NOORUL ISLAM CENTRE FOR HIGHER EDUCATION

(Deemed to be University Under Section 3 of the UGC Act, 1956)
Kumaracoil, Thuckalay

DEPARTMENT OF

ELECTRONICS AND COMMUNICATION ENGINEERING

M.E. COMMUNICATION SYSTEMS

CURRICULUM AND SYLLABI

REGULATION 2023

NOORUL ISLAM CENTRE FOR HIGHER EDUCATION, Kumaracoil

Regulation : 2023

Curriculum and Syllabi

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

M.E. COMMUNICATION SYSTEMS

Vision of the University

To be recognized by the Government and society at large as an institution able to deliver excellence with relevance in the field of higher education and research focusing on the needs of the nation in tune with the technological revolution to cope with the knowledge explosion and global competence.

Mission of the University

To develop the institution as a Centre of Excellence, keeping pace with the advances in the field, so as to provide quality higher education to the students and instill in them high standards of discipline and ethics so that they become enlightened individuals in the service of humanity and to carry out focused research in the frontier areas of science and technology.

Faculty of Electrical and Electronics Engineering

Department of Electronics and Communication Engineering

Vision of the Department

To impart the students of Electronics and Communication Engineering Department the latest technical knowledge, professional excellence and social responsibility.

Mission of the Department

- To attain academic excellence in Electronics and Communication Engineering through commitment in duty, innovation in learning and research.
- To establish a suitable environment for the students to develop professionalism and face life challenges with ethical integrity.
- To develop the students to understand the societal needs and equip them with technical expertise to provide the necessary solutions

Description of the programme

A Master of Engineering (M.E.) program in Communication Systems typically focuses on advanced studies in the design, analysis, and optimization of communication systems and networks. In the present scenario of Information & Communication Technology, Communication Engineering is of vital importance for any society. The communication revolution has led the whole world being global village concept. The prominent domains covered in this programme are Modern Digital Communication Techniques, Advanced Digital Signal Processing, Advanced Microwave Communication, Optical Communication & Networking, Wireless Communication and Networks, Cryptography & Network Security, Antenna Theory & Design, Image processing and Multimedia Compression Techniques.

Graduates of M.E. program in Communication Systems are well-equipped for careers in various industries, including telecommunications companies, wireless network providers, satellite communications firms, research and development organizations, and government agencies. They may work as communication engineers, network architects, systems analysts, or research scientists, among other roles.

Overall, an M.E. program in Communication Systems provides students with a solid foundation in both theoretical principles and practical skills necessary to design, analyze, and optimize communication systems in today's rapidly evolving technological landscape.

Programme Educational Objectives - PEO	
PEO-01	To equip the graduates to apply the knowledge of mathematics and science in Communication system design and related fields for professional achievement in industry, and research and development organizations.
PEO-02	To have the ability and attitude to adapt to technological changes in the related areas of Communication System.
PEO-03	To have the ability to identify and analyze social problems and provide optimal technological solutions in cost effective manner.
PEO-04	To exhibit their innovative ideas in multidisciplinary areas of communication system to meet the day to day technical challenges.

PEO-05	To exhibit a desire for life long learning through technical training and professional activities.
PEO-06	To inculcate a strong favour of research activities among the students and impart them with good scientific and engineering depth including proficiency in hardware and software.
PEO-07	To inculcate in students the finest professional attributes, ethics, a positive attitude, effective communication and presentation skills, ownership, responsibility and accountability
PEO-08	To prepare the students for successful and productive career choices in both public and private sectors in the field of communication system.
PEO-09	To equip the students by imparting professional development courses and industrial trainings, preparing students to crack various national level competitive examinations like GATE, IES, etc.
PEO-10	To provide students with an academic environment that ignites in one the spirit of excellence, develop the urge of discovery, creativity, inventiveness, and a passion to be the best by providing state-of-the-art facility

Graduate Attributes-	
GA-1	**Advanced Engineering Expertise** Master advanced engineering principles and apply them to design, analyze, and innovate systems that address both present and emerging global challenges across diverse industries.
GA-2	**Leadership in Research and Innovation** Lead groundbreaking research and foster innovation by identifying opportunities for technological advancements, contributing original ideas that push the boundaries of engineering knowledge.
GA-3	**Sustainable Engineering Practices** Develop and implement engineering solutions that integrate sustainability, environmental stewardship, and resource efficiency, ensuring the long-term impact and responsibility of all projects.
GA-4	**Ethical and Strategic Decision-Making** Make informed, ethical decisions in complex engineering contexts, considering societal needs, environmental implications, and the long-term consequences of engineering practices.
GA-5	**Global Competence in Engineering Solutions** Exhibit a deep understanding of global engineering standards and practices, addressing international challenges and cultural sensitivities in engineering projects to make a broader societal impact.

GA-6	**Technological Agility and Lifelong Learning** Stay ahead of technological trends and exhibit agility in learning new tools, methodologies, and technologies, ensuring continuous professional growth in a rapidly evolving engineering landscape.
GA-7	**Interdisciplinary and Collaborative Innovation** Excel in multidisciplinary collaborations, leveraging knowledge from multiple fields to solve complex, large-scale engineering problems that require comprehensive and innovative solutions.
GA-8	**Data-Driven Decision Making** Employ advanced data analytics, machine learning, and computational tools to derive insights and make informed engineering decisions that
GA-9	**Entrepreneurial Mindset and Innovation Leadership** Cultivate an entrepreneurial mindset, translating engineering innovations into viable products, solutions, or services, and leading teams toward commercialization and societal impact.
GA-10	**Safety, Risk, and Crisis Management** Implement and manage advanced safety protocols and risk mitigation strategies to protect individuals, communities, and ecosystems in engineering practices, particularly in high-stakes and crisis environments.

Programme Outcome - PO	
PO-A	To acquire in-depth knowledge of various aspects of communication systems namely satellite communication, mobile networks and sensor networks in wider and global perspective with an ability to evaluate and analyze and synthesize the
PO-B	To identify, formulate and analyze complex problems in modern communication system and apply the acquired knowledge for research in a wider theoretical and practical context.
PO-C	To design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health, safety, manufacturability and sustainability.
P0-D	To apply techniques, skills, and modern engineering tools necessary for engineering practice
PO-E	To develop and model complex Communication hardware and software systems for human needs.
PO-F	To comprehend the impact of engineering solutions in a global, economic, environmental, and societal context
PO-G	To train the students to get employability in private and public sectors

Mapping of Graduate Attributes and Programme Educational Objectives(PEO)

GAs / PEOs	G A-01	GA-02	GA-03	GA-04	GA-05	GA-06	GA-07	GA-08	GA-09	GA-10
PEO-01	H	H	H	H	H	H	Not	A	A	A
PEO-02	H	H	H	H	H	H	Not	A	A	A
PEO-03	H	H	H	H	H	H	A	A	H	H
PE0-04	H	H	H	H	H	H	H	H	H	A
PEO-05	H	H	H	H	H	H	A	H	H	H
PEO-06	H	H	H	H	H	H	A	H	H	Not
PEO-07	H	H	H	H	H	H	H	H	H	H
PEO-08	H	H	H	H	H	H	Not	A	A	A
PEO-09	H	H	H	H	H	H	Not	A	A	A
PEO-10	H	H	H	H	H	H	A	A	H	H

H- Highly Associated A- Associated Not – Not Associated

Mapping of Graduate Attributes and Programme Outcomes (PO)

GAs / PEOs	G A-01	GA-02	GA-03	GA-04	GA-05	GA-06	GA-07	GA-08	GA-09	GA-10
PO-A	H	H	H	H	H	H	Not	A	A	A
PO-B	H	H	H	H	H	H	Not	A	A	A
PO-C	H	H	H	H	H	H	A	A	H	H
P0-D	H	H	H	H	H	H	H	H	H	A
PO-E	H	H	H	H	H	H	A	H	H	Not
PO-F	H	H	H	H	H	H	A	H	H	Not
PO-G	H	H	H	H	H	H	H	H	H	H

H- Highly Associated A- Associated Not – Not Associated

Mapping of Programme Educational Objective (PEOs) and Programme Outcomes (POs)

PEO / PO	PEO-01	PEO-02	PEO-03	PEO-04	PEO-05	PEO-06	PEO-07	PEO-08	PEO-09	PEO-10
PO-A	H	H	H	A	Not	A	Not	A	A	A
PO-B	H	H	H	H	Not	H	Not	Not	A	A
PO-C	H	H	H	H	H	H	H	A	Not	A
P0-D	H	H	H	H	H	H	H	H	Not	H
PO-E	H	H	H	H	H	H	A	H	Not	H
PO-F	H	H	H	H	H	H	H	H	Not	H
PO-G	H	H	H	H	H	H	H	H	Not	H

H- Highly Associated A- Associated Not – Not Associated

Duration of the programme: Years/Semesters (II / IV)

Total credit : 66

CURRICULUM & SYLLABI

SEMESTER I

Sl. No	Course Code	Course Title	L	T	P	C
THEORY						
1.	MA4501	Advanced Mathematics	3	1	0	4
2.	OE45D1	Research Methodology and IPR	2	0	0	2
3.	EC4501	Advanced Radiation Systems	3	0	0	3
4.	EC4502	Modern Digital Communication Techniques	3	0	0	3
5.	EC4503	Advanced Digital Signal Processing	3	0	0	3
6.	EC45**	Programme Elective-I	3	0	0	3
PRACTICAL						
7.	EC4571	Communication Systems Lab-I	0	0	2	1
TOTAL			**17**	**1**	**2**	**19**

SEMESTER II

Sl. No	Course Code	Course Title	L	T	P	C
THEORY						
1.	EC4504	Wireless Communication Engineering	3	0	0	3
2.	EC4505	Multimedia Compression Techniques	3	0	0	3
3.	EC4506	Microwave Integrated Circuits	3	0	0	3
4.	EC4507	Satellite Communication and Applications	3	0	0	3
5.	EC45**	Programme Elective-II	3	0	0	3
6.	EC45**	Programme Elective-III	3	0	0	3

PRACTICAL						
7.	EC4572	Communication Systems Lab-II	0	0	2	1
TOTAL			**18**	**0**	**2**	**19**

SEMESTER III

Sl. No	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
THEORY						
1.	EC45**	Programme Elective-IV	3	0	0	3
2.	XXXXXX	Open Elective-I	3	0	0	3
PRACTICAL						
7.	EC45P1	Project Work – Phase I	0	0	12	6
TOTAL			**6**	**0**	**12**	**12**

SEMESTER IV

Sl. No	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
PRACTICAL						
1.	EC45P5	Project Work – Phase II	0	0	32	16
TOTAL			0	0	**32**	**16**

LIST OF PROGRAM ELECTIVES

Sl. No.	Course Code	COURSE TITLE	L	T	P	C
1	EC45A1	Wavelets and Multiresolution Processing	3	0	0	3
2	EC45A2	Software Defined Radio	3	0	0	3
3	EC45A3	Communication Network Security	3	0	0	3
4	EC45A4	Optical Communication Networks	3	0	0	3
5	EC45A5	Simulation Of Communication Systems & Networks	3	0	0	3
6	EC45A6	Global Positioning Systems	3	0	0	3
7	EC45A7	High Speed Switching Architecture	3	0	0	3
8	EC45A8	RF System Design	3	0	0	3
9	EC45A9	Digital Image Processing and Applications	3	0	0	3
10	EC45B1	High Performance Communication Networks	3	0	0	3
11	EC45B2	Millimeter wave communication	3	0	0	3
12	EC45B3	VLSI for Wireless Communication	3	0	0	3
13	EC45B4	Information Theory and Coding	3	0	0	3
14	EC45B5	Smart antennas	3	0	0	3
15	EC45B6	Wireless Adhoc And Sensor Networks	3	0	0	3
16	EC45B7	RADAR Signal Processing	3	0	0	3
17	EC45B8	Internet of Things	3	0	0	3
18	EC45B9	Co-Operative Communications	3	0	0	3
19	EC45C1	Machine learning and Deep learning Techniques	3	0	0	3
20	EC45C2	Fundamental of Soft Computing Techniques	3	0	0	3
21	EC45C3	Medical Image Processing	3	0	0	3
22	EC45C4	Speech Processing	3	0	0	3

LIST OF OPEN ELECTIVES

Sl.No	SUBJECT CODE	SUBJECT NAME	L	T	P	C
1.	OE45D1	Research Methodology and IPR	2	0	0	2
2.	OE45D2	Business Analytics	3	0	0	3
3.	OE45D3	Industrial Safety	3	0	0	3
4.	OE45D4	Operations Research	3	0	0	3
5.	OE45D5	Composite Materials	3	0	0	3
6.	OE45D6	Waste to Energy	3	0	0	3

Syllabus

SEMESTER I

Sl. No	Course Code	Course Title	L	T	P	C
THEORY						
1.	MA4501	Advanced Mathematics	3	1	0	4
2.	OE45D1	Research Methodology and IPR	2	0	0	2
3.	EC4501	Advanced Radiation Systems	3	0	0	3
4.	EC4502	Modern Digital Communication Techniques	3	0	0	3
5.	EC4503	Advanced Digital Signal Processing	3	0	0	3
6.	EC45**	Programme Elective-I	3	0	0	3
PRACTICAL						
7.	EC4571	Communication Systems Lab-I	0	0	2	1
TOTAL			**17**	**1**	**2**	**19**

MA4501	**Advanced Mathematics**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**

OBJECTIVES

The course objective is, the students will be able to apply various methods in Linear Algebra to solve the system of linear equations, use two-dimensional random variables, and correlations in solving application problems apply the ideas of Random Processes and understand the basic characteristic features of a queueing system and acquire skills in analyzing queueing models.

