEGORY	I	II	III	IV	Total
FC	4				4
PC	16	12	3		31
PE		9	3		12
EEC			6	12	18
MC	3				3
OE			3		3
Total	**23**	**21**	**15**	**12**	**71**

SYLLABUS

SEMESTER I

Subject Code	Subject Name	Category	L	T	P	C
MH19105	APPLIED MATHEMATICS FOR COMMUNICATION ENGINEERS	FC	3	1	0	4

Objectives:	
●	To develop the ability to use the concepts of Linear algebra for solving problems related to Networks.
●	To formulate and construct a mathematical model for a linear programming problem in real life situation;
●	To expose the students to solve ordinary differential equations by various techniques.

UNIT-I	**LINEAR ALGEBRA**	**12**
Vector spaces – norms – Inner Products – Eigen values using QR transformations – QR factorization - generalized eigenvectors – Canonical forms – singular value decomposition and applications - pseudo inverse – least square approximations --Toeplitz matrices and some applications.		
UNIT-II	**LINEAR PROGRAMMING**	**12**
Formulation – Graphical solution – Simplex method – Two phase method - Transportation and Assignment Models		
UNIT-III	**ORDINARY DIFFERENTIAL EQUATIONS**	**12**
RungeKutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.		
UNIT-IV	**TWO DIMENSIONAL RANDOM VARIABLES**	**12**
Joint distributions – Marginal and Conditional distributions – Functions of two dimensional random variables – Regression Curve – Correlation**.**		
UNIT-V	**QUEUEING MODELS**	**12**
Poisson Process – Markovian queues – Single and Multi-server Models – Little's formula - Machine Interference Model – Steady State analysis – Self Service queue.		
	Total Contact Hours : 60	

Course Outcomes: On completion of the course, students will be able to	
●	Analyze and solve system of equations using the techniques of matrix decomposition and least square sense
●	Make decisions using the principles of optimality on the problems of dimensionality.
●	Solve differential equation using various numerical techniques.
●	Apply the concept of correlation and regression in real life situation.
●	Analyze and solve those problems that arise in the field of network theory through Queueing models.

Reference Books(s) / Web links:	
1	Veerarajan T, Probability, statistics and random process with queueing theory and queueing networks, 4th edition, McGraw - Hill Publishing Company Limited.
2	Richard Bronson, "Matrix Operation", Schaum's outline series, 2nd Edition, McGraw Hill, 2011.
3	Taha H.A., "Operations Research: An introduction", Pearson Education Asia, New Delhi, Ninth Edition, 2012.
4	Richard Bronson, Gabriel B.Costa, "Linear Algebra", Academic Press, Second Edition, 2007.
5	Richard Johnson, Miller & Freund, "Probability and Statistics for Engineers", 7th Edition, Prentice – Hall of India, Private Ltd., New Delhi (2007).

6	Donald Gross and Carl M. Harris, "Fundamentals of Queueing Theory", 2nd Edition, John Wiley and Sons, New York.
7	Moon, T.K., Sterling, W.C., Mathematical methods and algorithms for signal processing, Pearson Education,2000

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	-	-	1	1
CO2	2	1	-	-	1	1
CO3	1	1	-	-	1	2
CO4	1	1	-	-	1	1
CO5	1	1	-	-	1	1
Average	1.4	1	-	-	1	1.2

Subject Code	Subject Name	Category	L	T	P	C
CU19101	**ADVANCED RADIATION SYSTEMS**	**PC**	**3**	**1**	**0**	**4**

Objectives:	
●	To understand the fundamental parameters of various antennas
●	To be able to learn the various apertures and design considerations of modern antennas
●	To explore MEMS technology in the field of antenna arrays
●	To impart knowledge on the antenna measurements and instrumentations

UNIT-I	**RADIATION FROM APERTURES**	**12**
Review of antenna fundamental parameters, Field equivalence principle, Radiation from Rectangular and Circular apertures, Uniform aperture distribution on an infinite ground plane; Slot antenna; Horn antenna; Reflector antenna, aperture blockage, and design consideration.		
UNIT-II	**ARRAYS AND SMART ANTENNAS**	**12**
Introduction-General structure of phased array, linear array theory, variation of gain as a function of pointing direction, effects of phase quantization, frequency scanned arrays, MEMS technology in phased arrays-Retro directive and self-phased arrays. Analog beam forming matrices- Active modules, digital beam forming, smart antenna methods, algorithms.		
UNIT-III	**MICRO STRIP ANTENNA**	**12**
Radiation Mechanism from patch; Excitation techniques; Microstrip dipole; Rectangular patch, Circular patch, and Ring antenna – radiation analysis from transmission line model, cavity model; input impedance of rectangular and circular patch antenna; Microstrip array and feed network; Application of microstrip array antenna.		
UNIT-IV	**WEARABLE AND RECONFIGURABLE ANTENNAS**	**12**
Overview of wearable systems and its characteristics, antennas for wearable devices, design requirements, modeling and characterization of wearable antennas; reconfigurable methodologies, design considerations for reconfigurable systems, reconfigurable planar and printed antenna configurations.		
UNIT-V	**EMC ANTENNA AND ANTENNA MEASUREMENTS**	**12**
Concept of EMC measuring antenna; Receiver and Transmitter antenna factors; Log periodic dipole, Biconical, Ridge guide, Multi turn loop; Antenna measurement and instrumentation – Gain, Impedance, antenna factor measurement; Antenna test range Design.		
	Total Contact Hours : 60	

Course Outcomes:	
On completion of the course, students will be able to	
●	To apply the knowledge of fundamental parameters of various antennas

●	To analyse the radiation from rectangular, circular and uniform apertures
●	To design the micro strip patch antenna
●	To analyse and design various reconfigurable antennas
●	To explain the radiation mechanism and the antenna factor measurements

Reference Books(s) / Web links:

1	Zhijun Zhang" Antenna Design for Mobile Devices" 1st Edition, John Wiley & Sons (Asia) Ltd, Newyork,2011.
2	Balanis.A, "Antenna Theory Analysis and Design", John Wiley and Sons, New York, 1982.
3	Krauss.J.D, "Antennas", II edition, John Wiley and sons, New York, 1997.
4	W.L.Stutzman and G.A.Thiele,"Antenna Theory and Design", 2nd Edition, John Wiley& Sons Inc., 1998.
5	S.DrabowitchEt.al,"Modern Antennas", 2nd Edition Springer science business Media, Inc.2005.
6	ZhiNing Chen, "Antennas for portable devices", John Wiley& Sons Inc., 2007.
7	Eng Hock Lim, "Compact multifunctional antennas for wireless systems", John Wiley& Sons Inc., 2012.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	1	1	1
CO2	3	3	1	2	2	1
CO3	3	3	2	2	3	1
CO4	2	3	1	2	3	2
CO5	2	2	3	3	2	1
Average	**2.6**	**2.6**	**1.6**	**1.4**	**2.2**	**1.2**

Subject Code	Subject Name	Category	L	T	P	C
CU19102	**OPTICAL NETWORKS**	**PC**	**3**	**0**	**0**	**3**

Objectives:	
●	To have deep learning about the different optical system components and network architecture
●	To enrich the knowledge about the different topologies, protocols related to optical network
●	To explore the different system models, control and management of optical networks
●	To deal with the issues related to fault and safety managements

UNIT-I	**OPTICAL NETWORK ARCHITECTURES**	**9**
Introduction to Optical Networks; SONET / SDH standards, Layered Architecture; Broadcast and Select Networks– Topologies for Broadcast Networks, Media Access Control Protocols, Wavelength Routing Architecture.		
UNIT-II	**WAVELENGTH ROUTING NETWORKS**	**9**
The optical layer, Node Designs, Optical layer cost tradeoff, Routing and wavelength Assignment, Virtual topology design, Architectural variations.		
UNIT-III	**PACKET SWITCHING AND ACCESS NETWORKS**	**9**
Photonic Packet Switching – OTDM, Multiplexing and Demultiplexing, Synchronisation, Broadcast OTDM networks, Switch-based networks; Access Networks – Network Architecture overview, OTDM networks; Optical Access Network Architectures.		
UNIT-IV	**NETWORK DESIGN AND MANAGEMENT**	**9**
Transmission System Engineering – System model, Power penalty - transmitter, receiver, Optical amplifiers, crosstalk, dispersion; Wavelength stabilization; Overall design considerations. Control and Management – Network management functions, Configuration management, Fault management.		
UNIT-V	**NETWORK PERFORMANCE AND FUTURE TRENDS**	**9**
Performance Impairments in an Optical Network Environment, Performance Evaluation: Methodology and Case		

Studies, Passive Optical Networks, Metropolitan Area Networks, Long-Haul and Ultra Long-Haul Networks.			
	Total Contact Hours	**:**	**45**

Course Outcomes:	
On completion of the course, students will be able to	
●	Identify the transmission of data in different optical network architectures
●	Design the virtual topology and various routing assignments
●	Discuss the various routing topologies in packet switching and access networks
●	Analyse and address the issues related to faults and safety management in the optical networks
●	Evaluate the methods for network performance.

Reference Books(s) / Web links:	
1	Rajiv Ramaswami and Kumar N. Sivarajan, "Optical Networks: A Practical Perspective", Harcourt Asia Pte Ltd., Second Edition 2004.
2	C. Siva Ram Moorthy and Mohan Gurusamy, "WDM Optical Networks: Concept, Design and Algorithms", Prentice Hall of India, Ist Edition, 2002.
3	Biswanath Mukherjee, "Optical Communication Networks", Mc-GrawHill ©1997, First Edition
4	P.E. Green, Jr., "Fiber Optic Networks", Prentice Hall, NJ, 1993.
5	Rajiv Ramaswami and Kumar N. Sivarajan, "Optical Networks: A Practical Perspective", Harcourt Asia Pte Ltd., First Edition 2006.
6	Thomas E. Stern, Georgios Ellinas, Krishna Bala, —Multiwavelength Optical Networks – Architecture, Design and control —, Cambridge University Press, 2nd Edition, 2009.

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	1	1	1
CO2	3	3	3	2	1	1
CO3	3	3	3	1	1	1
CO4	3	3	3	1	1	2
CO5	3	3	2	1	1	1
Average	**3**	**3**	**2.8**	**1.2**	**1**	**1.2**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
CU19103	**ADVANCED DIGITAL COMMUNICATION TECHNIQUES**	**PC**	**3**	**0**	**0**	**3**

Objectives:	
●	To understand the basics of signal-space analysis and coherent & non-coherent receivers and its impact on different channel characteristics.
●	To understand the different Equalizers.
●	To understand the different block coded digital communication systems.
●	To understand the convolutional coded digital communication systems.
●	To understand Orthogonal Frequency Division Multiplexing.

UNIT-I	**COHERENT AND NON-COHERENT COMMUNICATION**	**9**
Coherent receivers – Optimum receivers in WGN- Coherent receivers – QPSK; QAM– Rayleigh and Rician channels –Partially coherent receivers –DPSK; M-PSK-BER Performance Analysis. Carrier Synchronization- Bit synchronization. Non-coherent FSK Receiver		
UNIT-II	**EQUALIZATION TECHNIQUES**	**9**
ISI – Nyquist Criterion- Controlled ISI-Partial Response signals-Equalization algorithms– Linear equalizer – Decision feedback equalization – Adaptive Equalization algorithms.		

UNIT-III	BLOCK CODED DIGITAL COMMUNICATION	9
Shannon's channel coding theorem; Channel capacity; Matched filter; Concepts of Spread spectrum communication –Linear block codes; Hamming; Golay; Cyclic; BCH; Reed – Solomon codes - Space time block codes.		
UNIT-IV	**CONVOLUTIONAL CODED DIGITAL COMMUNICATION**	**9**
Representation of codes using Polynomial, State diagram, Tree diagram, and Trellis diagram – Decoding techniques using Maximum likelihood, Viterbi algorithm, Sequential and Threshold methods – Error probability performance for BPSK and Viterbi algorithm, Turbo Coding.		
UNIT-V	**OFDM**	**9**
Generation of sub -carriers using the IFFT; Guard Time and Cyclic Extension; Windowing; OFDM signal processing; Peak Power Problem: PAP reduction schemes- Clipping, Filtering, Coding and Scrambling. ICI reduction schemes, Case study-IEEE 802.11 physical layer design using OFDM.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
●	Describe the concepts of signal space analysis in coherent and non-coherent receivers.
●	Describe different Equalization techniques.
●	Apply different block codes.
●	Apply convolutional code.
●	Design OFDM based wireless systems.

Reference Books(s) / Web links:	
1	M.K.Simon, S.M.Hinedi and W.C.Lindsey, Digital communication techniques; Signalling and detection, Prentice Hall India, New Delhi. 1995.
2	Simon Haykin, Digital communications, John Wiley and sons, 1998
3	Bernard Sklar., 'Digital Communications', second edition, Pearson Education, 2001.
4	John G. Proakis., 'Digital Communication', 4 th edition, McGraw Hill Publication, 2001
5	Theodore S.Rappaport., 'Wireless Communications', 2nd edition, Pearson Education, 2002
6	Stephen G. Wilson., 'Digital Modulation and Coding', First Indian Reprint, Pearson Education, 2003.
7	Richard Van Nee & Ramjee Prasad., 'OFDM for Multimedia Communications' Artech House Publication, 2001.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	2
CO2	3	3	3	2	2	2
CO3	3	3	3	2	2	2
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3
Average	**3**	**3**	**3**	**2.4**	**2.4**	**2.4**

Subject Code	Subject Name	Category	L	T	P	C
CU19141	**ADVANCED DIGITAL SIGNAL PROCESSING**	**PC**	**3**	**0**	**2**	**4**

Objectives:	
●	To provide in-depth treatment on methods and techniques in discrete-time signal transforms, digital filter design, optimal filtering
●	To understand the methods and techniques in power spectrum estimation and signal modeling
●	To know the concepts of adaptive filters and algorithms.

