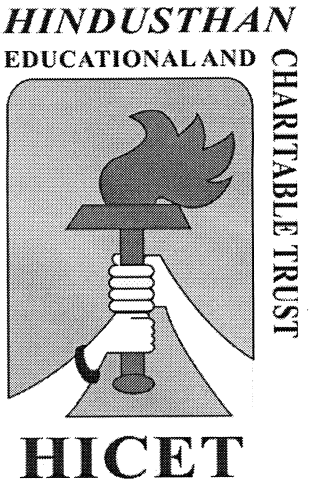
HINDUSTHAN COLLEGE OF ENGINEERING AND TECHNOLOGY
(An Autonomous Institution, Affiliated to Anna University, Chennai
Approved by AICTE, New Delhi& Accredited by NAAC with 'A ++' Grade)
Valley Campus, Pollachi Highway, Coimbatore, Tamil Nadu



DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

ME COMMUNICATION SYSTEMS

CURRICULUM & SYLLABUS

Batch: 2024-2026

REGULATIONS 2024

Institution Vision and Mission

Vision

To become a premier institution by producing professionals with strong technical knowledge, innovative research skills and high ethical values.

Mission

M1: To provide academic excellence in technical education through novel teaching methods.

M2: To empower students with creative skills and leadership qualities.

M3: To produce dedicated professionals with social responsibility.

VISION OF THE DEPARTMENT

DV:To achieve excellence in Electronics and Communication Engineering keeping in pace with evolving technologies through quality education instilling employability skills and ethical values in graduates for the betterment of society.

MISSION OF THE DEPARTMENT

DM1: To expand frontiers of knowledge through provision of inspiring learning environment

DM2: To develop intellectual skills towards employability by fostering innovation, and creativity in learning.

DM3: To inculcate professional ethics, values and entrepreneurial attitude addressing industrial and societal demands.

PROGRAMME OUTCOMES

1. **ENGINEERING KNOWLEDGE** : Apply the knowledge of mathematics,science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **PROBLEM ANALYSIS** :Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

3. **DESIGN/ DEVELOPMENT OF SOLUTIONS** : Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate considerations for the public health and safety, and the cultural, societal and environmental consideration.

4. **CONDUCT INVESTIGATIONS OF COMPLEX PROBLEMS**: Use research-based knowledge and research methods including design of experiments,analysis and interpretation of data and synthesis of the information to provide valid conclusions.

5. **MODERN TOOL USAGE** : Create ,select and apply appropriate techniques,resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6. **THE ENGINEER AND SOCIETY** : Apply reasoning informed by the contextual knowledge to assess societal, health, safety , legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **ENVIRONMENT AND SUSTAINABILITY**: understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of , and need for sustainable development.

8. **ETHICS**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **INDIVIDUAL AND TEAM WORK**: Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.

10. **COMMUNICATION:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **PROJECT MANAGEMENT AND FINANCE**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work , as a member and leader in a team, to manage projects and in multidisciplinary environment.

12. **LIFE LONG LEARNING**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES

PSO1: Graduates will be able to analyze, design and develop solutions for real-time challenges, facilitating the creation of quality products in the Electronics and Communication industry.

PSO2: Graduates will exhibit resilience in embracing emerging technologies, nurturing innovation in Signal Processing, Communication Systems, Embedded Systems, IoT, Networking, and VLSI to address contemporary demands.

PROGRAMME EDUCATIONAL OBJECTIVES

PEO1: To prepare the graduates to solve, analyze and develop real time engineering products by providing strong foundation in the fundamentals of Electronics and Communication Engineering.

PEO2: To prepare the graduates to succeed in multidisciplinary dimensions by providing adequate trainings and exposure to emerging technologies.

PEO3: To prepare the graduates to become a successful leader and innovator following ethics with the sense of social responsibility for providing engineering solutions.

CURRICULUM R2024

R – 24

CURRICULUM AND SYLLABI

I SEMESTER										
S.No	CODE	Courses	CAT	L	T	P	C	CIA	ESE	TOTAL
Theory										
1	24MA1102	Advanced Mathematics for Communication Engineering	PCC	3	0	0	4	40	60	100
2	24CM1201	Digital Modulation and coding Techniques	PCC	3	0	0	3	40	60	100
3	24CM1202	Advanced Digital Signal Processing	PCC	3	0	0	3	40	60	100
4	24CM1203	Optical Communication Networks	PCC	3	0	0	3	40	60	100
5	24CM1204	RF System Design	PCC	3	0	0	3	40	60	100
6	24CM1205	Research Methodology and IPR	RMC	2	0	0	3	40	60	100
7	24AC10XX	Audit Course I	AC	2	0	0	0	-	-	-
Practical Courses										
8	24CM1001	Signal Processing and Communication Laboratory	0	0	0	4	2	50	50	100
		Total Credits		**19**	**0**	**4**	**21**			

II SEMESTER										
S. No	CODE	Courses	CAT	L	T	P	C	CIA	ESE	TOTAL
Theory										
1	24CM2201	Advanced Wireless Communication and Networks	PCC	3	0	0	3	40	60	100

2	24CM2202	Microwave Integrated Circuits	PCC	4	0	0	3	40	60	100
3	24CM23XX	Professional Elective I	PE	3	0	0	3	40	60	100
4	24CM23XX	Professional Elective II	PE	3	0	0	3	40	60	100
5	24CM23XX	Professional Elective III	PE	3	0	0	3	40	60	100
6	24AC20XX	Audit Course II	AC	2	0	0	0	-	-	-
Practical Courses										
7	24CM2001	Communication Networks Laboratory	PCC	0	0	4	2	50	50	100
8	24CM2002	Mini Project / Internship	EEC	0	1	2	2	50	50	100
		Total Credits		**18**	**1**	**6**	**19**			

III SEMESTER										
S. No	CODE	Courses	CAT	L	T	P	C	CIA	ESE	TOTAL
Theory										
1	24CM33XX	Professional Elective IV	PE	3	0	0	3	40	60	100
2	24CM33XX	Professional Elective V	PE	3	0	0	3	40	60	100
3	24CM33XX	Professional Elective VI	PE	3	0	0	3	40	60	100
4	24XX34XX	Open Elective	OE	3	0	0	3	40	60	100
Practical Courses										
5	24CM3901	Project Phase I	EEC	0	0	12	6	50	50	100
		Total Credits		**12**	**0**	**0**	**18**			

IV SEMESTER										
S. No	CODE	Courses	CAT	L	T	P	C	CIA	ESE	TOTAL
Practical Courses										
1	24CM4901	Project Phase II	EEC	0	0	24	12	50	50	100
		Total Credits		**0**	**0**	**24**	**12**			

AUDIT COURSES SEMESTER - I

S.No	Course Code	Course Name	L	T	P	C
1	24AC1091	English for Research Paper writing	2	0	0	0
2	24AC1092	Disaster Management	2	0	0	0
3	24AC1093	Sanskrit for Technical knowledge	2	0	0	0
4	24AC1091	Pedagogy Studies	2	0	0	0
5	24AC1095	Constitution of India	2	0	0	0

AUDIT COURSES SEMESTER - II

S.No	Course Code	Course Name	L	T	P	C
1	24AC2094	Value Education	2	0	0	0
2	24AC2092	Stress Management by Yoga	2	0	0	0
3	24AC2093	Personality Development Through Life Enlightenment Skills	2	0	0	0
4	24AC2094	Unnat Bharat Abhiyan	2	0	0	0

LIST OF PROFESSIONAL ELECTIVES

PROFESSIONAL ELECTIVES

S. No.	Course Code	Course Title	CAT	L	T	P	C	CIA	ESE	TOTAL
1.	24CM2301	Information Theory and Coding Techniques	PE	3	0	0	3	40	60	100
2.	24CM2302	*Signal Estimation for wireless communication	PE	3	0	0	3	40	60	100
3.	24CM2303	Vehicular systems and Networks	PE	3	0	0	3	40	60	100
4.	24CM2304	Advanced Radiation Systems	PE	3	0	0	3	40	60	100
5.	24CM2305	Embedded and IOT	PE	3	0	0	3	40	60	100
6.	24CM3306	Wireless Senor Networks	PE	3	0	0	3	40	60	100
7.	24CM3307	Cognitive Radio Network	PE	3	0	0	3	40	60	100
8.	24CM3308	Micro-Electro Mechanical Systems	PE	3	0	0	3	40	60	100
9.	24CM3309	High Speed Switching and Network	PE	3	0	0	3	40	60	100
10.	24CM3310	Satellite Communication and Navigation	PE	3	0	0	3	40	60	100
11.	24CM2311	Massive MIMO and mmWave Systems	PE	3	0	0	3	40	60	100
12.	24CM2312	Machine Learning	PE	3	0	0	3	40	60	100

13.	24CM2313	Communication Protocol for IOT	PE	3	0	0	3	40	60	100
14.	24CM2314	Speech Signal Processing	PE	3	0	0	3	40	60	100
15.	24CM3315	Multimedia Compression	PE	3	0	0	3	40	60	100
16.	24CM3316	Wavelets and Sub coding	PE	3	0	0	3	40	60	100
17.	24CM3317	Deep Learning	PE	3	0	0	3	40	60	100
18.	24CM3318	Spread Spectrum communication	PE	3	0	0	3	40	60	100
19.	24CM3319	Block chain and its applications	PE	3	0	0	3	40	60	100
20.	24CM3320	5G Technology	PE	3	0	0	3	40	60	100

LIST OF OPEN ELECTIVES

S. No.	Course Code	Course Title	CAT	L	T	P	C	CIA	ESE	TOTAL
1.	24CM3401	Green Communication	OE	3	0	0	3	40	60	100
2.	24CM3402	**Industrial IOT	OE	3	0	0	3	40	60	100

Semester	**I**	**II**	**III**	**IV**	**Total**
Credits	20	20	18	12	70

*Principles of Signal Estimation for MIMO/OFDM wireless communication (NPTEL course)

** Introduction to Industry 4.0 and Industrial Internet of Things (NPTEL course)

SYLLABUS

Programme	Course Code	Name of the Course	L	T	P	C
M.E (EEE, ECE CS)/I	24MA1102	ADVANCED MATHEMATICS FOR COMMUNICATION ENGINEERING	3	1	0	4

Course Objective	1. Introduce fundamental concepts in matrix theory. 2. Understand fundamental probability concepts and applications, including random variables and probability laws. 3. Understand concepts of joint probability distributions and correlation for two-dimensional random variables. 4. Discuss the concept of stationary process and correlation function 5. Introduce optimization techniques for problem solving

Unit	Description	Instructional Hours
I	**MATRIX THEORY** The Cholesky decomposition – Generalized Eigen vectors – Canonical basis – QR factorization – Least squares method – Singular value decomposition.	12
II	**PROBABILITY AND RANDOM VARIABLES** Probability – Axioms of probability – Conditional probability – Baye's theorem – Random variables – Probability function – Moments – Moment generating functions and their properties.	12
III	**TWO DIMENSIONAL RANDOM VARIABLES** Joint distributions of two-dimensional random variables – Marginal and conditional distributions – Correlation and Regression of two-dimensional random variables.	12
IV	**RANDOM PROCESSES** Classification – Stationary random process – Markov process – Markov chain – Poisson process – Auto correlation – Cross correlation.	12
V	**OPTIMIZATION TECHNIQUES** Linear programming – Basic concepts – Graphical and simplex methods – Big M method – Transportation problems – Assignment problems.	12
	Total Instructional Hours	60

Course Outcome	**At the end of the course, the learner will be able to** CO1: Achieve the ability of modeling and analyzing by applying matrix theory CO2: Demonstrate proficiency in solving diverse probability problems. CO3: Analyze random variables and solve real-world problems effectively. CO4: Apply the fundamental knowledge of the Markov and Poisson processes. CO5: Apply diverse optimization methods effectively

TEXT BOOKS:

T1 – Saeed Ghahramani, "Fundamentals of probability with stochastic processes", Prentice Hall New Jersy, 2016

T2 – Taha, H.A., "Operations Research: An Introduction", 9th Edition, Pearson Education, 2016.

REFERENCE BOOKS:

R1 -Richard Bronson, Gabriel B.Costa, "Linear Algebra", Academic Press, Second Edition, 2007.

R2 - Veerarajan, T., "Probability, Statistics and Random Processes", Tata McGraw-Hill,2 nd Edition, NewDelhi, 2010.

R3 -Prem Kumar Gupta,D.S.Hira,"Operations Research," S.Chand& Company Ltd, New Delhi,3rd edition, 2008.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	-	1	-	-	1	2	2	3	2
CO2	3	3	3	3	3	-	1	-	-	1	2	2	3	2
CO3	3	3	3	3	2	-	1	-	-	1	3	2	3	2
CO4	3	3	3	2	2	-	1	-	-	1	3	2	2	2
CO5	3	3	3	2	2	-	1	-	-	1	3	2	2	2
AVG	3	3	3	2.6	2.4	-	1	-	-	1	2.6	2	2.6	2

Chairman- BoS

Chairman - Bos
ECE - HiCET

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM1201	Digital Modulation and Coding techniques	3	0	0	3

Course Objective

1.To gain knowledge on various digital modulation schemes.
2.To gain thorough understanding of optimum detection.
3.To learn about the different coding schemes.
4.To understand the concepts of spread spectrum communication.
5.To learn about the communication through band limited channel.