Course Outcome		Cognitive Skill
CO-01	Compute various methods in Linear Algebra to solve the system of linear equations. Using generalized eigenvectors, find the inverse of a singular matrix using the Pseudo inverse method.	R,U,A,E, An
CO-02	Formulate real-life problems and solve them using Linear Programming. Minimize the cost of distributing a product from many sources using TP. Assign a job to some workers so that the jobs are completed at the least cost or time.	R, U, A, E, An
CO-03	The random variable needs the analysis of random phenomena. Apply the concept of the moment, moment generating function. Extended one-dimensional random variables to two-dimensional random variables and analyze. Understand the concept of correlation	R, U, A, E, An
CO-04	Know the concepts which describe the random wave transforms in a probabilistic sense.Trace the nature of random signals.Analyze the random signals in the frequency domain	R, U, A, E, An
CO-05	To understand the basic characteristic features of a queuing system and acquire skills in analyzing queuing models.	R, U, A, E, An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	M	M	L	M	M
CO-02	S	S	M	M	L	M	M
CO-03	S	S	M	M	L	M	M
CO-04	S	S	M	M	L	M	M
CO-05	S	S	M	M	L	M	M

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: Linear Algebra **9**

Vector spaces – Norms – Inner products – Eigenvalues using QR transformations — Generalized eigenvectors – Jordan Canonical forms – Singular value decomposition and applications – Pseudo inverse

UNIT II: Linear Programming **9**

Formulation – Graphical solution – Simplex method: Big M Method– Transportation problems – Assignment models.

UNIT III: Probability and Random Variables **9**

Probability Concepts – Axioms of probability – Conditional probability – Random variables – Probability functions – Two-dimensional random variables – Joint distributions – Marginal and conditional distributions – Correlation.

UNIT IV: Random Processes **9**

Classification – Stationary random processes – Ergodic process - The autocorrelation – Cross Correlations – Properties - Power spectral density, Cross Power spectral density.

UNIT V: Queuing Theory **9**

Birth and Death process - Markovian queuing models – Little's formulae - M/M/1, M/M/C finite and infinite capacity (steady state solutions only).

TOTAL: 45+15=60 HOURS

REFERENCES:

1. Friedberg A.H, Insel A.J. and Spence L, "Linear Algebra", Prentice Hall of India, New Delhi, 2004.
2. Taha, H.A., "Operations Research – An Introduction", Sixth Edition, Prentice-Hall of India, New Delhi.
3. Gupta, P.K. and Hira, D.S., "Operations Research", S.Chand& Co. New Delhi.
4. Peebles Jr., P.Z., "Probability, Random Variables and Random Signal Principles", McGraw-Hill Inc.
5. Gross, D., Shortie, J.F., Thompson, J.M and Harris, C.M., "Fundamentals of Queueing Theory", 4th Edition, Wiley,2014.

EC4501	**Advanced Radiation Systems**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- To study radiation from a wire antennas.
- To design the antenna and antenna arrays for various radiation pattern characteristics.
- To study the radiation of aperture antennas.
- To study the radiation characteristics of microstrip and reflector antennas.
- To learn special antennas for wireless applications.

Course Outcome		**Cognitive Skill**
CO-01	Familiar with the fundamental of radiation and its characteristics from wire antennas	R
CO-02	Able to design of uniform and non-uniform amplitude arrays	A, An

CO-03	Understand the concept of apertures and radiation from various aperture antenna.	U
CO-04	Knowledge about the various microstrip and reflector antennas.	A
CO-05	Familiar with radiation from smart antennas and antenna measurements.	E

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	S	M	L
CO-02	S	S	S	M	M	L	S
CO-03	S	M	S	S	M	S	L
CO-04	S	S	M	S	M	L	M
CO-05	S	S	M	M	S	L	S

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: Concepts of Radiation and Wire Antennas **9**

Retarded vector potentials – Heuristic approach and Maxwell's equation approach. The Lorentz gauge condition. Vector potential in Phasor form. Fields radiated by an alternating current element.. Radiation from Half wave dipole from assumed current distribution. Loop antennas and radiation fields.

UNIT II: Antenna Arrays **9**

Two-Element Array, *N*-Element Linear Array: Uniform Amplitude and Spacing, *N*-Element Linear Array: Directivity, *N*-Element Linear Array: Uniform Spacing, Non uniform Amplitude, Superdirectivity, Planar Array , Circular Array

UNIT III: Aperture Antennas **9**

Field equivalence principle, Radiation from Rectangular and Circular apertures, Uniform aperture distribution on an infinite ground plane; Slot antenna; Horn antenna -E Plane, H Plane and Pyramidal Horns, Lens antenna.

UNIT IV: Microstrip and Reflector Antennas **9**

Radiation mechanism from patch; Excitation techniques; Rectangular patch, Circular patch, and Ring antenna – radiation analysis from transmission line model, cavity model, Applications of microstrip array antenna. Reflector Antennas,Plane Reflector, Corner Reflector, Parabolic Reflector, Spherical Reflector, Feed Antennas for Reflectors.

UNIT V: Special Antennas and Measurements **9**

Satellite Terminal Antennas , Base Station Antennas , Mobile Terminal Antennas, Smart Antennas , Adaptive and Spatial Filtering Antennas ,wearable antennas, Vivaldi antennas,Pattern Measurement and Antenna Ranges , Gain Measurement , Polarization Measurement , Field Intensity Measurement .

TOTAL: 45 HOURS

REFERENCES

1. Balanis, C.A., "**Antenna Theory Analysis and Design"** Wiley, Fourth edition 2016
2. Jordan, E.C., "**Electromagnetic waves and Radiating systems".** PHI 2003
3. Krauss, J.D., "**Antennas",** McGraw-Hill 1966, for the last unit (reprints available)
4. Krauss, J.D.,, Fleisch,D.A., "**Electromagnetics"** McGraw-Hill,1999
5. W.L.Stutzman and G.A.Thiele, "**Antenna Theory and Design**", Third Edition, John Wiley &Sons Inc.,2012.
6. Fran K. B. Gross, "**Frontiers in Antennas**", Mc Graw Hill, 2011.
7. I.J. Bahl and P. Bhartia," **Microstrip Antennas**", Artech House,Inc.,1980

EC4502	**Modern Digital Communication Techniques**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- To understand the basics of signal-space analysis and digital transmission.
- To understand the coherent and noncoherent receivers and its impact on different channel characteristics.
- To understand the different Equalizers
- To understand the different block coded and convolutional coded digital communication systems.
- To understand the basics of Multicarrier and Multiuser Communications.

Course Outcome		**Cognitive Skill**
CO-01	Able to develop the ability to understand the concepts of signal space analysis for coherent and non- coherent receivers.	U
CO-02	Able to understand equalization techniques and Algorithms	U, An

CO-03	Able to analyze the block coded digital communication	An
CO-04	Able to understand and analyze convolutional coding techniques in digital communication	U,An
CO-05	Able to illustrate Multicarrier and Multiuser Communications	U, A

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	S	M	L
CO-02	S	S	S	M	M	L	S
CO-03	S	M	S	S	M	S	L
CO-04	S	S	M	S	M	L	M
CO-05	S	S	M	M	S	L	S

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: Coherent and Non-Coherent Communication 9

Coherent and noncoherent demodulation, Matched filter, Correlator demodulator, square-law, and envelope detection; Detector: Optimum rule for ML and MAP detection Performance: Bit-error-rate, the symbol error rate for coherent and noncoherent schemes, Noncoherent receivers in random phase channels; MFSK receivers – Rayleigh and Rician channels – Partially coherent receivers – DPSK; M-PSK; M-DPSK

UNIT II: Equalization Techniques 9

Band Limited Channels- ISI – Nyquist Criterion- Controlled ISI-Partial Response signals-Equalization algorithms – Viterbi Algorithm – Linear equalizer – Decision feedback equalization – Adaptive Equalization algorithms.

UNIT III: Block Coded Digital Communication 9

Architecture and performance – Binary block codes; Orthogonal; Biorthogonal; Transorthogonal – Shannon's channel coding theorem; Channel capacity; Matched filter; Concepts of Spread spectrum communication – Coded BPSK and DPSK demodulators– Linear block codes; Hammning; 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: Multicarrier and Multiuser Communications 9

Single Vs multicarrier modulation, orthogonal frequency division multiplexing (OFDM), Modulation and demodulation in an OFDM system, An FFT algorithmic implementation of an OFDM system, Bit and power allocation in multicarrier modulation, Peak-to-average ratio in multicarrier modulation. Introduction to CDMA systems, multiuser detection in CDMA systems – optimum multiuser receiver, suboptimum detectors, successive interference cancellation.

TOTAL : 45 HOURS

REFERENCES:

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, Mc Graw 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.

EC4503	Advanced Digital Signal Processing	L	T	P	C
		3	0	0	3

OBJECTIVES

- To learn and understand the concepts of stationary and non-stationary random signals and analysis & characterization of discrete-time random processes
- To enunciate the significance of estimation of power spectral density of random processes
- To introduce the principles of optimum filters such as Wiener and Kalman filters
- To introduce the principles of adaptive filters and their applications to communication Engineering.

Course Outcome		Cognitive Skill
CO-01	Choose appropriate spectrum estimation techniques for a given random process	U
CO-02	Apply optimum filters appropriately for a given communication application	A

CO-03	Apply appropriate adaptive algorithm for processing non-stationary signals	A
CO-04	Able to design adaptive filters	An
CO-05	Apply and analyse wavelet transforms for signal and image processing based applications	An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	S	M	L
CO-02	S	S	S	M	M	L	S
CO-03	S	M	S	S	M	S	L
CO-04	S	S	M	S	M	L	M
CO-05	S	S	M	M	S	L	S

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: Discrete-Time Random Processes **9**

Random variables - ensemble averages a review, random processes - ensemble averages, autocorrelation and autocovariance matrices, ergodic random process, white noise, filtering random processes, spectral factorization, special types of random processes - AR, MA, ARMA.

UNIT II: Spectrum Estimation **9**

Bias and consistency, Non-parametric methods - Periodogram, modified-Periodogram - performance analysis. Bartlett's method,Welch's method, Blackman-Tukey method. Performance comparison. Parametric methods - autoregressive (AR) spectrum estimation - autocorrelation method, Prony's method, solution using Levinson Durbin recursion.

UNIT III: Optimum Filters **9**

Wiener filters - FIR Wiener filter - discrete Wiener Hopf equation, Applications - filtering, linear prediction. IIR Wiener filter - causal and non-causal filters. Recursive estimators - discrete Kalman filter.

UNIT IV: Adaptive Filters **9**

Principles and properties of adaptive filters - FIR adaptive filters. Adaptive algorithms - steepest descent algorithm, the LMS algorithm - convergence. Applications of adaptive filtering - noise cancellation, channel equalization.

UNIT V: Multi-Resolution Analysis **9**

Short-time Fourier transform - Heisenberg uncertainty principle. Principles of multi-resolution analysis - sub-band coding, the continuous and discrete wavelet transform - properties. Applications of wavelet transform - noise reduction, image compression.

TOTAL : 45 HOURS

TEXT BOOK:

1. Monson H. Hayes, "Statistical digital signal processing and modeling", John Wiley and Sons Inc. New York, Indian reprint 2008. (UNIT I-IV)
2. P. P. Vaidyanathan, "Multirate systems and filter banks", Prentice Hall Inc. 1993 (UNIT V)

REFERENCES:

1. John G. Proakis& Dimitris G.Manolakis, ―Digital Signal Processing – Principles, Algorithms & Applications‖, Fourth Edition, Pearson Education / Prentice Hall, 2007.
2. Sophoncles J. Orfanidis, "Optimum signal processing", McGraw Hill, 2000

EC4571	**Communication System Lab - I**	**L**	**T**	**P**	**C**
		0	**0**	**2**	**1**

OBJECTIVES

- To have a knowledge about the radiation pattern of different antennas
- To study the different modulation techniques used practically
- To have a knowledge about spread spectrum techniques
- To study about the error correcting coding techniques

Course Outcome		**Cognitive Skill**
CO-01	To have a knowledge about the radiation pattern of different antennas	U
CO-02	To study the different modulation techniques used practically	R
CO-03	To have a knowledge about spread spectrum techniques	A
CO-04	To study about the error correcting coding techniques	An
CO-05	Able to compare the performance of various filters	E

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	S	S	S
CO-02	S	S	M	S	S	S	S
CO-03	S	S	M	S	S	S	S
CO-04	S	S	S	S	S	S	S
CO-05	S	S	M	S	S	S	S

S-Strong, M-Medium,L-Low,N-Not relevant

Experiments:

1. Antenna Radiation Pattern measurement.
2. Simulation of Adaptive Filters and multistage multirate systems.
3. Performance evaluation of Digital Data Transmission through Fiber Optic Link.
4. Simulation of QMF using Simulation Packages.
5. Implementation of Video Link using Optical Fiber.
6. Implementation of Linear and Cyclic Codes.
7. Power spectral density estimation.
8. Implementation of Pseudorandom noise generator.
9. Simulation of MIMO systems
10. OFDM transceiver design using MATLAB/SIMULINK

SEMESTER II

Sl. No	Course Code	Course Title	L	T	P	C
THEORY						
1.	EC4504	Wireless Communication Engineering	3	0	0	3
2.	EC4505	Multimedia Compression Techniques	3	0	0	3
3.	EC4506	Microwave Integrated Circuits	3	0	0	3
4.	EC4507	Satellite Communication and Applications	3	0	0	3
5.	EC45**	Programme Elective-II	3	0	0	3
6.	EC45**	Programme Elective-III	3	0	0	3

PRACTICAL						
7.	EC4572	Communication Systems Lab-II	0	0	2	1
TOTAL			**18**	**0**	**2**	**19**

EC4504	**Wireless Communication Engineering**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

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

Course Outcome		**Cognitive Skill**
CO-01	Able to develop the ability to understand the concepts of wireless channel propagation and model	R,U
CO-02	Able to understand Receiver Diversity, Transmitter Diversity	U
CO-03	Able to analyze the multiantenna communication	U,An
CO-04	Able to understand and analyze **MIMO** Communications techniques in wireless communication	U,An
CO-05	Able to illustrate standardized wireless systems and cognitive radio	U,An

Mapping of Course Outcome with Programme Outcome

PO **CO**	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	S	M	L
CO-02	S	S	S	M	M	L	S
CO-03	S	M	S	S	M	S	L
CO-04	S	S	M	S	M	L	M
CO-05	S	S	M	M	S	L	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: Wireless Channel Propagation and Model **9**

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

UNIT II: 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:MIMO Communications **9**

Narrowband MIMO model, Parallel decomposition of the 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.

