VELAMMAL COLLEGE OF ENGINEERING AND TECHNOLOGY, MADURAI–625009
(AUTONOMOUS)
REGULATIONS 2021

M.E. COMMUNICATION SYSTEMS (CBCS)

CURRICULUM FOR I TO IV SEMESTERS

SEMESTER I

S. NO.	COURSE CODE	COURSETITLE	CATE-GORY	PERIODS PERWEEK			CREDITS
				L	T	P	
THEORY							
1.	21MA122	Linear Algebra, Probability and Queueing Theory	FC	3	2	0	4
2.	21RM102	Research Methodology for Telecom Engineers	RM	3	0	0	3
3.	21CM101	Statistical Signal Processing	PC	3	2	0	4
4.	21CM102	Modern Digital Communication Systems	PC	3	0	0	3
5.	21CM103	Advanced Wireless Communication	PC	3	0	0	3
6.	21CM104	Radiating Systems	PC	3	2	0	4
7.	21AC101	Audit Course I* *(Common to all PG Programmes)*					
PRACTICALS							
8.	21CM105	Digital Communication Systems Laboratory	PC	0	0	4	2
9.	21CM106	Advanced Digital Signal Processing Laboratory	PC	0	0	4	2
			TOTAL	**18**	**6**	**8**	**25**

**- Audit Course I is optional*

SEMESTER II

S. NO.	COURSE CODE	COURSETITLE	CATE-GORY	PERIODS PERWEEK			CREDITS
				L	T	P	
THEORY							
1.	21CM107	MIC and RF System Design	PC	3	0	0	3
2.	21CM108	Optical Networks	PC	3	0	0	3
3.	21CM109	Signal Detection and Estimation Theory	PC	3	0	0	3
4.	21CM110	Advanced Digital Image Processing	PC	3	2	0	4
5.	21CMPXX	Professional Elective I	PE	3	0	0	3
6.	21CMPXX	Professional Elective II	PE	3	0	0	3
7.	21AC102	Audit Course II* *(Common to all PG Programmes)*					
PRACTICALS							
8.	21CM111	Product Development Laboratory	EE	0	0	6	3
9.	21CM112	Technical Paper Writing and Seminar Presentation	EE	0	0	2	1
			TOTAL	**18**	**2**	**8**	**23**

*- *Audit Course II is optional*

SEMESTER III

S. NO.	COURSE CODE	COURSETITLE	CATE-GORY	PERIODS PERWEEK			CREDITS
				L	T	P	
THEORY							
1.	21CMPXX	Professional Elective III	PE	3	0	0	3
2.	21CMPXX	Professional Elective IV	PE	3	0	0	3
3.	21CMPXX	Professional Elective V	PE	3	0	0	3
PRACTICALS							
5.	21CM201	Project Work Phase I	EE	0	0	12	6
TOTAL				**9**	**0**	**12**	**15**

SEMESTER IV

S. NO.	COURSE CODE	COURSETITLE	CATE-GORY	PERIODS PERWEEK			CREDITS
				L	T	P	
PRACTICALS							
1.	21CM202	Project Work Phase II	EE	0	0	24	12
TOTAL				**0**	**0**	**24**	**12**

TOTAL NUMBER OF CREDITS: 75

PROFESSIONAL ELECTIVES

SEMESTER II, ELECTIVE I

S. NO.	COURSE CODE	COURSETITLE	CATE-GORY	PERIODS PERWEEK			CREDITS
				L	T	P	
THEORY							
1.	21CMP01	Machine Learning	PE	3	0	0	3
2.	21CMP02	Wavelets Transforms and its Applications	PE	3	0	0	3
3.	21CMP03	Advanced Satellite Communication and Navigation Systems	PE	3	0	0	3
4.	21CMP04	MIMO OFDM Systems	PE	3	0	0	3
5.	21CMP05	Analog and Mixed Signal VLSI Design	PE	3	0	0	3

SEMESTER II, ELECTIVE II

S. NO.	COURSE CODE	COURSETITLE	CATE-GORY	PERIODS PERWEEK			CREDITS
				L	T	P	
THEORY							
1.	21CMP06	Electromagnetic Metamaterials	PE	3	0	0	3
2.	21CMP07	Advanced Antenna Design	PE	3	0	0	3
3.	21CMP08	Millimeter Wave Communication	PE	3	0	0	3
4.	21CMP09	Multimedia Compression Techniques	PE	3	0	0	3
5.	21CMP10	Cognitive Radio Networks	PE	3	0	0	3