UNIT-I	**DISCRETE RANDOM SIGNAL PROCESSING**	**9**
Introduction to Estimation of probability theory-Mathematical preliminaries- Weiner Khitchine relation – Power spectral density – filtering random process, Spectral Factorization Theorem, special types of random process –		
UNIT-II	**SIGNAL MODELING**	**9**
Model based approach – AR, MA, ARMA Signal modelling – Parameter estimation using Yule-Walker method.Signal modelling-Least Squares method, Pade approximation, Prony's method, iterative Prefiltering, Finite Data records, Stochastic Models.		
UNIT-III	**SPECTRUM ESTIMATION**	9
Non-Parametric methods – Correlation method – Co-variance estimator – Performance analysis of estimators – Unbiased consistent estimators – Periodogram estimator – Barlett spectrum estimation – Welch estimation.		
UNIT-IV	**LINEAR ESTIMATION AND PREDICTION**	**9**
Efficiency of estimator – Least mean squared error criterion – Wiener filter – Discrete Wiener Hoff equations – Recursive estimators – Kalman filter – Linear prediction, Prediction error – Whitening filter, Inverse filter – Levinson recursion, Levinson recursion algorithm for solving Toeplitz system of equations.		
UNIT-V	**ADAPTIVE FILTERS**	**9**
FIR Adaptive filters – Newton's steepest descent method – Adaptive filters based on steepest descent method – Widrow Hopf LMS Adaptive algorithm – Adaptive channel equalization – Adaptive echo canceller – Adaptive noise cancellation – RLS Adaptive filters – Exponentially weighted RLS – Sliding window RLS – Simplified IIR LMS Adaptive filter.		
	Contact Hours : 45	

List of Experiments			
1	Basic Signal Representation		
2	Auto and Cross Correlation		
3	Sampling FFT Of Input Sequence		
4	Butterworth Low pass And High pass Filter Design		
5	Normal Equation Using Levinson Durbin		
6	Cascade Digital IIR Filter Realization		
7	Estimation Of PSD		
	Contact Hours	**:**	**30**
	Total Contact Hours	**:**	**75**

Course Outcomes: On completion of the course, students will be able to	
●	Understand the various techniques to estimate the probability of a random signal
●	Identify the appropriate method for spectrum estimation
●	Estimate and predict the error present in different types of filters
●	Apply adaptive filters for various applications
●	Analyze random signals and simulate random signal processing techniques.

Reference Books(s) / Web links:	
1	Monson H. Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley and Sons Inc., New York, 2006.
2	Sophoncles J. Orfanidis, "Optimum Signal Processing ", McGraw-Hill, 2000.
3	John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing", Prentice Hall of India, New Delhi, 2005.
4	Simon Haykin, "Adaptive Filter Theory", Prentice Hall, Englehood Cliffs, NJ1986.
5	S. Kay," Modern spectrum Estimation theory and application", Prentice Hall, Englehood Cliffs, NJ1988.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	-	1	-	1
CO2	3	3	3	1	1	2
CO3	1	1	2	2	3	2
CO4	-	-	1	1	1	3
CO5	-	-	-	1	3	3
Average	**2.3**	**2.3**	**2**	**1.2**	**2**	**2.2**

Subject Code	Subject Name	Category	L	T	P	C
PG19101	**RESEARCH METHODOLOGY AND IPR**	**MC**	**3**	**0**	**0**	**3**

Objectives:	
●	To inculcate the importance of research methodology and Intellectual Property Rights. The main objective of the IPR is to make the students aware of their rights for the protection of their invention done in their project work.
●	To get registration of patents in our country and foreign countries of invention, designs and thesis or theory written. To get knowledge of patents, copy right, trademarks and designs.

UNIT-I	**RESEARCH METHODOLOGY**	**9**
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.		
UNIT-II	**REVIEW OF LITERATURE AND TECHNICAL WRITING**	**9**
Effective literature studies approaches, analysis Plagiarism, Research ethics, 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-III	**INTELLECTUAL PROPERTY RIGHTS**	**9**
Nature of Intellectual Property: Patents, Designs, Trade and Copyright, copyright registration in India Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under Patent Cooperation Treaty.		
UNIT-IV	**PATENT RIGHTS AND RECENT DEVELOPMENTS IN IPR**	**9**
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. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.		
UNIT-V	**INDUSTRIAL DESIGNS AND GEOGRAPHICAL INDICATIONS**	**9**
Industrial designs and IC Layout design, Registrations of designs, conditions and procedures of industrial designs-Cancellation of Registration, International convention of design- types and functions. Semiconductor Integrated circuits and layout design Act- Geographical indications-potential benefits of Geographical Indications.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
●	Student can understand the research problem formulation and analyze research related information.
●	Understanding that when IPR would take such important place in growth of individuals & nation.
●	Understand the importance of copyright and industrial designs.
●	Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.
●	The students once they complete their academic projects, they get awareness of acquiring the patent and copyright for their innovative works.

Text Book(s):	
1	Neeraj Pandey and Khushdeep Dharni, Intellectual Property Rights, First edition, PHI learning Pvt. Ltd., Delhi, 2014.
2	Uma Sekaran and Roger Bougie, Research methods for Business, 5th Edition, Wiley India, New Delhi, 2012.
3	Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'" ,2nd edition, Juta Academic, 2001.
4	Ramakrishna B & Anilkumar H S, Fundamentals of Intellectual Property Rights, Ist edition, Notion Press, 2017.

Reference Books(s) / Web links:	
1	William G Zikmund, Barry J Babin, Jon C.Carr, Atanu Adhikari,Mitch Griffin, Business Research methods, A South Asian Perspective, 8th Edition, Cengage Learning, New Delhi, 2012.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	-	3	2	3
CO2	-	-	-	2	3	3
CO3	-	-	-	3	2	2
CO4	-	-	-	3	3	2
CO5	-	-	-	3	2	3
Average	-	-	-	**2.8**	**2.4**	**2.6**

Subject Code	Subject Name	Category	L	T	P	C
AC19101	**ENGLISH FOR RESEARCH PAPER WRITING (Common to all branches of M.E. /M.Tech / MBA – I Semester)**	**HS**	**3**	**0**	**0**	**0**

Objectives:	
●	Express technical ideas in writing
●	Plan and organize the research paper
●	Understand the structure and familiarise the mechanics of organised writing
●	Improvise academic English and acquire research writing skills

UNIT-I	INTRODUCTION TO RESEARCH WRITING	9
Research – Types of Research – Selecting the Primary resources – Categorizing secondary sources – Discovering a researchable area and topic – Need Analysis – Research Question- Focussing on the Research Problem- Developing Research Design – Framing the Hypothesis – Identifying the Scope of the Research – Writing – General and Academic Writing		
UNIT-II	**LANGUAGE OF WRITING**	**9**
Active reading – text mining – use of academic words – jargons – ambiguities – use of expression – use of tense – proper voices – third person narration – phraseology – use of foreign words – use of quotes – interpreting quotes.		
UNIT-III	**THE FORMAT OF WRITING**	**9**
Types of Journals – different formats and styles – IEEE format – Structure – Margins – Text Formatting – Heading and Title – Running Head with Page Numbers – Tables and illustrations – Paper and Printing – Paragraphs – Highlighting – Quotation – Footnotes		
UNIT-IV	**ORGANISING A RESEARCH PAPER**	**9**
Title- Abstract – Introduction – Literature review – Methodology – Results –Discussion –Conclusion – Appendices – Summarising – Citation and Bibliography		
UNIT-V	**PUBLISHING PAPER**	**9**
Finding the Prospective publication or Journal – analysing the credits – Reviewing – Revising – Plagiarism Check –		

Proof reading – Preparing the Manuscript- Submitting – Resubmitting – Follow up – Publishing			
	Total Contact Hours	**:**	**45**

Course Outcomes: On completion of the course, students will be able to	
●	Understand the basic structure of research work
●	Apply proper use of language in writing paper
●	Comprehend different formats of journal paper
●	Learn the process of writing a research paper
●	Know the process of publishing journal paper

Reference Books(s) / Web links:	
1	Adrian Wallwork: "English for Writing Research Papers", Springer Science Business Media, Second Edition, LLC 2011
2	Stephen Howe and Kristina Henrikssion: "Phrasebook for Writing Papers and Research in English", The Whole World Company Press, Cambridge, Fourth edition 2007
3	The Modern Language Association of America: "MLA Handbook for Writers of Research Papers" 8th Edition, The Modern Language Association of America, 2016
4	Rowena Murray: The Handbook of Academic Writing: A Fresh Approach, Sarah Moore Open University Press, 2006
5	Stephen Bailey: Academic Writing: A Practical Guide for Students Routledge Falmer: 2003
6	Joseph M. Moxley: Publish, Don't Perish: The Scholar's Guide to Academic Writing and Publishing, Praeger Publishers, 1992

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	-	2	2	3
CO2	-	-	-	2	2	3
CO3	-	-	-	2	2	2
CO4	-	-	-	2	2	2
CO5	-	-	-	2	2	3
Average	-	-	-	**2**	**2**	**2.6**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
CU19111	**COMMUNICATION SYSTEMS LABORATORY**	**PC**	**0**	**0**	**4**	**2**

Objectives:	
●	To facilitate the knowledge about different modulation techniques and error control codes
●	To explore the trends in microwave devices and transmission lines
●	To enrich the ideas in simulation tools for antenna radiation pattern measurement
●	To learn the design procedures of OFDM
●	To familiar in vector network analyser for S-parameter estimation.

List of Experiments	
1	Channel equalizer design (LMS, RLS)
2	Performance Evaluation of digital modulation schemes
3	OFDM transceiver design

4	Performance evaluation of simulated CDMA System.			
5	Error control codes			
6	Simulation of Microstrip Antennas			
7	Antenna Radiation Pattern measurement.			
8	Measurement of transmission line parameters.			
9	S-parameter estimation of Microwave device using Network Analyser.			
10	BER performance of MC-CDMA system			
		Total Contact Hours	**:**	**60**

Course Outcomes:	
On completion of the course, students will be able to	
●	To evaluate the performance of digital modulation techniques and error control codes.
●	To measure the parameters of microwave devices and transmission lines.
●	To measure the antenna radiation pattern.
●	To evaluate the performance of CDMA, OFDM and MC-CDMA systems.
●	To measure the S-parameters of microwave devices using vector network analyser.

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	1	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	3	2
CO4	3	3	3	2	2	2
CO5	3	3	3	3	3	2
Average	**3**	**3**	**3**	**2.6**	**2.2**	**2**

SEMESTER II

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
CU19201	**WIRELESS COMMUNICATION NETWORKS**	**PC**	**3**	**0**	**0**	**3**

Objectives:	
●	To make the students to know about the various propagation methods and channel models.
●	To understand the concepts of transmit and receive diversity.
●	To introduce the various multiple access schemes.
●	To know the concepts of MIMO techniques.
●	To enhance the understanding of 3G systems and 4G networks.

UNIT-I	**WIRELESS CHANNEL PROPAGATION AND MODEL**	**9**
Propagation of EM signals in wireless channel – Reflection, diffraction and Scattering-Small scale fading- channel classification- channel models – COST -231 Hata model, Longley-Rice Model, NLOS Multipath Fading Models: Rayleigh, Rician, Nakagami, Link power budget Analysis.		
UNIT-II	**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-III	**MULTI USER SYSTEMS**	**9**

Multiple Access: FDMA, TDMA, CDMA, SDMA, Hybrid techniques, Random Access: ALOHA, SALOHA, CSMA, Scheduling, power control, multiuser diversity.		
UNIT-IV	**MIMO COMMUNICATIONS**	**9**
Narrowband MIMO model, Parallel decomposition of MIMO channel, MIMO channel capacity, MIMO Diversity Gain: Beamforming, Diversity-Multiplexing trade-offs, Space time Modulation and coding: STBC, STTC, Spatial Multiplexing and BLAST Architectures- MIMO-MU systems.		
UNIT-V	**WIRELESS NETWORKS**	**9**
3G Overview, Migration path to UMTS, UMTS Basics, Air Interface, 3GPP Network Architecture,4G features and challenges, Introduction to wireless LANs - IEEE 802.11 WLANs –Physical Layer- MAC sub layer, Introduction to LTE.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
●	Analyse the characteristics of wireless propagation channel.
●	Infer the various diversity techniques
●	Outline the various multi-user systems like FDMA, CDMA, TDMA and SDMA.
●	Analyse the techniques in MIMO communications
●	Summarise the concepts of 3G and 4G Wireless networks.

Reference Books(s) / Web links:	
1	Andreas Goldsmith, Wireless Communications, Cambridge University Press, 2007.
3	Harry R. Anderson, “Fixed Broadband Wireless System Design” John Wiley – India, 2003.
4	Andreas.F. Molisch, “Wireless Communications”, John Wiley – India, 2006.
5	Simon Haykin& Michael Moher, “Modern Wireless Communications”, Pearson Education, 2007.
5	Rappaport. T.S., “Wireless communications”, Pearson Education, 2003.
6	Clint Smith. P.E., and Daniel Collins, “3G Wireless Networks”, 2nd Edition, Tata McGraw Hill, 2007.
7	Vijay. K. Garg, “Wireless Communication and Networking”, Morgan Kaufmann Publishers,
8	KavethPahlavan, K. PrashanthKrishnamuorthy, "Principles of Wireless Networks", Prentice Hall of India, 2006.
9	William Stallings, "Wireless Communications and networks" Pearson / Prentice Hall of India, 2nd Ed., 2007.
10	SumitKasera and NishitNarang, “3G Networks–Architecture, Protocols and Procedures”, Tata McGraw Hill, 2007.