UNIT IV: Multi User Systems **9**

Multiple Access: FDMA, TDMA, CDMA,SDMA, Hybrid techniques, Random Access: ALOHA,SALOHA,CSMA, Scheduling, power control, uplink downlink channel capacity, multiuser diversity, MIMO-MU systems.

UNIT V: Standardized Wireless Systems **9**

Cognitive Radio - Cognitive Transceiver Architecture - Principles of Interweaving - Spectrum Sensing - Spectrum Management - Spectrum Sharing - Overlay - Recent Techniques.

TOTAL: 45 HOURS

REFERENCES:

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

EC4505	Multimedia Compression Techniques	L	T	P	C
		3	0	0	3

OBJECTIVES

- To understand the need for data compression.
- To give basics of lossy and lossless compression techniques.
- To give detailed description of audio, video, image and text compression techniques and its standards.

Course Outcome		Cognitive Skill
CO-01	Able to demonstrate an understanding of the different multimedia components and their characteristics.	R,U
CO-02	Familiar with the challenges involved in multimedia text compression used.	R,U,A
CO-03	Able to demonstrate an understanding of the multimedia audio compression.	R,U,A
CO-04	Able to demonstrate an understanding of the image compression.	R,U,A
CO-05	Able to demonstrate an understanding of the multimedia video compression	R,U,A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	S	S	S
CO-02	S	S	S	M	S	S	S
CO-03	S	S	M	M	S	S	S
CO-04	S	S	M	S	S	S	S
CO-05	S	S	S	M	S	S	S

UNIT I :Introduction **9**

Introduction-Need for image compression-Redundancy in images-Classification of Redundancy in images-Image compression scheme-Classification of Image compression schemes-Fundamentals of Information Theory.

UNIT II:Text Compression **9**

Compaction techniques – Huffmann coding – Adaptive Huffmann Coding – Arithmatic coding – Shannon-Fano coding – Dictionary techniques – LZW family algorithms.

UNIT III:Audio Compression **9**

Audio compression techniques - μ- Law and A- Law companding. 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, 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: 45 HOURS

REFERENCES:

1. Khalid Sayood : Introduction to Data Compression, Morgan Kauffman Harcourt India, 2nd Edition, 2000.
2. Ze-Nian Li, and Mark S. Drew, "Fundamentals of Multimedia", Pearson Prentice Hall, October 2003.
3. K. Rammohanarao, Z. S. Bolzkovic, D. A. Milanovic, "Multimedia Communication Systems", 1st edition, Prentice Hall, May 2002.
4. Yao Wang, Joern Ostermann, and Ya-Qin Zhang, "Video Processing and Communications", Prentice Hall, 2002.
5. Jayaraman, S, Esakkirajan S and Veerakumar T, "Digital Image Processing", McGraw Hill Pub., 2010.
6. Fred Halsall, Multimedia Communications: Applications, Networks, Protocols and Standards, Addison-Wesley, 2001.
7. Peter Symes , "Digital Video Compression," McGraw Hill Pub., 2004.

EC4506	**Microwave Integrated Circuits**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- To study Fabrication of MMIC.
- To study Monolithic circuit and hybrid circuit and its analysis.
- To study various components used in MMIC.

Course Outcome		**Cognitive Skill**
CO-01	Implement the knowledge in the area of planar microwave engineering and made them understand the intricacies in the design of microwave circuits.	R
CO-02	Understand microwave measurements	U
CO-03	Design microwave control circuits	A
CO-04	Analyze the working of coupled microstrips	An
CO-05	Impart the knowledge about the state of art in MIC technology	A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	S	S	S
CO-02	S	S	S	M	S	S	S
CO-03	S	S	M	M	S	S	S
CO-04	S	S	M	S	S	S	S
CO-05	S	S	S	M	S	S	S

UNIT I: Technology of Hybrid MICS **9**

Dielectric substrates - thick film technology and materials - thin film technology and materials – methods of testing – encapsulation of devices for MICs – mounting of active devices.

UNIT II: Microwave Ic Design and Measurement Techniques **9**

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

UNIT III:Mixers And Control Circuits **9**

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

UNIT IV: Coupled Microstrips, Slot Line and Coplanar Waveguides **9**

Coupled microstrips – even and odd mode analysis – microstrip directional couplers – branch line couplers – periodic branch line couplers – synchronous branch line couplers.

UNIT V: Lumped Elements And Non-Reciprocal Components **9**

Design and fabrication using microstrips – flat resistors – flat inductors – interdigital capacitors – sandwich capacitors – ferromagnetic substrates for non-reciprocal devices – microstrip circulators – latching circulators – isolators – phase shifters.

TOTAL: 45 HOURS

REFERENCES:

1.Gupta,K.C, and Amarjitsingh – "Microwave Integrated Circuits" – John Wiley and sons – Wiley Eastern Reprint, 1978.

2 .Hoffmann, R.K – "Handbook of Microwave Integrated Circuits" – Artech House, 1987.

EC4507	Satellite Communication and Applications	L	T	P	C
		3	0	0	3

OBJECTIVES

- To study about the satellite orbits and launching.
- To become familiar with theory of earth segment and space segment components
- To understand the concept of Space link and multiple access techniques
- To know about application of satellite services.

Course Outcome		Cognitive Skill
CO-01	Describe the motion of satellite in the orbit and compute the look angle.	U, A
CO-02	Describe the concepts of signal propagation effects, link design and perform interference calculation.	U,A
CO-03	Calculate the carrier-to-noise ratio at the input of earth station or satellite transponder.	An, E
CO-04	Critically analyze the design requirements and the performance of satellite communication systems.	An, E
CO-05	Understand the concept of technology: FDMA, TDMA, CDMA and various applications.	U, An

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	S	S	S
CO-02	S	S	M	S	S	S	S
CO-03	S	S	M	S	S	S	S
CO-04	S	S	S	S	S	S	S
CO-05	S	S	M	S	S	S	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: Orbital Mechanics **9**

Kepler's laws of motion, Orbits, Orbit Equations, Orbit Description, Locating the Satellite in the Orbit with Respect to Earth, Orbital Elements-Look Angle Determination and Visibility - Orbital Perturbations, Orbit Determination, Launch Vehicles, Orbital Effects in Communication System-spectrum allocations for satellite system .

Spacecraft Sub Systems and Earth Station

Spacecraft Subsystems- Altitude and Orbit Control, Telemetry and Tracking, Power Systems, Communication Subsystems, Transponders, Antennas, Earth Stations.

UNIT II: Space Links and Multiple Access 9

The Space Link, Transmission losses, Link Power budget equation, System noise, Satellite uplink, Down link, C/N ratio ,

Multiple Access Techniques

Frequency division multiple access (FDMA), Time division multiple access TDMA. Code division multiple access (CDMA),SDMA.

UNIT III: Broadcast Application 9

Television Applications- Entertainment Programming - Cable TV -Video Teleconferencing Digital Video Broadcasting Standard- The Satellite Standard (DVB-S) - Supporting DVB Services—Sound, Service Information, and Conditional Access Data Broadcasting and Internet Protocol Encapsulation - IP Encapsulation in the MPEG Transport Stream - Packet Identification, Direct-to-Home Satellite Television Broadcasting- DTH System Architecture- Satellite Architecture Satellite Digital Audio Radio Service- XM satellite radio- Sirius Satellite Radio

UNIT IV: MSS, Location Application and Remote Sensing Systems 9

VSAT Networks, Mobile Satellite Service -GEO and Non-GEO MSS Systems- Intelligent MSS Services- Multiple Access in MSS- Ground Segment Architecture in MSS
Location Applications –Cospas-Sarsat, INMARSAT .
Introduction to remote sensing systems, Commercial imaging, Digital globe, GeoEye, Meteorology, Meteosat, Land observation, Landsat, Remote sensing data

UNIT V: Satellite Navigation and Global Positioning System 9

Global Navigation Satellite Systems- Basic concepts of GPS, Space segment, Control segment, user segment, GPS constellation, GPS measurement characteristics, Indian Remote Sensing and ISRO GPS Systems Inertial Navigation-Introduction to Differential GPS, LADGPS, WADGPS, WAAS, GEO Uplink Subsystem (GUS), Clock steering algorithms, GEO orbit determination.IRNSS, GAGAN, GLONASS and Galileo.

TOTAL: 45 HOURS

REFERENCES

1. Dennis Roddy, “Satellite Communications”, Third Edition, McGraw Hill International Editions, 2001
2. Bruce R.Elbert, "The Satellite Communication Applications Hand Book, Artech House Boston,1997.
3. Mohinder S. Grewal, Lawrence R. Weill, Angus P. Andrews, Global Positioning Systems, Inertial Navigation, and Integration, 2011, 1st Edition, John Wiley & Sons, New Jersey.
4. T. Pratt, C.W. Boastian, Jeremy Allnutt, Satellite Communication, 2013, 2nd Edition, John Wiley & Sons, New Jersey.
5. Wilbur L.Pritchard, HendriG.Suyderhood, Robert A.Nelson,"Satellite Communication Systems Engineering", II Edition, Prentice Hall, New Jersey, 1993.
6. Tri T.Ha, "Digital satellite communication", 2nd Edition, McGraw Hill, New york.1990

EC4572	Communication Systems Lab-II	L	T	P	C
		3	0	0	3

OBJECTIVES

- To have an idea about the different compression techniques
- To study about the micro strip antennas
- To study about the Global Positioning Systems.

Course Outcome -		Cognitive Skill
CO-01	To have an idea about the different compression techniques	U
CO-02	To study about the micro strip antennas	R
CO-03	To study about the Global Positioning Systems.	A
CO-04	Able to test the radiation pattern of various antennas	An
CO-05	Able to design an optical link	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	S	S	S
CO-02	S	S	M	S	S	S	S
CO-03	S	S	M	S	S	S	S
CO-04	S	S	S	S	S	S	S
CO-05	S	S	M	S	S	S	S

S- Strong, M- Medium, L-Low, N- Not Relevant

List of Experiments

Use Network Analyser for the following experiments:

1.Measurement of transmission line parameters.
2. S-parameter estimation of Microwave devices.
3. Design and testing of a Microstrip coupler.
4. Characteristics of $\lambda/4$ and $\lambda/2$ transmission lines.

Use appropriate simulation tools for the following experiments:

1. Channel equalizer design (LMS, RLS)
2. Antenna Radiation Pattern measurement.
3. Performance Evaluation of digital modulation schemes
4. OFDM transceiver design
5. Simulation of Microstrip Antennas
6. Performance evaluation of simulated

SEMESTER III

Sl. No	Course Code	Course Title	L	T	P	C
THEORY						
1.	EC45**	Programme Elective-IV	3	0	0	3
2.	XXXXXX	Open Elective-I	3	0	0	3
PRACTICAL						
7.	EC45P1	Project Work – Phase I	0	0	12	6
TOTAL			**6**	**0**	**12**	**12**

LIST OF PROGRAM ELECTIVES

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1	EC45A1	Wavelets and Multiresolution Processing	3	0	0	3
2	EC45A2	Software Defined Radio	3	0	0	3
3	EC45A3	Communication Network Security	3	0	0	3
4	EC45A4	Optical Communication Networks	3	0	0	3
5	EC45A5	Simulation Of Communication Systems & Networks	3	0	0	3
6	EC45A6	Global Positioning Systems	3	0	0	3
7	EC45A7	High Speed Switching Architecture	3	0	0	3
8	EC45A8	RF System Design	3	0	0	3
9	EC45A9	Digital Image Processing and Applications	3	0	0	3
10	EC45B1	High Performance Communication Networks	3	0	0	3
11	EC45B2	Millimeter wave communication	3	0	0	3
12	EC45B3	VLSI for Wireless Communication	3	0	0	3
13	EC45B4	Information Theory and Coding	3	0	0	3
14	EC45B5	Smart antennas	3	0	0	3

15	EC45B6	Wireless Adhoc And Sensor Networks	3	0	0	3
16	EC45B7	RADAR Signal Processing	3	0	0	3
17	EC45B8	Internet of Things	3	0	0	3
18	EC45B9	Co-Operative Communications	3	0	0	3
19	EC45C1	Machine learning and Deep learning Techniques	3	0	0	3
20	EC45C2	Fundamental of Soft Computing Techniques	3	0	0	3
21	EC45C3	Medical Image Processing	3	0	0	3
22	EC45C4	Speech Processing	3	0	0	3

EC45A1	**Wavelets and Multiresolution Processing**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- To introduce preliminary knowledge required for wavelets.
- To study in detail about multiresolution analysis.
- To learn about continuous wavelet transform.
- To discuss about discrete wavelet transform.
- To give an idea about the application area of this subject to students

Course Outcome		**Cognitive Skill**
CO-01	Understand the concepts and definitions in wavelet transform	R
CO-02	Familiar with the concepts of multiresolution analysis	U
CO-03	Understand the concepts and properties of Continuous Wavelet Transform	U
CO-04	Familiar with the concepts and properties of Discrete Wavelet Transform	A
CO-05	Understand the applications of Wavelet transform	An

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	M	S	M
CO-02	S	M	M	S	M	S	M
CO-03	S	M	S	S	S	S	S
CO-04	M	S	S	M	M	S	S
CO-05	M	S	M	M	S	S	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: Introduction **9**

Vector Spaces - properties - dot product - basis - dimension, orthogonality and orthonormality - relationship between vectors and signals - Signal spaces - concept of Convergence - Hilbert spaces for energy signals - Generalised Fourier Expansion.