Unit	Description	Instructional Hours
I	**DIGITAL MODULATION TECHNIQUES** Representation of Digitally Modulated signals, Memory less Modulation Methods, Signaling Schemes with Memory –CPFSK, CPM, Power Spectrum of Digitally Modulated Signals-PSD of a digitally modulated signal with memory, PSD of a linear modulated signal, PSD of a digitally modulated signal with Finite memory, PSD of a digitally modulation scheme with a Markov Structure.	9
II	**OPTIMUM RECEIVERS FOR AWGN CHANNEL** Waveform and vector channel Models, Waveform and vector AWGN channel, Optimal Detection and Error Probability for band limited Signaling, Optimal Detection and Error Probability for power limited signaling. Non-coherent detection of carrier modulated signals,	9

	Optimal Noncoherent detection of FSK modulated signals, Error probability of Orthogonal signaling with Noncoherent detection, Differential PSK (DPSK).	
III	**CHANNEL CODING** BCH codes, Reed – Solomon Codes, Low Density Parity Check codes, Coding for channels with burst errorsInterleavers, Combining Codes. Convolutional codes- Decoding of Convolutional codes- Distance properties of Convolutional codes, Turbo codes and iterative decoding, Trellis Coded Modulation.	9
IV	**SPREAD SPECTRUM COMMUNICATION** Model of Spread Spectrum Digital Communication System, Direct Sequence Spread Spectrum Signals, Frequency-Hopped Spread Spectrum Signals, CDMA- Multi user detection in CDMA-Synchronization of SS systems.	9
V	**COMMUNICATION THROUGH BAND LIMITED CHANNELS** Band Limited Channels- ISI – Nyquist Criterion- Controlled ISI-Partial Response signals-Optimum receiver for channels with ISI and AWGN. Equalization algorithms – Linear equalizer – Decision feedback equalization – Adaptive Equalization algorithms. Reduced complexity ML detectors, Iterative equalization and decodingTurbo equalization.	9
	Total Instructional Hours	**45**

Course Outcome	**After completion of the course the learner will be able to** CO1: Formulate a mathematical model for digital modulation schemes. CO2: Design optimum coherent and non coherent receiver for digital modulation schemes CO3: Apply mathematical modeling for BER analysis and Band width calculation of digital modulation schemes CO4: Compare the performance of linear block codes CO5: Design channel encoder and decoder based on the given specification using the channel coding algorithms.

REFERENCE BOOKS:

R1- John G. Proakis., and Masoud Salehi. "Digital Communication" , McGraw- Hill, International Edition 2008

R2-M.K.Simon, S.M.Hinedi and W.C.Lindsey, "Digital communication techniques; Signaling and detection", prentice Hall India, New Delhi.1995

R3- Simon Haykin, "Digital communications", John Wiley and sons, 2006

R4-B.P.Lathi "Modern digital and analog communication systems", 3rd Edition, Oxford University press 1998.

R5-Andrew J. Viterbi, "CDMA: Principles of Spread Spectrum Communications,"Prentice Hall, USA, 1995.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2							2	2	3	2
CO2	3	3	2	2							2	2	3	2
CO3	3	3	2	2							3	2	2	3
CO4	3	2	2	2							2	2	2	3
CO5	3	3	3	3							2	2	3	3
AVG	3	2.6	2.2	2.2							2.2	2	2.6	2.6

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Programme	Course Code	Name of the Course	L	T	P	C
ME	**24CM1202**	**Advanced Digital Signal Processing**	**3**	**0**	**0**	3

Course Objective	1.To study the basic operation of various signals and system 2.To learn the fundamentals of filters 3.To know the concepts of signal processing 4.To understand the concepts of various filter banks and spectrum analysis 5.To study the concepts and fundamentals of adaptive filter

Unit	Description	Instructional Hours
I	**INTRODUCTION:** Classification of signals and systems – Properties of Systems – LTI Systems – Need for frequency domain analysis - Fourier transform for continuous and discrete time signals – Z-Transform - relationships between system representations - DFT – FFT - recursive and non-recursive filters – Linear phase FIR filters – Realization of FIR filters – finite word length effects in DSP system design	9
II	**MULTIRATE SIGNAL PROCESSING** Representation of discrete time signals – down sampling – up sampling - Noble identities – cascading sampling rate convertors - Decimation with transversal filters – interpolation with transversal filters – decimation with polyphase filters – interpolation with polyphase filters – decimation and interpolation with rational sampling factors - multistage implementation of sampling rate convertors.	9

III	**FILTER BANKS** Two channel filter banks - QMF filter banks - Perfect Reconstruction Filter banks - Filter banks with tree structure and parallel structure - Applications – speech and audio coding – image and video coding	9
IV	**POWER SPECTRUM ESTIMATION** Introduction – Non parametric methods - Periodogram – Modified Periodogram - Bartlett, Welch & Blackman Tukey methods - Performance comparison - Parametric methods - Auto Regressive (AR) spectrum estimation - Relationship between autocorrelation and model parameters – Moving Average and Auto Regressive Moving Average spectrum estimation.	9
V	**ADAPTIVE FILTERS:** Introduction – Applications – System identification – Inverse modeling – Prediction - Interference Cancellation- Adaptive linear combiner – Performance function – Gradient and Minimum Mean Square error – Gradient search by the method of steepest descent – LMS algorithm – convergence of LMS algorithm – Learning curve – Misadjustment – RLS algorithm	9
	Total Instructional Hours	**45**

Course Outcome	**After completion of the course the learner will be able to** CO1: Interpret functions of various systems and signals. CO2: Analyze working and operation of different filter CO3: Understand the concept of various signal processing. CO4:Analyze and understand the power spectrum of different filters CO5: Analyszeand understand the concepts of adaptive filter.

REFERENCE BOOKS:

R1-Fliege N J, "Multirate Digital Signal Processing", John Wiley and sons, 2010

R2-Vaidyanathan P P, "Multirate Systems and Filter banks", Prentice Hall, 2008.

R3-Ifeachor E C and Jervis B W, "Digital Signal Processing: A Practical Approach", Prentice Hall,2009

R4-Hayes M H, "Statistical Digital Signal Processing and Modeling", Wiley, New York,2008

R5-Simon Haykin "Adaptive Filter Theory", Pearson education,2010

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-		-	-	-	1	-	3	3	2
CO2	3	3	3	2	-		-	-	-	1	-	3	3	2
CO3	3	3	3	2	-		-	-	-	-	-	3	3	2
CO4	3	2	3	2	-		-	-	-	1	-	3	3	2
CO5	3	2	3	2	-		-	-	-	-	-	3	3	2
AVG	3	2.6	3	2						1		3	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM1203	Optical Communication Networks	3	0	0	3

Course Objective	1.To study the operation of various optical system components 2.To learn the fundamentals of different optical network architectures 3.To know the concepts of wavelength routing networks and its characteristics 4.To understand the concepts of various packet switching and access networks 5.To design the network with different parameters and study the issues in network management

Unit	Description	Instructional Hours
I	**OPTICAL SYSTEM COMPONENTS** 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.	9
II	**OPTICAL NETWORK ARCHITECTURES** Introduction to Optical Networks; SONET / SDH, Metropoliton-Area Networks, Layered Architecture ; Broadcast and Select Networks – Topologies for Broadcast Networks, Media-Access Control Protocols, Testbeds for Broadcast & Select WDM; Wavelength Routing Architecture.	9
III	**WAVELENGTH ROUTING NETWORKS** The optical layer, Node Designs, Optical layer cost tradeoff, Routing and wavelength assignment, Virtual topology design, Wavelength Routing Testbeds, Architectural variations.	9
IV	**PACKET SWITCHING AND ACCESS NETWORKS** Photonic Packet Switching – OTDM, Multiplexing and Demultiplexing, Synchronisation, Broadcast OTDM networks, Switch-based networks; Access Networks – Network Architecture overview, Future Access Networks, Optical Access Network Architectures; and OTDM networks.	9
V	**NETWORK DESIGN AND MANAGEMENT** Transmission System Engineering – System model, Power penalty - transmitter, receiver, Optical amplifiers, crosstalk, dispersion; Wavelength stabilization ; Overall design considerations; Control and Management – Network management functions, Configuration management, Performance management, Fault management, Optical safety, Service interface.	9
	Total Instructional Hours	**45**

Course Outcome	**After completion of the course the learner will be able to** CO1: Interpret functions of various optical network components. CO2: Analyze broadcast-and-select and wavelength routing networks CO3: Understand the working of various power devices and display devices. CO4: Explain photonic packet switching concepts and access networks CO5: Analysze different network management functions.

REFERENCE BOOKS:

R1 - C. Siva Ram Moorthy and Mohan Gurusamy, "WDM Optical Networks : Concept, Design and Algorithms", Prentice Hall of India, Ist Edition, 2002.

R2 - Vivek Alwayn, "Optical Network Design and Implementation", Pearson Education, 2004.

R3 - Hussein T.Mouftab and Pin-Han Ho, "Optical Networks: Architecture and Survivability", Kluwer Academic Publishers, 2002.

R4 - Biswanath Mukherjee, "Optical Communication Networks", McGraw Hill, 1997.

R5 - P.E. Green, Jr., "Fiber Optic Networks", Prentice Hall, NJ, 1993

R6 - Rajiv Ramaswami and Kumar N. Sivarajan, "Optical Networks : A Practical Perspective", Harcourt Asia Pvt Ltd., Second Edition 2004

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PO12	PSO 1	PSO 2
CO1	3	3	2	3	-	-	-	-	3	-	-	2	3	3
CO2	3	3	3	3	-	-	-	-	3	-	-	2	3	3
CO3	3	3	2	3	-	-	-	-	3	-	-	2	3	3
CO4	3	3	3	3	-	-	-	-	3	-	-	3	3	3
CO5	3	3	2	3	-	-	-	-	3	-	-	3	3	3
AVG	3	3	2.4	3	-	-	-	-	3	-	-	2.6	3	3

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM1204	RF System Design	3	0	0	3

Course Objective	The student should be able to 1.Study the general behavior of RF design 2.Gain knowledge on RF filters. 3.Give thorough understanding on various RF components. 4.Provide knowledge on basic characteristics of RF amplifier 5.Impart knowledge on Oscillators and mixers.

Unit	Description	Instructional Hours
I	**INTRODUCTION TO RF DESIGN** Importance of RF design, Electromagnetic Spectrum, RF behavior of passive Components, Chip components and Circuit Board considerations, Scattering Parameters, Smith Chart and applications.	9
II	**RF FILTER DESIGN** Overview , Basic resonator and filter configuration, Special filter realizations, Filter implementations, Coupled filter.	9
III	**ACTIVE RF COMPONENTS & APPLICATIONS** 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	9
IV	**RF AMPLIFIER DESIGNS** Characteristics, Amplifier power relations, Stability considerations, Constant gain circles, Constant VSWR circles, Broadband , high power and multistage amplifiers	9
V	**OSCILLATORS, MIXERS & APPLICATIONS** Basic Oscillator model, High frequency oscillator configuration, Basic characteristics of Mixers, Phase Locked Loops , RF couplers Wilkinson divider and Lange coupler , Detector and demodulator circuits.	9
	Total Instructional Hours	45

Course Outcome	**After completion of the course the learner will be able to** CO1:Describe the various active and passive components of RF circuits CO2;Analyze the microstrip line filters CO3: Analyze the biasing methods for RF amplifiers CO4: Design matching networks using smith chart. CO5:Compare various Oscillators for their performance.

REFERENCE BOOKS:
R1 - Reinhold Ludwig and Powel Bretchko, "RF Circuit Design – Theory and Applications", Pearson Education Asia, First Edition, 2001
R2 - Joseph . J. Carr, "Secrets of RF Circuit Design" , McGraw Hill Publishers, Third Edition, 2000.
R3 - Mathew M. Radmanesh, "Radio Frequency & Microwave Electronics", Pearson Education Asia, Second Edition, 2002.
R4 - Ulrich L. Rohde and David P. NewKirk, "RF & Microwave Circuit Design", John Wiley & Sons USA 2000.
R5 - Roland E. Best, "Phase - Locked Loops : Design, simulation and applications", McGraw Hill Publishers 5th edition 2003

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PO12	PSO 1	PSO 2
CO1	3	2	2	-	2	2	-	-	2	-	-	2	3	3
CO2	3	3	3	2	2	1	-	-	3	-	-	2	3	3
CO3	3	3	3	2	2	1	-	-	2	-	-	3	3	3
CO4	3	3	3	3	3	2	-	-	3	-	-	3	3	3
CO5	2	1	2	1	3	-	-	-	3	-	-	3	3	3
AVG	2.8	2.4	2.6	2	2.4	1.5	-	-	2.8	-	-	2.6	3	3

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM1205	RESEARCH METHODOLOGY AND IPR	3	0	0	3
Course Objective	1.To impart knowledge and skills required for research and IPR: 2.Problem formulation, analysis and solutions. 3.Technical paper writing / presentation without violating professional ethics 4.Patent drafting and filing patents.					
Unit	Description				Instructional Hours	

I	**RESEARCH PROBLEM FORMULATION** -Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations	9
II	**LITERATURE REVIEW** Effective literature studies approaches, analysis, plagiarism, and research ethics	9
III	**TECHNICAL WRITING /PRESENTATION** Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.	9
IV	**INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR)** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	9
V	**INTELLECTUAL PROPERTY RIGHTS (IPR)** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	9
	Total Instructional Hours	**45**
Course Outcome	**After completion of the course the learner will be able to** CO1:Ability to formulate research problem CO2:Ability to carry out research analysis CO3:Ability to follow research ethics CO4:Ability to understand that today's world is controlled by Computer, Information Technology, but CO5:tomorrow world will be ruled by ideas, concept, and creativity CO6:Ability to understand about IPR and filing patents in R & D.	

REFERENCE BOOKS:

R1- Asimov, "Introduction to Design", Prentice Hall, 1962

R2- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.

R3- Mayall, "Industrial Design", McGraw Hill, 1992

R4- Niebel, "Product Design", McGraw Hill, 1974.