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	2
CO2	3	3	3	2	2	2
CO3	3	3	2	2	2	2
CO4	3	3	3	2	2	2
CO5	3	3	3	2	2	2
Average	**3**	**3**	**2.8**	**2**	**2**	**2**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
CU19202	**MIC AND RF SYSTEM DESIGN**	**PC**	**3**	**1**	**0**	**4**

Objectives:	
●	To understand the fundamentals of RF radio system design.
●	To understand the various components that constitutes an RF radio system for wireless Communications.
●	To know the basic analysis techniques needed for evaluating the performance of an RF radio system for Wireless applications.

UNIT-I	**CMOS PHYSICS, TRANSCEIVER SPECIFICATIONS AND ARCHITECTURES**	**12**
CMOS: Introduction to MOSFET Physics – Noise: Thermal, shot, flicker, popcorn noise transceiver Specifications: Two port Noise theory, Noise Figure, THD, IP2, IP3, Sensitivity, SFDR, Phase noise - Specification distribution over a communication link Transceiver Architectures: Receiver: Homodyne, Heterodyne, Image reject, Low IF Architectures – Transmitter: Direct up conversion, two step up conversion		
UNIT-II	**IMPEDANCE MATCHING AND AMPLIFIERS**	**12**
S-parameters with Smith chart – Passive IC components - Impedance matching networks Amplifiers: Common Gate, Common Source Amplifiers – OC Time constants in bandwidth estimation and enhancement – High frequency amplifier design Low Noise Amplifiers: Power match and Noise match – Single ended and Differential LNAs – Terminated with Resistors and Source Degeneration LNAs.		
UNIT-III	**FEEDBACK SYSTEMS AND POWER AMPLIFIERS**	**12**
Feedback Systems: Stability of feedback systems: Gain and phase margin, Root-locus techniques – Time and Frequency domain considerations – Compensation Power Amplifiers: General model – Class A, AB, B, C, D, E and F amplifiers –Linearization Techniques – Efficiency boosting techniques – ACPR metric – Design considerations.		
UNIT-IV	**RF FILTER DESIGN, OSILLATOR, MIXER**	**12**
Overview-basic resonator and filter configuration-special filter realizations-filter implementation. Basic oscillator model-high frequency oscillator configuration- basic characteristics of mixers-phase locked loops-RF directional couplers hybrid couplers-detector and demodulator circuits.		
UNIT-V	**MIC COMPONENTS, ANTENNAS AND MEASUREMENT TECHNIQUES**	**12**
Introduction to MICs-Fabrication Technology, Advantages and applications, MIC components-Micro strip components, Coplanar circuits, Integrated antennas, photonic band gap antennas, Measurement techniques-test fixture measurements, probe station measurements, thermal and cryogenic measurements, experimental field probing techniques.		
	Total Contact Hours : 60	

Course Outcomes:

On completion of the course, students will be able to

- To understand the specification and architectures of transceivers
- To analyze time and frequency domain of various power amplifiers
- To able to design RF circuits
- To able to analyze the performance of RF circuits
- To explain the radiation mechanism and the antenna factor measurements

Reference Books(s) / Web links:

1	T. Lee,"Design of CMOS RF Integrated Circuits", Cambridge, 2004.
2	B.Razavi, "RF Microelectronics", Pearson Education, 1997.
3	Jan Crols, MichielSteyaert,"CMOS Wireless Transceiver Design", Kluwer Academic Publications, 1997.
4	B. Razavi, Design of analog CMOS Integrated Circuits", McGraw Hill, 2001
5	I.D. Robertson &S. Lucyszyn, "RFIC and MMIC Design and Technology", IEE Circuits, Devices and Systems series 13, London, UK, 2001.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	1	1
CO2	3	3	3	2	1	1
CO3	3	3	3	2	2	1
CO4	3	3	3	2	2	1
CO5	3	3	2	1	2	1
Average	**3**	**3**	**2.6**	**1.8**	**1.6**	**1**

Subject Code	Subject Name	Category	L	T	P	C
CU19203	**COMMUNICATION SYSTEM MODELING AND SIMULATION**	**PC**	**3**	**0**	**0**	**3**

Objectives:	
●	To understand the aspect of simulation and modeling.
●	To understand random signals and process
●	To get exposed to simulation methods for wireless systems
●	To know modeling procedures for various channels.

UNIT-I	**INTRODUCTION**	**9**
Role of Simulation-Fundamental Concepts and Techniques: Sampling - quantizing - reconstruction and interpolation - simulation sampling frequency - low pass simulation models for band pass – low pass complex envelope for bandpass signals - linear bandpass systems - multicarrier signals - nonlinear and time - varying systems.		
UNIT-II	**GENERATING AND PROCESSING RANDOM SIGNALS**	**9**
Stationary and Ergodic Processes: Uniform random number generators - mapping uniform RVs to an arbitrary PDF - generating uncorrelated Gaussian random numbers - generating correlated Gaussian random numbers - PN sequence generators		
UNIT-III	**METHODOLOGY FOR SIMULATING A WIRELESS SYSTEM**	**9**
Monte Carlo Simulation Fundamental Concepts: Applications and integration - two Monte Carlo examples; Semi Analytic Techniques System: Level simplifications and sampling rate considerations - overall methodology; Modeling and Simulation of Nonlinearities: Introduction - modeling and simulation of memory less nonlinearities - modeling and simulation of nonlinearities with memory		
UNIT-IV	**MODELING AND SIMULATION OF TIME-VARYING SYSTEMS**	**9**
Introduction: Models for LTV systems - random process models - simulation models for LTV systems; Wired and guided wave - radio channels - multipath fading channels - modeling multipath fading channels; Random process models - simulation methodology; Discrete Channel Models: Discrete memory less channel models - Markov models for discrete channels with memory- example HMMs - Gilbert and Fritchman models - estimation of Markov model parameters.		
UNIT-V	**EFFICIENT SIMULATION TECHNIQUES**	**9**
Tail Extrapolation: PDF estimators- importance sampling; Case study of a cellular radio system; Cellular radio system - simulation methodology - two example simulations; A code-division multiple access system - FDM system with a nonlinear satellite transponder		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
●	Design various models for wireless communication
●	Generate and process various random signals
●	Paraphrase various methodology to simulate a wireless system
●	Model and simulate various channels
●	Apply various efficient techniques in simulating wireless communication technologies

Reference Books(s) / Web links:	
1	William H. Tranter, K. Sam Shanmugan, Theodore S. Rappaport and Kurt L. Kosbar "Principles of Communication Systems Simulation with Wireless Applications", Prentice Hall, Upper Saddle River, 2003.
2	M. C. Jeruchim, Philip Balaban and K.Samshanmugam. "Simulation of Communication Systems", Plenum Press, 2007.
3	M. Law and W. David Kelton, "Simulation Modelling and Analysis", McGraw Hill, 2008.
4	K. Hayes, "Modelling and Analysis of Computer Communication Networks", Plenum Press, 1984.
5	Banks, J. S. Carson, Nelson and D. M. Nicol, "Discrete Event System Simulation", 4th Edition, Prentice Hall of India, 2005.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	2	-	-
CO2	3	2	2	2	1	1
CO3	3	3	2	2	1	1
CO4	3	3	2	2	1	1
CO5	2	3	2	2	1	1
Average	**2.8**	**2.6**	**2**	**2**	**1**	**1**

Subject Code	Subject Name	Category	L	T	P	C
AC19201	**CONSTITUTION OF INDIA**	**MC**	**3**	**0**	**0**	**0**

Objectives:	
●	To inculcate the values enshrined in the Indian constitution.
●	To create a sense of responsible and active citizenship.
●	To know about Constitutional and Non- Constitutional bodies
●	To understand sacrifices made by the freedom fighters.

UNIT-I	**INTRODUCTION**	**9**
Historical Background - Constituent Assembly of India - Philosophical foundations of the Indian Constitution - Features - Basic Structure – Preamble.		
UNIT-II	**UNION GOVERNMENT**	**9**
Union and its territory - Citizenship - Fundamental Rights - Directive Principles of State Policy (DPSP) - Fundamental Duties. **Union Government: Executive, Legislature and Judiciary:** President - Vice President - Prime Minister - Central Council of Ministers - Cabinet Committees - Parliament: Committees, Forums and Groups - Supreme Court.		
UNIT-III	**STATE GOVERNMENT & UNION TERRITORIES**	**9**
State Government : Executive, Legislature and Judiciary- Governor - Chief Minister - State Council of Ministers - State Legislature - High Court - Subordinate Courts -Panchayati Raj – Municipalities-Union Territories - Scheduled and Tribal Areas.		
UNIT-IV	**RELATIONS BETWEEN UNION AND STATES**	**9**
Relations between Union and States - Services under Union and States. Cooperative Societies - Scheduled and Tribal Areas - Finance, Property, Contracts and Suits - Trade and Commerce within Indian Territory – Tribunals.		
UNIT-V	**CONSTITUTIONAL BODIES AND AMENDMENTS**	**9**

Introduction to Constitutional & Non-Constitutional Bodies-Elections - Special Provisions relating to certain classes - Languages - Emergency Provisions - Miscellaneous - Amendment of the Constitution - Temporary, Transitional and Special Provisions – Short title, date of commencement, Authoritative text in Hindi and Repeals. Schedules of the Constitution of India - Appendices in the Constitution of India.

	Total Contact Hours	**:**	**45**

Course Outcomes:	
On completion of the course, students will be able to	
●	Appreciate the philosophical foundations of the Indian Constitution.
●	Understand the functions of the Indian government.
●	Understand and abide the rules of the Indian constitution.
●	Gain knowledge on functions of state Government and Local bodies.
●	Gain Knowledge on constitution functions and role of constitutional bodies and amendments of constitution.

Text Book(s):	
1	M Lakshmikanth "Indian Polity", McGraw Hill Education, 5th edition 2017.
2	Durga Das Basu, "Introduction to the Constitution of India ", Lexis Nexis, New Delhi., 21st edition, 2013.
Reference Books(s) / Web links:	
1	Sharma, Brij Kishore, "Introduction to the Constitution of India", Prentice Hall of India, New Delhi, 7th edition, 2015.
2	Subhash Kashyap, "Our Constitution: An Introduction to India's Constitution and Constitutional Law", National Book Trust India, 1994.
3	Mahendra Prasad Singh and Himanshu Roy, "Indian Political System", Pearson India, 4th edition, 2017.

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	-	-	-	3
CO2	-	-	--	-	-	2
CO3	-	-	-	-	-	3
CO4	-	-	-	-	-	2
CO5	-	-	-	-	-	3
Average	-	-	-	-	-	**2.6**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
CU19211	**RF SYSTEM DESIGN LABORATORY**	**PC**	**0**	**0**	**4**	**2**

Objectives:	
●	To enable the students to verify the basic principles and design aspects involved in high frequency communication systems components
●	To expose the student to different high frequency components and conduct the experiments to analyze and interpret data to produce meaningful conclusion and match with theoretical concepts.
●	To design and develop RF components using microstrip technology

List of Experiments	
1	Measurement of S parameters for a) Inductor b) Capacitor c) impedance matching circuits, filters using network analyzer

2	Design of λ/2, λ/4 micro strip transmission line.			
3	Design of microstrip inductor and capacitor.			
4	Design of impedance matching network.			
5	Design of low pass, high pass, band pass and band stop filter at RF.			
6	Design and characterization of microstrip patch antenna array.			
7	Design and characterization of Mixer			
8	Design and characterization of VCO			
		Total Contact Hours	**:**	**60**

Course Outcomes:	
On completion of the course, students will be able to	
●	Apply knowledge to identify a suitable architecture and systematically design an RF system.
●	Comprehensively record and report the measured data, and would be capable of analyzing, interpreting the experimentally measured data and produce the meaningful conclusions.
●	Design and characterize microstrip patch antenna array.
●	Design and develop filters.
●	Characterize Mixer and VCO.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	1
CO2	2	2	2	3	2	1
CO3	2	3	3	2	3	2
CO4	2	3	3	2	3	2
CO5	2	2	2	2	2	1
Average	**2.2**	**2.4**	**2.4**	**2.2**	**2.4**	**1.4**

SEMESTER III

Subject Code	Subject Name	Category	L	T	P	C
CU19301	**WIRELESS AD HOC AND SENSOR NETWORKS**	**PC**	**3**	**0**	**0**	**3**

Objectives:	
●	To learn the concepts of Ad hoc wireless networks
●	To understand the basics of routing protocols
●	To learn the security concepts
●	To study the architecture and MAC protocols of sensor networks
●	To know the concepts of various operating systems and routing protocols of sensor networks

UNIT-I	**ADHOC NETWORKS AND ROUTING PROTOCOLS**	**9**
Ad hoc Wireless Networks –Heterogeneity in Mobile Devices – Types of Ad hoc Mobile Communications – Types of Mobile Host Movements – Challenges Facing Ad hoc Mobile Networks. Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks – Classifications of Routing Protocols – Table–Driven Routing Protocols – Destination Sequenced Distance Vector (DSDV) – Wireless Routing Protocol (WRP) – Cluster Switch Gateway Routing (CSGR) – Source–Initiated On–Demand Approaches – Ad Hoc On–Demand Distance Vector Routing (AODV) – Dynamic Source Routing (DSR) –Temporally Ordered Routing Algorithm (TORA) –Location–Aided Routing (LAR) – Power–Aware Routing (PAR) – Zone Routing Protocol (ZRP).		