UNIT II: Multi Resolution Analysis **9**

Definition of Multi Resolution Analysis (MRA) – Haar basis - Construction of general orthonormal MRA-Wavelet basis for MRA – Continuous time MRA interpretation for the DTWT – Discrete time MRA- Basis functions for the DTWT – PRQMF filter banks

UNIT III: Continuous Wavelet Transform **9**

Wavelet Transform - definition and properties - concept of scale and its relation with frequency - Continuous Wavelet Transform (CWT) - Scaling function and wavelet functions (Daubechies, Coiflet, Mexican Hat, Sinc, Gaussian, Bi-Orthogonal) - Tiling of time -scale plane for CWT.

UNIT IV: Discrete Wavelet Transform **9**

Filter Bank and sub band coding principles - Wavelet Filters - Inverse DWT computation by Filter banks -Basic Properties of Filter coefficients - Choice of wavelet function coefficients - Derivations of Daubechies Wavelets -Mallat's algorithm for DWT – Multi-band Wavelet transforms.

Lifting Scheme: Wavelet Transform using Polyphase matrix Factorization - Geometrical foundations of lifting scheme - Lifting scheme in Z -domain

UNIT V: Applications **9**

Signal Compression – Image Compression techniques: EZW-SPHIT Coding - Image denoising techniques: Noise estimation - Shrinkagerules -. Shrinkage Functions - Edge detection and object Isolation, Image Fusion, and Object Detection. Curve and Surface Editing- Variational modeling and finite element method using wavelets.

TOTAL: 45 HOURS

REFERENCES

1. Rao .R.M andA.S.Bopardikar, "Wavelet Transforms: Introduction to theory and Applications", Pearson Education Asia Pte. Ltd., 2000.
2. K.P.Soman and K.I.Ramachandran," Insight into Wavelets – From Theory to practice", Prentice- Hall, 2004.
3. Strang G, Nguyen T, "Wavelets and Filter Banks," Wellesley Cambridge Press, 1996
4. Vetterli M, Kovacevic J., "Wavelets and Sub-band Coding," Prentice Hall, 1995
5. Mallat S., "Wavelet Signal Processing", Academic Press, 1996

EC45A2	Software Defined Radio	L	T	P	C
		3	0	0	3

OBJECTIVES

- To have an introduction about SDR.
- To study about the optimum receivers for AWGN channel and fading channel
- To discuss about the estimation theory.
- To study in detail about various synchronization techniques.
- To study about different types of adaptive equalization techniques and applications of SDR.

Course Outcome		Cognitive Skill
CO-01	Understand the architecture and various signal processing techniques for SDR	R, U
CO-02	Able to acquire and apply the knowledge about the optimum receivers for AWGN channel and fading channel	U, A
CO-03	Understand and analyze the performance of estimators in SDR.	U, An
CO-04	Understand the concept of synchronization and estimate SNR values.	U, E
CO-05	Understand the concept of adaptive equalization and apply it for echo cancellation.	U, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	S	S	S
CO-02	S	S	S	S	S	S	S
CO-03	S	S	S	S	S	S	S
CO-04	S	S	S	S	S	S	S
CO-05	S	S	S	S	S	S	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: Introduction to Software-Defined Radio 9

Introduction - Networking and SDR- RF architectures for SDR -Processing architectures for SDR- Softwae Environments for SDR, Receive Techniques for SDR, Digital Signal Processing Techniques for SDR, Transmit Techniques for SDR-Components of an SDR- AD9363 Details-Zynq Details -Linux Industrial Input/Output Details.

UNIT II:Optimum Receivers for AWGN Channel And Fading Channels 9

Detection of known signals in noise, Correlation receiver, Matched filter receiver, Optimum receiver for CPM signals, envelope detectors for M-ary and correlated binary signals.Diversity technique, RAKE demodulator, coded waveform for fading channel

UNIT III:Estimation Theory 9

Minimum mean square error estimator, Maximum a posteriori estimator, Maximum likelihood estimation, Receivers Based on MLSE -Symbol-Spaced MLSE-Fractionally-Spaced MLSE , Cramer Rao bound (CRB) for parameter estimation.

UNIT IV:Synchronization Techniques 9

Carrier and symbol synchronization, Frame synchronization, carrier phase estimation – PLL, Decision directed loops, symbol timing estimation, maximum likelihood and non-decision directed timing estimation, joint estimation.

UNIT V:Adaptive Equalization and Applications Of SDR 9

Zero forcing algorithm, LMS algorithm, Linear Equalization – Fractionally-Spaced Equalizers , Non-Linear Equalization – The Predictive DFE , Adaptive decision – feedback equalizer, and equalization of Trellis-coded signals, Kalman algorithm, blind equalizers, and stochastic gradient algorithm, Echo cancellation.

Cognitive Radio- Cognitive radio for Internet of Things – M2M technologies -– MIMO Cognitive Radio –Vehicular Networking

TOTAL: 45 HOURS

REFERENCES

1. Travis F. Collins, Robin Getz, Di Pu, Alexander M. Wyglinski, "Software-Defined Radio for Engineers" **2018**
2. Heinrich Meyer, Mare Moeneclacy and Stefan.A. Fechtel, "Digital Communication Receivers", Vol I & II, John Wiley, New York, 1997
3. John. G. Proakis, "Digital Communication", 4th ed., McGraw Hill, New York, 2001
4. K. Vasudevan, Digital Communications and Signal Processing, IIT ,Kanpur,2020
5. E.A. Lee and D.G. Messerschmitt, "Digital Communication", 2nd edition, Allied Publishers, New Delhi, 1994
6. Simon Marvin, "Digital Communication Over Fading channel; An unified approach to performance Analysis", John Wiley, New York, 2000
7. Bernard Sklar, "Digital Communication Fundamentals and Applications, Prentice Hall, 1998

EC45A3	Communication Network Security	L	T	P	C
		3	0	0	3

OBJECTIVES

- To learn the basics of security
- To learn the types of symmetric, asymmetric key algorithms and key management
- To understand the concept of Firewalls, web security and wireless network security

Course Outcome		Cognitive Skill
CO-01	Describe network security services and mechanisms.	R, U
CO-02	Identify and classify particular examples of attack	U, An
CO-03	Recognize symmetrical and asymmetrical cryptography and knowing various encryption standards.	An, E
CO-04	Understand data integrity and digital signature and concepts of firewalls in networks.	U
CO-05	Understand and analyse the various wireless network security systems and the concept of secure in Adhoc sensor networks.	U, An

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	M	S	M
CO-02	S	M	M	S	M	S	M
CO-03	S	M	S	S	S	S	S
CO-04	M	S	S	M	M	S	S
CO-05	M	S	M	M	S	S	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: Introduction to Security **9**

Security Goals, Types of Attacks: Passive attack, active attack, attacks on confidentiality, attacks on Integrity and availability. Security services and mechanisms, Techniques : Cryptography, Steganography , Revision on Mathematics for Cryptography.

UNIT II: Symmetric & Asymmetric Key Algorithms **9**

Substitutional Ciphers, Transposition Ciphers, Stream and Block Ciphers, Data Encryption Standards (DES), Advanced Encryption Standard (AES), RC4, principle of asymmetric key algorithms, RSA Cryptosystem

UNIT III: Integrity, Authentication and Key Management **9**

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

UNIT IV: Network Security, Firewalls and Web Security **9**

Introduction on Firewalls, Types of Firewalls, Firewall Configuration and Limitation of Firewall. IP Security Overview, IP security Architecture, authentication Header, Security payload, security associations, Key Management. Web security requirement, secure sockets layer, transport layer security, secure electronic transaction, dual signature.

UNIT V: Wireless Network Security **9**

Security Attack issues specific to Wireless systems: Worm hole, Tunneling, DoS. WEP for Wi-Fi network, Security for 4G networks: Secure Ad hoc Network, Secure Sensor Network

TOTAL: 45 HOURS

REFERENCES

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

EC45A4	Optical Communication Networks	L	T	P	C
		3	0	0	3

OBJECTIVES

- To learn the basic optical system components .
- To learn the types of optical network architectures, Wave length Routing Networks, packet switching and Access networks.
- To understand the concept of coherent systems.

Course Outcome		Cognitive Skill
CO-01	Demonstrate an understanding of the differences and challenges involved in the design of optical systems and networks.	R,U
CO-02	Apply his knowledge for designing a fiber optic system addressing the channel impairments.	R,U,A
CO-03	Familiar with the architectures and the protocol stack in use.in optical networks and would be able to identify a suitable backbone infrastructure for our present and future communication needs	R,U,A
CO-04	Understand how connections are managed in the network and the pros and cons of the different approaches.	R,U,A
CO-05	Understand the need for coherent systems.	R,U,A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	M	S	M
CO-02	S	M	M	S	M	S	M
CO-03	S	M	S	S	S	S	S
CO-04	M	S	S	M	M	S	S
CO-05	M	S	M	M	S	S	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: Optical System Components **9**

Light propagation in optical fibers – Loss & bandwidth, System limitations, Non-Linear effects; Solitons; Optical Network Components – Couplers, Isolators & Circulators, Multiplexers & Filters, Optical Amplifiers, Switches, Wavelength Converters.

UNIT II: Optical Network Architectures **9**

Introduction to Optical Networks; SONET / SDH standards, Metropolitan Area Networks, Layered Architecture; Broadcast and Select Networks–Topologies for Broadcast Networks, Media Access Control Protocols, Test beds for Broadcast & Select WDM; Wavelength Routing Architecture.

UNIT III: Wavelength Routing Networks **9**

The optical layer, Node Designs- Optical layer cost tradeoff- Routing and wavelength Assignment [RWA]- Virtual topology design- Wavelength Routing Test beds, Architectural Networks.

.**UNIT IV: Packet Switching And Access Networks** **9**

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

UNIT V: Coherent Systems **9**

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

TOTAL: 45 HOURS

REFERENCES:

1. Max Ming-Kang Liu, "Principles and Applications of Optical Communication", Tata McGraw Hill Education Pvt., Ltd., New Delhi. 2010.
2. Thomas E. Stern, Georgios Ellinas, Krishna Bala, "Multiwavelength Optical Networks – Architecture, Design and control ", Cambridge University Press, 2nd Edition, 2009.
3. Rajiv Ramaswami and Kumar N. Sivarajan, "Optical Networks : A Practical Perspective",Harcourt Asia Pte Ltd., Second Edition 2004.
4. C. Siva Ram Moorthy and Mohan Gurusamy, "WDM Optical Networks : Concept, Design andAlgorithms", Prentice Hall of India, Ist Edition, 2002.
5. Biswanath Mukherjee, "Optical Communication Networks", Mc-GrawHillⓒ1997, First Edition ISBN 0-07-044435-8.
6. P.E. Green, Jr., "Fiber Optic Networks", Prentice Hall, NJ, 1993.
7. Rajiv Ramaswami and Kumar N. Sivarajan, "Optical Networks : A Practical Perspective",Harcourt Asia Pte Ltd., First Edition 2004.

EC45A5	**Simulation of Communication Systems & Networks**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- To learn simulation of random variables and random process
- To learn modeling of radio communication channels
- To understand various simulation techniques
- To understand simulation methodologies and performance evaluation
- To analyse some digital communication optical communication and satellite communication techniques as case studies through simulation.

Course Outcome		**Cognitive Skill**
CO-01	Able to know the Modeling of Communication System	Un
CO-02	Able to learn modeling of Random Variables and Random Process	An
CO-03	Able to Measures Estimation of Performance	E

CO-04	To understand simulation methodologies of Communication Networks	Un
CO-05	Able to analyze Network of Queues	An

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	S	S	S
CO-02	S	S	S	s	S	S	S
CO-03	S	S	M	S	S	S	S
CO-04	S	S	M	S	S	S	S
CO-05	S	S	S	M	S	S	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: Modelling of Communication System **9**

Model of speech and picture signals, Pseudo noise sequences, Non-linear sequences, Analog channel model, Noise and fading, Digital channel model-Gilbert model of bursty channels, HF, Troposcatter and satellite channels, Switched telephone channels, Analog and Digital communication system models, Light wave system models.