SEMESTER III, ELECTIVE III

S. NO.	COURSE CODE	COURSETITLE	CATE-GORY	PERIODS PERWEEK			CREDITS
				L	T	P	
THEORY							
1.	21CMP11	Electromagnetic Interference and Compatibility	PE	3	0	0	3
2.	21CMP12	Frequency Selective Surfaces	PE	3	0	0	3
3.	21CMP13	Soft Computing Techniques	PE	3	0	0	3
4.	21CMP14	Space Time Wireless Communication	PE	3	0	0	3
5.	21CMP15	System on Chip Architecture	PE	3	0	0	3

SEMESTER III, ELECTIVE IV

S. NO.	COURSE CODE	COURSETITLE	CATE-GORY	PERIODS PERWEEK			CREDITS
				L	T	P	
THEORY							
1.	21CMP16	Wearable Electronics	PE	3	0	0	3
2.	21CMP17	Network Routing Algorithms	PE	3	0	0	3
3.	21CMP18	5G Technologies and Applications	PE	3	0	0	3
4.	21CMP19	Advanced Wireless Networks	PE	3	0	0	3
5.	21CMP20	Internet of Things for Health Care Applications	PE	3	0	0	3

SEMESTER III, ELECTIVE V

S. NO.	COURSE CODE	COURSETITLE	CATE-GORY	PERIODS PERWEEK			CREDITS
				L	T	P	
THEORY							
1.	21CMP21	Numerical Techniques for Electromagnetic Fields	PE	3	0	0	3
2.	21CMP22	Deep Learning Techniques	PE	3	0	0	3
3.	21CMP23	Wireless Ad-Hoc and Sensor Networks	PE	3	0	0	3
4.	21CMP24	Real Time Systems	PE	3	0	0	3
5.	21CMP25	Testing of VLSI Circuits	PE	3	0	0	3

SEMESTERWISE CREDIT DISTRIBUTION

Category/ Semester	I	II	III	IV	TOTAL CREDITS
FC	4	-	-	-	4
RM	3	-	-	-	3
PC	18	13	-	-	31
PE	-	6	9		15
EE	-	4	6	12	22
TOTAL	**25**	**23**	**15**	**12**	**75**

S.No.	Category
1.	Fundamental Course (FC)
2.	Professional Core Courses (PC)
3.	Professional Elective Courses (PE)
4.	Employability Enhancement Courses (EE)
5.	Research Methodology Courses (RM)

VELAMMAL COLLEGE OF ENGINEERING AND TECHNOLOGY (AUTONOMOUS), MADURAI

M.E. COMMUNICATION SYSTEMS

REGULATIONS – 2021

(CHOICE BASED CREDIT SYSTEM)

I TO IV SEMESTERS SYLLABUS

SEMESTER I

21MA122	LINEAR ALGEBRA PROBABILITY AND QUEUEING THEORY	L	T	P	C
		3	2	0	4

COURSE OBJECTIVES:

- To encourage students to develop a working knowledge of the central ideas of linear algebra.
- To grasp the basic concepts of probability, random variables, correlation and regression.
- To understand the basic concepts of random processes.
- To acquire skills in analyzing queueing models.
- To develop a fundamental understanding of linear programming models and apply simplex method for solving linear programming problems.

UNIT I	LINEAR ALGEBRA	12

Vector spaces – Norms – Inner products – Eigenvalues using QR transformations – QR factorization – Generalized eigenvectors – Jordan canonical forms – Singular value decomposition and applications – Pseudo inverse – Least Square approximations.

UNIT II	PROBABILITY AND RANDOM VARIABLES	12

Probability concepts – Axioms of probability – Conditional probability – Bayes theorem – Random variables – Probability functions – Two-dimensional random variables – Joint distributions –Marginal and conditional distributions – Correlation – Linear regression.

UNIT III	RANDOM PROCESSES	12

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

UNIT IV	QUEUEING THEORY	12

Markovian queues – Single and multi-server models – Little's formula – Steady state analysis –Self-service queue.

UNIT V	LINEAR PROGRAMMING	12
Formulation – Graphical solution – Simplex method – Big M method – Variants of Simplex method – Transportation problems – Assignment models**.**		
		TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1: Apply various methods in Linear algebra to solve the system of linear equations.