R5- Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" 2010

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3			-	2	2	2	-	2	2	2
CO2	3	2	3	3			-	2	2	2	-	3	2	2
CO3	3	3	3	3			-	2	2	2	-	2	2	2
CO4	3	2	2	3			-	2	2	2	-	3	2	2
CO5	3	3	3	3			-	2	2	2	-	2	2	2
AVG	3	3	3	3				2	2	2		2	2	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	**24CM1001**	**Signal Processing and Communication Laboratory**	**0**	**0**	**4**	**2**
Course Objective	1. To design IIR filters 2. To effectively remove the noise during transmission 3. To analyze the signals in the frequency domain using sub bands. 4. To estimate the noise signals. 5. To implement digital modulation techniques.					
S.NO	**LIST OF EXPERIMENTS**					
Simulation using MATLAB / EQUIVALENT SOFTWARE PACKAGE						
1.	IIR Filter Design					
2.	Noise Cancellation					
3.	Echo Cancellation					

4.	Multirate signal processing
5.	Subband Coding of Speech Signals
6.	Estimate the PSD of a noisy signal using periodogram and modified periodogram
7.	Generation & detection of binary digital modulation techniques
8.	Performance evaluation of simulated CDMA system
9.	Spread Spectrum communication system - Pseudo random binary sequence generation
10.	Channel equalizer design
	TOTAL HOURS 45

Course Outcome	**After completion of the course the learner will be able to** CO1: Design filter for processing specific frequency bands CO2: Implement the adaptive filtering algorithms CO3: Estimate and predict the noise for effective communication CO4: generate and detect digital communication signals of various modulation techniques CO5: Evaluate cellular mobile communication technology and propagation model

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	3		-	-	2	2	-	2	2	2
CO2	3	2	3	3	3		-	-	2	2	-	3	2	2
CO3	3	3	3	3	2		-	-	2	2	-	2	2	2
CO4	3	2	2	3	3		-	-	2	2	-	3	2	2
CO5	3	3	3	3	2		-	-	2	2	-	2	2	2
AVG	3	3	3	3	3				2	2		2	2	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM2201	Advanced Wireless Communication and Networks	3	0	0	3

Course Objective	1. To understand the basics multipath propagation and its characteristics. 2. To know the concepts and performance of OFDM and OFDMA systems. 3. To learn the block diagram of transmitter and receiver ofMC-CDMA, MIMO and LTE systems. 4. To understand the concepts of cognitive radio and its applications. 5. To study the various wireless networks and its characteristics management.

Unit	Description	Instructional Hours
I	**MULTIPATH FADING CHANNELS AND DIVERSITY** Multipath Propagation-Fading-intersymbol Interference-Spectrum Limitations-Fast Fading Wireless Channel Modeling-Rayleigh and Ricean Fading Channels-BER Performance in Fading Channels - Frequency Selective and Frequency Nonselective Fading Channels - Examples of Multipath Fading Channels- Diversity modeling for Wireless Communications- BER Performance Improvement with diversity.	9
II	**OFDM AND OFDMA SYSTEMS** Basic principles of OFDM – Block diagram of transmitter and receiver in OFDM system- Effect of multipath on OFDM symbols, cyclic prefix and zero padding – BER performance of OFDM scheme – Performance of Coded OFDM System - Synchronization for OFDM - Effect of CFO- Introduction to PAPR- PAPR Reduction Techniques.Introduction to OFDMA - Block diagram of OFDMA uplink and downlink transmission – Resource Allocation - Resource Allocation Algorithms - Scheduling-Quality of Service- OFDMA based Mobile WiMax (IEEE 802.16e.)	9
III	**MC-CDMA, MIMO AND LTE** Introduction to MC-CDMA System – Block diagram of Transmitter and receiver of MC-CDMA -Bit Error Rate of MC-CDMA System- Variants Based on MC-CDMA Scheme. Introduction to MIMO– Channel Capacity and Information rates of noisy, AWGN and fading channels –MIMO for multi-carrier systems (MIMO-OFDM) – MIMO Diversity (Alamouti, OSTBC); Motivation and Targets for LTE- Overview of LTE- LTE network architecture – LTE Advanced- Architecture of LTE Radio Protocol Stacks.	9
IV	**COGNITIVE RADIO AND ITS APPLICATIONS** Introduction to Cognitive Radio-Motivation and Purpose – Spectrum Allocation in Cognitive Radio Networks - Cognitive Transceiver architecture- Radio Resource Allocation for Cognitive Radio - Spectrum Sensing – Spectrum Sharing – Spectrum Mobility – Spectrum Management – Regulatory issues – Implications of Cognitive radio network- Emerging Cognitive Radio Applications in Cellular Networks.	9

V	**WIRELESS NETWORKS** Networking Basics - Development of Computer Networks: An Overview- Network Types- Peer-to-Peer Networks- Local Area Networks (LANs)- Wide Area Networks (WANs)- Personal Area Networksee (PANs)- The Internet- Virtual Private Networks (VPNs) - Network Topologies- Choosing the Right Topology- Network Hardware and Software- Networking Components- Networking Software- Networking Protocol: TCP/IP, Wireless LANs evolution- Basic architecture – WLAN Adopters –Access Points- WLAN Configurations- WLAN Standards, Architecture and specifications , WiMAX, WiBro, and WiFi.	9
	Total Instructional Hours	**45**
Course Outcome	**After completion of the course the learner will be able to** CO1:Analyze the basics of multipath propagation and its characteristics CO2:Compare and contrast the performance of OFDM and OFDMA systems CO3:Describe the operation of transmitter and receiver ofMC-CDMA, MIMO and LTE systems CO4:Demonstrate the impact of cognitive radio and its applications CO5:Analyze the various wireless networks and its characteristics	

REFERENCE BOOKS:

R1- Andreas F. Molisch, Wireless Communications, 2nd Edition, John Wiley & Sons Ltd, 2011.

R2- Yong Soo Cho, Jaekwon Kim, Won Young Yang and Chung G. Kang, MIMO-OFDM Wireless Communications with MATLAB, John Wiley & Sons (Asia) Pte Ltd, 2010.

R3- Shinsuke Hara and Ramjee Prasad, "Multicarrier Techniques for 4G Mobile Communications", 2003.

R4- Harri Holma and Antti Toskala, "LTE for UMTS –OFDMA and SC-FDMA Based Radio Access", John Wiley & Sons Ltd., 2009.

R5- Tao Jiang, Lingyang Song and Van Zhang, "Orthogonal Frequency Division Multiple Access Fundamentals and Applications" Taylor and Francis Group, 2010.

R6- Tolga M. Duman and Ali Ghrayeb, "Coding for MIMO Communication Systems", John Wiley & Sons Ltd, 2007.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	3		-	-	3	-	-	2	3	1
CO2	3	2	3	3	3		-	-		-	-	3	3	3
CO3	3	3	3	3	2		-	-	3	2	-	2	3	3
CO4	3	2	2	3	3		-	-			-	3	3	2
CO5	3	3	3	3	2		-	-	3	2	-	2	3	2
AVG	3	3	3	3	3				3	2		2	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM2202	MICROWAVE INTEGRATED CIRCUITS	3	0	0	3

Course Objective	1. To study and understand the purpose of planar transmission lines and components at microwave frequencies 2. To understand and design various impedance matching networks using lumped and distributed elements 3. To enable the student to understand and design different microwave amplifiers and oscillators 4. To study and understand the mixer and control circuits used at microwave frequencies 5. To understand the various techniques used in Microwave IC Design and Measurements

Unit	Description	Instructional Hours
I	**PLANAR TRANSMISSION LINES AND COMPONENTS** Review of Transmission line theory – S parameters-Transmission line equations – reflection coefficient – VSWR – Microstrip lines: Structure, waves in microstrip, Quasi-TEM approximation, Coupled lines: Even mode and odd mode analysis – Microstrip discontinuities and components – Strip line – Slot line – Coplanar waveguide – Filters – Power dividers and Couplers	9
II	**IMPEDANCE MATCHING NETWORKS** Circuit Representation of two port RF/Microwave Networks: Low Frequency Parameters, High Frequency Parameters, Transmission Matrix, ZY Smith Chart, Design of Matching Circuits using Lumped Elements, Matching Network Design using Distributed Elements	9
III	**MICROWAVE AMPLIFIER AND OSCILLATOR DESIGN** Characteristics of microwave transistors – Stability considerations in active networks – Gain Consideration in Amplifiers – Noise Consideration in active networks – Broadband Amplifier design – Oscillators: Oscillator versus Amplifier Design – Oscillation conditions – Design and stability considerations of Microwave Transistor Oscillators.	9
IV	**MIXERS AND CONTROL CIRCUITS** 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	9
V	**MICROWAVE IC DESIGN AND MEASUREMENT TECHNIQUES** Microwave Integrated Circuits – MIC Materials- Hybrid versus Monolithic MICs – Multichip Module Technology – Fabrication Techniques, Miniaturization Techniques, Introduction to SOC, SOP, Test Fixture Measurements, Probe Station Measurements, Thermal and Cryogenic Measurements, Experimental Field Probing Techniques.	9
	Total Instructional Hours	**45**

Course Outcome	**After completion of the course the learner will be able to** CO1: Understand the theory of transmission lines used at microwave frequencies CO2: Design and analyze various impedance matching networks using microwave components. CO3: Perform stability analysis and be able to design amplifiers and oscillators at microwave frequencies. CO4: Understand and analyze various the mixer and control circuits used at microwave frequencies CO5: Perform stability analysis in the design of microwave amplifiers and oscillators

REFERENCE BOOKS:

R1- Jia Sheng Hong, M. J. Lancaster, "Microstrip Filters for RF/Microwave Applications", John Wiley & Sons, 2001

R2- David M. Pozar, "Microwave Engineering", II Edition, John Wiley & Sons, 1998

R3- Guillermo Gonzalez, "Microwave Transistor Amplifiers – Analysis and Design", II Edition, Prentice Hall, New Jersy

R4- Thomas H.Lee, "Planar Microwave Engineering", Cambridge University Press, 2004

R5- Matthew M. Radmanesh, "Radio Frequency and Microwave Electronics", Pearson Education, II Edition 2002

R6- Ravender Goyal, "Monolithic MIC; Technology & Design", Artech House, 1989.

R7- Gupta K.C. and Amarjit Singh, "Microwave Integrated Circuits", John Wiley, New York, 1975

R8- Hoffman R.K. "Handbook of Microwave Integrated Circuits", Artech House, Boston, 1987

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-		-	-	-	-	-	3	3	2
CO2	3	3	3	2	-		-	-	-	-	-	3	3	2
CO3	3	2	3	2	-		-	-	-	-	-	3	3	2
CO4	3	2	3	2	-		-	-	-	-	-	3	3	2
CO5	3	2	3	-	-		-	-	-	-	-	3	2	2
AVG	3	2.4	3	2								3	2.8	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM2001	COMMUNICATION NETWORKS LABORATORY	0	0	4	2
Course Objective	1. To understand the basics multipath propagation and its characteristics. 2. To know the concepts and performance of OFDM and OFDMA systems. 3. To understand MIMO system and match with the theoretical concepts. 4. To interpret MC-CDMA system Bit Error Rate 5. To understand the functioning of IP network and TCP protocols in Wireless Environment.					
Exp.No.	**Description of the Experiments**					
1.	Path loss Measurement and Characterization of Wireless Channels					
2.	Wireless Channel equalizer design (ZF / LMS / RLS) using Simulation Packages.					
3.	OFDM transceiver design using Simulation Packages.					
4.	Simulation of MIMO systems using Simulation Packages.					
5.	Analysis of Bit Error Rate of MC-CDMA System					
6.	Cellular network modelling and performance analysis in terms of Blocking Probability and Spectral Efficiency.					
7.	Implement wireless to wireless communication using wireless protocol.					
8.	Algorithms to implement packet forwarding/ packet classification/packet switching in IP Routers					
9.	Implement applications using TCP & UDP sockets like (i) DNS (ii)SNMP (iii) File Transfer					
10.	Simulating a Mobile Adhoc Network using Wifi Network					
		Total Practical Hours	**45**			
Course Outcome	**After completion of the course the learner will be able to** CO1: Design and analyse the multipath fading channels and diversity. CO2: Design and implement BER performance of OFDM scheme CO3: Analyse the performance of MIMO for multi carrier system. CO4. Analyze the performance of MC-CDMA system. CO5: Design and implement communication protocol for different functionalities					

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	3		-	-	3	2	-	2	3	1
CO2	3	2	3	3	3		-	-	3	2	-	3	3	3
CO3	3	3	3	3	2		-	-	3	2	-	2	3	3
CO4	3	2	2	3	3		-	-	3	2	-	3	3	2
CO5	3	3	3	3	2		-	-	3	2	-	2	3	2
AVG	3	3	3	3	3				3	2	-	2	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM2301	Information Theory and Coding Techniques	3	0	0	3
Course Objective	1. To review the fundamentals of various coding techniques 2. To acquire knowledge on iteratively decoded codes 3. To impart knowledge on various low density parity check codes 4. To understand the design of LDPC decoders 5. To learn the design principles of space-time coding techniques					
Unit	Description				Instructional Hours	
I	BCH AND REED-SOLOMON CODES BCH codes - Reed-Solomon codes - Decoding BCH and RS codes - finding the Error Locator Polynomial - Non-binary BCH and RS Decoding - Erasure decoding for Non-binary BCH and RS codes - Galois field Fourier Transform method - variations and extensions of Reed-Solomon codes.				9	

II	**ITERATIVELY DECODED CODES** Construction and Notation - Tanner Graphs - Transmission through Gaussian Channel - Decoding LDPC codes - The iterative decoder on General Block Codes - Density Evolution - EXIT charts for LDPC codes - Irregular LDPC codes- LDPC code construction - Encoding LDPC codes - Low-Density Generator Matrix codes - Serial Concatenated codes- Repeat - Accumulate codes - Irregular RA codes.	9
III	**LOW DENSITY PARITY CHECK CODES** EG-LDPC codes - PG-LDPC codes - Shortened finite geometry LDPC codes - Gallager LDPC codes - Masked EG-Gallager LDPC codes - Quasi-cyclic codes by circulant decomposition - Random LDPC codes - Graph - Theoretic LDPC codes - Construction of LDPC codes based on Balanced incomplete block designs - Concatenations with LDPC and Turbo codes.	9
IV	**DESIGN OF LDPC DECODERS** An Overview of Trellis - coded Modulation - Capacity of Two-dimensional Signal Sets-Bit-interleaved Trellis Coded Modulation Based on Turbo and -LDPC Codes - Design of Flexible Inter-leavers and Parity - check Matrices - Puncturing Strategies - Parallel Architectures for High-speed Decoders and Their Implementation.	9
V	**SPACE-TIME CODING** Introduction - Fading Channels - Diversity Transmission and Reception: the MIMO channel - Space-time block codes - complex orthogonal Designs - Space-time trellis codes.	9
	Total Instructional Hours	**45**
Course Outcome	**After completion of the course the learner will be able to** CO1: Analyze various source coding and decoding techniques CO2: Analyze various iteratively decoded codes and their techniques CO3: Understand and analyze various low density parity check codes. CO4: Understand the design of LDPC decoders. C05: Understand the design principles and solve problems using space-time coding techniques	

REFERENCE BOOKS:

R1-Todd K Moon, "Error Correction Coding: Mathematical Methods and Algorithms", Wliey, 2005

R2-Richard B Wells, "Applied Coding and Information Theory for Engineers", Prentice Hall, 1999.