UNIT-II	MULTICAST ROUTING	9
Issues in Designing a Multicast Routing Protocol – Operation of Multicast Routing Protocols – An Architecture Reference Model for Multicast Routing Protocols –Classifications of Multicast Routing Protocols – Tree–Based Multicast Routing Protocols– Mesh–Based Multicast Routing Protocols – Summary of Tree and Mesh based Protocols – Energy–Efficient Multicasting – Multicasting with Quality of Service Guarantees – Application Dependent Multicast Routing –Comparisons of Multicast Routing Protocols.		
UNIT-III	**SECURITY AND ENERGY MANAGEMENT**	**9**
Security in Ad Hoc Wireless Networks – Network Security Requirements – Issues and Challenges in Security Provisioning – Network Security Attacks – Key Management – Secure Routing in Ad hoc Wireless Networks. Energy Management in Ad Hoc Wireless Networks – Introduction – Classification of Energy Management Schemes – Battery Management Schemes – Transmission Power Management Schemes –System Power Management Schemes.		
UNIT-IV	**SENSOR NETWORKS – ARCHITECTURE AND MAC PROTOCOLS**	**9**
Single node architecture – Hardware components, Network architecture – Sensor network scenarios, types of sources and sinks, single hop versus multi-hop networks, multiple sinks and sources, physical layer and transceiver design consideration in wireless sensor networks, choice of modulation, MAC protocols – fundamentals of wireless MAC protocols, low duty cycle protocols and wakeup concepts - SMAC, contention based protocols - CSMA,PAMAS, Schedule based protocols -LEACH, Traffic-adaptive medium access protocol (TRAMA).		
UNIT-V	**SENSOR NETWORKS – ROUTING PROTOCOLS AND OPERATING SYSTEMS**	**9**
Gossiping and agent-based unicast forwarding, Energy-efficient unicast, Broadcast and multicast, geographic routing, mobile nodes, Data-centric routing – SPIN, Directed Diffusion, Energy aware routing, Gradient-based routing – COUGAR, ACQUIRE, Hierarchical Routing – LEACH, PEGASIS, Location Based Routing – GAF, GEAR. Introduction to TinyOS – NesC, Programming in TinyOS using Nes C, Simulator TOSSIM.		
	Total Contact Hours : 45	

Course Outcomes:

On completion of the course, students will be able to

- Acquire the knowledge of wireless Adhoc networks.
- Solve the various security issues in Adhoc sensor networks
- Acquire the knowledge on sensor node and its architectures
- Design energy efficient routing protocols
- Acquire the knowledge of operating system and simulator tools.

Reference Books(s) / Web links:

1	C. Siva Ram Murthy and B. S. Manoj, "Ad Hoc Wireless Networks Architectures and Protocols", Prentice Hall, PTR, 2004.
2	C. K. Toh, "Ad Hoc Mobile Wireless Networks Protocols and Systems", Prentice Hall, PTR, 2001.
3	Charles E. Perkins, "Ad Hoc Networking", Addison Wesley, 2000.
4	KazemSohraby, Daniel Minoli and TaiebZnati, "Wireless Sensor Networks Technology-Protocols and Applications", John Wiley & Sons, 2007.
5	Feng Zhao, Leonidas Guibas, "Wireless Sensor Networks: an information processing approach", Elsevier publication, 2004.
6	C.S.Raghavendra Krishna, M.Sivalingam and Taribznati, "Wireless Sensor Networks", Springer publication, 2004.
7	Holger Karl, Andreas willig, "Protocol and Architecture for Wireless Sensor Networks", John Wiley publication, Jan 2006.
8	K.Akkaya and M.Younis, "A Survey of routing protocols in wireless sensor networks", Elsevier Adhoc Network Journal, Vol.3, no.3, pp. 325-349, 2005.
9	Philip Levis, "TinyOS Programming", 2006 – www.tinyos.net.
10	I.F. Akyildiz, W. Su, Sankarasubramaniam, E. Cayirci, "Wireless sensor networks: a survey", computer networks, Elsevier, 2002, 394 - 422.
11	Jamal N. Al-karaki, Ahmed E. Kamal, "Routing Techniques in Wireless sensor networks: A survey", IEEE wireless communication, December 2004, 6 – 28.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	2	1	1
CO2	3	3	2	3	3	2
CO3	2	2	1	2	1	1
CO4	3	3	2	3	3	2
CO5	3	2	3	3	3	3
Average	**2.6**	**2.4**	**1.8**	**2.6**	**2.2**	**1.8**

PROFESSIONAL ELECTIVES

PROFESSIONAL ELECTIVE-I

Subject Code	Subject Name	Category	L	T	P	C
CU19P11	**ADVANCED SATELLITE COMMUNICATION SYSTEMS**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	To understand the basics of satellite orbits
●	Learn M2M developments and satellite applications
●	Understand Satellite Communication in IPv6 Environment
●	To understand the basic concepts of remote sensing and navigation systems**.**
●	To study the various broadcast and satellite networking systems

UNIT-I	**OVERVIEW OF COMMUNICATION**	**9**
Overview of satellite communication and orbital mechanics, coverage angle and slant range, eclipse, placement of satellite in geostationary orbit. Link budget Parameters, Link budget calculations, Auxiliary Equations, Performance Calculations.		
UNIT-II	**M2M DEVELOPMENTS AND SATELLITE APPLICATIONS**	**9**
Overview of the Internet of Things and M2M- M2M Applications Examples and Satellite Support-Satellite Roles Context and Applications- Antennas for Satellite M2M Applications- M2M Market Opportunities for Satellite Operators- Ultra HD Video/TV and Satellite Implications- High Throughput Satellites (HTS) and Ka/Ku Spot Beam Technologies- Aeronautical, Maritime and other Mobility Services.		
UNIT-III	**SATELLITE NETWORKING SYSTEM WITH IPV6**	**9**
Overview of IPv6 and its benefits- Migration and Coexistence- Implementation scenarios and support- Preparations for IPv6 in Satellite communication- Satellite specific Protocol issues in IPv6 – Impact of IPv6 on Satellite Network architecture and services-Detailed transitional plan- IPv6 demonstration over satellites		
UNIT-IV	**SATELLITE NAVIGATION AND GLOBAL POSITIONING SYSTEM**	**9**
Introduction - Commercial Imaging – Digital Globe – GeoEye - Meteorology – Meteosat - Land Observation – Landsat- Remote Sensing Data- Sensors- Overview - Optical Sensors: Cameras-Non-Optical Sensors- Image Processing - Image Interpretation- System Characteristics. Global Navigation Satellite Systems - Basic concepts of GPS. Space segment, Control segment, user segment, GPS constellation, GPS measurement characteristics, selective availability (AS), Anti spoofing (AS).Applications of Satellite and GPS for 3D position, Distress and Safety-Cospas-Sarsat.		
UNIT-V	**BROADCAST SYSTEMS**	**9**
Introduction - Satellite Radio Systems - XM Satellite Radio Inc. - Sirius Satellite Radio –world space - Direct Multimedia Broadcast- MBCO and TU Multimedia - European Initiatives - Direct-to-Home Television - Implementation Issues - DTH Services- Representative DTH Systems - Military Multimedia Broadcasts - US Global Broadcast Service (GBS)- Business TV(BTV), GRAMSAT, Specialized services – E –mail, Video conferencing, Internet.		
	Total Contact Hours : 45	
Course Outcomes: On completion of the course, students will be able to		

●	Analyze the satellite orbits
●	Prepare the budget plan for the uplink and downlink subsystems
●	Understand GPS based navigation system.
●	Analyze IPv6 in satellite system
●	Outline various Broadcasting systems.

Reference Books(s) / Web links:	
1	Dennis Roddy, 'Satellite Communication', McGraw Hill International, 4th Edition, 2006.
2	Daniel Minoli 'Innovations in Satellite Communication and Satellite Technology' Wiley, 2015
3	Daniel Minoli, "Satellite Systems Engineering in an IPv6 Environment", CRC Press, First Edition, 2009.
4	Global Positioning Systems, Inertial Navigation, and Integration. Mohinder S. Grewal California State University at Fullerton, A John Wiley & Sons, Inc. Publication.
5	Satellite Systems Engineering in an IPv6 Environment, Daniel Minoli, CRC Press.
6	Satellite systems for personal Applications, Madhavendra Richharia, A John Wiley and Sons, Ltd.Publication.
7	Dennis Roddy, 'Satellite Communication', McGraw Hill International, 4th Edition, 2006.
8	Wilbur L. Pritchard, Hendri G. Suyderhoud, Robert A. Nelson, 'Satellite Communication Systems Engineering', Prentice Hall/Pearson, 2007 (Books to be added)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	1	3
CO2	3	3	2	3	3	2
CO3	3	3	3	3	3	3
CO4	3	3	3	2	2	3
CO5	2	3	3	3	2	2
Average	**2.8**	**2.8**	**2.6**	**2.6**	**2.2**	**2.6**

Subject Code	Subject Name	Category	L	T	P	C
CU19P12	**REAL TIME EMBEDDED SYSTEMS**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	To study the concepts and basic architecture of ARM processor model
●	To understand the concepts of program designing.
●	To design multiple tasks using ARM processor.
●	To enable the network based design.
●	To apply for real time modeling

UNIT-I	**INTRODUCTION TO EMBEDDED COMPUTING**	**9**
Complex systems and microprocessors – Design example: Model train controller – Embedded system design process – Formalism for system design – Instruction sets Preliminaries – ARM Processor – CPU: Programming input and output – Supervisor mode, exception and traps – Coprocessor – Memory system mechanism – CPU performance – CPU power consumption.		
UNIT-II	**COMPUTING PLATFORM AND DESIGN ANALYSIS**	**9**
CPU buses – Memory devices – I/O devices – Component interfacing – Design with microprocessors – Development and Debugging – Program design – Model of programs – Assembly and Linking – Basic compilation techniques – Analysis and optimization of execution time, power, energy, program size – Program validation and testing.		
UNIT-III	**PROCESS AND OPERATING SYSTEMS**	**9**

Multiple tasks and multi processes – Processes – Context Switching – Operating Systems – Scheduling policies - Multiprocessor – Inter Process Communication mechanisms – Evaluating operating system performance – Power optimization strategies for processes, Examples of RTOS – Vxworks, POSIX.		
UNIT-IV	**HARDWARE ACCELERATES & NETWORKS**	**9**
Accelerators – Accelerated system design – Distributed Embedded Architecture – Networks for Embedded Systems – Network based design – Internet enabled systems.		
UNIT-V	**CASE STUDY**	**9**
Hardware and software co-design - Data Compressor - Software Modem – Personal Digital Assistants – Set–Top–Box. – System-on-Silicon – FOSS Tools for embedded system development.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
●	Describe The Architecture And Programming Of ARM Processor
●	Outline the concepts of embedded systems
●	Explain the basic concepts of real time operating systems.
●	Use the system design techniques to develop software for embedded system
●	Model real time applications using embedded system concepts

Reference Books(s) / Web links:	
1	Wayne Wolf, "Computers as Components - Principles of Embedded Computer System Design", Morgan Kaufmann Publisher, 2006.
2	David E-Simon, "An Embedded Software Primer", Pearson Education, 2007.
3	K.V.K.K.Prasad, "Embedded Real-Time Systems: Concepts, Design & Programming", dreamtech press, 2005.
4	Tim Wilmshurst, "An Introduction to the Design of Small Scale Embedded Systems", Pal grave Publisher, 2004.
5	Sriram V Iyer, Pankaj Gupta, "Embedded Real Time Systems Programming", Tata Mc-Graw Hill, 2004.
6	Tammy Noergaard, "Embedded Systems Architecture", Elsevier, 2006.

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	3	3	3	3	3
CO2	2	2	3	3	2	2
CO3	2	2	3	3	3	3
CO4	2	2	3	3	3	3
CO5	3	3	3	3	3	3
Average	**2**	**2.4**	**3**	**3**	**2.8**	**2.8**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
CU19P13	**MEMS AND NEMS**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	To introduce the concepts of micro electro mechanical devices.
●	To know the fabrication process of microsystems.
●	To know the design concepts of micro sensors and micro actuators.
●	To introduce the concepts of quantum mechanics and nano systems.

UNIT-I	OVERVIEW AND INTRODUCTION	9
New trends in Engineering and Science: Micro and Nano scale systems-Introduction to Design of MEMS and NEMS, Overview of Nano and Micro electro mechanical Systems, Applications of Micro and Nano electro mechanical systems, Micro electromechanical systems, devices and structures Definitions, Materials for MEMS: Silicon, silicon compounds, polymers, metals		
UNIT-II	**MEMS FABRICATION TECHNOLOGIES**	**9**
Microsystem fabrication processes: clean room standards, Semiconductor wafer cleaning, Photolithography, Ion Implantation, Diffusion and Oxidation. Thin film depositions: LPCVD, Sputtering, Evaporation, Electroplating; Etching techniques: Dry and wet etching, electrochemical etching; Micromachining: Bulk Micromachining, Surface Micromachining, High Aspect-Ratio (LIGA and LIGA-like) Technology; Packaging: Microsystems packaging, Essential packaging technologies, Selection of packaging materials.		
UNIT-III	**MICRO SENSORS**	**9**
MEMS Sensors: Design of Acoustic wave sensors, resonant sensor, Vibratory gyroscope, Capacitive and Piezo Resistive Pressure sensors- engineering mechanics behind these Microsensors. Case study: Piezo-resistive pressure sensor, MEMS Gas sensors.		
UNIT-IV	**MICRO ACTUATORS**	**9**
Design of Actuators: Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals, Actuation using Electrostatic forces (Parallel plate, Torsion bar, Comb drive actuators), Micromechanical Motors and pumps. Case study: Micro Tweezers, Micro Accelerometers.		
UNIT-V	**NANOSYSTEMS AND QUANTUM MECHANICS**	**9**
Atomic structures and Quantum mechanics, Molecular and Nanostructure Dynamics: Schrodinger equation and Wave function theory, Density functional theory, Nanostructures and Molecular Dynamics, Electromagnetic Fields and their quantization, Molecular wires and Molecular circuits.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
●	Students are enriched with the concepts of MEMS and NEMS.
●	Students can design a system using MEMS components
●	Students are able to design various MEMS sensors
●	Students are able to design micro actuators
●	Students can understand nanosystems theory.