CO2: Examine the performance in terms of probability achieved by the determined solutions and compute the correlation and regression.

CO3: Estimate the functions of time when the probability measure is associated through random process.

CO4: Understand the basic characteristic features of a queueing system and acquire skills in analyzing queueing models.

CO5: Predict an optimal solution of an optimization problem using Linear programming concepts.

REFERENCES:

1. Miller,S.L. and Childers D.G., "Probability and Random Processes with Applications to Signal Processing and Communications", 2nd Edition, Academic Press, 2004.
2. Friedberg A.H, Insel A.J. and Spence L, "Linear Algebra", 4th Edition, Prentice Hall of India, New Delhi, 2004.
3. Gross, D., Shortie, J.F., Thompson, J.M and Harris, C.M., "Fundamentals of Queuing Theory", 4th Edition, Wiley, 2014.
4. Taha H.A., "Operations Research: An Introduction", 9th Edition, Pearson Education Asia, New Delhi, 2016.
5. Richard Bronson, "Matrix Operations- Schaum's outline series", 2nd Edition, McGraw Hill, New York, 2011.
6. Oliver C. Ibe, "Fundamentals of Applied Probability and Random Processes, 2nd Edition, Academic Press, Boston, 2014.

21RM102	RESEARCH METHODOLOGY FOR TELECOM ENGINEERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand research methodology, process and design.
- To know the details of sampling designs, and also different methods of data collections.
- To introduce the art of interpretation and writing research reports.
- To be familiar with various forms of the intellectual property, its relevance and business impact in the changing global business environment.
- To understand the law of patent and licensing.

UNIT I	RESEARCH DESIGN	9

Overview of research process and design, Use of secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys.

UNIT II	DATA COLLECTION AND SOURCES	9

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data: preparing, exploring, examining and displaying.

UNIT III	DATA ANALYSIS AND REPORTING	9

Overview of Multivariate analysis, Hypotheses testing and Measures of association. Presenting insights and findings using written reports and oral presentation. Case studies.

UNIT IV	INTELLECTUAL PROPERTY RIGHTS	9

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, Utility models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of property, Common rules of IPR practices, Types and features of IPR agreement, Trademark, Functions of UNESCO in IPR maintenance. Case studies.

UNIT V	PATENTS	9

Patents – objectives and benefits of patent, Concept, Features of patent, Inventive step, Specification, Types of patent application, Process: E-filing, Examination of patent, Grant of patent, Revocation, Equitable assignments, Licenses, Licensing of related patents, patent agents, Registration of patent agents. Case studies.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the technique of defining a research problem.

CO2: Outline the concepts of data collection and analysis.

CO3: Interpret data and write research reports.

CO4: Explain the concepts of IPR and rules of IPR practices.

CO5: Infer the law of patent and licensing.

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, "Business Research Methods", 11th Edition, Tata McGraw Hill Education, 2012.
2. Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.
3. David Hunt, Long Nguyen and Matthew Rodgers, "Patent searching: Tools &Techniques", Wiley, 2007.
4. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and Practice", September 2013.

21CM101	STATISTICAL SIGNAL PROCESSING	L	T	P	C
		3	2	0	4

COURSE OBJECTIVES:

- To introduce the basics of random signal processing.
- To learn the concept of estimation and signal modeling.
- To familiarize with the spectrum estimation.
- To know about the design of optimum filters.
- To understand adaptive filtering and its applications.

UNIT I	DISCRETE RANDOM SIGNAL PROCESSING	12

Discrete random processes – Ensemble averages – Wide sense stationary process – Properties - Ergodic process – Sample mean & variance - Auto-correlation and Auto-correlation matrices- Auto covariance and Cross covariance- Properties – White noise process – Wiener Khintchine relation - Power spectral density – Filtering random process – Spectral factorization theorem – Special types of random processes – AR, MA, ARMA processes – Yule-Walker equations.

UNIT II	PARAMETER ESTIMATION THEORY	12

Principle of estimation and applications-Properties of estimates-unbiased and consistent estimators, Minimum Variance Unbiased Estimates (MVUE)-Cramer Rao bound- Efficient estimators; Criteria of estimation: Methods of maximum likelihood and its properties; Bayesian estimation: Mean square error and MMSE, Mean absolute error, Hit and Miss cost function and MAP estimation.