R3-Peter Sweeney, "Error Control Coding: From Theory to Practice", Wiley,2002.

R4-Shu Lin, Daniel J. Costello, "Error control coding", 2nd Edition, Pearson,2005

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	3	-	-	-	-	-	-	2	3	1
CO2	3	2	3	3	3	-	-	-	-	-	-	3	3	3
CO3	3	3	3	3	2	-	-	-	-	-	-	2	3	3
CO4	3	2	2	3	3	-	-	-	-	-	-	3	3	2
CO5	3	3	3	3	2	-	-	-	-	-	-	2	3	2
AVG	3	3	3	3	3	-	-	-	-	-	-	2	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM2303	VEHICULAR SYSTEMS AND NETWORK	3	0	0	3

Course Objective

The student should be able to

1. To understand the basic concepts of vehicular networks and the applications.
2. To describe MAC protocols and heterogeneous wireless communication used in vehicular networks.
3. To explain the various routing protocols and IP address configuration.
4. To analyze message scheduling.
5. To understand network mobility problem in vehicular networks.

Unit	Description	Instructional Hours
I	**INTRODUCTION TO VEHICULAR NETWORK** Vehicular network definition, special characteristics, technical challenges, Evolution and progress, Vehicular network application and services, public safety application, vehicular traffic coordination, road traffic management.	9
II	**MAC PROTOCOLS & HETEROGENEOUS WIRELESS COMMUNICATION** DSRC spectrum and applications for vehicular networks, IEEE standards for MAC protocols - A cluster based, A distributed MAC protocol, Priority based secure MAC protocol, Introduction to heterogeneous wireless communications, enabling technologies for vehicular communication networks, platform for design and simulation.	9

III	**ROUTING IN VEHICULAR NETWORKS** Challenges and requirements for routing protocols, classification, basic solutions, Map based solutions, based on trajectories, based on traffic information. Adhoc IP address auto configuration problem, IP address auto configuration solution requirements, Analysis of solution space, IP address auto configuration in vehicular networks	9
IV	**MESSAGE SCHEDULING** Context and motivations, congestion control approaches, dynamic message scheduling, Analysis and validation	9
V	**NETWORK MOBILITY** The network mobility problem, NEMO basic support protocol, NEMO route optimization, NEMO in vehicular scenario, Mobile ADhoc NEMO.	9
	Total Instructional Hours	**45**

Course Outcome	**After completion of the course the learner will be able to** CO1 : Understand the basic concepts of vehicular networks and the applications. CO2 : Understand MAC protocols and heterogeneous wireless communication used in vehicular networks. CO3 : Evaluate the routing protocols and IP address configuration. CO4 : Analyze message scheduling and network mobility problem in vehicular networks

REFERENCE BOOKS:

R1-HassnaaMoustafa and Yan Zhang, — Vehicular networks – Techniques, Standards and applicationsl CRC Press, New York, 2009

R2-StephenOlariu and Michele C Weigle, — Vehicular networks – From theory to Practicel, CRC Press, New York, 2009.

R3 - H. Hartensteinand K. P. Laberteaux, —VANET: Vehicular Applications and InterNetworking Technologies, Wiley, 2010

R4-C. Sommer, F. Dressler, —Vehicular Networkingl,Cambridge University Press, 2015

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	2	2	-	-	1	2	2	3	2
CO2	3	3	3	3	2	2	2	-	-	1	2	2	2	2
CO3	3	3	3	3	2	2	2	-	-	1	2	2	2	2
CO4	3	3	3	3	2	2	2	-	-	1	2	2	2	2
CO5	3	3	3	3	2	2	2	-	-	1	2	2	3	3
AVG	3	3	3	3	2.2	2	2			1	2	2	2.4	2.2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM2304	ADVANCED RADIATION SYSTEMS	3	0	0	3

Course Objective	1. To learn the fundamentals of antenna radiation 2. To enhance the students knowledge in the area of Aperture and Reflector antenna design 3. To design various broad band antennas 4. To learn basics of microstrip antennas and its radiation analysis 5. To study the applications of various antennas

Unit	Description	Instructional Hours
I	**CONCEPTS OF RADIATION** Physical Concept of Radiation: Radiation from surface and line current distributions -radiation pattern - near and far field regions - reciprocity - directivity and gain – effective aperture - polarization - input impedance - efficiency - Friss transmission equation – radiation integrals and auxiliary potential functions.	12
II	**APERTURE AND REFLECTOR ANTENNAS** Huygens's principle - radiation from rectangular and circular apertures – design considerations - Babinets principle - radiation from sectoral - pyramidal - conical and corrugated horns - design concepts of parabolic reflectors and cassegrain antennas.	12
III	**BROADBAND ANTENNAS** Principles - design and properties of log periodic - yagi-uda - frequency independent antennas - loop antenna - helical antennas - biconical antennas - broadcast antenna - spiral antenna and slot antennas.	12
IV	**MICROSTRIP ANTENNAS** Microstrip Antennas: Radiation mechanism - parameters and applications - feeding methods - method of analysis - design of rectangular and circular patch - impedance matching of microstrip antennas.	12
V	**MEASUREMENT TECHNIQUES AND APPLICATIONS** Antenna Impedance and Radiation Measurements-Antennas for biomedical applications - smart antennas for mobile communications – antenna for infrared detectors - marine applications - plasma antennas.	12
	Total Instructional Hours	**60**

Course Outcome	**After completion of the course the learner will be able to** CO1:Understand the fundamentals behind the recent techniques in antenna technology CO2:Design and assess the performance of various Aperture and Reflector antennas CO3:Analyze various broadband antennas and design techniques CO4:Design a Micro strip antenna CO5:Identify the antennas specific to the applications

REFERENCE BOOKS:

R1-Jordan E.C, "Electromagnetic Waves and Radiating Systems", Prentice Hall of India,2003.

R2- Balanis C.A, "Antenna Theory", 2nd Edition, Wiley, 2003

R3- J.D. Krauss, "Antennas", Tata McGraw Hill, 2006.

R4-Elliot, "Antenna Theory and Design", IEEE press, 2003.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-		-	-	-	-	-	3	3	2
CO2	3	3	3	2	-		-	-	-	-	-	3	3	2
CO3	3	2	3	2	-		-	-	-	-	-	3	3	2
CO4	3	2	3	2	-		-	-	-	-	-	3	3	2
CO5	3	2	3	2	-		-	-	-	-	-	3	3	2
AVG	3	2.4	3	2								3	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM2305	EMBEDDED AND INTERNET OF THINGS	3	0	0	3

Course Objective

The student should be able to

1. Understand and acquire knowledge on the architecture of embedded systems.
2. Understand the different peripheral devices, Communication buses and Protocols.
3. Understand the evolution of Internet of Things (IoT).
4. Understand different cloud servers and APP development tools.
5. Apply the concept of Internet of Things in real world scenario.

Unit	Description	Instructional Hours
I	**COMPONENTS OF EMBEDDED SYSTEMS** Introduction to Embedded Systems Embedded Design Life Cycle. Overview of ARM Processors. Functional block diagram of ARM Cortex-A, Cortex-R and Cortex-M series controllers and its features.	9

II	**PERIPHERAL INTERFACING TECHNIQUES** Memory Management - Program Memory, Data Memory. AHB and APB Bus Structure. GPIOs, Timer/Counters, Capture/Compare Modules, PWM, QEI, RTC, WDT, DMA, EEPROM and PLL. Serial Peripherals: UART, I2C, SPI, CAN and USB. Hardware and Software Interrupts, Analog Peripherals: ADC, DAC and Analog Comparators.	9
III	**INTERNET OF THINGS** Introduction, IoT protocols: MQTT and AMQP, IoT Security: AES and TLS1.2, FOTA, Consumer Electronics IoT, Automotive IoT, Health Care IoT and Industrial IoT.	9
IV	**CLOUD AND APP FACILITIES FOR IoT** Amazon Web Services Cloud (AWS), MS Azure, IBM Bluemix, Carriots and Thing Speak, GE predix. MIT App Inventor and Android App Development tools.	9
V	**CASE STUDY** Simple problems simulation using IDE, Smart Sensors Interfacing, Experimenting Serial Communication Protocols, Remote Monitoring and Control through Web Browser using WiFi, Cloud based Data Analysis.	9
	Total Instructional Hours	**45**
Course Outcome	**After completion of the course the learner will be able to** CO1: Describe the architecture of embedded system and compare various embedded processors. CO2: Understand and compare various communication protocols. CO3: Describe the concepts of IoT. CO4: Describe cloud servers and APP development. CO5: Analyze applications of IoT in real time scenario.	

REFERENCE BOOKS:

R7 - Arshdeep Bahga and Vijai Madisetti "Internet of Things: A Hands-on Approach", Bahga & Madisetti, 2014

R8 - Jonathan W. Valvano, "Embedded Systems: Real-Time Interfacing to Arm(r) Cortex -M Microcontrollers: Volume 2", Create Space Independent Publishing Platform, 2012.

R9 - Jonathan W. Valvano, "Embedded Systems: Real-Time Interfacing to Arm(r) Cortex -M Microcontrollers: Volume 1", Create Space Independent Publishing Platform, 2011.

R10 - Steve Furber," ARM System-on-Chip Architecture", Prentice Hall of India, New Delhi, 2009

R11 - Arnold S. Berger, "Embedded Systems Design: An Introduction to Processes, Tools, and Techniques" CMP Books, 2002.

R12 - Tiva TM4C123GH6PM Microcontroller Datasheet.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	2	2	-	-	1	2	2	3	2
CO2	3	3	3	3	2	2	2	-	-	1	2	2	2	2
CO3	3	3	3	3	2	2	2	-	-	1	2	2	2	2
CO4	3	3	3	3	2	2	2	-	-	1	2	2	2	2
CO5	3	3	3	3	2	2	2	-	-	1	2	2	3	3
AVG	3	3	3	3	2.2	2	2			1	2	2	2.4	2.2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM3306	WIRELESS SENSOR NETWORKS	3	0	0	3

Course Objective

1. To learn the basics of wireless sensor networks with their technology.
2. To learn how to design and implement the wireless sensor networks in various structures to meet the requirements.
3. To learn how to use various protocols in implementing wireless sensors.
4. To learn how to locate and control the sensors in a network.
5. To learn tools for designing of wireless sensor networks and usage of hardware's along with software's.

Unit	Description	Instructional Hours
I	**OVERVIEW OF WIRELESS SENSOR NETWORKS** Challenges for Wireless Sensor Networks-Characteristics requirements-required mechanisms, Difference between mobile ad-hoc and sensor networks, Applications of sensor networks-Enabling Technologies for Wireless Sensor Networks.	9
II	**ARCHITECTURES** Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes , Operating Systems and Execution Environments, Network Architecture - Sensor Network Scenarios, Optimization Goals and Figures of Merit, Gateway Concepts	9

III	**NETWORKING OF SENSORS** Physical Layer and Transceiver Design Considerations, MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols And Wakeup Concepts - S-MAC , The Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols- Energy-Efficient Routing ,Geographic Routing.	9
IV	**INFRASTRUCTURE ESTABLISHMENT** Topology Control, Clustering, Time Synchronization, Localization and Positioning, Sensor Tasking and Control.	9
V	**SENSOR NETWORK PLATFORMS AND TOOLS** Operating Systems for Wireless Sensor Networks, Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level software platforms, Node-level Simulators, State-centric programming.	9
	Total Instructional Hours	**45**

Course Outcome	**After completion of the course the learner will be able to** CO1: Able to define wireless sensor networks for various applications. CO2: To design multiple architectures to build wireless sensor networks. CO3: To Estimate the protocols to ensure proper message transfer between nodes CO4: To Construct wireless sensor networks in exact positions with proper control over it CO5: To Choose a proper hardware with software to build sensor network with multiple tools

REFERENCE BOOKS:

R1- Holger Karl and Andreas Willig, Protocols And Architectures for Wireless Sensor Networks , John Wiley,2005.

R2- Feng Zhao and Leonidas J. Guibas, Wireless Sensor Networks - An Information Processing Approach, Elsevier, 2007.

R3-Kazem Sohraby, Daniel Minoli and Taieb Znati, Wireless Sensor Networks-Technology, Protocols, And Applications, John Wiley, 2007

R4- Anna Hac, Wireless Sensor Network Designs, John Wiley, 2003.