Reference Books(s) / Web links:	
1	Marc Madou, “Fundamentals of Microfabrication”, CRC press 1997.
2	Stephen D. Senturia,” Micro system Design”, Kluwer Academic Publishers,2001
3	Tai Ran Hsu,”MEMS and Microsystems Design and Manufacture” ,Tata Mcraw Hill, 2002.
4	Chang Liu, “Foundations of MEMS”, Pearson education India limited, 2006,
5	Sergey Edward Lyshevski, “MEMS and NEMS: Systems, Devices, and Structures” CRC Press, 2002

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	3	2	2
CO2	2	2	2	2	2	2
CO3	2	2	1	3	2	3
CO4	3	2	2	3	2	3
CO5	3	2	3	3	2	3
Average	**2.4**	**2**	**2**	**2.8**	**2**	**2.6**

Subject Code	Subject Name	Category	L	T	P	C
CU19P14	MULTIMEDIA COMPRESSION TECHNIQUES	PE	3	0	0	3

Objectives:	
●	To understand the various storage requirements and evaluation techniques for data compression
●	To learn the various Text Compression techniques
●	To know about the various speech compression methods
●	To understand the Image Compression techniques and standards
●	To gain knowledge on Video compression techniques and standards

UNIT-I	INTRODUCTION	9
Special features of Multimedia – Graphics and Image Data Representations -Fundamental Concepts in Video and Digital Audio – Storage requirements for multimedia applications -Need for Compression - Taxonomy of compression techniques – Overview of source coding, source models, scalar and vector quantization theory – Evaluation techniques – Error analysis and methodologies.		
UNIT-II	**TEXT COMPRESSION**	**9**
Compaction techniques – Huffman coding – Adaptive Huffman Coding – Arithmetic coding – Shannon-Fano coding – Dictionary techniques – LZW family algorithms.		
UNIT-III	**AUDIO COMPRESSION**	**9**
Audio compression techniques - μ- Law and A- Law companding. Speech compression- waveform codecs-source codecs- hybrid codecs-Shorten compressor, Frequency domain and filtering – Basic sub-band coding – Application to speech coding – G.722 –Application to audio coding – MPEG audio, progressive encoding for audio – Silence compression, speech compression techniques – Formant and CELP Vocoders.		
UNIT-IV	**IMAGE COMPRESSION**	**9**
Predictive techniques – DM, PCM, and DPCM: Optimal Predictors and Optimal Quantization– Contour based compression – Transform Coding – JPEG Standard – Sub-band coding algorithms: Design of Filter banks – Wavelet based compression: Implementation using filters – EZW, SPIHT coders – JPEG 2000 standards – JBIG, JBIG2 Standards.		
UNIT-V	**VIDEO COMPRESSION**	**9**
Video compression techniques and standards – MPEG Video Coding I: MPEG – 1 and 2 MPEG Video Coding II: MPEG – 4 and 7 – Motion estimation and compensation techniques – H.261 Standard – DVI technology – PLV performance – DVI real time compression – Packet Video.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
●	Explain Scalar quantization theory and evaluation techniques
●	Understand different coding techniques
●	Use the audio compression techniques
●	Describe Contour based compression and Motion estimation techniques
●	Explain the various video and real time compression methods

Reference Books(s) / Web links:	
1	Khalid Sayood: Introduction to Data Compression, Morgan Kauffman Harcourt India, 2nd Edition, 2000.
2	David Salomon: Data Compression – The Complete Reference, Springer Verlag New York Inc., 2nd Edition, 2001.
3	Yun Q.Shi, Huifang Sun: Image and Video Compression for Multimedia Engineering - Fundamentals, Algorithms & Standards, CRC press, 2003.
4	Peter Symes: Digital Video Compression, McGraw Hill Pub., 2004.
5	Mark Nelson: Data compression, BPB Publishers, New Delhi, 1998.
6	Mark S.Drew, Ze-Nian Li: Fundamentals of Multimedia, PHI, 1st Edition, 2003.
7	Watkinson,J : Compression in Video and Audio, Focal press,London.1995.
8	Jan Vozer : Video Compression for Multimedia, AP Profes, NewYork, 1995

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	2	2
CO2	3	3	3	2	2	2
CO3	3	3	3	2	2	2
CO4	3	3	3	2	2	2
CO5	3	3	3	2	3	2
Average	**3**	**3**	**3**	**2**	**2.2**	**2**

Subject Code	Subject Name	Category	L	T	P	C
CU19P15	**HIGH PERFORMANCE NETWORKS**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	To develop a comprehensive understanding of multimedia networking.
●	To study the types of VPN and tunneling protocols for security.
●	To learn about network security in many layers and network management.

UNIT-I	**INTRODUCTION**	**9**
Review of OSI, TCP/IP; Multiplexing, Modes of Communication, Switching, Routing. SONET – DWDM – ISDN – BISDN, Frame Relay, ATM.		
UNIT-II	**MULTIMEDIA NETWORKING APPLICATIONS**	**9**
Streaming stored Audio and Video – Best effort service – protocols for real time interactive applications – Beyond best effort – scheduling and policing mechanism – integrated services –RSVP- differentiated services.		
UNIT-III	**ADVANCED NETWORKS CONCEPTS**	**9**
VPN-Remote-Access VPN, site-to-site VPN, Tunneling to PPP, Security in VPN.MPLS-operation, Routing, Tunneling and use of FEC, Traffic Engineering, MPLS based VPN, overlay networks-P2P connections.		
UNIT-IV	**TRAFFIC MODELLING**	**8**
Little's theorem, Need for modeling, Poisson modeling and its failure, Non- poisson models, Network performance evaluation.		
UNIT-V	**NETWORK SECURITY AND MANAGEMENT**	**10**
Principles of cryptography – Authentication – integrity – key distribution and certification – Access control and: fire walls – attacks and counter measures – security in many layers. Infrastructure for network management – The internet standard management framework – SMI, MIB, SNMP, Security and administration – ASN.1		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
●	Understand the basic concepts of TCP/IP and ISDN
●	Describe about multimedia networking
●	Analyze the security and tunneling methods of advanced networks.
●	Assign the suitable the traffic models for the given network layer
●	Manage network security

Reference Books(s) / Web links:	
1	J.F. Kurose & K.W. Ross,"Computer Networking- A top down approach featuring the internet", Pearson, 2nd edition, 2003.
2	Walrand .J. Varatya, High performance communication network, Morgan Kauffman – Harcourt Asia Pvt. Ltd. 2nd Edition, 2000.

3	LEOM-GarCIA, WIDJAJA, “Communication networks”, TMH seventh reprint 2002.
4	Aunuragkumar, D. MAnjunath, Joy kuri, “Communication Networking”, Morgan Kaufmann Publishers, 1Ed. 2004.
5	HersentGurle& petit, “IP Telephony, packet Pored Multimedia communication Systems”, Pearson education 2003.
6	Fred Halsall and Lingana Gouda Kulkarni,”Computer Networking and the Internet” fifth edition, Pearson education
7	Nader F.Mir, Computer and Communication Networks, first edition.
8	Larry l.Peterson& Bruce S.David, “Computer Networks: A System Approach”-1996

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	1	2	2
CO2	2	1	1	1	2	2
CO3	3	2	2	2	3	2
CO4	3	2	3	2	3	2
CO5	2	2	2	2	2	2
Average	**2.6**	**1.6**	**1.8**	**1.6**	**2.4**	**2**

PROFESSIONAL ELECTIVE -II

Subject Code	Subject Name	Category	L	T	P	C
CU19P21	**RF MEMS**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	To learn the basic building blocks of RF electronics and Its improved feature
●	To acquire knowledge on RF switches and various passive components.
●	To understand the concepts of RF filters and oscillators
●	To study the basics of MEMS phase shifters
●	To acquire knowledge on reliability and packaging.

UNIT-I	**INTRODUCTION OF RF MEMS**	**9**
Basic building blocks of RF system, RF MEMS Features- High Frequency effects, Introduction to Microwave Engineering, RF transmission lines: theory, Types of transmission lines, Impedance matching, S – parameters and ABCD Parameters, Smith Chart for Impedance matching.		
UNIT-II	**SWITCHES AND PASSIVE COMPONENTS**	**9**
Introduction, basic design, case studies, Micromachined passive components, theory, features, tunable capacitors, inductors, RF modeling of passive RF MEMS components. MEM switches: shunt MEM switch, low voltage hinged MEM switch, push-pull series switch, folded beam springs suspension series switch		
UNIT-III	**FILTERS AND OSCILLATORS**	**9**
Design concepts, Mechanical filters: design approaches, MEMS RF filters; Microwave filters: SAW and BAW filters, Micro machined tunable filter, RF MEMS Oscillators – fundamentals, Micromachined cavity oscillator, MEMS based voltage controlled oscillator.		
UNIT-IV	**PHASE SHIFTERS**	**9**
Introduction, RF MEMS Phase shifters, Design of switched delay line phase shifters Antennas: Introduction, Microstrip antennas, Micromachined antennas, Micromachined Transmission lines and components for sub millimeter wave applications, Reconfigurable antennas		
UNIT-V	**RELIABILITY AND PACKAGING**	**9**
MEMS packaging, RF MEMS packaging, Wafer level packaging.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
●	Understand various parameters of RF signals and their interpretation in MEMS.
●	Design passive RF MEMS components and switches
●	Optimize the design of RF MEMS oscillators and filters
●	Design and fabricate antennas using MEMS technology
●	Understand the significance of packaging for improved performance.
Reference Books(s) / Web links:	
1	Gabriel M. Rebeiz, RfMems: Theory, Design, And Technology, Wiley.
2	Vijay K.Varadan, K.J. Vinoy, K.A. Jose., "RF MEMS and their Applications", John Wiley and sons, LTD, 2002
3	Hector J. De Los Santos, "RF MEMS Circuit Design for Wireless Communications", Artech House, 2002.
4	Stepan Lucyszyn, Advanced RF MEMS (The Cambridge RF and Microwave Engineering Series)" Cambridge University Press, 2010, ISBN: 0521897718.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	1
CO2	2	3	2	3	2	1
CO3	2	3	3	3	2	1
CO4	2	2	2	2	2	1
CO5	2	2	2	2	3	3
Average	**2.2**	**2.6**	**2.2**	**2.6**	**2.2**	**1.4**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
CU19P22	**DIGITAL COMMUNICATION RECEIVERS**	**PE**	**3**	**0**	**0**	**3**

Objectives:		
●	To understand the basic communication techniques	
●	To gain knowledge about optimum receivers	
●	To know about channel fading and its effects	
●	To know various synchronization techniques	
●	To learn various adaptive channel equalization	
UNIT-I	**REVIEW OF DIGITAL COMMUNICATION TECHNIQUES**	**9**
Base band communication; signal space representation, linear and nonlinear modulation techniques, Error tracking and Spectral characteristics of digital modulation.		
UNIT-II	**OPTIMUM RECEIVERS FOR AWGN CHANNEL**	**9**
Correlation demodulator matched filter, maximum likelihood sequence detector, optimum receiver for CPM signals, M-ary orthogonal signals, envelope detectors for M-ary and correlated binary signals.		
UNIT-III	**RECEIVERS FOR FADING CHANNELS**	**9**
Characterization of fading multiple channels, statistical models, flat and frequency selective fading, diversity technique, Optimal receivers for data detection and synchronization parameter estimation, coded waveform for fading channel.		
UNIT-IV	**SYNCHRONIZATION TECHNIQUES**	**9**
Carrier and signal synchronization, carrier phase estimation-PLL, Decision directed loops, symbol timing estimation, maximum likelihood and non-decision directed timing estimation, joint estimation.		
UNIT-V	**VADAPTIVE EQUALIZATION**	**9**
Zero forcing algorithm, LMS algorithm, adaptive decision-feedback equalizer and Equalization of Trellis-coded signals. Kalman algorithm, blind equalizers and stochastic gradient algorithm.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
●	Students are enriched with the basics of baseband communication
●	Students are able to analyze the various receivers for AWGN channel.
●	Students are able to characterize the fading multiple channels
●	Students are able to know the various synchronization techniques
●	Students can able to design receivers

Reference Books(s) / Web links:	
1	Heinrich Meyer, Mare Moeneclacy, Stefan.A.Fechtel, " Digital communication receivers ", Vol I &Vol II, John Wiley, New York, 1997.
2	U.Mengali&A.N.D'Andrea, Synchronization Techniques for Digital Receivers, Kluwer, 1997.
3	John.G.Proakis, "Digital communication "4th Edition, McGraw-Hill, New York, 2001.
4	E.A.Lee and D.G. Messerschmitt, "Digital communication ", 2nd Edition, Allied Publishers, New Delhi, 1994.
5	Simon Marvin, "Digital communication over fading channel; An unified approach to performance Analysis ", John Wiley, New York, 2000.
6	H.Meyr&G.Ascheid, Synchronization in Digital Communications, John Wiley, 1990.
7	R. G. Gallager, Principles of Digital Communication, Cambridge University Press, 2008.