UNIT II: Simulation of Random Variables and Random Process **9**

Univariate and multivariate models, Transformation of random variables, Bounds and approximation, Random process models-Markov and ARMA Sequences, Sampling rate for simulation, Computer generation and testing of random numbers

UNIT III: Estimation of Performance Measures **9**

Quality of an estimator, estimator for SNR, Probability density functions of analog communication system, BER of digital communication systems, Monte Carlo method and Importance of sampling method, estimation of power spectral density

UNIT IV: Communication Networks **9**

Queuing models, M/M/I and M/M/I/N queues, Little formula, Burke's theorem ,M/G/I queue, Embedded Markov chain analysis of TDM systems, Polling, Random access systems

UNIT V: Network of Queues **9**

Queues in tandem, store and forward communication networks, capacity allocation, Congestion and flow chart, Routing model, Network layout and Reliability

TOTAL: 45 HOURS

REFERENCES

1. M.C.Jeruchim,PhilipBalaban and K.SamShanmugam, "Simulation of communication systems", Plenum Press, New York,1992
2. A.M.Law and W.DavidKelton, "Simulation Modelling and analysis", McGraw Hill Inc., New York ,1991
3. J.F.Hayes, “Modelling and Analysis of Computer Communication networks”, Plenum Press, New York,1984
4. Jerry Banks and John S.Carson, “Discrete-event System Simulation”, Prentice Hall Inc., New Jersey,1984

EC45A6	Global Positioning Systems	L	T	P	C
		3	0	0	3

OBJECTIVES

- To have an idea about the basics and concepts of various global techniques
- To have a knowledge of different laws of planetary motion.
- To study about the different coding techniques used.
- To discuss about the different atmospheric effects on GPS.

Course Outcome		Cognitive Skill
CO-01	Able to get an idea about the basics and concepts of various global techniques	U
CO-02	Able to gain a knowledge of Coordinate Systems	An
CO-03	Able to understand knowledge of different laws of planetary motion.	An
CO-04	Able to study different coding techniques used	A
CO-05	Able to discuss about the different atmospheric effects on GPS	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	M	S	M
CO-02	S	M	M	S	M	S	M
CO-03	S	M	S	S	S	S	S
CO-04	M	S	S	M	M	S	S
CO-05	M	S	M	M	S	S	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: 9

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

UNIT II: 9

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

UNIT III: 9

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

UNIT IV: 9

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

UNIT V: 9

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

TOTAL: 45 HOURS

REFERENCES

1.B.Hoffman - Wellenhof, H.Lichtenegger and J.Collins, "GPS: Theory and Practice", 4th revised edition, Springer, Wein, New york,1997
2.A.Leick, "GPS Satellites Surveying", 2nd edition, John Wiley & Sons,NewYork,1995
3.B.Parkinson, J.Spilker, Jr.(Eds), "GPS: Theory and Applications", Vol.I&Vol.II, AIAA, 370 L'Enfant Promenade SW, Washington, DC 20024, 1996
4.A.Kleusberg and P.Teunisen(Eds), “GPS for Geodesy”, Springer-Verlag, Berlin,1996
5.L.Adams, "The GPS - A Shared National Asset”, Chair, National Academy Press, Washington, DC, 1995
Websites:
6. http://www.auslig.gov.au
7.http://igscb.jpl.nasa.gov
8.http://gibs.leipzig.ifag.de
9.http://www.navcen.uscg.mil

EC45A7	High Speed Switching Architecture	L	T	P	C
		3	0	0	3

OBJECTIVES

- Students will get an introduction about various high speed networks.
- Students will be provided with an up-to-date survey of developments in High Speed Networks.
- Enable the students to know techniques involved in LAN switching and ATM switching.
- Students will get an introduction about various Queuing techniques involved in high speed networks

Course Outcome		Cognitive Skill
CO-01	Understand the fundamental concepts of the High speed networks	U
CO-02	Interpret the network switching techniques	U, R
CO-03	Understand the concepts of ATM Switching Architecture	U,R
CO-04	Recognize the concepts of Queueing techniques and performance analysis of Queued switches	U,An
CO-05	Understand fundamentals of Network Security and Management	U, A

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	M	S	M
CO-02	S	M	M	S	M	S	M
CO-03	S	M	S	S	S	S	S
CO-04	M	S	S	M	M	S	S
CO-05	M	S	M	M	S	S	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I:High Speed Networks **9**

Introduction- LAN, WAN, Network evolution through ISDN to B-ISDN, Transfer mode andcontrol of B-ISDN, SDH multiplexing structure, ATM standard, ATM adaptation layers.

UNIT II: LAN Switching Technology **9**

Switching Concepts, switch forwarding techniques, switch path control, LAN Switching, cutthrough forwarding, store and forward, virtual LANs

UNIT III: ATM Switching Architecture **9**

Switch model, Blocking networks - basic - and- enhanced banyan networks, sorting networks - merge sorting, re-arrangeable networks - full-and- partial connection networks, non blocking networks - Recursive network construction, comparison of non-blocking network, Switching with deflection routing - shuffle switch, tandem banyan

UNIT IV: Queues in ATM Switches 9

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

UNIT V: Network Security and Management **9**

Principles of cryptography – Elliptic-AES Authentication – integrity – key distribution and certification– Access control and: fire walls – DoS-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: 45 HOURS

REFERENCES

1. AchillePattavina, Switching Theory: Architectures and performance in BroadbandATM networks "John Wiley & Sons Ltd, New York. 1998.
2. Christopher Y Metz, Switching protocols & Architectures, McGraw - Hill ProfessionalPublishing, NewYork.1998.
3. Rainer Handel, Manfred N Huber, Stefan Schroder, ATM Networks – ConceptsProtocols, Applications III Edition, Addison Wesley, New York. 1999.
4. John A.Chiong: Internetworking ATM for the internet and enterprise networks.McGraw Hill, New York, 1998.

EC45A8	**RF System Design**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- To have a basics of RF design
- To get an idea about the filter designed for RF communication.
- To discuss about the various active and components and their applications
- To study about the RF amplifier design.

Course Outcome		**Cognitive Skill**
CO-01	Understand the concepts of basics of RF design	R
CO-02	Familiar with the concepts of various RF Filter design	A
CO-03	Able to gain the knowledge of different active RF components and its applications.	U
CO-04	Understand the concepts and design of RF Amplifiers	U
CO-05	Familiar with the design of RF oscillators and its uses	A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	M	S	M
CO-02	S	M	M	S	M	S	M
CO-03	S	M	S	S	S	S	S
CO-04	M	S	S	M	M	S	S
CO-05	M	S	M	M	S	S	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: RF Issues **9**

Importance of RF design, Electromagnetic Spectrum, RF behavior of passive components, Chip components and Circuit Board considerations, Scattering Parameters, Smith Chart and applications.

UNIT II : RF Filter Design **9**

Overview , Basic resonator and filter configuration, Special filter realizations, Filter implementations, Coupled filter.

UNIT III : Active RF Components & Applications **9**

RF diodes, BJT, RF FETs, High electron mobility transistors; Matching and Biasing Networks – Impedance matching using discrete components, Microstripline matching networks, Amplifier classes of operation and biasing networks.

UNIT IV: RF Amplifier Designs **9**

Characteristics, Amplifier power relations, Stability considerations, Constant gain circles, Constant VSWR circles, Low Noise circuits, Broadband , high power and multistage amplifiers.

UNIT V: Oscillators, Mixers & Applications **9**

Basic Oscillator model, High frequency oscillator configuration, Basic characteristics of Mixers; Phase Locked Loops; RF directional couplers and hybrid couplers ; Detector and demodulator circuits.

TOTAL: 45 HOURS

REFERENCES:

1. 1.Reinhold Ludwig and Powel Bretchko, RF Circuit Design – Theory and Applications, Pearson Education Asia, First Edition, 2001.
2. Joseph . J. Carr, Secrets of RF Circuit Design , McGraw Hill Publishers, Third Edition, 2000.Mathew M. Radmanesh, Radio Frequency & Microwave Electronics, Pearson Education Asia, Second Edition, 2002.

3. Ulrich L. Rohde and David P. NewKirk, RF / Microwave Circuit Design, John Wiley & Sons USA 2000.
4. Roland E. Best, Phase - Locked Loops : Design, simulation and applications, McGraw Hill Publishers 5TH edition 2003.

EC45A9	Digital Image Processing and Applications	L	T	P	C
		3	0	0	3

OBJECTIVES

- To study the image fundamentals and mathematical transforms necessary for image processing.
- To study the image enhancement techniques
- To study image restoration procedures.
- To study the image compression procedures.
- To study the image segmentation and representation techniques.

Course Outcome		Cognitive Skill
CO-01	Familiar with the basics of Digital Image Processing system and the basic preliminaries	R
CO-02	Idea about the various 2D Separable image Transforms	U
CO-03	Knowledge about Image Filtering & 2D Image Degradation model	U
CO-04	Discussion about the various segmentation techniques	A
CO-05	Familiar with the deep learning techniques used in image processing.	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	M	M	L
CO-02	S	S	S	M	M	L	S
CO-03	S	M	S	M	M	L	L
CO-04	S	S	M	M	M	L	M
CO-05	S	S	M	M	M	L	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I:Digital Image Fundamentals and Transforms 9

Elements of digital image processing systems, Elements of visual perception, psycho visual model, brightness, contrast, hue, saturation, mach band effect, Image Transforms - Discrete Cosine Transform, Walsh Transform, Hadamard Transform, Slant Transform, Haar Transform Discrete Wavelet Transform.

UNIT II:Image Enhancement and Restoration 9

Histogram Processing, Histogram modification and specification techniques, Noise distributions, Spatial averaging, Homomorphic filtering, Image Restoration – degradation model, Unconstrained and Constrained restoration, Wiener filtering, Geometric transformations – spatial transformations, Gray-Level interpolation.

UNIT III: Image Segmentation, Representation and Description 9

Point, Line and Edge detection – Thresholding – Region based segmentation, Region growing, Region splitting and Merging – Image representation schemes – Boundary descriptors – Regional descriptors – Relational descriptors.

UNIT IV:Image Compression 9

Need for data compression, Huffman, Shannon Fano Coding, Run Length Encoding, Shift codes, Arithmetic coding, Vector Quantization, Block Truncation Coding. Transform Coding – DCT, JPEG, MPEG Standards

UNIT V:Deep Learning 9

Deep Learning Fundamentals - Artificial Neural Networks and their components - Training neural networks using back propagation - Activation functions, loss functions, and optimization algorithms; Convolutional Neural Networks (CNNs) - Introduction to CNN architecture and its advantages for image processing - Convolutional layers, pooling layers, and padding.

TOTAL: 45 HOURS

REFERENCES:

1. Rafael C. Gonzalez, Richard E.Woods, 'Digital Image Processing', Pearson Education, Inc., Second Edition, 2004.
2. Anil K. Jain, 'Fundamentals of Digital Image Processing', Prentice Hall of India, 2002.
3. David Salomon : Data Compression – The Complete Reference, Springer Verlag New York Inc., 2nd Edition, 2001
4. Rafael C. Gonzalez, Richard E.Woods, Steven Eddins, ' Digital Image Processing using MATLAB', Pearson Education, Inc., 2004.
5. William K.Pratt, ' Digital Image Processing', John Wiley, NewYork, 2002.
6. MilmanSonka, Vaclav Hlavac, Roger Boyle, 'Image Processing, Analysis, and Machine Vision', Brooks/Cole, Vikas Publishing House, II ed., 1999.

EC45B1	High Performance Communication Networks	L	T	P	C
		3	0	0	3

OBJECTIVES

- To understand physical as wireless MAC layer alternatives techniques.
- To learn planning and operation of wireless networks.
- To study various wireless LAN and WAN concepts.

Course Outcome		Cognitive Skill
CO-01	Able to understand evolution of communication and networking	U
CO-02	Able to identify the existing communication networks around	R
CO-03	Able to analyze the various services provided by the network	An
CO-04	Able to analyze the parameters of networking	An
CO-05	Able to select the wireless network for channel access in various network design	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

CO \ PO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	M	M	S	M	S	M	S
CO-02	M	S	M	S	M	S	S
CO-03	S	S	M	M	S	S	S
CO-04	S	S	M	M	M	M	S
CO-05	S	S	S	S	M	S	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: Packet Switched Networks **9**

OSI and IP models, Ethernet (IEEE 802.3), Token ring (IEEE 802.5), Wireless LAN (IEEE 802.11) FDDI, DQDB, SMDS: Internetworking with SMDS

UNIT II: ISDN and Broadband ISDN **9**

ISDN - overview, interfaces and functions, Layers and services - Signaling System 7 (SS7)- Broadband ISDN architecture and Protocols.

UNIT III: ATM and Frame Relay **9**

ATM: Main features-addressing, signaling and routing, ATM header structure-adaptation layer, management and control, ATM switching and transmission.

Frame Relay: Protocols and services, Congestion control, Internetworking with ATM, Internet and ATM, Frame relay via ATM.

UNIT IV: Advanced Network Architecture **9**

IP forwarding architectures overlay model, Multi Protocol Label Switching (MPLS), integrated services in the Internet, Resource Reservation Protocol (RSVP), Differentiated services

UNIT V: Blue Tooth Technology **9**

The Blue tooth module-Protocol stack Part I: Antennas, Radio interface, Base band, The Link controller, Audio, The Link Manager, The Host controller interface; The Blue tooth module-

Protocol stack Part I: Logical link control and adaptation protocol, RFCOMM, Service discovery protocol, Wireless access protocol, Telephony control protocol.