R5- Bhaskar Krishnamachari, Networking Wireless Sensors, Cambridge Press, 2005.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	3		-	-	3	2	-	2	3	1
CO2	3	2	3	3	3		-	-	3	2	-	3	3	3
CO3	3	3	3	3	2		-	-	3	2	-	2	3	3
CO4	3	2	2	3	3		-	-	3	2	-	3	3	2
CO5	3	3	3	3	2		-	-	3	2	-	2	3	2
AVG	3	3	3	3	3				3	2	-	2	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
M.E-CS	24CM3307	COGNITIVE RADIO NETWORK	3	0	0	3

Course Objective	1. To understand the fundamentals of Software Defined radio and compare various SDR platforms. 2. To enable the student to understand the evolving paradigm of cognitive radio communication and the enabling technologies for its implementation. 3. To enable the student to understand the essential functionalities and requirements in designing software defined radios and their usage for cognitive communication. 4. To analyze the various methods of implementing the Cognitive Radio functions 5. To exemplify the research challenges in designing a Cognitive Radio Network and the applications

Unit	Description	Instructional Hours
I	**SOFTWARE DEFINED RADIO AND ITS ARCHITECTURE** Definitions and potential benefits, software radio architecture evolution, technology tradeoffs and architecture implications. Essential functions of the software radio, basic SDR, hardware architecture, Computational processing resources, software architecture, top level component interfaces, interface topologies among plug and play modules.	9
II	**COGNITIVE RADIOS AND ITS ARCHITECTURE** Marking radio self-aware, cognitive techniques – position awareness, environment awareness in cognitive radios, optimization of radio resources, Artificial Intelligence Techniques, Cognitive Radio – functions, components and design rules, Cognition cycle – orient, plan, decide and act phases, Inference Hierarchy, Architecture maps, Building the Cognitive Radio Architecture on Software defined Radio Architechture.	9
III	**SPECTRUM SENSING AND IDENTIFICATION** Overview-Classification-Matched Filter , waveform based sensing - cyclo stationary based sensing -Energy detector based sensing - Radio Identifier - Cooperative Sensing -Spectrum Opportunity Detection , Fundamental Trade-offs: Performance versus Constraint , MAC Layer Performance Measures, Global Interference Model, Local Interference Model, Fundamental Trade-offs: Sensing Accuracy versus Sensing Overhead.	9
IV	**USER COOPERATIVE COMMUNICATIONS** User Cooperation and Cognitive Systems , Relay Channels: General Three-Node Relay Channel, Wireless Relay Channel , User Cooperation in Wireless Networks: Two-User Cooperative Network, Cooperative Wireless Network , Multihop Relay Channel	9
V	**INFORMATION THEORETICAL LIMITS ON CR NETWORKS** Types of Cognitive Behavior, Interference-Avoiding Behavior: Spectrum Interweave, Interference-Controlled Behavior: Spectrum Underlay, Underlay in Small Networks: Achievable Rates, Underlay in Large Networks: Scaling Laws, Interference-Mitigating Behavior: Spectrum Overlay, Opportunistic Interference Cancellation, Asymmetrically Cooperating Cognitive Radio Channels.	9
	Total Instructional Hours	**45**

Course Outcome	**After completion of the course the learner will be able to** CO1: Appreciate the motivation and the necessity for cognitive radio communication strategies. CO2: Demonstrate understanding of the enabling technologies for its implementation CO3: Demonstrate understanding of the essential functionalities and requirements in designing software defined radios and their usage for cognitive communication. CO4: Evolve new techniques and demonstrate their feasibility using mathematical validations and simulation tools. CO5: Interpret the impact of the evolved solutions in future wireless network design.

REFERENCE BOOKS:

R1- . Alexander M. Wyglinski, Maziar Nekovee, And Y. Thomas Hou, "Cognitive Radio Communications and Networks - Principles And Practice", Elsevier Inc. , 2010.

R2 - Kwang-Cheng Chen and Ramjee Prasad, "Cognitive Radio Networks", John Wiley & Sons, Ltd, 2009.

R3 -. Khattab, Ahmed, Perkins, Dmitri, Bayoumi, Magdy, "Cognitive Radio Networks - From Theory to Practice", Springer Series, Analog Circuits and Signal Processing, 2009.

R4- J. Mitola, "Cognitive Radio: An Integrated Agent Architecture for software defined radio", Doctor of Technology thesis, Royal Inst. Technology, Sweden 2000.

R5- Simon Haykin, "Cognitive Radio: Brain –empowered wireless communications", IEEE Journal on selected areas in communications, Feb 2005.

R6-Ian F. Akyildiz, Won – Yeol Lee, Mehmet C. Vuran, Shantidev Mohanty, "Next generation / dynamic spectrum access / cognitive radio wireless networks: A Survey Elsevier Computer Networks", May 2006.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	3		-	-	3	2	-	2	3	1
CO2	3	2	3	3	3		-	-	3	2	-	3	3	3
CO3	3	3	3	3	2		-	-	3	2	-	2	3	3
CO4	3	2	2	3	3		-	-	3	2	-	3	3	2
CO5	3	3	3	3	2		-	-	3	2	-	2	3	2
AVG	3	3	3	3	3				3	2	-	2	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM2308	Micro-Electro Mechanical Systems	3	0	0	3

Course Objective	1. To introduce students with concepts of MEMS products, sensors and fabrication. 2. To study about mechanics for MEMS design. 3. To Study about the electro static design and system issues for MEMS. 4. To understand the MEMS applications. 5. To understand the concepts of RF MEMS and optical MEMS.

Unit	Description	Instructional Hours
I	**UNIT I INTRODUCTION TO MEMS** MEMS and Microsystems, Miniaturization, Typical products, Micro sensors, Micro actuation, MEMS with micro actuators, Micro-accelerometers and Micro fluidics, MEMS materials, Micro fabrication	9
II	**UNIT II MECHANICS FOR MEMS DESIGN** Elasticity, Stress, strain and material properties, Bending of thin plates, Spring configurations, torsional deflection, Mechanical vibration, Resonance, Thermo mechanics – actuators, force and response time, Fracture and thin film mechanics	9
III	**UNIT III ELECTRO STATIC DESIGN AND SYSTEM ISSUES** Electrostatics: basic theory, electro static instability. Surface tension, gap and finger pull up, Electro static actuators, Comb generators, gap closers, rotary motors, inch worms, Electromagnetic actuators. Bi-stable actuators. Electronic Interfaces, Feedback systems, Noise , Circuit and system issues	9
IV	**UNIT IV MEMS APPLICATION** Case studies – Capacitive accelerometer, Peizo electric pressure sensor, Micro-fluidics application, Modeling of MEMS systems, CAD for MEMS.	9
V	**UNIT V INTRODUCTION TO OPTICAL AND RF MEMS** Optical MEMS, - System design basics – Gaussian optics, matrix operations, resolution. Case studies, MEMS scanners and retinal scanning display, Digital Micro mirror devices. RF Memes – design basics, case study – Capacitive RF MEMS switch, performance issues	9
	Total Instructional Hours	45

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

REFERENCE BOOKS:	
R1 -	Stephen Santeria, "Microsystems Design", Kluwer publishers, 2000.
R2 -	N.P.Mahalik, "MEMS",Tata McGraw hill, 2007
R3 -	Nadim Maluf, "An introduction to Micro electro mechanical system design", Artech House, 2000
R4 -	Mohamed Gad-el-Hak, "The MEMS Handbook", CRC press Baco Raton,2000.
R5 -	Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture", Tata McGraw Hill, New Delhi, 2002.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	3		-	-	3	-	-	2	3	1
CO2	3	2	3	3	3		-	-		-	-	3	3	3
CO3	3	3	3	3	2		-	-	3	2	-	2	3	3
CO4	3	2	2	3	3		-	-			-	3	3	2
CO5	3	3	3	3	2		-	-	3	2	-	2	3	2
AVG	3	3	3	3	3				3	2		2	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM3309	High Speed Switching and Network	3	0	0	3

Course Objective

1. To understand the basics of switching technologies and their implementation LANs, ATM networks and IP networks
2. To understand the different queuing strategies and their impact on the blocking performances.
3. To understand the concepts of various packet switching architectures
4. To learn the fundamentals of Optical Switching Architectures
5. To exploit and integrate the best features of different architectures for high speed switching.

Unit	Description	Instructional Hours

I	**UNIT I LAN SWITCHING TECHNOLOGY** Switching Concepts, LAN Switching, switch forwarding techniques - cut through and store and forward, Layer 3 switching, Loop Resolution, Switch Flow control, virtual LANs. .	9
II	**UNIT II QUEUES IN HIGH SPEED SWITCHES** Internal Queueing -Input, output and shared queueing, multiple queueing networks – combined Input, output and shared queueing - performance analysis of Queued switches	9
III	**UNIT III PACKET SWITCHING ARCHITECTURES** Architectures of Internet Switches and Routers- Bufferless and buffered Crossbar switches, Multi-stage switching, Optical Packet switching; Switching fabric on a chip; Internally buffered Crossbars	9
IV	**UNIT IV. OPTICAL SWITCHING ARCHITECTURES** Need for Multilayered Architecture-, Layers and Sub-layers, Spectrum partitioning, Optical Network Nodes, Network Access Stations, Overlay Processor, Logical network overlays, Connection Management and Control	9
V	**UNIT V IP SWITCHING** Addressing model, IP Switching types - flow driven and topology driven solutions, IP Over ATM address and next hop resolution, multicasting, Ipv6 over ATM.	9
	Total Instructional Hours	**45**
Course Outcome	**After completion of the course the learner will be able to** CO1: Familiar with the basics of switching technologies and their implementation in LANs, ATM , IP and Optical networks. CO2: Familiar with the different switching architectures and queuing strategies CO3: Able to analyze switching networks based on their blocking performances and implementation complexities. CO4: Able to identify suitable switch architectures for a specified networking scenario CO5: To apply switching technologies, architectures and buffering strategies for designing high speed communication networks and analyse their performance	

REFERENCE BOOKS:

R1-AchillePattavina, "Switching Theory: Architectures and performance in Broadband ATM networks ",John Wiley & Sons Ltd, New York. 1998

R2-Thomas E. Stern, Georgios Ellinas, Krishna Bala, "Multiwavelength Optical Networks – Architecture, Design and control" , Cambridge University Press, 2nd Edition, 2009.

R3- Rich Siefert, Jim Edwards, "The All New Switch Book – The Complete Guide to LAN Switching Technology", Wiley Publishing, Inc., 2nd Edition, 2008.

R4-Elhanany M. Hamdi, "High Performance Packet Switching architectures", Springer Publications, 2007.

R5-Christopher Y Metz, "Switching protocols & Architectures", McGraw - Hill Professional Publishing, New York, 1998.

R6-Rainer Handel, Manfred N Huber, Stefan Schroder, "ATM Networks - Concepts Protocols, Applications", Addison Wesley, New York, 3rd Edition, 1999

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	3	-	-	-	-	-	-	2	3	1
CO2	3	2	3	3	3	-	-	-	-	-	-	3	3	3
CO3	3	3	3	3	2	-	-	-	-	-	-	2	3	3
CO4	3	2	2	3	3	-	-	-	-	-	-	3	3	2
CO5	3	3	3	3	2	-	-	-	-	-	-	2	3	2
AVG	3	3	3	3	3	-	-	-	-	-	-	2	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM3310	SATELLITE COMMUNICATIONS AND NAVIGATION SYSTEMS	3	0	0	3

Course Objective

The student should be able to

Understand the necessity for satellite based communication, the essential elements involved and the transmission methodologies.
Understand the different interferences and attenuation mechanisms affecting the satellite link design.
Expose the advances in satellite based navigation, GPS and the different application scenarios.

Unit	Description	Instructional Hours
I	**ELEMENTS OF SATELLITE COMMUNICATION** Satellite Systems, Orbital description and Orbital mechanics of LEO, MEO and GSO, Placement of a Satellite in a GSO, Antennas and earth coverage, Altitude and eclipses, Satellite drift and station keeping, Satellite – description of different Communication subsystems, Bandwidth allocation.	9
II	**SATELLITE SPACE SEGMENT AND ACCESS** Introduction; attitude and orbit control system; telemetry, tracking and command; power systems, communication subsystems, antenna subsystem, equipment reliability and space qualification, Multiple Access: Demand assigned FDMA - spade system - TDMA - satellite switched TDMA –CDMA.	9

III	**SATELLITE LINK DESIGN** Basic link analysis, Interference analysis, Rain induced attenuation and interference, Ionospheric characteristics, Link Design: System noise temperature and G/T ratio, Downlink and uplink design, C/N, Link Design with and without frequency reuse, link margins, Error control for digital satellite link.	9
IV	**SATELLITE BASED BROADBAND COMMUNICATION** VSAT Network for Voice and Data – TDM/TDMA, SCPC/DAMA, Elements of VSAT Network, Mobile and Personal Communication Services, Satellite based Internet Systems, Multimedia Broadband Satellite Systems, UAVs.	9
V	**SATELLITE NAVIGATION AND GLOBAL POSITIONING SYSTEM** Radio and Satellite Navigation, GPS Position Location Principles of GPS Receivers and Codes, Satellite Signal Acquisition, GPS Receiver Operation and Differential GPS, INS, Indian Remote Sensing and ISRO GPS Systems.	9
	Total Instructional Hours	**45**
Course Outcome	**After completion of the course the learner will be able to** CO1: Demonstrate an understanding of the basic principles of satellite based communication the essential elements involved and the transmission methodologies. CO2: Familiarize with satellite orbits, placement and control, satellite link design and the communication system components. CO3: Demonstrate an understanding of the different interferences and attenuation mechanisms affecting the satellite link design. CO4: Demonstrate an understanding of the different communication, sensing and navigational applications of satellite. CO5: Familiarize with the implementation aspects of existing satellite based systems.	

REFERENCE BOOKS:

R1 - Wilbur L. Pritchard, Hendri G. Suyderhoud and Robert A. Nelson, "Satellite Communication Systems Engineering", Prentice Hall/ Pearson, 2007.

R2 - Timothy Pratt and Charles W.Bostain, "Satellite Communications", John Wiley and Sons, 2nd Edition, 2012.

R3 - D.Roddy, "Satellite Communication", McGraw Hill, 4th Edition (Reprint), 2009.

R4 - Tri T Ha, "Digital Satellite Communication", McGraw Hill, 2nd Edition, 1990.

R5 - B.N.Agarwal, "Design of Geosynchronous Spacecraft", Prentice Hall, 1993.