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	1	1	1
CO2	3	3	3	1	1	1
CO3	3	3	3	1	1	1
CO4	3	3	3	1	1	1
CO5	3	3	3	1	1	1
Average	**3**	**3**	**3**	**1**	**1**	**1**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
CU19P23	**COGNITIVE RADIO**	**PE**	**3**	**0**	**0**	**3**

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 become knowledgeable in 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	**INTRODUCTION TO SDR**	**9**
Definitions and potential benefits, software radio architecture evolution – foundations, technology trade-offs and architecture implications		
UNIT-II	**SDR ARCHITECTURE**	**9**
Essential functions of the software radio, architecture goals, quantifying degrees of programmability, top level component topology, computational properties of functional components, interface topologies among plug and play modules, architecture partitions.		
UNIT-III	**INTRODUCTION TO COGNITIVE RADIOS**	**9**
Making radio self-aware, the cognition cycle, organization of cognition tasks, structuring knowledge for cognition		

tasks, Enabling location and environment awareness in cognitive radios – concepts, architecture, design considerations.		
UNIT-IV	**COGNITIVE RADIO ARCHITECTURE**	**9**
Primary Cognitive Radio functions, Behaviors, Components, A–Priori Knowledge taxonomy, observe – phase data structures, Radio procedure knowledge encapsulation, components of orient, plan, decide phases, act phase knowledge representation, design rules.		
UNIT-V	**NEXT GENERATION WIRELESS NETWORKS**	**9**
The XG Network architecture, spectrum sensing, spectrum management, spectrum mobility, spectrum sharing, upper layer issues, cross – layer design.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
●	Understand the concepts of SDR.
●	Understand the various architectures of SDR.
●	Appreciate the motivation and the necessity for cognitive radio communication strategies.
●	Appreciate new techniques and demonstrate their feasibility using mathematical validations and simulation tools.
●	Demonstrate the impact of the evolved solutions in future wireless network design.

Reference Books(s) / Web links:	
1	Alexander M. Wyglinski, MaziarNekovee, And Y. Thomas Hou, "Cognitive Radio Communications and Networks - Principles and Practice", Elsevier Inc., 2010.
2	"E. Biglieri, A.J. Goldsmith. L.J. Greenstein, N.B. Mandayam, H.V. Poor, Principles ofCognitive Radio", Cambridge University Press, 2013.
3	Kwang-Cheng Chen and Ramjee Prasad, "Cognitive Radio Networks", John Wiley & Sons, Ltd, 2009.
4	Khattab, Ahmed, Perkins, Dmitri, Bayoumi, Magdy, "Cognitive Radio Networks - From Theory to Practice", Springer Series: Analog Circuits and Signal Processing, 2009.
5	J. Mitola, "Cognitive Radio: An Integrated Agent Architecture for software defined radio", PhD thesis, Royal Institute Technology, Sweden 2000.
6	Simon Haykin, "Cognitive Radio: Brain –empowered wireless communications", IEEE Journal on selected areas in communications, Feb 2005.
7	Ian F. Akyildiz, Won – Yeol Lee, Mehmet C. Vuran, ShantidevMohanty, " NeXt generation /dynamic spectrum access / cognitive radio wireless networks: A Survey Elsevier Computer Networks, May 2006.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	2	3	2	1
CO2	2	3	2	3	2	1
CO3	2	3	3	3	2	1
CO4	3	3	3	2	3	1
CO5	2	2	2	2	3	3
Average	**2.2**	**2.7**	**2.4**	**2.6**	**2.4**	**1.4**

Subject Code	Subject Name	Category	L	T	P	C
CU19P24	VLSI FOR WIRELESS COMMUNICATION	PE	3	0	0	3

Objectives:	
●	To understand the concepts of basic wireless communication concepts.
●	To study the parameters in receiver and low noise amplifier design.
●	To study the various types of mixers designed for wireless communication.
●	To study and design PLL and VCO.
●	To understand the concepts of VLSI architecture for multiplier and power amplifiers in wireless communication.

UNIT-I	COMMUNICATION CONCEPTS	9
Introduction – Overview of Wireless systems – Standards – Access Methods – Modulation schemes – Classical channel – Wireless channel description – Path loss – Multipath fading – Standard Translation		
UNIT-II	**RECEIVER ARCHITECTURE & LOW NOISE AMPLIFIERS**	**9**
Receiver front end – Filter design – Non-idealities – Design parameters – Noise figure & Input intercept point. LNA Introduction – Wideband LNA design – Narrow band LNA design: Impedance matching & Core amplifier.		
UNIT-III	**MIXERS**	**9**
Balancing Mixer - Qualitative Description of the Gilbert Mixer - Conversion Gain – Distortion – Noise - A Complete Active Mixer. Switching Mixer – Distortion, Conversion Gain & Noise in Unbalanced Switching Mixer - A Practical Unbalanced Switching Mixer. Sampling Mixer - Conversion Gain, Distortion, Intrinsic & Extrinsic Noise in Single Ended Sampling Mixer.		
UNIT-IV	**FREQUENCY SYNTHESIZERS**	**9**
PLL – Phase detector – Dividers – Voltage Controlled Oscillators – LC oscillators – Ring Oscillators – Phase noise – Loop filters & design approaches – A complete synthesizer design example (DECT) – Frequency synthesizer with fractional divider.		
UNIT-V	**IMPLEMENTATIONS & POWER AMPLIFIERS**	**9**
VLSI architecture for Multitier Wireless System - Hardware Design Issues for a Next generation CDMA System– Power amplifier design.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
●	Design LNA and Mixers
●	Evaluate frequency synthesizers
●	Design and analyze power amplifiers

Reference Books(s) / Web links:	
1	Bosco H Leung “VLSI for Wireless Communication”, Pearson Education, 2002.
2	B.Razavi ,”RF Microelectronics” , Prentice-Hall ,1998.
3	BehzadRazavi, “Design of Analog CMOS Integrated Circuits” McGraw-Hill, 1999.
4	Emad N Farag and Mohamed I Elmasry, “Mixed Signal VLSI wireless design – Circuits & Systems”, Kluwer Academic Publishers, 2000.
5	J. Crols and M. Steyaert, “CMOS Wireless Transceiver Design,” Boston, Kluwer Academic Pub., 1997.
6	Thomas H.Lee, “The Design of CMOS Radio – Frequency Integrated Circuits”, Cambridge University Press ,2003.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	2	1
CO2	3	3	3	3	3	2
CO3	3	3	3	3	2	1

CO4	3	3	3	3	3	2
CO5	3	3	3	3	3	2
Average	**3**	**3**	**2.8**	**2.8**	**2.6**	**1.6**

Subject Code	Subject Name	Category	L	T	P	C
CU19P25	**DIGITAL COMMUNICATION OVER FADING CHANNELS**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	To study and understand the wireless channels
●	To learn how to model the fading channels mathematically
●	To understand the coherent and non-coherent detections
●	To investigate the performance metrics of the digital communication
●	To derive the error rates of the wireless communication systems

UNIT-I	**FADING CHANNEL CHARACTERIZATION AND MODELING**	**9**
System Performance Measures: average SNR, outage probability, average bit error probability, amount of fading, average outage duration. Main characteristics of fading channels: Slow and fast fading, flat and frequency selective fading. Multipath modeling using Rayleigh, Nakagami-m, Rice distributions. Log normal Shadowing.		
UNIT-II	**COHERENT AND NON-COHERENT DETECTIONS**	**9**
Ideal Coherent Detection: M-ary Phase-Shift-Keying (M-PSK), Differentially Encoded M-ary Phase-Shift-Keying (M-PSK), π/4-QPSK, Offset QPSK (OQPSK) or Staggered QPSK (SQPSK), , Minimum-Shift-Keying (MSK) Non-ideal Coherent Detection, Non-Coherent Detection.		
UNIT-III	**USEFUL EXPRESSIONS FOR EVALUATING ERROR PERFORMANCE**	**9**
Integrals Involving the Gaussian Q-Function: Rayleigh Fading Channel, Nakagami-q (Hoyt), Nakagami-n (Rice) Integrals Involving the Incomplete Gamma Function: Rayleigh, Nakagami-n (Rice), Nakagami-m, Log-Normal Shadowing Channel Integrals Involving Other Functions: M-PSK Error Probability Integral, Rayleigh Fading Channel, Nakagami-m, Arbitrary Two-Dimensional Signal Constellation Error Probability Integral, Higher-Order Integer Powers of the Gaussian Q-Function. Rayleigh Fading Channel, Nakagami-m Fading Channel.		
UNIT-IV	**PERFORMANCE OF MULTICHANNEL RECEIVERS**	**9**
Diversity Combining: Diversity Concept, Mathematical Modeling, Brief Survey of Diversity Combining Techniques, Pure Combining Techniques, Hybrid Combining Techniques, Complexity–Performance Tradeoffs. Maximal-Ratio Combining (MRC): Receiver Structure, PDF-Based Approach, MGF-Based Approach: Average Bit Error Rate of Binary Signals, Average Symbol Error Rate of Square M-QAM Signals, Bounds and Asymptotic SER Expressions		
UNIT-V	**ANALYSIS OF SELECTION COMBINING AND SWITCHED DIVERSITY**	**9**
Selection Combining: MGF of Output SNR, Average Output SNR, Outage Probability and Analysis, Average Probability of Error, BDPSK and Non-Coherent BFSK, Coherent BPSK and BFSK. Switched Diversity: Dual-Branch Switch-and-Stay Combining (SSC), Performance of SSC over Independent Identically Distributed Branches, Effect of Branch Unbalance, Effect of Branch Correlation.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
●	Model the fading channel mathematically
●	Differentiate the coherent and non-coherent detections
●	Appreciate the various analytical tools used in the evaluation of wireless systems
●	Can derive performance metrics such as outage, error probability and capacity analysis
●	Understand the transmission of signals over signal antenna and multiple antennas

Reference Books(s) / Web links:	
1	M.K.Simon, M.-S. Alouini,"Digital Communication over Fading Channels" John Wiley &Sons Inc., 2nd Edition, 2000.
2	John Proakis, MasoudSalehi "Digital Communication", McGraw Hill Education, 5th Edition, 2014.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	2	2	1	2
CO5	3	3	2	3	2	2
Average	**3**	**3**	**2.6**	**2.8**	**1.8**	**2**

PROFESSIONAL ELECTIVE- III

Subject Code	Subject Name	Category	L	T	P	C
CU19P31	**SPEECH AND AUDIO SIGNAL PROCESSING**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	To study the basic concepts of speech and audio.
●	To study the analysis of various M-band filter banks for audio coding
●	To learn various transform coders for audio coding.
●	To study the speech processing methods in time and frequency domain

UNIT-I	**FUNDAMENTALS OF SPEECH AND AUDIO**	**9**

Introduction - Review of Signal Processing Theory-Speech production mechanism – Nature of Speech signal – Discrete time modeling of Speech production – Classification of Speech sounds – Phones – Phonemes – Phonetic and Phonemic alphabets – Articulatory features.

Absolute Threshold of Hearing - Critical Bands- Simultaneous Masking, Masking-Asymmetry, and the Spread of Masking- Non-simultaneous Masking - Perceptual Entropy - Basic measuring philosophy -Subjective versus objective perceptual testing - The perceptual audio quality measure (PAQM) - Cognitive effects in judging audio quality.

UNIT-II	**TIME AND FREQUENCY DOMAIN METHODS FOR SPEECH**	**9**

Time domain parameters of Speech signal – Methods for extracting the parameters: Energy, Average Magnitude – Zero crossing Rate – Silence Discrimination using ZCR and energy, Short Time Fourier analysis – Formant extraction – Pitch Extraction using time and frequency domain methods. Homomorphic Speech Analysis: Cepstral analysis of Speech – Formant and Pitch Estimation – Homomorphic Vocoder.

UNIT-III	**LINEAR PREDICTIVE ANALYSIS OF SPEECH**	**9**

Formulation of Linear Prediction problem in Time Domain – Basic Principle – Auto correlation method – Covariance method – Solution of LPC equations – Cholesky method – Durbin's Recursive algorithm – lattice formation and solutions – Comparison of different methods – Application of LPC parameters – Pitch detection using LPC parameters – Formant analysis – VELP – CELP.

UNIT-IV	**TIME-FREQUENCY ANALYSIS: FILTER BANKS AND TRANSFORMS**	**9**

Introduction -Analysis-Synthesis Framework for M-band Filter Banks- Filter Banks for Audio Coding: Design Considerations - Quadrature Mirror and Conjugate Quadrature Filters- Tree-Structured QMF and CQF M-band Banks - Cosine Modulated "Pseudo QMF" M-band Banks - Cosine Modulated Perfect Reconstruction (PR) M- band Banks and the Modified Discrete Cosine Transform (MDCT) - Discrete Fourier and Discrete Cosine Transform - Pre-echo Distortion- Pre-echo Control Strategies.

UNIT-V	**AUDIO CODING AND TRANSFORM CODERS**	**9**

Lossless Audio Coding-Lossy Audio Coding- ISO-MPEG-1A,2A,2A Advanced, 4AudioCoding - Optimum Coding in the Frequency Domain - Perceptual Transform Coder -Brandenburg-Johnston Hybrid Coder - CNET Coders - Adaptive Spectral Entropy Coding -Differential Perceptual Audio Coder - DFT Noise Substitution -DCT with Vector Quantization -MDCT with Vector Quantization.