TOTAL: 45 HOURS

REFERENCES

1. William Stallings,"ISDN and Broadband ISDN with Frame Relay and ATM", 4th edition, Pearson education Asia, 2002.
2. Leon Gracia, Widjaja, "Communication networks ", Tata McGraw-Hill, New Delhi, 2000.
3. Jennifer Bray and Charles F.Sturman,"Blue Tooth" Pearson education Asia, 2001.
4. SumitKasera, PankajSethi, "ATM Networks ", Tata McGraw-Hill, New Delhi, 2000.
5. Rainer Handel, Manfred N.Huber and Stefan Schroder ,"ATM Networks",3rd edition, Pearson education asia,2002.
6. Jean Walrand and Pravinvaraiya ,"High Performance Communication networks",2nd edition, Harcourt and Morgan Kauffman,London,2000.
7. William Stallings,"High-speed Networks and Internets", 2nd edition, Pearson education Asia, 2003.

EC45B2	Millimeter Wave Communication	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the channel behaviour in millimeter wave communication systems
- To understand the fundamentals of Millimeter wave devices and circuits
- To understand the various components of Millimeter wave Communication systems
- To know the antenna design at Millimeter wave frequencies

Course Outcome		Cognitive Skill
CO-01	Understand the channel behavior in millimeter wave communication systems	R, U
CO-02	Understand the fundamentals of Millimeter wave devices and circuits	U, A
CO-03	Understand the various components of Millimeter wave Communication systems	U
CO-04	Understand the various components of Millimeter wave MIMO systems	U
CO-05	Able to do the antenna design at Millimeter wave frequencies.	U, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	M	S	M
CO-02	S	S	S	S	M	S	M
CO-03	S	S	S	S	M	S	M
CO-04	S	S	S	S	M	S	M
CO-05	S	S	S	S	M	S	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: Introduction to Millimeter Waves **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: 45 HOURS

REFERENCES:

1. K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", WileyIEEE 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.

EC45B3	VLSI for Wireless Communication	L	T	P	C
		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 design the transmitters and power amplifiers in wireless communication.

Course Outcome		Cognitive Skill
CO-01	Understand the concepts of basic wireless communication concepts.	R, U
CO-02	Study the parameters in receiver and low noise amplifier design	U, A
CO-03	Able to design the various types of mixers for wireless communication	U, A
CO-04	Able to design PLL and VCO	U, A
CO-05	Understand the concepts of transmitters and power amplifiers in wireless communication.	U,a

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H
CO-01	S	S	S	S	S	S	M	S
CO-02	S	S	S	S	S	S	M	S
CO-03	S	S	S	S	S	S	M	S
CO-04	S	S	S	S	S	S	M	S
CO-05	S	S	S	S	S	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

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 & Inputintercept 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 & Noisein 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: Transmitter Architectures & Power Amplifiers **9**

Transmitter back end design – Quadrature LO generator – Power amplifier design.

TOTAL : 45 HOURS

.

REFERENCES:

1. Bosco H Leung "VLSI for Wireless Communication", Pearson Education, 2002.
2. B.Razavi ,"RF Microelectronics" , Prentice-Hall ,1998.
3. Behzad Razavi, "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.

EC45B4	**Information Theory and Coding**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

The students will learn about:

- The concepts, principles and applications of information theory on communication systems.
- The data compression techniques with different coding techniques.
- The block codes for coding and decoding of digital data.
- The convolutional Codes for coding and decoding of digital data.

Course Outcome		Cognitive Skill
CO-01	Explain concept of Dependent & Independent Source, measure of information, Entropy	R
CO-02	Represent the information using Shannon Encoding, Shannon Fano, Prefix and Huffman Encoding Algorithms	U
CO-03	Model the continuous and discrete communication channels using input, output and joint probabilities	U
CO-04	Familiar with the Different types of Block Code representation	A
CO-05	Discussion of convolutional codes and their representations	An

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	M	S	M
CO-02	S	M	M	S	M	S	M
CO-03	S	M	S	S	S	S	S
CO-04	M	S	S	M	M	S	S
CO-05	M	S	M	M	S	S	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: Information Theory **9**

Information Theory: Introduction, Measure of information, Information content of message, Average Information content of symbols in Long Independent sequences, Average Information content of symbols in Long dependent sequences, Markov Statistical Model for Information Sources, Entropy and Information rate of Mark off Sources

UNIT II: Source Coding **9**

Encoding of the Source Output, Shannon's Encoding Shannon Fano Encoding Algorithm. Source coding theorem, Prefix Codes, Kraft McMillan Inequality property KMI, Huffman codes

UNIT III: Information Channels **9**

Information Channels: Communication Channels, Discrete Communication channels Channel Matrix, Joint probability Matrix, Binary Symmetric Channel, System Entropies. Mutual Information, Channel Capacity, Channel Capacity of Binary Symmetric Channel, Binary Erasure Channel, Muroga's Theorem

UNIT IV: Error Control Coding **9**

Error Control Coding: Introduction, Examples of Error control coding, methods of Controlling Errors, Types of Errors, types of Codes, Linear Block Codes: matrix description of Linear Block

Codes, Error detection & Correction capabilities ofLinear Block Codes, Single error correction Hamming code, Table lookup Decoding using Standard Array.
Binary Cyclic Codes: Algebraic Structure of Cyclic Codes, Encoding using an (n-k) Bit Shift register, Syndrome Calculation, Error Detection and Correction

UNIT V: Convolution Codes **9**
Convolution Codes: Convolution Encoder, Time domain approach, Transform domain approach, Code Tree, Trellis and State Diagram, The Viterbi Algorithm.

TOTAL : 45 HOURS

TEXT BOOK:

1. Digital and Analog Communication Systems, K. Sam Shanmugam, John Wiley India Pvt Ltd, 1996.
2 Digital Communication, Simon Haykin, John Wiley India Pvt Ltd, 2008.

REFERENCES:

1. lTC and Cryptography, Ranjan Bose, TMH, II edition, 2007
2 Principles of Digital Communication, J. Das, S. K. Mullick, P. K. Chatterjee, Wiley, 1986- Technology & Engineering
3. Digital Communications- Fundamentals and Applications, Bernard Sklar, Second Edition, Pearson Education, 2016, ISBN: 9780134724058.
4. Information Theory and Coding, Hari Bhat, Ganesh Rao, Cengage, 2017.
5. Error Correction Coding, Todd K Moon, Wiley Std. Edition, 2006

EC45B5	**Smart Antennas**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- To study the construction and working of smart antennas.
- To study the various techniques used for the Spectral estimation.
- To study the beam form technique used for the directional transmission and reception.
- To design the array which steers the beam in the desired direction.
- To design the antenna which increase the performance of signal processing.

Course Outcome		**Cognitive Skill**
CO-01	Familiar with the configuration and working of smart antennas.	R
CO-02	Able to evaluate the spectral estimation by using various techniques	A, An
CO-03	Able to analyze the beam form techniques for directional transmission and reception.	An
CO-04	Able to design antenna array which steers the beam in the desired direction.	A
CO-05	Familiar to design the antenna system which improve the performance of signal processing.	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	L	S	M	M
CO-02	S	S	S	M	S	L	S
CO-03	S	M	S	S	L	S	L
CO-04	S	S	M	S	M	L	M
CO-05	S	S	L	M	S	L	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I :Introduction to Smart Antennas 9

Introduction, Need for Smart Antennas, Overview, Smart Antenna Configurations, Switched-Beam Antennas, Adaptive Antenna Approach, Space Division Multiple Access (SDMA), Architecture of a Smart Antenna System, Receiver, Transmitter, Benefits and Drawbacks, Basic Principles, Mutual Coupling Effects.

UNIT II: DOA Estimation Fundamentals 9

Introduction, Array Response Vector, Received Signal Model, Subspace-Based Data Model, Signal Autocovariance, Conventional DOA Estimation Methods, Conventional Beamforming Method, Capon's Minimum Variance Method, Subspace Approach to DOA Estimation, MUSIC Algorithm, ESPRIT Algorithm, Uniqueness of DOA Estimates .

UNIT III: Beam Forming Fundamentals 9

Classical Beam former, Statistically Optimum Beamforming Weight Vectors, Maximum SNR Beam former, Multiple Sidelobe Canceller and Maximum, SINR Beam former, Minimum Mean Square Error (MMSE), Direct Matrix Inversion (DMI), Linearly Constrained Minimum Variance (LCMV), Adaptive Algorithms for Beamforming

UNIT IV:Integration and Simulation of Smart Antennas 9

Overview, Antenna Design, Mutual Coupling, Adaptive Signal Processing Algorithms, DOA, Adaptive Beam forming, Beam forming and Diversity Combining for Rayleigh-Fading, Channel, Trellis-Coded Modulation (TCM) for Adaptive Arrays, Smart Antenna Systems for Mobile Adhoc Networks (MANETs), Protocol, Simulations, Discussion.

UNIT V: Space–Time Processing 9

Introduction, Discrete Space–Time Channel and Signal Models, Space– Time Beamforming, Intersymbol and Co-Channel Suppression, Space–Time Processing for DSCDMA, Capacity, and Data Rates in MIMO Systems, Discussion.

TOTAL : 45 HOURS

TEXT BOOKS:

1. Constantine A. Balanis & Panayiotis I. Ioannides, "Introduction to Smart Antennas", Morgan & Claypool Publishers' series-2007

REFERENCES:

1. Joseph C. Liberti Jr., Theodore S Rappaport, "Smart Antennas for Wireless CommunicationsIS-95 and Third Generation CDMA Applications", PTR – PH publishers, 1st Edition, 1989.
2. T.S Rappaport, "Smart Antennas Adaptive Arrays Algorithms and Wireless Position Location", IEEE press 1998, PTR – PH publishers 1999.
3. Lal Chand Godara, "Smart Antennas", CRC Press, LLC-20

EC45B6	**Wireless Adhoc and Sensor Networks**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

- To understand the basics of Ad-hoc & Sensor Networks.
- To learn various fundamental and emerging protocols of all layers.
- To study about the issues pertaining to major obstacles in establishment and efficient management of Ad-hoc and sensor networks.
- To understand the nature and applications of Ad-hoc and sensor networks.
- To understand various security practices and protocols of Ad-hoc and Sensor Networks.

Course Outcome		**Cognitive Skill**
CO-01	Understand the concepts of the basics of Ad-hoc & Sensor Networks.	R, U
CO-02	learn various fundamental and emerging protocols of all layers.	U
CO-03	Explain and solve the issues pertaining to major obstacles in establishment and efficient management of Ad-hoc and sensor networks.	U, A
CO-04	Understand the nature and applications of Ad-hoc and sensor networks	U, A
CO-05	Understand various security practices and protocols of Ad-hoc and Sensor Networks.	U

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	M	S	S
CO-02	S	S	S	S	M	S	M
CO-03	S	S	S	S	M	S	M
CO-04	S	S	S	S	M	S	M
CO-05	S	S	S	S	M	S	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I : MAC & TCP IN ADHOC Networks 9

Fundamentals of WLANs – IEEE 802.11 Architecture - Self configuration and Auto configuration-Issues in Ad-Hoc Wireless Networks – MAC Protocols for Ad-Hoc Wireless Networks – Contention Based Protocols - TCP over Ad-Hoc networks-TCP protocol overview - TCP and MANETs – Solutions for TCP over Ad-Hoc Networks.

UNIT II: Routing in Ad Hoc Networks 9

Routing in Ad-Hoc Networks- Introduction-Topology based versus Position basedApproaches-Proactive, Reactive, Hybrid Routing Approach-Principles and issues – Location services - DREAM – Quorums based location service – Grid – Forwarding strategies – Greedypacket forwarding – Restricted directional flooding- Hierarchical Routing- Issues and Challenges in providing QoS.

UNIT III: MAC, Routing& QOS in Wireless Sensor Networks 9

Introduction – Architecture - Single node architecture – Sensor network design considerations– Energy Efficient Design principles for WSNs – Protocols for WSN –Physical Layer :Transceiver Design considerations – MAC Layer Protocols – IEEE802.15.4 Zigbee – Link Layer and Error Control issues - Routing Protocols – Mobile Nodesand Mobile Robots - Data Centric & Contention Based Networking – Transport Protocols &QOS – Congestion Control issues – Application Layer support.

UNIT IV: Sensor Management 9

Sensor Management - Topology Control Protocols and Sensing Mode Selection Protocols - Time synchronization - Localization and positioning – Operating systems and Sensor Networkprogramming – Sensor Network Simulators.

UNIT V: Security in AdHoc and Sensor Networks 9

Security in Ad-Hoc and Sensor networks – Key Distribution and Management – Softwarebased Anti-tamper techniques – water marking techniques – Defense against routing attacks - Secure Adhoc routing protocols – Broadcast authentication WSN protocols –TESLA – Biba – Sensor Network Security Protocols – SPINS.

TOTAL : 45 HOURS

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REFERENCES:

1. Adrian Perrig, J. D. Tygar, "Secure Broadcast Communication: In Wired and Wireless Networks", Springer, 2006.
2. Carlos De Morais Cordeiro, Dharma Prakash Agrawal "Ad Hoc and Sensor Networks:Theory and Applications (2nd Edition), World Scientific Publishing, 2011.
3. C.Siva Ram Murthy and B.S.Manoj, "Ad Hoc Wireless Networks – Architectures and Protocols", Pearson Education, 2004.
4. C.K.Toh, "Ad Hoc Mobile Wireless Networks", Pearson Education, 2002.
5. Erdal Çayırcı , Chunming Rong, "Security in Wireless Ad Hoc and Sensor Networks", John Wiley and Sons, 2009.
6. Holger Karl, Andreas willig, Protocols and Architectures for Wireless Sensor Networks, John Wiley & Sons, Inc .2005.
7. Subir Kumar Sarkar, T G Basavaraju, C Puttamadappa, "Ad Hoc Mobile Wireless Networks", Auerbach Publications, 2008.
8. Waltenegus Dargie, Christian Poellabauer, "Fundamentals of Wireless Sensor Networks Theory and Practice", John Wiley and Sons, 2010.