R6 - Brian Ackroyd, "World Satellite Communication and Earth Station Design", BSP Professional Books, 1990.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-		-	-	-	-	-	3	3	2
CO2	3	3	3	2	-		-	-	-	-	-	3	3	2
CO3	3	2	3	2	-		-	-	-	-	-	3	3	2
CO4	3	2	3	2	-		-	-	-	-	-	3	3	2
CO5	3	2	3	2	-		-	-	-	-	-	3	3	2
AVG	3	2.4	3	2								3	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM2311	MASSIVE MIMO AND mm WAVE SYSTEMS	3	0	0	3

Course Objective	1.To understand the principles and challenges involved in the design of Massive MIMO systems 2.To understand the propagation aspects of Millimeter wave signals and the fundamentals of Millimeter wave devices and circuits. 3.To understand the various components of Millimeter wave MIMO systems.

Unit	Description	Instructional Hours
I	**INTRODUCTION** Massive MIMO: principles, characteristics and transmission/detection techniques; Channel hardening in large dimensions,- Channel Models – Effect of spatial correlation – Channel Estimation – Pilot contamination in massive MIMO – Implementation challenges and Standardization.	9
II	**PRECODING IN LARGE MIMO SYSTEMS** SVD precoding, Precoding in a multiuser MIMO downlink –Linear precoding- Linear precoding, Non-linear precoding, Precoding in large multiuser MISO systems, Multicell precoding.	9

III	**mmWAVE PROPAGATION** 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.	9
IV	**mmWAVE COMMUNICATION SYSTEMS** 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.	9
V	**mmWAVE MIMO SYSTEMS** Massive MIMO Communications, Spatial diversity of Antenna Arrays, Multiple Antennas, Multiple Transceivers, Noise coupling in MIMO system, Potential benefits for mm wave systems, Spatial, Temporal and Frequency diversity, Dynamic spatial, frequency and modulation allocation, Beamforming for MmWave communications: Analog beamforming, digital beamforming and hybrid Beamforming.	9
	Total Instructional Hours	**45**
Course Outcome	**After completion of the course the learner will be able to** CO1: Ability to appreciate Massive MIMO: characteristics and implementation challenges CO2: Understand the need and impact of different precoding approaches CO3: Ability to characterize propagation issues at Millimeter wave frequencies CO4: Ability to estimate link budget and identity Millimeter wave devices and circuits specifications CO5: Understand and appreciate the various implementation aspects of mmWave MIMO systems.	

REFERENCE BOOKS:

R1- Chockalingam and B. Sundar Rajan, " Large MIMO Systems ", Cambridge University Press, 2014.

R2- Ezio Biglieri, Robert Calderbank, Anthony Constantinides, Andrea Goldsmith, Arogyaswami Paulraj, Vincent Poor, "MIMO Wireless Communications", Cambridge University Press, 2006.

R3- I. Robertson, N. Somjit and M. Chongcheawchamnan, "Microwave and Millimetre-Wave Design for Wireless Communications", 2016.

R4- T.S. Rappaport, R.W. Heath Jr., R.C. Daniels and J.N. Murdock, "Millimeter Wave Wireless Communications: Systems and Circuits", 2015.

R5- K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, 2011.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-		-	-	-	-	-	3	3	2
CO2	3	3	3	2	-		-	-	-	-	-	3	3	2
CO3	3	2	3	2	-		-	-	-	-	-	3	3	2
CO4	3	2	3	2	-		-	-	-	-	-	3	3	2
CO5	3	2	3	2	-		-	-	-	-	-	3	3	2
AVG	3	2.4	3	2								3	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM2312	Machine Learning	3	0	0	3

Course Objective

1. To study the Mathematical background of machine learning.
2. To enable the student to understand the concept of machine learning.
3. To learn the fundamentals of different Neural network architectures.
4. To know the machine learning application in wireless communication and bio-medical.
5. To expose the student to be familiar with a set of well-known supervised, semi-supervised and unsupervised learning algorithms

Unit	Description	Instructional Hours
I	**MATHEMATICAL BACKGROUND** Linear Algebra – Arithmetic of matrices, Norms, Eigen decomposition, Singular value decomposition, Pseudo inverse, Component analysis. Probability theory – probability distribution, conditional probability, Chain rule, Bayes rule, Information theory, Structured Probabilistic models.	9

II	**MACHINE LEARNING BASICS** Supervised and Unsupervised learning, Capacity, Overfitting and Underfitting, Cross Validation, Linear regression, Logistic Regression, Regularization, Naive Bayes, Support Vector Machines (SVM), Decision tree, Random forest, K-Means Clustering, k nearest neighbor.	9
III	**NEURAL NETWORKS** Feedforward Networks , Back propagation, Convolutional Neural Networks-LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet, Visualizing Convolutional Neural Networks, Guided Back propagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks. Recurrent Neural Network(RNN) – Back propagation through time (BPTT), Vanishing and Exploding Gradients.	9
IV	**ML IN WIRELESS AND SECURITY** Water-filling power allocation, Optimization for MIMO Systems, OFDM Systems and MIMO-OFDM systems. Optimization in beamformer design – Robust receive beamforming, Transmit downlink beamforming. Application: Radar for target detection, Array Processing, MUSIC, ML in Side channel analysis.	9
V	**ML IN BIO-MEDICAL** Machine Learning in Medical Imaging. Deep Learning for Health Informatics. Deep Learning Automated ECG Noise Detection and Classification System for Unsupervised Healthcare Monitoring. Techniques for Electronic Health Record (EHR) Analysis.	9
	Total Instructional Hours	**45**
Course Outcome	**After completion of the course the learner will be able to** CO1: Demonstrate understanding of the mathematical principles underlying machine learning. CO2: Familiar with the different machine learning techniques and their use cases. CO3: In a position to formulate machine learning problems corresponding to different applications. CO4: Able to recognize the characteristics of machine learning techniques that are useful to solve real-world problems. CO5: In a position to read current research papers, understand the issues and the machine learning based solution approaches.	

REFERENCE BOOKS:

R1-Ian Goodfellow, Yoshua Bengio, and Aaron Courville, "Deep learning",Cambridge,MA, MIT Press, 2017.

R2-Tom M. Mitchell, "Machine Learning", McGraw Hill, 1997.

R3-Ethem Alpaydın, "Introduction to machine learning", MIT Press, 3rd Edition, 2014.

R4-M. N. Wernick, Y. Yang, J. G. Brankov, G. Yourganov and S. C. Strother, "Machine Learning in Medical Imaging", IEEE Signal Processing Magazine, vol. 27, no. 4, pp. 25-38, July 2010.

R5-Ravì et al., "Deep Learning for Health Informatics," IEEE Journal of Biomedical and Health Informatics, vol. 21, no. 1, pp. 4-21, Jan. 2017.

R6-U. Satija, B. Ramkumar and M. S. Manikandan, "Automated ECG Noise Detection and Classification", IEEE Journal of Biomedical and Health Informatics PP(99), March 2017.

R7-"System for Unsupervised Healthcare Monitoring," IEEE Journal of Biomedical and Health Informatics, vol. 22, no. 3, pp. 722-732, May 2018.

R8-B. Shickel, P. J. Tighe, A. Bihorac and P. Rashidi, "Deep EHR: A Survey of Recent Advances in Deep Learning Techniques for Electronic Health Record (EHR) Analysis," IEEE Journal of Biomedical and Health Informatics, vol. 22, no. 5, pp. 1589-1604, Sept. 2018.

R9-A. Heuser, S. Picek, S. Guilley and N. Mentens, "Lightweight Ciphers and their Side-channel Resilience," IEEE Transactions on Computers.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	3	-	-	-	-	-	-	2	3	1
CO2	3	2	3	3	3	-	-	-	-	-	-	3	3	3
CO3	3	3	3	3	2	-	-	-	-	-	-	2	3	3
CO4	3	2	2	3	3	-	-	-	-	-	-	3	3	2
CO5	3	3	3	3	2	-	-	-	-	-	-	2	3	2
AVG	3	3	3	3	3	-	-	-	-	-	-	2	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM2313	Communication Protocol for IOT	3	0	0	3

Course Objective	1. To learn the fundamentals IoT 2. To understand the design principles of IoT 3.To compare and analyze different standards for IoT 4. To give exposure to M2M Architecture and Light weight protocols 5. To design and Implement IoT applications

Unit	Description	Instructional Hours
I	**INTRODUCTION:** Internet of things overview, Design principles for connected devices, Web thinking for connected devices, Internet Principles.	9
II	**6LOWPAN AND RPL:** 6LoWPAN and RPL Standardization Adaptation Layer RPL Downward Routes, Multicast Membership, Packet Routing	9

III	**ZIGBEE SMART ENERGY 2.0**: REST Overview, ZigBee SEP 2.0 Overview, Function Sets and Device Types, ZigBee SE 2.0 Security	9
IV	**ETSI M2M ARCHITECTURE:** Introduction to ETSI TC M2M, System Architecture, ETSI M2M Interactions Overview, Security in the ETSI M2M Framework, Interworking with Machine Area Networks	9
V	**COAP AND MQTT**: Constrained application protocol overview, RFC 7252, MQTT basics, Developing Projects , connecting to server ,Controlling Output Devices.	9
	Total Instructional Hours	**45**
Course Outcome	**After completion of the course the learner will be able to** CO1: Study the introduction of IoT. CO2: Ability to understand the concepts of 6LOWPAN and RPL CO3: Understand the working of various Zigbee function and security. CO4: Explain different architecture of M2M CO5: Analysze different output devices	

REFERENCE BOOKS:

R1 - Adrian McEwen,Hakim Cassimally ‖Designing the Internet of Things‖ John Wiley and Sons, Ltd , 2014.

R2 - Olivier Hersent, David Boswarthick, Omar Elloumi —The Internet of Things: Key Applications and Protocols‖, 2nd Edition John Wiley & Sons Ltd 2012

R3 - Peter Waher —Learning Internet of Things‖ 2015 Packt Publishing.

R4 - Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle —From Machine-to-Machine to the Internet of Things‖ Introduction to a New Age of Intelligence , Academic Press 2014

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	2	2	-	-	1	2	2	3	2
CO2	3	3	3	3	2	2	2	-	-	1	2	2	2	2
CO3	3	3	3	3	2	2	2	-	-	1	2	2	2	2
CO4	3	3	3	3	2	2	2	-	-	1	2	2	2	2
CO5	3	3	3	3	2	2	2	-	-	1	2	2	3	3
AVG	3	3	3	3	2.2	2	2			1	2	2	2.4	2.2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM2314	Speech Signal Processing	3	0	0	3

Course Objective	The student should be able to CO1: Study the mechanism and model of speech production CO2: Apply auditory transforms Techniques CO3: Estimate LPC parameters and Feature extraction of of speech signal CO4: Illustrate Speech synthesis CO5: Apply various algorithms for speech and audio signal processing

Unit	Description	Instructional Hours
I	**MECHANISM OF SPEECH** Introduction : Speech processing and application - Voice production Mechanism - Physiological and Mathematical Model – Nature of Speech signal - Acoustic Phonetics – Acoustics of speech production – Discrete time modeling of Speech production – Representation of Speech signals – Categorization of Speech Sounds based on the source-system and the articulatory model - Articulatory features.	9
II	**SPEECH SIGNAL PROCESSING CONCEPTS** Discrete time speech signals, Fast Fourier transform and Z-transform for speech recognition, Convolution - Linear and Non linear filter banks. Spectral estimation of speech using the Discrete Fourier transform. Pole-zero modeling of speech and linear prediction (LP) analysis of speech. Homomorphic speech signal de convolution, real and complex cepstrum, application of cepstral analysis to speech signals..	9
III	**LINEAR PREDICTIVE ANALYSIS AND FEATURE EXTRACTION OF SPEECH** Formulation of Linear Prediction problem in Time Domain – Basic Principle – Auto Correlation method – Covariance method – Solution of LPC equations – Cholesky Method – Durbin's Recursive algorithm – pattern recognition methods for Pitch detection – Vocoders : CELP - VELP – Feature Extraction - MFCC, LPCC - Speech distortion measures :mathematical and perceptual – Log–Spectral Distance, Cepstral Distances,	9
IV	**UNIT V SPEECH SYNTHESIS** Text-to-Speech Synthesis: Concatenative and waveform synthesis methods, hidden Markov model-based TTS, context dependent sub-word units for TTS, intelligibility and naturalness – role of prosody, Applications and current status.	9
V	**APPLICATION OF SPEECH & AUDIO SIGNAL PROCESSING** Spectral Estimation – Spectral enhancement algorithm, dynamic time warping – Music analysis – Pitch Detection –Feature Extraction for ASR - Auditory models – Speaker identification and verification – Voice response system – voice over IP.	9
	Total Instructional Hours	**45**

Course Outcome	**After completion of the course the learner will be able to** CO1: Describe the fundamentals of speech and Model speech production. CO2: Estimate the different parameters and analysis in speech signal. CO3: Implement linear predictive analysis and extract features of speech signal. CO4: Build speech synthesis systems. CO5: Choose an appropriate algorithm in speech model for a given application.

REFERENCE BOOKS:

R1 - Lawrence Rabiner and Biing-Hwang Juang, "Fundamentals of Speech Recognition", Pearson Education, 2003.

R2 - Thomas F Quatieri, "Discrete-Time Speech Signal Processing – Principles and Practice", Pearson 2012

R3 - B. Gold and N. Morgan, "Speech and Audio Signal Processing: Processing and perception of speech and music", Wiley, Second edition,2011

R4 - L. R. Rabiner and Schaffer, "Digital Processing of Speech signals Pearson Education", 2004

R5 - Heiga Zen, Keiichi Tokuda, Alan W. Black, "Statistical Parametric Speech Synthesis", Speech Communication, Vol. 51, Issue 11, Nov. 2009, pp. 1039 - 1064.