	Total Contact Hours	**:**	**45**

Course Outcomes:

On completion of the course, students will be able to

- Model Speech production system and describe the fundamentals of speech
- Use different speech analysis technique
- Choose an appropriate audio coder
- Analyze the time and frequency domain methods for speech processing
- Design a speech processing system for study of articulatory phonetics

Reference Books(s) / Web links:

1. Digital Processing of Speech signals – L.R.Rabiner and R.W.Schaffer - Prentice Hall –1978.
2. Digital Audio Signal Processing, Second Edition, Udo Zölzer**,** A John Wiley& sons Ltd Publicatioons
3. Applications of Digital Signal Processing to Audio And Acoustics Mark Kahrs, Karlheinz Brandenburg, Kluwer Academic Publishers New York, Boston, Dordrecht, London , Moscow

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	2
CO2	3	3	3	3	3	2
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	2
CO5	2	2	2	2	2	2
Average	**2.8**	**2.8**	**2.6**	**2.6**	**2.6**	**2.2**

Subject Code	Subject Name	Category	L	T	P	C
CU19P32	**DIGITAL IMAGE AND VIDEO PROCESSING**	**PE**	**3**	**0**	**0**	**3**

Objectives:

- To know the digital image fundamentals and transforms
- To study various techniques for image enhancement and restoration.
- To learn various techniques for image segmentation and compression.
- To acquire the knowledge of extracting information from surveillance videos.
- To understand the models used for recognition Human Activity, Face and Gait.

UNIT-I	**DIGITAL IMAGE FUNDAMENTALS AND IMAGE ENHANCEMENT**	**9**
Steps in digital image processing, Elements of digital image processing systems and visual perception, brightness, contrast, hue, saturation, mach band effect, 2D image transforms-DFT, DCT, KLT, SVD.		
UNIT-II	**IMAGE ENHANCEMENT AND RESTORATION**	**9**
Spatial averaging, Directional Smoothing, Median, Geometric mean, Harmonic mean, Contra harmonic mean filters, Homomorphic filtering, Color image enhancement. Reasons for image degradation, Image degradation model, Inverse filter, Wiener filter		
UNIT-III	**IMAGE SEGMENTATION AND COMPRESSION**	**9**
Edge detection, Thresholding, Region based segmentation – Region growing, Region splitting and Merging. Need for data compression, Huffman, Run Length Encoding, Shift codes, Arithmetic coding, Transform coding, JPEG standard.		

UNIT-IV	VIDEO ANALYTICS	9
Introduction – Video Basics – Fundamentals for Video Surveillance, Object Detection and Tracking: Adaptive Background Modelling and Subtraction – Pedestrian Detection and Tracking, Vehicle Detection and Tracking – MPEG compression.		
UNIT	**HUMAN ACTIVITY, FACE AND GAIT RECOGNITION**	**9**
The framework for activity inference – Human Activity Recognition – Activity modeling using 3D shape, Video summarization – Suspicious Activity Detection – Human Face Recognition from video – Human Recognition using gait: HMM Framework for Gait Recognition.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
●	Describe digital image fundamentals and transforms.
●	Exhibit various image enhancement and restoration techniques.
●	Demonstrate various image segmentation and compression techniques.
●	Describe surveillance videos for analytics.
●	Model a framework for Human Activity, Face and Gait Recognition.

Text Book(s):	
1	Rafael C. Gonzalez, Richard E. Woods, , Digital Image Processing', Pearson , Second Edition, 2004.
2	Michael Berthold, David J.Hand, “Intelligent Data Analysis”, Springer, 2007.

Reference Books(s) / Web links:	
1	Anil K. Jain, Fundamentals of Digital Image Processing', Pearson 2002.
2	Rafael C. Gonzalez, Richard E. Woods, Steven Eddins,' Digital Image Processing using MATLAB', Pearson Education, Inc., 2004.
3	AnandRajaraman and Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
4	Yunqian Ma, Gang Qian, “Intelligent Video Surveillance: Systems and Technology”, CRC Press (Taylor and Francis Group), 2009
5	Rama Chellappa, Amit K.Roy– Chowdhury, Kevin Zhou.S, “Recognition of Humans and their Activities using Video”, Morgan & Claypool Publishers, 2005

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	2
CO2	3	3	3	2	2	2
CO3	3	3	3	2	2	2
CO4	3	3	3	2	2	3
CO5	3	3	3	2	3	3
Average	**3**	**3**	**3**	**2**	**2.2**	**2.4**

Subject Code	Subject Name	Category	L	T	P	C
CU19P33	**RADAR SIGNAL PROCESSING**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	To understand the Radar Signal acquisition and sampling in multiple domains
●	To provide clear instruction in radar DSP basics
●	To equip the skills needed in both design and analysis of common radar algorithms
●	To understand the basics of synthetic aperture imaging and adaptive array processing
●	To illustrate how theoretical results are derived and applied in practice

UNIT-I	**INTRODUCTION TO RADAR SYSTEMS**	**9**
History and application of radar, basic radar function, elements of pulsed radar, review of signal processing concepts and operations, A preview of basic radar signal processing, radar system components, advanced radar signal processing		
UNIT-II	**SIGNAL MODELS**	**9**
Components of a radar signal, amplitude models, types of clutters, noise model and signal-to-noise ratio, jamming, frequency models: the doppler shift, spatial models, spectral model		
UNIT-III	**SAMPLING AND QUANTIZATION OF PULSED RADAR SIGNALS**	**9**
Domains and criteria for sampling radar signals, Sampling in the fast time dimension, Sampling in slow time: selecting the pulse repetition interval, sampling the Doppler spectrum, Sampling in the spatial and angle dimension, Quantization, I/Q Imbalance and Digital I/Q		
UNIT-IV	**RADAR WAVEFORMS**	**9**
Introduction, waveform matched filter, Matched filtering of moving targets, The ambiguity function, The pulse burst waveform, frequency-modulated pulse compression waveforms, Range side lobe control for FM waveforms, the stepped frequency waveform, Phase-modulated pulse compression waveforms, COSTAS Frequency Codes.		
UNIT-V	**DOPPLER PROCESSING**	**9**
Alternate forms of the Doppler spectrum, Moving target indication (MTI), Pulse Doppler processing, dwell-to- dwell stagger, Pulse pair processing, additional Doppler processing issues, clutter mapping and the moving target detector, MTI for moving platforms: adaptive displaced phase centre antenna processing.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
●	Understand the concepts of radar processing
●	Analyze the various amplitude and frequency models
●	Outline the concepts of sampling and quantization
●	Analyze the various radar waveforms
●	Explain the processing of radar signal and its associated issues.

Reference Books(s) / Web links:	
1	Fundamentals of Radar Signal Processing, Mark A. Richards McGraw-Hill, New York, 2005
2	Principles of Radar and Sonar Signal Processing, Francois Le Chevalier, Artech House
3	systems, Peak Detection and Tracking, Michael O Kolawole ,2010,Elseveir
4	Introduction to Radar Systems 3/E, Skolnik, McGraw Hill.
5	Radar Principles, Peyton Z. Peebles, 2009 Wiley India
6	Radar Design Principles-Signal Processing and the environment, Fred E. Nathanson, PHI

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	3	3	3
CO2	3	3	3	2	2	2
CO3	3	3	3	3	3	2
CO4	3	3	3	3	3	2
CO5	3	3	3	2	2	2
Average	**3**	**3**	**3**	**2.6**	**2.6**	**2.2**

Subject Code	Subject Name	Category	L	T	P	C
CU19P34	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	PE	3	0	0	3

Objectives:	
●	To understand the basics of EMI
●	To acquire knowledge on EMI problems
●	To gain ideas on Solution methods in PCB
●	To learn Measurement technique for emission
●	To understand Measurement technique for immunity

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- Shielding Material-Shielding integrity at discontinuities, Filtering- Characteristics of Filters-Impedance and Lumped element filters-Telephone line filter, Power line filter design, Filter installation and Evaluation, Grounding-Measurement of Ground resistance-system grounding for EMI/EMC-Cable shielded grounding, Bonding, Isolation transformer, Transient suppressors, Cable routing, Signal control. EMI gaskets		
UNIT-IV	**EMC DESIGN OF PCBS**	**9**
EMI Suppression Cables-Absorptive, ribbon cables-Devices-Transient protection hybrid circuits ,Component selection and mounting; PCB trace impedance; Routing; Cross talk control Electromagnetic Pulse-Noise from relays and switches, 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. Frequency assignment - spectrum conversation. British VDE standards, Euro norms standards in japan - comparisons. EN Emission and Susceptibility standards and Specifications.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
●	Design a EMI free system
●	Demonstrate their acquired knowledge in reducing system level crosstalk
●	Design high speed Printed Circuit board with minimum interference
●	Make our world free from unwanted electromagnetic environment

Reference Books(s) / Web links:	
1	V.P.Kodali, “Engineering EMC Principles, Measurements and Technologies”, IEEE Press, Newyork, 1996.
2	Clayton R.Paul,” Introduction to Electromagnetic Compatibility”, John Wiley Publications, 2008
3	Henry W.Ott.,”Noise Reduction Techniques in Electronic Systems”, A Wiley Inter Science Publications, John Wiley and Sons, Newyork, 1988.
4	Bemhard Keiser, “Principles of Electromagnetic Compatibility”, 3rd Ed, Artech house, Norwood, 1986.
5	Don R.J.White Consultant Incorporate, “Handbook of EMI/EMC”, Vol I-V, 1988.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	-	1	2
CO2	3	2	1	1	1	2
CO3	3	3	3	3	3	1
CO4	3	3	3	3	3	2
CO5	3	3	3	3	3	2
Average	**3**	**2.6**	**2.5**	**2.5**	**2.2**	**1.8**

Subject Code	Subject Name	Category	L	T	P	C
CU19P35	**SOFT COMPUTING**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	To learn the key aspects of soft computing and neural networks.
●	To know about the components and building block hypothesis of Genetic algorithm.
●	To understand the features of neural network and its applications
●	To gain insight onto Neuro Fuzzy modeling and control.
●	To gain knowledge in machine learning through Support vector machines.

UNIT-I	**INTRODUCTION TO SOFT COMPUTING**	**9**
Evolution of Computing - Soft Computing Constituents – From Conventional AI to Computational Intelligence - Machine Learning Basics.		
UNIT-II	**NEURAL NETWORKS**	**9**
Machine Learning using Neural Network, Adaptive Networks – Feed Forward Networks– Supervised Learning Neural Networks – Radial Basis Function Networks - Reinforcement Learning – Unsupervised Learning Neural Networks – Adaptive Resonance Architectures –Advances in Neural Networks.		
UNIT-III	**GENETIC ALGORITHMS**	**9**
Introduction, Building block hypothesis, working principle, Basic operators and Terminologies like individual, gene, encoding, fitness function and reproduction, Genetic modeling: Significance of Genetic operators, Inheritance operator, cross over, inversion & deletion, mutation operator, Bitwise operator, GA optimization problems, JSPP (Job Shop Scheduling Problem), TSP (Travelling Salesman Problem),Differences & similarities between GA & other traditional methods, Applications of GA.		
UNIT-IV	**FUZZY LOGIC**	**9**
Fuzzy Sets – Operations on Fuzzy Sets – Fuzzy Relations – Membership Functions-Fuzzy Rules and Fuzzy Reasoning – Fuzzy Inference Systems – Fuzzy Expert Systems – Fuzzy Decision Making.		
UNIT-V	**NEURO-FUZZY MODELING**	**9**
Adaptive Neuro-Fuzzy Inference Systems – Coactive Neuro-Fuzzy Modeling – Classification and Regression Trees – Data Clustering Algorithms – Rule base Structure Identification – Neuro-Fuzzy Control – Case Studies.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
●	Understand machine learning through neural networks.
●	Remember various learning algorithm used in neural network.
●	Write Genetic Algorithm to solve the optimization problem
●	Apply fuzzy logic concepts for decision making
●	Analyze Neuro Fuzzy system for clustering and classification

Reference Books(s) / Web links:	
1	Jyh-Shing Roger Jang, Chuen-Tsai Sun, EijiMizutani, “Neuro-Fuzzy and Soft Computing”, Prentice-Hall of India, 2003.
2	KwangH.Lee, “First course on Fuzzy Theory and Applications”, Springer–Verlag Berlin Heidelberg, 2005.
3	George J. Klir and Bo Yuan, “Fuzzy Sets and Fuzzy Logic-Theory and Applications”, Prentice Hall, 1995.
4	James A. Freeman and David M. Skapura, “Neural Networks Algorithms, Applications, and Programming Techniques”, Pearson Edn., 2003.
5	David E. Goldberg, “Genetic Algorithms in Search, Optimization and Machine Learning”, Addison Wesley, 2007.
6	Mitsuo Gen and RunweiCheng,”Genetic Algorithms and Engineering Optimization”, Wiley Publishers 2000.
7	Mitchell Melanie, “An Introduction to Genetic Algorithm”, Prentice Hall, 1998.
8	S.N.Sivanandam, S.N.Deepa, “Introduction to Genetic Algorithms”, Springer, 2007.
9	Eiben and Smith “Introduction to Evolutionary Computing” Springer
10	E. Sanchez, T. Shibata, and L. A. Zadeh, Eds., "Genetic Algorithms and Fuzzy Logic Systems: Soft Computing Perspectives, Advances in Fuzzy Systems - Applications and Theory", Vol. 7, River Edge, World Scientific, 1997.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	3	2
CO2	1	3	3	2	3	2
CO3	1	3	3	2	1	1
CO4	1	2	3	2	1	-
CO5	1	2	3	2	1	-
Average	**1.4**	**2.4**	**2.6**	**2**	**1.8**	**1.7**

PROFESSIONAL ELECTIVE- IV

Subject Code	Subject Name	Category	L	T	P	C
CU19P41	**DETECTION AND ESTIMATION THEORY**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	To learn the usage of tools from probability and signal processing domains
●	To gain knowledge on detection of deterministic signals
●	To obtain optimum detector/estimator for an digital communication system
●	To learn the detection of random signals with unknown parameters
●	To identify the (error) performance bounds of any detector/estimator adopted in communication systems

UNIT-I	**STATISTICAL DECISION THEORY**	**9**
Bayesian, minimax, and Neyman-Pearson decision rules, likelihood ratio, receiver operating characteristics, composite hypothesis testing, locally optimum tests, detector comparison techniques, asymptotic relative efficiency.		
UNIT-II	**DETECTION OF DETERMINISTIC SIGNALS**	**9**
Matched filter detector and its performance; generalized matched filter; detection of sinusoid with unknown amplitude, phase, frequency and arrival time, linear model		
UNIT-III	**DETECTION OF RANDOM SIGNALS**	**9**
Estimator-correlator, linear model, general Gaussian detection, detection of Gaussian random signal with unknown parameters, weak signal detection.		