UNIT III	SPECTRUM ESTIMATION	12

Estimation of spectra from finite duration signals, Bias and Consistency of estimators - Non-Parametric methods: Periodogram, Modified periodogram, Bartlett, Welch and Blackman-Tukey methods, Parametric methods: AR, MA and ARMA spectrum estimation - Detection of harmonic signals - Performance analysis of estimators. MUSIC and ESPRIT algorithms.

UNIT IV	SIGNAL MODELING AND OPTIMUM FILTERS	12

Introduction- Least Square method – Pade approximation – Prony's method – Levinson recursion– Lattice filter - FIR Wiener filter – Filtering – Linear prediction – Non causal and causal IIR Wiener filter – MSE – State-space model and the optimal state estimation problem, discrete Kalman filter, continuous-time Kalman filter, extended Kalman filter.

UNIT V	ADAPTIVE FILTERS	12

FIR Adaptive filters - Newton's steepest descent method – Widrow Hoff LMS adaptive algorithm – Convergence – Normalized LMS – Applications: Noise cancellation, channel

equalization, echo canceller, Adaptive recursive filters: RLS adaptive algorithm, Exponentially weighted RLS-sliding window RLS, Matrix inversion Lemma, Initialization tracking of non-stationarity.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Analyze discrete time random processes.

CO2: Apply appropriate model for estimation and signal modeling for the given problem.

CO3: Analyze non-parametric and parametric methods for spectral estimation.

CO4: Design optimum filter for the given application.

CO5: Design adaptive filters for different applications.

REFERENCES:

1. Monson. H. Hayes, "Statistical Digital Signal Processing and Modeling", John Willey and Sons, Reprint, 2008
2. Simon Haykin, "Adaptive Filter Theory", 5th Edition, Pearson Prentice Hall, 2014
3. D.G. Manolakis, V.K. Ingle and S.M. Kogon, "Statistical and Adaptive Signal Processing", 1st Edition, Artech House Publishers, 2005.
4. Steven. M. Kay, "Modern Spectral Estimation, Theory and Application", 1st Edition, Pearson India,2009
5. A.Veloni, N I. Miridakis and E Boukouvala, "Digital and Statistical Signal Processing", CRC Press, 2019
6. S Nandi and D Kundu, "Statistical Signal Processing- Frequency Estimation", Springer Nature Singapore, 2nd Edition , 2020
7. M.D. Srinath, P.K. Rajasekaran and R. Viswanathan, "Statistical Signal Processing with Applications", 1st Edition, PHI, 1996.

21CM102	MODERN DIGITAL COMMUNICATION SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the coherent and non-coherent receivers and their performance under various channel conditions.
- To know the effect of signaling through band limited channels and the use of equalization techniques to overcome ISI.
- To familiarize with channel capacity theorem and different block coding techniques to mitigate channel errors.
- To understand the principle of convolutional coding to alleviate channel errors and different decoding techniques.
- To learn the basics of OFDM as a multicarrier communication and CDMA as a multiuser communication technique.

UNIT I	COHERENT AND NON-COHERENT COMMUNICATION	9

Coherent receivers – Optimum receivers in WGN – IQ modulation & demodulation – QAM modulation and demodulation Non-coherent receivers in random phase channels; MFSK receivers – Rayleigh and Rician channels – Partially coherent receivers – DPSK; M-PSK; M-DPSK-BER Performance analysis. Carrier synchronization, Bit synchronization

UNIT II	EQUALIZATION TECHNIQUES	9

Band limited channels- ISI – Nyquist criterion- Controlled ISI-Partial response signals-Equalization algorithms– Linear equalizer – Decision feedback equalization – Adaptive equalization algorithms

UNIT III	BLOCK CODED DIGITAL COMMUNICATION	9

Architecture and performance – Binary block codes; – Shannon's channel coding theorem; Channel capacity; Matched filter; Concepts of spread spectrum communication – Coded BPSK and DPSK demodulators– Linear block codes; Hamming; Golay; Cyclic; BCH ; Reed–Solomon codes. Space time block codes.

UNIT IV	CONVOLUTIONAL CODED DIGITAL COMMUNICATION	9

Representation of codes using Polynomial, State diagram, Tree diagram, and Trellis diagram – Decoding techniques using Maximum likelihood, Viterbi algorithm, Sequential and Threshold methods – Error probability performance for BPSK and Viterbi algorithm, Turbo coding.