R6 - J.L.Flanagan, "Speech analysis: Synthesis and Perception", 2nd edition, Berlin, 1972.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-		-	-	-	-	-	3	3	2
CO2	3	3	3	2	-		-	-	-	-	-	3	3	2
CO3	3	2	3	2	-		-	-	-	-	-	3	3	2
CO4	3	2	3	2	-		-	-	-	-	-	3	3	2
CO5	3	2	3	2	-		-	-	-	-	-	3	3	2
AVG	3	2.4	3	2								3	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
BE	24CM3315	MULTIMEDIA COMPRESSION	3	0	0	3

Course Objective	The student should be conversant with 1. To introduce the significance of data compression and the idea of various Huffman codes. 2. To develop the knowledge of generating tags, deciphering the tag in Arithmetic coding approaches,and the application of static and dynamic dictionary approaches. 3. To introduce the concept of Audio compression and various audio compression standards and its applications. 4. To understand the need, concept of 2D and 3D compression and to develop the knowledge of various recent compression standards and techniques. 5. To introduce the concept of Video compression and various Video compression standards and its applications.

Unit	Description	Instructional Hours
I	**UNIT I INTRODUCTION** Compression Techniques - Overview of information theory - lossless and lossy coding– Modeling and Coding - Taxonomy of compression techniques – Rate distortion theory - Huffman coding – Non-Binary Huffman codes – adaptive Huffman coding – Application of Huffman coding.	9
II	**UNIT II ARITHMETIC CODING AND DICTIONARY TECHNIQUES** Introduction- coding a sequence – generating deciphering the tag – Generating a binary code – Uniqueness of arithmetic code – Algorithm, integer implementation – comparison of Huffman and arithmetic coding – Applications -Static and Adaptive dictionary – LZ77, LZ78, LZW approach – Applications - Facsimile encoding – run length coding – comparison of MH, MR, MMR and JBIG. Scalar and Vector Quantization	9
III	**UNIT III AUDIO COMPRESSION** Audio compression techniques - frequency domain and filtering - basic sub-band coding - application to speech coding - G.722 - application to audio coding - MPEG audio - silence suppression - speech compression techniques –Vocoders.	9
IV	**UNIT IV IMAGE COMPRESION** Predictive techniques - DPCM, DM - KL transform – discrete cosine, Walsh- Hadamard transform - JPEG, Wavelet based compression: quad-trees, EZW, SPIHT, JPEG-2000	9
V	**UNIT V VIDEO COMPRESSION** Video signal representation – Motion compensation – MPEG standards - Motion estimation techniques - H.261 family of standards - Motion video compression.	9
	Total Instructional Hours	**45**

Course Outcome	**After the completion of the course, the learner will be able to** CO1: Able to differentiate different coding techniques. CO2: Able to understand different arithmetic coding techniques. CO3: Able to illustrate different audio compression standards CO4: Able to illustrate different Image compression standards CO5: Able to differentiate different video compression standards

REFERENCE BOOKS:
R2.-Salomon D, —Data Compression The Complete Referencel, Springer, 2007.
R3- Salomon D, —A Guide to Data Compression Methodsl, Springer, 2002.
R4-Jan Vozer, —Video Compression for Multimedial, AP Press, New York, 1995.
R5-Alistar Moffat, —Compression and Coding Algorithmsl, Kluwer Academic Publishers, 2002.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	3		-	-	3	-	-	2	3	1
CO2	3	2	3	3	3		-	-		-	-	3	3	3
CO3	3	3	3	3	2		-	-	3	2	-	2	3	3
CO4	3	2	2	3	3		-	-			-	3	3	2
CO5	3	3	3	3	2		-	-	3	2	-	2	3	2
AVG	3	3	3	3	3				3	2		2	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM3316	WAVELETS AND SUBBAND CODING	3	0	0	3
Course Objective	1.To study the analysis of various transform 2.To learn the fundamentals of Continuous Wavelet Transforms 3.To learn the fundamentals of Discrete Wavelet Transforms 4.To understand the concepts of various advanced wavelet techniques 5.To design applications based on wavelets					
Unit	Description				Instructional Hours	

I	**INTRODUCTION** Signal spaces - concept of Convergence - Hilbert spaces for energy signals. Fourier basis & Fourier Transform – Limitations of standard Fourier analysis – Need for Time-Frequency Analysis, Spectrogram plot – Windowed Fourier transform Tiling of the Time-Frequency Plane for STFT – Heisenberg"s Uncertainty principle – Short time Fourier transform (STFT) Analysis- short comings of STFT- Need for Wavelets.	9
II	**CONTINUOUS WAVELET TRANSFORMS (CWT)** Introduction, Continuous Time wavelets, Definition of CWT, The CWT as a correlation, Constant Q-Factor Filtering Interpolation and time frequency resolution, the CWT as an operator, inverse CWT.	9
III	**DISCRETE WAVELET TRANSFORM (DWT) AND MRA** Introduction,Approximation of vectors in nested linear vector spaces, example of an MRA-Bases for the approximations subspaces and Haar scaling function, Bases for detail subspaces and Haar wavelet, Formal definition of an MRA, Construction of a general orthonormal MRA, A wavelet basis for MRA, Interpreting orthonormal MRAs for Discrete time signals, Daubechies Wavelets, Relationship between Filter banks and wavelet basis, Important wavelets: Haar, Mexican hat, Meyer, Shannon, Daubechies	9
IV	**ADVANCED TOPICS** Wavelet packets, Non - separable multidimensional wavelets, Bi-orthogonal basis-B-Splines, Lifting scheme of wavelet generation, Multiwavelets, Ridgelets, Curvelets.	9
V	**APPLICATIONS OF WAVELETS** Signal Denoising - Sub-band coding of Speech and music– Image Compression using 2-D DWT- JPEG 2000 standard - Fractal Signal Analysis.	9
	Total Instructional Hours	**45**

Course Outcome	**After completion of the course the learner will be able to** CO1: Interpret analysis on various transform. CO2: Understand fundamentals of Continuous Wavelet Transforms CO3: Understand the fundamentals of Discrete Wavelet Transforms CO4: Explain concepts of various advanced wavelet techniques CO5: design applications based on wavelets

REFERENCE BOOKS:

R1. Soman K P and Ramachandran K I, "Insight into Wavelets from Theory to Practice", Prentice Hall India, 2010

R2. Jaideva C Goswami and Andrew K Chan, "Fundamentals of Wavelets – Theory, Algorithms and Applications", John Wiley and Sons, Inc., Singapore, 1999.

R3. Fliege. N J, "Multirate Digital Signal Processing", John Wiley and Sons, Newyork,1994.

R4. Wornell G W, "Signal Processing with Fractals: A Wavelet based Approach", Prentice Hall, 1995.

R5. Vetterli M and Kovacevic J, "Wavelets and Subband Coding," Prentice Hall, 1995.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-		-	-	-	-	-	3	3	2
CO2	3	3	3	2	-		-	-	-	-	-	3	3	2
CO3	3	2	3	2	-		-	-	-	-	-	3	3	2
CO4	3	2	3	2	-		-	-	-	-	-	3	3	2
CO5	3	2	3	2	-		-	-	-	-	-	3	3	2
AVG	3	2.4	3	2								3	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM3317	DEEP LEARNING	3	0	0	3

Course Objective

1. Introduce to the basic concepts of neural networks.
2. Identify and analyze the various types of neural networks and models of neuron and apply accordingly.
3. Introduce the concept of deep learning and its types.
4. Explore the concepts of applications of deep learning.

Unit	Description	Instructional Hours
I	**INTRODUCTION TO NEURAL NETWORKS** Characteristics of Neural Networks, Historical Development of Neural Networks Principles, Artificial Neural Networks: Terminology, Models of Neuron, Topology, Basic Learning Laws, Pattern Recognition Problem, Basic Functional Units, Pattern Recognition Tasks by the Functional Units. Introduction, Analysis of pattern Association Networks, Analysis of Pattern Classification Networks, Analysis of pattern storage Networks. Analysis of Pattern Mapping Networks.	9

II	**FEEDBACK NEURAL NETWORKS** Introduction, Analysis of Linear Auto associative FF Networks, Analysis of Pattern Storage Networks. Competitive Learning Neural Networks & Complex pattern Recognition Introduction, Analysis of Pattern Clustering Networks, Analysis of Feature Mapping Networks, Associative Memory.	9
III	**FUNDAMENTALS OF DEEP LEARNING** Defining Deep Learning, Common architectural principles of Deep Networks, Building Blocks of Deep Networks, and Major architectures of Deep Networks: Unsupervised Pretrained Networks, Convolution Neural Networks (CNNs), Recurrent Neural Networks.	9
IV	**CONVOLUTION NEURAL NETWORKS** The convolution operation, motivation, pooling, Convolution and Pooling as an Infinitely Strong Prior, Applications of deep learning: Large scale deep learning, Computer vision, Speech Recognition, Natural Processing, other applications.	9
V	**SEQUENTIAL MODELLING** Recurrent neural networks: Recursive neural networks, The long short –term Memory, explicit memory, Auto encoders: Under complete, regularised, Stochastic Encoders and Decoders, Denoising Auto encoders	9
	Total Instructional Hours	**45**
Course Outcome	**After completion of the course the learner will be able to** CO1:Analyze and apply the basic the concepts of neural networks CO2:Analyze various types of neural networks and use various activation functions to solve complex problems. CO3:Relate the concept of deep learning and its architecture. CO4:Design and carry out empirical analysis for various types of applications of deep learning systems.	
REFERENCE BOOKS:		
R13 - Neural Networks by Simon Haykin PHI		
R14 - Deep learning (Adaptive computation &Machine learning) by Ian Good Fellow, YoshuaBengio, AranCourville.		
R15 - Fundamentals of Neural Networks: Architectures, Algorithms and Applications, by Fausett..		

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3							2	2	3	2
CO2	3	3	3	3							2	2	3	2
CO3	3	3	2	3							2	2	2	3
CO4	3	3	2	2							2	2	2	3
CO5	3	3	3	3							2	2	3	3
AVG	3	3	2.6	2.8							2	2	2.6	2.6

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM3318	Spread Spectrum Communications	3	0	0	3

Course Objective	1. Understand the concept of Spread Spectrum and study various types of Spread spectrum sequences and their generation. 2. Understand the principles of Code Division Multiple Access (CDMA) and use of Spread spectrum concept in CDMA 3. Understand various Code tracing loops for optimum tracking of wideband signals viz spread spectrum signals 4. Understand the procedure for synchronization of receiver for receiving the Spread spectrum signal. 5. Study the performance of spread spectrum systems in Jamming environment, systems with Forward Error Correction and Multiuser detection in CDMA cellular radio.

Unit	Description	Instructional Hours
I	Introduction to Spread Spectrum Systems: Fundamental Concepts of Spread Spectrum Systems, Pseudo Noise Sequences, Direct Sequence Spread Spectrum, Frequency Hop Spread Spectrum, Hybrid Direct Sequence Frequency Hop Spread Spectrum, Code Division Multiple Access. Binary Shift Register Sequences for Spread Spectrum Systems Introduction, Definitions, Mathematical Background and Sequence Generator Fundamentals, Maximal Length Sequences, Gold Codes.	9

II	Code Tracking Loops: Introduction, Optimum Tracking of Wideband Signals, Base Band Delay-Lock Tracking Loop, Tau-Dither Non- Coherent Tracking Loop, Double Dither Non-Coherent Tracking Loop.	9
III	Initial Synchronization of the Receiver Spreading Code: Introduction, Problem Definition and the Optimum Synchronizer, Serial Search Synchronization Techniques, Synchronization using a Matched Filter, Synchronization by Estimated the Received Spreading Code.	9
IV	Cellular Code Division Multiple Access (CDMA) Principles: Introduction, Wide Band Mobile Channel, The Cellular CDMA System, Single User Receiver in a Multi User Channel, CDMA System Capacity, Multi-User Detection in CDMA Cellular Radio, Optimal Multi-User Detection, Linear Suboptimal Detectors, Interference Combat Detection Schemes, Interference Cancellation Techniques.	9
V	Performance of Spread Spectrum Systems in Jamming Environments Spread Spectrum, Communication System Model, Performance of Spread Spectrum Systems without Coding. Performance of Spread Spectrum Systems with Forward Error Correction Elementary Block Coding Concepts, Optimum Decoding Rule, Calculation of Error Probability, Elementary Convolution Coding Concepts, Viterbi Algorithm, Decoding and Bit-Error Rate.	9
	Total Instructional Hours	**45**
Course Outcome	**After completion of the course the learner will be able to** CO1:Ability to understand the concept of Spread Spectrum and study various types of Spread spectrum sequences and their generation. CO2: Ability to understand the principles of Code Division Multiple Access (CDMA) and use of Spread spectrum concept in CDMA CO3:Ability to understand various Code tracing loops for optimum tracking of wideband signals viz spread spectrum signals CO4: Ability to understand the procedure for synchronization of receiver for receiving the Spread spectrum signal. CO5:Study the performance of spread spectrum systems in Jamming environment, systems with Forward Error Correction and Multiuser detection in CDMA cellular radio.	
REFERENCE BOOKS:		
R1-Rodger E Ziemer, Roger L. Peterson and David E Borth - "Introduction to Spread Spectrum Communication- Pearson, 1st Edition, 1995.		
R2-Mosa Ali Abu-Rgheff – "Introduction to CDMA Wireless Communications." Elsevier Publications, 2008		
R3-George R. Cooper, Clare D. Mc Gillem - "Modern Communication and Spread Spectrum," McGraw Hill, 1986.		
R4-Andrew j. Viterbi - "CDMA: Principles of spread spectrum communication," Pearson Education, 1st Edition, 1995.		
R5-Kamilo Feher - "Wireless Digital Communications," PHI, 2009. 4. Andrew Richardson - "WCDMA Design Handbook," Cambridge University Press, 2005. 5. Steve Lee - Spread Spectrum CDMA, McGraw Hill, 2002.		