EC45B7	**Radar Signal Processing**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

- To understand the basic concepts of Radar systems and Signal models.
- To illustrate the concepts of Sampling and Quantization of pulsed radar signals.
- To provide in-depth knowledge in Radar waveforms and Doppler processing.

Course Outcome		**Cognitive Skill**
CO-01	Understand the basic concepts of Radar systems and Signal models.	R, U
CO-02	Learn the Radar signal model.	U, A
CO-03	Illustrate the concepts of Sampling and Quantization of pulsed radar signals.	U, A
CO-04	Have in-depth knowledge in Radar waveform.	U, A
CO-05	Bo familiar with Doppler processing	U

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	S	S	S
CO-02	S	S	S	S	S	S	S
CO-03	S	S	S	S	S	S	S
CO-04	S	S	S	S	S	S	S
CO-05	S	S	S	S	S	S	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: Introduction to Radar Systems **9**

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 Waveform **9**

Introduction, The waveform matched filter, Matched filtering of moving targets, The ambiguity function, The pulse burst waveform, frequency-modulated pulse compression waveforms, Range sidelobe 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 center antenna processing.

TOTAL: 45 HOURS

REFERENCES:

1. Francois Le Chevalier, "Principles of Radar and Sonar Signal Processing", Artech House
2. Fred E. Nathanson, "Radar Design Principles-Signal Processing and the Environment", , PHI
3. Mark A. Richards, "Fundamentals of Radar Signal Processing", McGraw-Hill, New York,2005
4. Michael O Kolawole, Radar systems, Peak Detection and Tracking, 2010,Elsevier
5. Introduction to Radar Systems 3rd Edition, Skolnik, McGraw Hill. 2004

6. Peyton Z. Peebles, "Radar Principles", 2009 Wiley India.

EC45B8	Internet of Things	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the fundamentals of Internet of Things
- 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.

Course Outcome		Cognitive Skill
CO-01	Understand the fundamentals of Internet of Things.	R, U
CO-02	Learn the basics of IOT Architecture.	U
CO-03	Learn the basics of IOT protocol.	U
CO-04	Build a small low cost embedded system using Raspberry Pi.	U, A
CO-05	Apply the concept of Internet of Things in the real world scenario	U, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	M	S	S
CO-02	S	S	S	S	M	S	S
CO-03	S	S	S	S	M	S	S
CO-04	S	S	S	S	M	S	S
CO-05	S	S	S	S	M	S	S

S- Strong, M- Medium, L-Low, N- Not Relevant

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 PhysicalDevices & 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 : 45 HOURS

REFERENCES:

1. Arshdeep Bahga, Vijay Madisetti, “Internet of Things – A hands-on approach ”, Universities Press, 2015
2. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), “Architecting the Internetof Things”, Springer, 2011.
3. Honbo Zhou, “The Internet of Things in the Cloud: A Middleware Perspective”, CRCPress, 2012.
4. Jan Ho¨ ller, Vlasios Tsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand.
5. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a NewAge of Intelligence", Elsevier, 2014.

		L	T	P	C
EC45B9	**Cooperative Communications**	**3**	**0**	**0**	**3**

OBJECTIVES:

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

Course Outcome		Cognitive Skill
CO-01	Understand the necessity of co-operative wireless communication. And Green concepts	R, U
CO-02	Learn the basics of co operative Techniques.	U
CO-03	Understand relay-based Cooperative cellular networks.	U
CO-04	Understand the concepts of green radio networks	U, A
CO-05	Explain access techniques for green radio networks	U, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	M	S	S
CO-02	S	S	S	S	M	S	S
CO-03	S	S	S	S	M	S	S
CO-04	S	S	S	S	M	S	S
CO-05	S	S	S	S	M	S	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: Cooperative Communications And Green Concepts 9

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

UNIT II: Cooperative Techniques 9

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

UNIT III: Relay-Based Cooperative Cellular Networks 9

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

UNIT IV: Green Radio Networks 9

Base Station Power-Management Techniques- Opportunistic spectrum and load management, Energy-saving techniquesin cellular wireless base stations, Power- management for base stations

in smart grid environment , Cooperative multicell processing techniques for energy-efficient cellular wireless communications.

UNIT V: Access Techniques for Green Radio Networks **9**

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

TOTAL : 45 HOURS

REFERENCES:

1. Ekram Hossain, Dong In Kim, Vijay K. Bhargava , "Cooperative Cellular Wireless Networks", Cambridge University Press, 2011.
2. Ekram Hossain, Vijay K. Bhargava(Editor), Gerhard P. Fettweis (Editor), "Green Radio Communication Networks", Cambridge University Press, 2012.
3. F. Richard Yu, Yu, Zhang and Victor C. M. Leung, "Green Communications and Networking", CRC press, 2012.
4. Mazin Al Noor, "Green Radio Communication Networks Applying Radio-Over-Fibre Technology for Wireless Access", GRIN Verlag, 2012.
5. Mohammad S. Obaidat, Alagan Anpalagan and Isaac Woungang, "Handbook of Green Information and Communication Systems", Academic Press, 2012.
6. Ramjee Prasad and Shingo Ohmori, Dina Simunic, "Towards Green ICT", River Publishers, 2010.
7. Jinsong Wu, Sundeep Rangan and Honggang Zhang, "Green Communications: Theoretical Fundamentals, Algorithms and Applications", CRC Press, 2012.

EC45C1	**Machine Learning and Deep Learning Techniques**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVE:

To understand the basic concepts of Neural network

To understand the basics of machine learning
To enable the students to know about Deep Neural network
To enable the students to know about Convolutional Neural Network
To apply different optimization algorithm

Course Outcome		**Cognitive Skill**
CO-01	Understand the basic concepts of Neural network	R, U
CO-02	understand the basics of machine learning	U
CO-03	Apply Deep Neural network	U
CO-04	Apply Convolutional Neural Network	U, A

CO-05	Apply different optimization algorithm	U, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	S	S	S
CO-02	S	S	S	S	S	S	S
CO-03	S	S	S	S	S	S	S
CO-04	S	S	S	S	S	S	S
CO-05	S	S	S	S	S	S	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT 1: Neural Networks **9**

Basic concept of Neurons – Perceptron Algorithm – Multilayer Perceptron – Concept of Feed Forward and Back Propagation – Feed Forward Neural Network – Back Propagation Neural Network. Radial Basis Function Network (RBFN

UN**IT II: Machine Learning** **9**

Introduction to Machine Learning – Types of ML – Supervised Learning – Semi Supervised Learning– Regression - linear, logistic, ridge, Classification – decision trees, SVM, random forests, Model performance evaluation – MSE, lift, AUC, Dimensionality reduction: PCA, clustering – k-means, hierarchical clustering, Reinforcement Learning

UNIT III: Deep Neural Networks **9**

Introduction to Deep Neural Network – Deep Learning Algorithms – Convolutional Neural Network – Recurrent Neural Network – Bayesian Network – Long Short Term Memory Network– Generative Adversarial Network–Deep Belief Network.

UNIT IV: Convolutional Neural Networks **9**

CNN Architecture – Layers of CNN - Convolution – Pooling – Activation Functions – Linear Function – Non Linear Function - Sigmoid – Hyperbolic tangent – Rectified Linear Unit – Leaky ReLU –Fully Connected – softmax.

UNIT V: Optimization **9**

Gradient Descent - Batch Gradient Descent - Stochastic Gradient Descent Stochastic Gradient Descent with Momentum - The Concept of Under fitting and Overfitting – Loss Function– Metaheuristic – Swarm Intelligence.

TOTAL : 45 HOURS

REFERENCES:

1. Huang, Kaizhu, Amir Hussain, Qiu-Feng Wang, and Rui Zhang, eds. "Deep learning:fundamentals,theoryandapplications".Vol.2. Springer, 2019.
2. Kelleher,JohnD."Deeplearning".MITpress,2019.
3. Wani, M. Arif, Farooq Ahmad Bhat, SadufAfzal, and AsifIqbal Khan. "Advances in deep learning". Springer, 2020.
4. Deep Learning, Good fellow et al.'s, 2013
5. Artificial Intelligence, 2nd Edition, Rich and Knight, 2012.

EC45C2	Fundamental of Soft Computing Techniques	L	T	P	C
		3	0	0	3

OBJECTIVES:

To impart knowledge about the following topics:

- Basics of artificial neural network.
- Concepts of modelling and control of neural and fuzzy control schemes.
- Features of hybrid control schemes.

Course Outcome		Cognitive Skill
CO-01	Able to understand the concepts of ANN, different features of fuzzy logic and their modelling, control aspects and different hybrid control schemes.	R,U
CO-02	Able to understand the basics of artificial neural network	U
CO-03	Able to get knowledge on modelling and control of neural.	U, A
CO-04	Able to get knowledge on modelling and control of fuzzy control schemes.	A
CO-05	Able to acquire knowledge on hybrid control schemes.	An

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	S	S	M	S	M
CO-02	S	M	M	S	M	S	M
CO-03	S	M	S	S	S	S	S
CO-04	M	S	S	M	M	S	S
CO-05	M	S	M	M	S	S	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: Artificial Neural Network **9**

Review of fundamentals – Biological neuron, artificial neuron, activation function, single layer perceptron – Limitation – Multi layer perceptron – Back Propagation Algorithm (BPA) – Recurrent Neural Network (RNN) – Adaptive Resonance Theory (ART) based network – Radial basis function network

UNIT II: Unsupervised Networks **9**

Introduction- unsupervised learning -Competitive learning networks-Kohonen self organising networks-Learning vector quantisation - Hebbian learning - Hopfield network-Content addressable nature, Binary Hopfield network, Continuous Hopfield network Travelling Salesperson problem - Adaptive resonance theory –Bidirectional Associative Memory-Principle component Analysis.

UNIT III: Fuzzy Set Theory **9**

Fuzzy set theory – Fuzzy sets – Operation on fuzzy sets – Scalar cardinality, fuzzy cardinality, union and intersection, complement (Yager and Sugeno), equilibrium points, aggregation, projection, composition, cylindrical extension, fuzzy relation – Fuzzy membership functions.

UNIT IV: Neuro-Fuzzy Modelling **9**

Adaptive Neuro Fuzzy based inference systems – classification and regression trees: decision tress, Cart algorithm – Data clustering algorithms: K means clustering, Fuzzy C means clustering, Mountain clustering, Subtractive clustering – rule base structure identification – Neuro fuzzy control: Feedback Control Systems, Expert Control, Inverse Learning, Specialized Learning, Back propagation through Real –Time Recurrent Learning.

UNIT V: Genetic Algorithm **9**

Fundamentals of genetic algorithm-Mathematical foundations-Genetic modeling-Survival of the fittest-crossover-Inversion and Deletion-mutation-reproduction-Generational cycle-rank method-rank space method- Other derivative free optimization-simulated annealing, Random search, Downhill simplex search-Application

TOTAL : 45 HOURS

REFERENCES:

1. Goldberg, “Genetic Algorithm in Search, Optimization and Machine learning”, Addison Wesley Publishing Company Inc. 1989.
2. Millon W.T., Sutton R.S. and Webrose P.J., “Neural Networks for Control”, MIT press, 1992.
3. Ethem Alpaydin, “Introduction to Machine learning (Adaptive Computation and Machine Learning series)’, MIT Press, Second Edition, 2010.
4. Zhang Huaguang and Liu Derong, “Fuzzy Modeling and Fuzzy Control Series: Control Engineering”, 2006
5. Laurence Fausett, “Fundamentals of Neural Networks”, Prentice Hall, Englewood Cliffs, N.J., 1992.
6. Timothy J. Ross, “Fuzzy Logic with Engineering Applications”, McGraw Hill Inc., 2000.

EC45C3	**Medical Image Processing**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

To acquire an up-to-date background in current state-of- art in medical imaging and medical image analysis.

To show how to extract, model, and analyze information from medical data and applications in order to help diagnosis, treatment and monitoring of diseases through computer science.

Course Outcome		**Cognitive Skill**
CO-01	Understand the principle of various medical imaging technology.	U
CO-02	Understand the various medical image preprocessing techniques	U
CO-03	Gain knowledge on medical image visualization	U
CO-04	Can perform segmentation, feature extraction and classification of medical images	An, A
CO-05	Gain a good knowledge on nuclear imaging	U

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	M	M	L	M	M
CO-02	S	S	M	M	L	M	M
CO-03	S	S	M	M	L	M	M
CO-04	S	S	M	M	L	M	M
CO-05	S	S	M	M	L	M	M

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: Introduction **9**

Introduction to Medical Imaging Technology, Systems, and Modalities. Medical Image Formation Principles: X-Ray Physics; X-Ray Generation, Attenuation, Scattering; X-Ray. Detection, Image Quality, Dose Basic Principles of CT; Reconstruction Methods; Artifacts; CT Hardware.

UNIT II: Storage and Preprocessing **9**

Medical Image Storage, Archiving and Communication Systems and Formats Picture Archiving and Communication System (PACS); Formats: DICOM Radiology Information Systems (RIS) and Hospital Information Systems (HIS). Medical Image Processing, Enhancement, Filtering Basic Image Processing Algorithms Thresholding; Contrast Enhancement; SNR Characteristics; Filtering; Histogram Modeling.