UNIT V	MULTICARRIER AND MULTIUSER COMMUNICATIONS	9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Differentiate various receivers such as coherent, non-coherent and partially coherent receivers and analyze their performance under various channel conditions.

CO2: Illustrate the effect of signaling through band-limited channels and equalization techniques used to overcome ISI.

CO3: Determine the channel capacity and apply various block coding techniques to combat channel errors.

CO4: Construct convolutional coders and analyze the performance of different decoding techniques.

CO5: Describe the basics of OFDM as a multicarrier communication and CDMA as a multiuser communication technique.

REFERENCES:

1. John G. Proakis and Masoud Salehi "Digital Communication", 5th Edition, McGraw Hill Publication, 2014.
2. Simon Haykin, "Digital Communication Systems", 1st Edition, John Wiley and Sons, 2014.
3. Bernard Sklar and Pabitra Kumar Ray, "Digital Communications Fundamentals & Applications", 2nd Edition, Pearson Education, 2009.
4. Richard Van Nee and Ramjee Prasad, "OFDM for Multimedia Communications", 1st Edition, Artech House Publication, 2001.
5. Theodore S.Rappaport, 'Wireless Communications", 2nd Edition, Pearson Education, 2002.

21CM103	ADVANCED WIRELESS COMMUNICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn the concepts of wireless channels and models.
- To estimate channel capacity.
- To study the characteristics of diversity.
- To understand the concepts of MIMO systems
- To know the operation of multiple antennas and multiple user techniques.

UNIT I	WIRELESS CHANNEL PROPAGATION AND MODEL	9

Propagation of EM signals in wireless channel – Reflection, diffraction and Scattering-free space, two ray model. Small scale fading- channel classification- channel models – COST - 231 Hatamodel, NLOS Multipath Fading models: Rayleigh, Rician, Nakagami. 5G Channel model requirements and measurements, propagation scenarios, METIS channel models, Map-based model, stochastic model.

UNIT II	CAPACITY OF WIRELESS CHANNELS	9

Capacity in AWGN, Capacity of flat fading channel, Capacity of frequency selective fading channels. Capacity of MISO and SIMO systems.

UNIT III	DIVERSITY	9

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

UNIT IV	MIMO COMMUNICATIONS	9

Narrowband MIMO model, Parallel decomposition of the MIMO channel, MIMO channel capacity, MIMO Diversity gain: Beam forming, Diversity-Multiplexing trade-offs, Space time modulation and coding: STBC, STTC, Spatial multiplexing and BLAST architectures.

UNIT V	MULTIUSER SYSTEMS	9

Introduction to MUD, Linear de-correlator, MMSE MUD, Adaptive MUD, MIMO-MUD Application of convex optimization to wireless design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

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

CO2: Explain the mathematics behind the capacity calculation under different channel conditions.

CO3: Interpret the implication of diversity combining methods based on the knowledge of channel at the transmitter

CO4: Outline the concepts in MIMO communications.

CO5: Infer multiple access techniques and their use in different multi-user scenarios.

REFERENCES:

1. David Tse and Pramod Viswanath, "Fundamentals of Wireless Communications", 5th Edition, Cambridge University Press, 2012.
2. Andrea Goldsmith, "Wireless Communications", 1st Edition, Cambridge University Press, 2007.
3. Harry R. Anderson, "Fixed Broadband Wireless System Design", 1st Edition, John Wiley, India, 2003.
4. Andreas.F. Molisch, "Wireless Communications", 4th Edition, John Wiley, India, 2006.
5. Simon Haykin and Michael Moher, "Modern Wireless Communications", 1st Edition, Pearson Education, 2007.
6. Rappaport. T.S., "Wireless Communications", 6th Edition, Pearson Education, 2003.
7. Gordon L. Stuber, "Principles of Mobile Communication", Springer International Ltd., 2001.
8. Upena Dalal, "Wireless Communication", 2nd Edition, Oxford Higher Education, 2009.

21CM104	RADIATING SYSTEMS	L	T	P	C
		3	2	0	4

COURSE OBJECTIVES:

- To understand the fundamental concepts and parameters behind the different types of antennas.
- To learn about various antenna arrays.
- To interpret the performance of aperture and microstrip antennas.
- To be familiar with modern antennas and measurement techniques
- To study about different optimization techniques for designing application specific antennas.