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO1 1	PO1 2	PSO 1	PSO 2
CO1	3	2	2	-	2	2	-	-	2	-	-	2	3	3
CO2	3	3	3	2	2	1	-	-	3	-	-	2	3	3
CO3	3	3	3	2	2	1	-	-	2	-	-	3	3	3
CO4	3	3	3	3	3	2	-	-	3	-	-	3	3	3
CO5	2	1	2	1	3	-	-	-	3	-	-	3	3	3
AVG	2.8	2.4	2.6	2	2.4	1.5	-	-	2.8	-	-	2.6	3	3

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Programme	Course Code	Name of the Course	L	T	P	C
ME	**24CM3319**	**Block Chain and Its Applications**	**3**	**0**	**0**	3
Course Objective	1.To understand the need for Blockchain 2.To Explore the major components of Blockchain 3. To Learn about Hyperledger Fabric model and its Architecture 4. To Identify the use cases for a Blockchain application					
Unit	**Description**					**Instructional Hours**
I	Introduction to Blockchain: Digital Money to Distributed Ledgers , Design Primitives: Protocols, Security, Consensus, Permissions, Privacy. Blockchain Architecture and Design: Basic crypto primitives: Hash, Signature,) Hashchain to Blockchain, Basic consensus mechanisms					9

II	Consensus: Requirements for the consensus protocols, Proof of Work (PoW), Scalability aspects of Blockchain consensus protocols Permissioned Blockchains:Design goals, Consensus protocols for Permissioned Blockchains	9
III	Hyperledger Fabric (A): Decomposing the consensus process , Hyperledger fabric components, Chaincode Design and Implementation Hyperledger Fabric (B): Beyond Chaincode: fabric SDK and Front End (b) Hyperledger composer tool	9
IV	Use case 1 : Blockchain in Financial Software and Systems (FSS): (i) Settlements, (ii) KYC, (iii) Capital markets, (iv) Insurance Use case 2: Blockchain in trade/supply chain: (i) Provenance of goods, visibility, trade/supply chain finance, invoice management discounting, etc	9
V	Use case 3: Blockchain for Government: (i) Digital identity, land records and other kinds of record keeping between government entities, (ii) public distribution system social welfare systems Blockchain Cryptography, Privacy and Security on Blockchain	9
	Total Instructional Hours	**45**
Course Outcome	**After completion of the course the learner will be able to** CO1: Ability to understand the need for Block chain CO2: Ability to explore the major components of Block chain CO3: Ability to learn about Hyper ledger Fabric model and its Architecture CO4: Ability to identify the use cases for a Block chain application	

REFERENCE BOOKS:

R1- 1. Mastering Bitcoin: Unlocking Digital Crypto currencies, by Andreas Antonopoulos, ISBN: 978-1-449-37404-4,2014

R2- Blockchain by Melanie Swa, O'Reilly , Publisher(s): O'Reilly Media, ,2015,ISBN:9781491920480

R3-Zero to Blockchain - An IBM Redbooks course, by Bob Dill, David Smits. https://www.redbooks.ibm.com/Redbooks.nsf/RedbookAbstracts/crse0401.html

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PO12	PSO 1	PSO 2
CO1	3	3	2	3	-	-	-	-	3	-	-	2	3	3
CO2	3	3	3	3	-	-	-	-	3	-	-	2	3	3
CO3	3	3	2	3	-	-	-	-	3	-	-	2	3	3
CO4	3	3	3	3	-	-	-	-	3	-	-	3	3	3
CO5	3	3	2	3	-	-	-	-	3	-	-	3	3	3
AVG	3	3	2.4	3	-	-	-	-	3	-	-	2.6	3	3

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM3320	5G Technology	3	0	0	3

Course Objective

1. To introduce students with concepts, design issues in 5G networks.
2. To study about architectures and protocols and the state-of-the–art developments in next generation wireless network technologies.
3. To Study various Multiple Access techniques for wireless channels.
4. To understand the relevance of MIMO techniques.
5. To analyze different types of cooperative communications.

Unit	Description	Instructional Hours
I	**5G CHANNEL MODEL** Modeling requirements and scenarios, Channel model requirements and Measurements, Propagation scenarios, METIS channel models, Map-based model, stochastic model, Comparison of Models	9

II	**MULTI-CARRIER WAVEFORMS FOR 5G** Filter-bank based multi-carrier (FBMC)- Principles, Transceiver block diagram, Frame structure, Resource structure, allocation, mapping. Universal filtered multi carrier (UFMC)- Principles, Transceiver structure, Frame and Resource structure, allocation, mapping. Generalized frequency division multicarrier (GFDM) – Principles, Transceiver Block diagram, Frame structure, Resource structure, allocation, mapping, MIMO-GFDM.	9
III	**MULTIPLE ACCESS TECHNIQUES IN 5G** Challenges in OFDM- NOMA – Principle- Superposition Coding, Successive Interference Cancellation, Power Domain NOMA, Sparse Code NOMA- types, Power Domain Sparse Code NOMA, Cooperative NOMA- Benefits and Challenges.	9
IV	**MASSIVE MIMO** Introduction-pilot design and channel estimation- uplink data transmission and downlink data transmission for Single cell systems and multi cell systems – capacity analysis.	9
V	**COOPERATIVE COMMUNICATION** Machine Type Communication (MTC), Device to Device Communication (D2D), 5G Narrowband IoT, Cloud Computing architecture and Protocols, Relaying: Cooperative NOMA- Benefits and Challenges, Half duplex relaying, Full duplex relaying, Amplify and forward relaying, Decode and forward relaying, Decode and forward relaying with PLNC, BER Analysis, Capacity Analysis.	9
	Total Instructional Hours	**45**

Course Outcome	CO1: Able to analyze the performance of different channel models adopted in 5G wireless systems. CO2: Able to design a transceiver for Multicarrier waveforms. CO3: Able to analyze multiple access techniques in 5G networks CO4: Able to design a pilot, estimate channels and analyze capacity for single cell and multicell Massive MIMO CO5: Able to analyze different types of cooperative communications.

REFERENCE BOOKS:

R1-AfifOsseiran, Jose.F.Monserrat and Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2016.

R2-Robert W. Heath Jr., Nuria González-Prelcic, SundeepRangan, WonilRoh,and Akbar M. Sayeed, "An Overview of Signal Processing Techniques for Millimeter Wave MIMO Systems", IEEE Journal of Selected Topics in Signal Processing, Vol. 10, No. 3, April 2016

R3-MinChulJu and Il-Min Kim, "Error Performance Analysis of BPSK Modulation in Physical- Layer Network-Coded Bidirectional Relay Networks", IEEE Transactions on Communications, Vol. 58, No. 10, October 2010.

R4-Shengli Zhang, Soung-Chang Liew, Patrick P.Lam, "Physical Layer Network Coding", Mobicom _06, Proceeding of the 12th International Conference on Mobile Computing and Networking, pp.358-365, Los Angeles, CA, USA, Sep.23-29,2006

R5-Thomas L. Marzetta, Erik G. Larsson, Hong Yang, HienQuoc Ngo, "Fundamentals of Massive MIMO", Cambridge University Press, 1 st Edition, 2016.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-		-	-	-	1	-	3	3	2
CO2	3	3	3	2	-		-	-	-	1	-	3	3	2
CO3	3	3	3	2	-		-	-	-	-	-	3	3	2
CO4	3	2	3	2	-		-	-	-	1	-	3	3	2
CO5	3	2	3	2	-		-	-	-	-	-	3	3	2
AVG	3	2.6	3	2						1		3	3	2

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Programme	Course Code	Name of the Course	L	T	P	C
ME	24CM3401	Green Communication	3	0	0	3

Course Objective

1. To study about fundamentals of green radio networks.
2. To impart the importance of reducing energy consumption.
3. To learn about CO2 emissions and inculcate green concepts for energy efficient approaches.
4. To study about the power management technique.
5. To understand the concept of designing next generation wireless networks.

Unit	Description	Instructional Hours
I	**INTRODUCTION** Fundamental Tradeoffs on the Design of Green Radio Networks: Insight from Shannon's capacity formula - impact of practical constraints - latest research and directions; Algorithms for Energy Harvesting Wireless Networks: Energy harvesting technologies - PHY and MAC layer optimization for energy harvesting wireless networks.	9

II	**GREEN MODULATION AND CODING** Modulation: Green modulation and coding schemes in energy constrained wireless networks - energy consumption of uncoded scheme - energy consumption analysis of LT coded modulation.	9
III	**CO-OPERATIVE TECHNIQUES** Co-operative Techniques for Energy Efficient Wireless Communications: Energy efficiency metrics for wireless networks – co-operative networks - optimizing the energy efficiency performance of co-operative networks - energy efficiency in co-operative base stations.	9
IV	**BASE STATION POWER MANAGEMENT TECHNIQUES** Base Station Power Management Techniques for Green Radio Networks: Opportunistic spectrum and load management for green radio networks - energy saving techniques in cellular wireless base stations - power management for base stations in a smart grid environment.	9
V	**WIRELESS ACCESS TECHNIQUES FOR GREEN RADIO NETWORKS** Cross Layer Design: 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.	9
	Total Instructional Hours	**45**

Course Outcome	**After completion of the course the learner will be able to** CO1: To gain the knowledge about green radio networks CO2: To work with green modulation and coding technique. CO3: To apply the energy efficiency technique with wireless networks CO4: To analyze theradio techniques to reduce the overall energy consumption. CO5: To design new green radio architectures

REFERENCE BOOKS:

R1-Ekram Hossain, Vijay K. Bhargava and Gerhard P. Fettweis, "Green RadioCommunication Networks", Cambridge University Press, 2012.

R2-F. Richard Yu, Yu, Zhang and Victor C. M. Leung "Green Communications andNetworking", CRC press, 2012.

R3-Mohammad S. Obaidat, Alagan Anpalagan and Isaac Woungang, "Handbook of Green Information and Communication Systems", Academic Press, 2012.

R4-Jinsong Wu, Sundeep Rangan and Honggang Zhang, "Green Communications:Theoretical Fundamentals, Algorithms and Applications", CRC Press, 2012.

R5-Mazin Al Noor, "Green Radio Communication Networks Applying Radio-Over-FibreTechnology for Wireless Access", GRIN Verlag, 2012.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2							2	2	3	2
CO2	3	3	2	2							2	2	3	2
CO3	3	3	2	2							3	2	2	3
CO4	3	2	2	2							2	2	2	3
CO5	3	3	3	3							2	2	3	3
AVG	3	2.6	2.2	2.2							2.2	2	2.6	2.6

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Programme	Course Code	Name of the Course	L	T	P	C
BE	24CM3402	Industrial IoT	2	0	2	3

Course Objective

1. To make the students familiarize about role of IoT in industry
2. To impart knowledge about various data monitoring and control techniques.
3. To teach theoretical and practical skills in IIoT
4. To provide students with good depth of IIoT design platform.
5. To educate design and analysis of Industry 4.0 Systems

Unit	Description	Instructional Hours
I	**INTRODUCTION TO IMPLEMENTATION OF INDUSTRIAL IOT (IIOT) SYSTEMS** Fundamentals of Control System: Introduction, Components, Closed loop and Open loop System - Role of Internet of Things (IoT) & Industrial Internet of	9

	Things (IIoT) in Industry, Smart Factories, Sensors and Actuators for Industrial Processes, Sensor networks, Process automation and Data Acquisitions on IoT Platform, Microcontrollers and Embedded PC roles in IIoT	
II	**INTRODUCTION TO IMPLEMENTATION OF INDUSTRIAL IOT (IIOT) SYSTEMS** Fundamentals of Control System: Introduction, Components, Closed loop and Open loop System - Role of Internet of Things (IoT) & Industrial Internet of Things (IIoT) in Industry, Smart Factories, Sensors and Actuators for Industrial Processes, Sensor networks, Process automation and Data Acquisitions on IoT Platform, Microcontrollers and Embedded PC roles in IIoT	9
III	**CYBER PHYSICAL SYSTEMS** Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis.	9
IV	**INDUSTRIAL IOT- APPLICATIONS** Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management, IoT smart city, Robot surveillance, Smart irrigation.	9
V	**CASE STUDIES OF IIOT SYSTEMS** IIoT application development with Embedded PC based development boards, Development of mini Project on new version of Operating systems and Edge development board.	9
	Total Instructional Hours	**45**

Course Outcome	CO1: Relate the elements of IoT to build a total control plane in an Industrial application. CO2: Explain IIot data monitoring and control techniques. CO3: Apply the concept of digitalization and data acquisition. CO4 :Analyse smart factory based on the concepts. CO5 : Design IIoT applications.

TEXT BOOKS:

T1- Industry 4.0: The Industrial Internet of Things Alasdair Gilchrist Publications: Apress
T2- Hands-On Industrial Internet of Things: Create a powerful Industrial IoT by Giacomo Veneri, Antonio Capasso, Packt, 2018
T3- The Internet of Things in the Industrial Sector by Mahmood, Zaigham(Ed.) (Springer Publication)
T4- Industrial Internet of Things: Cyber manufacturing System by Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer Publication)
T5- Industrial IoT Challenges, Design Principles, Applications, and Security by Ismail Butun(editor)

T6- "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman (CRC Press)
REFERENCE BOOKS:
R1 - Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat , Industrial Internet of Things: Cyber manufacturing Systems, Springer, 2017 R2 - David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton, Jerome Henry, IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Thing, CISCO Press, 2017. R3. Arshdeep Bahga, Vijay Madisetti, Internet of Things: A Hands-On Approach, Universities Press, 2015.
List of Open Source Software/ Learning website: 1. https://nptel.ac.in/courses/106105195 2. https://www.coursera.org/learn/industrial-internet-of-things 3. https://www.naukri.com/learning/industrial-iot-certification 4. https://www.udemy.com/course/introduction-to-industrial-iot-for-it-professionals/ 5. Industrial IoT platform: Eurotech Everyware IoT.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	2	3	-	-	-	1	1	2	1	2	3
CO2	2	1	3	2	2	-	-	-	3	2	2	3	3	2
CO3	2	2	2	1	2	-	-	-	1	1	1	1	1	1
CO4	1	3	1	1	3	-	-	-	1	1	3	2	1	3
CO5	1	1	3	1	3	-	-	-	1	1	2	1	3	2
AVG	1.6	1.8	2	1.4	2.6	-	-	-	1.4	1.2	2	1.6	2	2.2

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