UNIT-IV	NONPARAMETRIC DETECTION	9
Detection in the absence of complete statistical description of observations, sign detector, Wilcoxon detector, detectors based on quantized observations, robustness of detectors.		
UNIT-V	**ESTIMATION OF SIGNAL PARAMETERS**	**9**
Minimum variance unbiased estimation, Fisher information matrix, Cramer-Rao bound, sufficient statistics, minimum statistics, complete statistics; linear models; best linear unbiased estimation; maximum likelihood estimation, invariance principle; estimation efficiency; Bayesian estimation: philosophy, nuisance parameters, risk functions, minimum mean square error estimation, maximum a posteriori estimation.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
●	State various detection problems in hypotheses testing framework
●	Describe various estimation algorithms for their error performance
●	Develop algorithms for various estimation problems
●	Design various sequential procedures for detection/estimation problems
●	Formulate algorithms for tracking

Reference Books(s) / Web links:	
1	H. L. Van Trees, "Detection, Estimation and Modulation Theory: Part I, II, and III", John Wiley, NY, 1968.
2	H. V. Poor, "An Introduction to Signal Detection and Estimation", Springer, 2/e, 1998.
3	S. M. Kay, "Fundamentals of Statistical Signal Processing: Estimation Theory", Prentice Hall PTR, 1993.
4	S. M. Kay, "Fundamentals of Statistical Signal Processing: Detection Theory", Prentice Hall PTR, 1998.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	3	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	2
Average	**3**	**3**	**3**	**2.8**	**2.6**	**2.2**

Subject Code	Subject Name	Category	L	T	P	C
CU19P42	**INTERNETWORKING MULTIMEDIA**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	To discuss the various multimedia standards
●	To understand the different broadband technologies
●	To analyze the transport protocols and its applications
●	To study various multimedia communication standards
●	To analyze multimedia across Wireless Network

UNIT-I	MULTIMEDIA NETWORKING	9
Digital Sound, Video and Graphics – Basic Multimedia Networking – Multimedia Characteristics – Evolution of Internet Services Model – Network Requirements for Audio/ Video Transform – Multimedia Coding and Compression for Text, Image Audio And Video.		
UNIT-II	**BROADBAND NETWORK TECHNOLOGY**	**9**

Broadband Services – ATM and IP, IPV6, High Speed Switching – Resource Reservation, Buffer Management – Traffic Shaping – Caching – Scheduling and Policing, Throughput, Delay and Jitter Performance – Storage and Media Services – Voice and Video Over IP – MPEG–2 over ATM/IP – Indexing Synchronization of Requests – Recording and Remote Control.		
UNIT-III	**RELIABLE TRANSPORT PROTOCOL AND APPLICATIONS**	**9**
Multicast over Shared Media Network – Multicast Routing and Addressing – Scaling Multicast and NBMA Networks – Reliable Transport Protocols – TCP Adaptation Algorithm – RTP, RTCP – MIME – Peer–to–Peer Computing – Shared Application – Video Conferencing, Centralized and Distributed Conference Control – Distributed Virtual Reality – Light Weight Session Philosophy		
UNIT-IV	**MULTIMEDIA COMMUNICATION STANDARDS**	**9**
Objective of MPEG – 7 Standard – Functionalities and Systems of MPEG–7 MPEG–21 Multimedia Framework Architecture – Content Representation – Content Management and Usage – Intellectual Property Management – Audio Visual System – H322: Guaranteed QOS LAN Systems – MPEG_4 Video Transport across Internet.		
UNIT-V	**MULTIMEDIA COMMUNICATION ACROSS NETWORKS**	**9**
Packet Audio/Video in The Network Environment –Video Transport across Generic Networks – Layered Video Coding– Error Resilient Video Coding Techniques – Scalable Rate Control – Streaming Video Across Internet – Multimedia Transport Across ATM Networks and IP Network – Multimedia Across Wireless Networks.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
●	Apply various communication standards in multimedia communication
●	Utilize different networks for multimedia communication
●	Understand Broadband Network technology
●	Improve different protocols for efficient communication.
●	Address various multimedia communication standards

Reference Books(s) / Web links:	
1	B O Szuprowicz, “Multimedia Networking”, McGraw Hill, Newyork, 1995.
2	K R Rao, Zoran S, Bojkovic and Dragorad A, Milovanovic “Multimedia communication systems”, PHI, 2003.
3	Jon Crowcroft, Mark Handley, Ian Wakeman “Internetworking Multimedia” Harcourt, Singapore, 1998.
4	Tay Vaughan,“Multimedia Making it to work”, 4th edition Tata McGraw Hill, NewDelhi, 2000.

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	3	2
CO5	3	3	3	3	3	2
Average	**3**	**3**	**3**	**2.8**	**2.4**	**2**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
CU19P43	**MILLIMETER WAVE COMMUNICATION**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	To understand the fundamentals of Millimeter wave devices and circuits.
●	To understand the various components of Millimeter wave Communications system.
●	To know the antenna design at Millimeter wave frequencies.

UNIT-I	INTRODUCTION	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-II	**MM WAVE DEVICES AND CIRCUITS**	**9**
Millimeter wave generation and amplification: Peniotrons, Ubitrons, Gyrotrons and Free electron lasers. HEMT, models for mm wave Transistors, transistor configurations, Analog mm wave components: Amplifiers, Mixers, VCO, PLL. Metrics for analog mm wave devices, Consumption factor theory, Trends and architectures for mm wave wireless, ADC's and DAC's.		
UNIT-III	**MM WAVE 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-IV	**MM WAVE 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.		
UNIT-V	**ANTENNAS FOR MM WAVE SYSTEMS**	**9**
Antenna beamwidth, polarization, advanced beam steering and beam forming, mm wave design consideration, On-chip and In package mm wave antennas, Techniques to improve gain of on-chip antennas, Implementation for mm wave in adaptive antenna arrays, Device to Device communications over 5G systems, Design techniques of 5G mobile.		
	Total Contact Hours : 45	

Course Outcomes:

On completion of the course, students will be able to

- Understand the basic concepts of Millimeter wave devices and circuits
- Analyze the Millimeter wave devices for various applications
- Design antenna for Millimeter wave frequencies
- Assess Knowledge of Millimeter wave technology.
- Implementation of mm wave in adaptive antenna arrays

Reference Books(s) / Web links:

1	K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, March 2011.
2	Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock, "Millimeter Wave Wireless Communication", Prentice Hall, 2014. 3. Xiang, W; Zheng, K; Shen, X.S; "5G Mobile Communications: Springer, 2016.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	1
CO2	3	3	3	1	2	1
CO3	3	3	3	2	1	2
CO4	3	3	3	2	1	2
CO5	3	3	3	2	1	1
Average	**3**	**3**	**3**	**1.8**	**1.4**	**1.4**

Subject Code	Subject Name	Category	L	T	P	C
CU19P44	COMMUNICATION NETWORK SECURITY	PE	3	0	0	3

Objectives:	
●	To introduce the concept of classical encryption techniques
●	To understand the various cryptographic techniques
●	To introduce the fundamental concept of public key encryption and hash functions
●	To introduce IP security
●	To learn the concept of security attacks and recent trends in wireless network security

UNIT-I	DATA ENCRYPTION STANDARD	9
Services – Mechanisms and Attacks – OSI security Architecture – Model for Network Security – Classical Encryption Techniques – Symmetric Cipher Model – Substitution Techniques – Transposition Techniques – Rotor Machines– Stenography – Block Ciphers and Data Encryption Standard – Simplified DES – Block Cipher Principles, Data Encryption Standard – Strength of DES– Differential and Linear Crypt Analysis, Block Cipher Design Principles – Block Cipher Modes of Operation.		
UNIT-II	**ADVANCED ENCRYPTION STANDARD**	**9**
Advanced Encryption Standard – Evaluation Criteria for AES, AES Cipher– Contemporary Symmetric Ciphers – Triple DES, Blowfish, RC5 – Characteristics of Advanced Symmetric Block Ciphers – RC4 Stream Cipher – Confidentiality using Symmetric Encryption – Placement of Encryption Function – Traffic Confidentiality – Key Distribution and Random Number Generation.		
UNIT-III	**PUBLIC KEY ENCRYPTION AND HASH FUNCTIONS**	**9**
Public Key Cryptography and RSA – Principles of Public Key Cryptosystems – RSA Algorithm – Key Management and other public key cryptosystems – Key Management– Diffie–Hellman Key Exchange – Elliptic Curve Arithmetic – Elliptic Curve Cryptography – Message Authentication and Hash Functions – Authentication Requirements – Authentication Functions – Message Authentication Codes – Hash Functions and MACs; Hash Algorithms – MD5 Message Digest Algorithm, Secure Hash Algorithm RIPEMD 160, HMAC– Digital Signatures and Authentication Protocols – Digital Signature Standards.		
UNIT-IV	**NETWORK SECURITY PRACTICE**	**9**
Authentication Applications – Kerberos – X.509 Authentication Service– Electronic Mail Security, Pretty Good Privacy – S/MIME– IP Security – IP Security Overview– IP Security Architecture, Authentication Header – Encapsulating Security Payload – Combining Security Associations –Web Security – Web Security Considerations – Secure Sockets Layer and Transport Layer, Security – Secure Electronic Transaction.		
UNIT-V	**WIRELESS NETWORK SECURITY**	**9**
Security Attack issues specific to Wireless systems: Worm hole, Tunnelling, DoS. WEP for Wi-Fi network, Security for 4G networks: Secure Ad hoc Network, Secure Sensor Network.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
●	Apply public key crypto system and analyze with the applications.
●	Apply authentication protocols and web security methods.
●	Address the basic issues and challenges in wireless networks.
●	Address various Security attacks issues.
●	Familiar with IP security.

Reference Books(s) / Web links:	
1	William Stallings, "Network Security Essentials", 2nd edition, Prentice Hall of India New Delhi, 2004.
2	Charlie Kaufman, "Network Security Private Communication in Public World" 2nd edition, Prentice Hall of India New Delhi, 2004.
3	William Stallings, "Cryptography and Network Security", 3rd edition, Prentice Hall of India, New Delhi, 2004.
4	R.K.Nichols and P.C. Lekkas ," Wireless Security" McGraw Hill 2002.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	3	1
CO2	3	3	3	3	3	2
CO3	3	3	2	2	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	3	2
Average	**3**	**3**	**2.6**	**2.8**	**2.6**	**1.8**

Subject Code	Subject Name	Category	L	T	P	C
CU19P45	**INTERNET OF THINGS**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	To understand the fundamentals of Internet of Things
●	To learn about IoT Architecture
●	To learn about the basics of IOT protocols
●	To build a small low cost embedded system using Raspberry Pi.
●	To apply the concept of Internet of Things in the real world scenario.

UNIT-I	**INTRODUCTION TO IoT**	**9**
Internet of Things - Physical Design- Logical Design- IoT Enabling Technologies - IoT Levels & Deployment Templates - Domain Specific IoTs - IoT and M2M - IoT System Management with NETCONF-YANG- IoT Platforms Design Methodology		
UNIT-II	**IoT ARCHITECTURE**	**9**
M2M high-level ETSI architecture - IETF architecture for IoT - OGC architecture - IoT reference model - Domain model - information model - functional model - communication model - IoT reference architecture		
UNIT-III	**IoT PROTOCOLS**	**9**
Protocol Standardization for IoT – Efforts – M2M and WSN Protocols – SCADA and RFID Protocols – Unified Data Standards – Protocols – IEEE 802.15.4 – BACNet Protocol – Modbus– Zigbee Architecture – Network layer – 6LowPAN - CoAP - Security		
UNIT-IV	**BUILDING IoT WITH RASPBERRY PI & ARDUINO**	**9**
Building IOT with RASPERRY PI- IoT Systems - Logical Design using Python – IoT Physical Devices & Endpoints - IoT Device -Building blocks -Raspberry Pi -Board - Linux on Raspberry Pi - Raspberry Pi Interfaces -Programming Raspberry Pi with Python - Other IoT Platforms - Arduino.		
UNIT-V	**CASE STUDIES AND REAL-WORLD APPLICATIONS**	**9**
Real world design constraints - Applications - Asset management, Industrial automation, smart grid, Commercial building automation, Smart cities - participatory sensing - Data Analytics for IoT – Software & Management Tools for IoT Cloud Storage Models & Communication APIs - Cloud for IoT - Amazon Web Services for IoT.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
●	Analyze various protocols for IoT
●	Develop web services to access/control IoT devices.
●	Design a portable IoT using Raspberry Pi
●	Deploy an IoT application and connect to the cloud.
●	Analyze applications of IoT in real time scenario

Reference Books(s) / Web links:	
1	ArshdeepBahga, Vijay Madisetti, “Internet of Things – A hands-on approach”, Universities Press, 2015
2	Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), “Architecting the Internet of Things”, Springer, 2011.
3	Honbo Zhou, “The Internet of Things in the Cloud: A Middleware Perspective”, CRC Press, 2012.
4	Jan Ho¨ ller, VlasiosTsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014.
5	Olivier Hersent, David Boswarthick, Omar Elloumi , “The Internet of Things – Key applications and Protocols”, Wiley, 2012.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	2	2
CO2	3	3	3	2	2	2
CO3	3	3	2	2	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	3	2
Average	**3**	**3**	**2.6**	**2.4**	**2.2**	**2**