UNIT III: Visualization **9**

Medical Image Visualization Fundamentals of Visualization; Surface and Volume Rendering /Visualization; Animation; Interaction. Magnetic Resonance Imaging (MRI) Mathematics of MR; Spin Physics; NMR Spectroscopy; Imaging Principles and Hardware; Image Artifacts.

UNIT IV: Segmentation, Feature Extraction and Classification **9**

Medical Image Segmentation - Histogram-Based Methods; Region Growing and Watersheds; Markov Random Field Models; Active Contours; Model-Based Segmentation. Multi-Scale Segmentation; Semi-Automated Methods; Feature Extraction Methods, Clustering-Based Methods; Classification-Based Methods; Atlas-Guided Approaches; Multi-Model Segmentation. Medical Image Registration Intensity-Based Methods; Cost Functions; Optimization Techniques.

UNIT V: Nuclear Imaging **9**

Ultrasound Imaging Methods – Resolution of Ultrasound Imaging Systems – Ultrasound Imaging Modalities, Modes of Ultrasound Image .Representation – Artifacts-3D Ultrasound Image Reconstruction. Positron Emission Tomography (PET). Signal.Acquisition-ET.Image.Formation-Processing.and.Feature.Extraction.of.PET.Image And Ultrasound Images – Sources of Noise and Blurring in PET, Image Registration with PET and Ultrasound Images .Medical Image Search and Retrieval Current Technology in Medical Image Search, Content-Based Image Retrieval, New Trends: Ontologies. Applications. Other Applications of Medical Imaging Validation, Image Guided Surgery, Image Guided Therapy, Computer Aided Diagnosis/Diagnostic Support Systems.

TOTAL: 45 PERIODS

TEXT BOOK

1. Kayvan Najarian and Robert Splinter, "Biomedical Signal and Image Processing", Second Edition, CRC Press, 2005.
2. Geoff Dougherty, "Digital Image Processing for Medical Applications", First Edition, Cambridge University Press, 2009.

REFERENCES:

1. Paul Suetens, "Fundamentals of Medical Imaging", Second Edition, Cambridge University Press, 2009.
2. J. Michael Fitzpatrick and Milan Sonka, "Handbook of Medical Imaging, Volume 2. Medical Image Processing and Analysis", SPIE Publications, 2009.
3. Geoff Dougherty, "Digital Image Processing for Medical Applications", First Edition, Cambridge University Press, 2009.
4. Jerry L. Prince and Jonathan Links, "Medical Imaging Signals and Systems", First Edition, Prentice Hall, 2005.
5. John L. Semmlow, "Biosignal and Medical Image Processing", Second Edition, CRC Press, 2008.

EC45C4	Speech Processing	L	T	P	C
		3	0	0	3

OBJECTIVES

Study the fundamentals of speech signal and extract various features
Understand different speech coding techniques for speech compression applications .
Learn to build speech enhancement, text-to-speech synthesis system.

Course Outcome		Cognitive Skill
CO-01	Understand the fundamentals of speech.	U
CO-02	Extract various speech features for speech related applications	An

CO-03	Choose an appropriate speech coder for a given application.	A
CO-04	Build a speech enhancement system.	An, A
CO-05	Build a text-to-speech synthesis system for various applications	An, A

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	S	S	M	M	L	M	M
CO-02	S	S	M	M	L	M	M
CO-03	S	S	M	M	L	M	M
CO-04	S	S	M	M	L	M	M
CO-05	S	S	M	M	L	M	M

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: Fundamentals of Speech **9**

The Human Speech Production Mechanism, Discrete-Time Model of Speech Production, Speech Perception - Human Auditory System, Phonetics - Articulatory Phonetics, Acoustic Phonetics, and Auditory Phonetics, Categorization of Speech Sounds, Spectrographic Analysis of Speech Sounds, Pitch Frequency, Pitch Period Measurement using Spectral and Cepstral Domain, Formants, Evaluation of Formants for Voiced and Unvoiced Speech.

UNIT II: Speech Features and Distortion Measures **9**

Significance of Speech Features in Speech-Based Applications, Speech Features – Cepstral Coefficients, Mel Frequency Cepstral Coefficients (Mfccs), Perceptual Linear Prediction (PLP), Log Frequency Power Coefficients (Lfpcs), Speech Distortion Measures–Simplified Distance Measure, LPC-Based Distance Measure, Spectral Distortion Measure, Perceptual Distortion Measure.

UNIT III: Speech Coding **9**

Need for Speech Coding, Waveform Coding of Speech – PCM, Adaptive PCM, DPCM, ADPCM, Delta Modulation, Adaptive Delta Modulation, G.726 Standard for ADPCM, Parametric Speech Coding – Channel Vocoders, Linear Prediction Based Vocoders, Code Excited Linear Prediction (CELP) Based Vocoders, Sinusoidal Speech Coding Techniques, Hybrid Coder, Transform Domain Coding of Speech

UNIT IV: Speech Enhancement **9**

Classes of Speech Enhancement Algorithms, Spectral-Subtractive Algorithms - Multiband Spectral Subtraction, MMSE Spectral Subtraction Algorithm, Spectral Subtraction Based on

Perceptual Properties, Wiener Filtering - Wiener Filters inthe Time Domain, Wiener Filters inthe Frequency Domain, Wiener Filters for Noise Reduction, Maximum-Likelihood Estimators, Bayesian Estimators, MMSE and Log-MMSE Estimator, Subspace Algorithms.

UNIT V: Speech Synthesis and Application **9**

A Text-To-Speech Systems (TTS), Synthesizers Technologies – Concatenative Synthesis, Use of Formants for Concatenative Synthesis, Use of LPC for Concatenative Synthesis, HMM-Based Synthesis, Sinewave Synthesis, Speech Transformations, Watermarking for Authentication ofa Speech, Emotion Recognition from Speech.

TOTAL:45 PERIODS

TEXT BOOKS :

1.Shaila D. Apte, Speech and Audio Processing, Wiley India (P) Ltd, New Delhi, 2012

2.Philipos C. Loizou, Speech Enhancement Theory and Practice, Second Edition, CRC Press, Inc., United States, 2013

REFERENCES:

1. Rabiner L. R. and Juang B. H, Fundamentals of speech recognition, Pearson Education, 2003

2. Thomas F. Quatieri, Discrete-time speech signal processing - Principles and practice, Pearson, 2012

LIST OF OPEN ELECTIVES

SI.No.	SUBJECT CODE	SUBJECT NAME	L	T	P	C
1.	OE45D1	Research Methodology and IPR	2	0	0	2
2.	OE45D2	Business Analytics	3	0	0	3
3.	OE45D3	Industrial Safety	3	0	0	3
4.	OE45D4	Operations Research	3	0	0	3
5.	OE45D5	Composite Materials	3	0	0	3
6.	OE45D6	Waste to Energy	3	0	0	3

OE45D1	Research Methodology &IPR	L	T	P	C
		2	0	0	2

Course Outcome		Cognitive Skill
CO-01	Able to Illustrate research problem formulation.	R, U
CO-02	Analyze research related information and research ethics.	U

CO-03	Correlate the results of any research article with other published results and write a review article in the field of engineering.	U
CO-04	Explain why intellectual property rights (IPR) will play such a significant role in the development of people and nations, and briefly discuss the necessity to spread awareness of IPR among students in general and engineers in particular.	U, A
CO-05	Discuss how IPR protection encourages innovators to conduct additional research and invest in R & D, which results in the development of new and improved products, which in turn leads to economic growth and societal benefits.	U, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

UNIT I: Research Methodology **6**

Meaning of research problem, Sources of research problem, Criteria and Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

UNIT II: Literature Survey and Ethics **6**

Effective literature studies approaches - analysis Plagiarism - Research ethics.

UNIT III: Technical Writing **6**

Effective technical writing - how to write a manuscript/ responses to reviewers comments - preparation of research article/ research report - Writing a Research Proposal - presentation and assessment by a review committee.

UNIT IV: Intellectual Property Rights **6**

Nature of Intellectual Property: Patents, Designs, Trade Mark and Copyright - Process of Patenting and Development: technological research, innovation, patenting & development - Procedure for grants of patents - Patenting under PCT.

UNIT V: Patent Rights and New Developments in IPR **6**

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.

TOTAL: 30 HOURS

TEXT BOOK:

1. C.R.Kothari, "Research Methodology", 3rd Edition, New Age International, 2017.
2. Ranjit Kumar, "Research Methodology – A Step by Step for Beginner's", 2nd Edition, Pearson, Education, 2016.
3. Ann M. Korner, Guide to Publishing a Scientific paper, Bioscript Press 2004.
4. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.
5. Kompal Bansal &Parshit Bansal, "Fundamentals of IPR for Beginner's", 1st Edition, BS Publications, 2016.

REFERENCES:

1. Kothari, C. R. Research Methodology - Methods and Techniques, New Age International publishers, New Delhi, 2004.
2. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students', Juta & Company, 1996.
3. Robert P. Merges, Peter S. Menell and Mark A. Lemley, "Intellectual Property in New Technological Age", Aspen Publishers, 2016.
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974. 7. Asimov , "Introduction to Design", Prentice Hall, 1962.

WEB RESOURCES:

1. https://nptel.ac.in/courses/106/105/106105077/

OE45D2	**Business Analytics**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Outcome		**Cognitive Skill**
CO-01	Analyze business data using statistical tools.	An
CO-02	Apply trend analysis and regression to make informed decisions.	A
CO-03	Design organizational structures for effective business analytics.	E
CO-04	Utilize forecasting techniques for prediction and decision-making.	U, A
CO-05	Employ decision analysis methods and stay updated on recent trends in business intelligence and data storytelling.	U, An

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

UNIT I: Business Analytics **9**

Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.

Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

UNIT II: Trendiness and Regression Analysis **9**

Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

UNIT III : Organization Structures Of Business Analytics **9**

Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

UNIT IV: Forecasting Techniques **9**

Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.

Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

UNIT V: Decision Analysis **9**

Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making, Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

TOTAL: 45 HOURS

REFERENCES:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

OE45D3	**Industrial Safety**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Outcome		**Cognitive Skill**
CO-01	Identify and mitigate industrial safety hazards effectively.	U
CO-02	Apply maintenance engineering principles to optimize equipment performance.	A
CO-03	Implement strategies for wear reduction and corrosion prevention.	E
CO-04	Utilize fault tracing techniques to diagnose equipment problems efficiently	U, A
CO-05	Develop and execute periodic and preventive maintenance programs for machinery and equipment.	U, An

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

UNIT I : Industrial safety **9**

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

UNIT II: Fundamentals Of Maintenance Engineering **9**

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

UNIT III : Wear and Corrosion and Their Prevention **9**

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

UNIT IV: Fault Tracing **9**

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

UNIT V: Periodic and Preventive Maintenance **9**

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

TOTAL: 45 HOURS

REFERENCES:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

		L	T	P	C
OE45D4	**Operations Research**	**3**	**0**	**0**	**3**

Course Outcome		Cognitive Skill
CO-01	Formulate and solve optimization problems using simplex method, sensitivity analysis, and parametric programming.	R, A
CO-02	Apply linear programming to model real-world scenarios, understand duality theory, and analyze sensitivity.	A
CO-03	Solve nonlinear programming problems with Kuhn-Tucker conditions.	E
CO-04	Develop scheduling and sequencing models for resource utilization and inventory control.	U, An
CO-05	Apply competitive modeling, dynamic programming, and game theory to optimize decision-making in various scenarios.	U, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

UNIT I **9**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models.

UNIT II **9**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming.

UNIT III **9**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT.

UNIT IV **9**

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

UNIT V **9**

Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation.

TOTAL: 45 HOURS

REFERENCES:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

OE45D5	Composite Materials	L	T	P	C
		3	0	0	3

Course Outcome		Cognitive Skill
CO-01	Understand the classification, characteristics, and advantages of composite materials, along with their applications in various industries.	U
CO-02	Demonstrate knowledge of different reinforcements used in composites and their preparation methods, properties, and applications.	R.U
CO-03	Gain proficiency in manufacturing metal matrix composites, ceramic matrix composites, and polymer matrix composites, including understanding the processes involved and their resulting properties.	U, E
CO-04	Analyze the mechanical behavior and strength of composite materials, including failure criteria and design considerations for laminated structures.	U, An
CO-05	Apply learned concepts to solve real-world problems related to the design, manufacturing, and application of composite materials in engineering projects.	U, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

UNIT I: Introduction **9**

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

UNIT II: Reinforcements **9**

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

UNIT III: Manufacturing of Metal Matrix Composites **9**

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

UNIT IV: Manufacturing of Polymer Matrix Composites **9**

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

UNIT V: Strength **9**

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

TOTAL: 45 HOURS

TEXT BOOK:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

REFERENCES:

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

OE45D6	**Waste to Energy**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Outcome		**Cognitive Skill**
CO-01	Identify and classify waste types for energy generation.	U
CO-02	Apply biomass pyrolysis and gasification techniques.	R. A
CO-03	Understand biomass combustion principles and technologies.	U
CO-04	Analyze biogas properties, plant technology, and applications.	U, An
CO-05	Evaluate biomass conversion processes and related energy programs	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

UNIT I: Introduction to Energy From Waste **9**

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

UNIT II: Biomass Pyrolysis **9**

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

UNIT III: Biomass Gasification **9**

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

UNIT IV: Biomass Combustion **9**

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

UNIT V: Biogas **9**

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

TOTAL: 45 HOURS

REFERENCES:

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