UNIT I	ANTENNA FUNDAMENTALS & WIRE ANTENNAS	12

Introduction –Types of antennas – Radiation mechanism – Current distribution on wire antennas – Maxwell‘s equations – Antenna fundamental parameters – Radiation integrals – Radiation from surface and line current distributions – dipole, monopole, loop antenna.

UNIT II	ANTENNA ARRAYS	12

Linear array –uniform array, end fire and broad side array, gain, beam width, side lobe level; Linear array synthesis techniques – Binomial and Chebyshev distributions; Two dimensional uniform arrays; phased array antennas, smart antennas, switched beam and adaptive arrays, Mutual coupling in finite arrays.

UNIT III	APERTURE ANTENNAS	12

Field equivalence principle, Radiation from rectangular and circular apertures, Babinets principle, Slot antenna; Horn antenna; Reflector antenna, aperture blockage, and design consideration. Radiation mechanism and excitation techniques, Microstrip dipole; Patch, Rectangular patch, Circular patch – Microstrip array and feed network; Lens antennas.

UNIT IV	MODERN ANTENNAS & MEASUREMENT TECHNIQUES	12

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

UNIT V	RECENT TRENDS IN ANTENNA DESIGN	12

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Evaluate and analyze various parameters of antennas.

CO2: Analyse the performance of different types of arrays.

CO3: Design microstrip antennas for the given specifications.

CO4: Demonstrate the performance of application specific antennas.

CO5: Optimise the parameters of various antennas using numerical techniques.

REFERENCES:

1. Balanis.A, "Antenna Theory Analysis and Design", 4th Edition, John Wiley and Sons, New York, 2012.
2. Frank B. Gross, "Frontiers in Antennas", 2nd Edition, Mc Graw Hill, 2011.
3. S. Drabowitch, A. Papiernik, H.D.Griffiths, J.Encinas and B.L.Smith, "Modern Antennas", 2nd Edition, Springer Publications, 2007.
4. Krauss.J.D, "Antennas", 2nd Edition, John Wiley and sons, New York, 1997.
5. I.J. Bahl and P. Bhartia, "Microstrip Antennas", 1st Edition, ArtechHouse,Inc.,1980
6. W.L.Stutzman and G.A.Thiele, "Antenna Theory and Design", 2nd Edition, John Wiley& Sons Inc., 1998.

21CM105	DIGITAL COMMUNICATION SYSTEMS LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To perform digital modulation & detection using SDR
- To evaluate the performance of CDMA, OFDM & MIMO systems
- To design channel equalizer using LMS / RLS algorithms
- To perform spectral estimation using non-parametric methods
- To construct channel encoder / decoder using MATLAB

LIST OF EXPERIMENTS

LIST OF EXPERIMENTS

1. Generation and detection of binary digital modulation techniques using SDR
2. Spread spectrum communication system-pseudo random binary sequence generation and baseband DSSS.
3. MIMO system transceiver design using MATLAB/SCILAB/LABVIEW.

4. Performance evaluation of simulated CDMA system.
5. Channel coder/decoder design (block codes / convolutional codes/ turbo codes).
6. OFDM transceiver design using MATLAB /SCILAB/LABVIEW.
7. Channel equalizer design using MATLAB (LMS, RLS algorithms).
8. Design and analysis of spectrum estimators (Bartlett, Welch) using MATLAB.
9. BER performance analysis of M-ary digital Modulation Techniques (coherent & non coherent) in AWGN Environment using MATLAB/SCILAB/LABVIEW.
10. Design and performance analysis of lossless coding techniques - Huffman coding and Lempel Ziv Algorithm using MATLAB/SCILAB/LABVIEW.
11. Noise / Echo cancellation using MATLAB (LMS / RLS algorithms).
12. Study of synchronization (frame, bit, symbol).
13. Wireless channel characterization.

COURSE OUTCOMES:

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

CO1: Generate and detect digital modulation techniques in AWGN channel

CO2: Evaluate the performance of CDMA / OFDM & MIMO systems

CO3: Illustrate the performance of channel equalizers using LMS / RLS algorithms.

CO4: Estimate power spectrum of the given random sequence using non-parametric estimation methods.

CO5: Implement various channel encoder / decoder using MATLAB

21CM106	ADVANCED DIGITAL SIGNAL PROCESSING LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To generate discrete and random time sequences
- To analyze frequency characteristics of FIR and IIR filters
- To investigate the spectral estimation methods and additive white Gaussian noise (AWGN) channel characterization
- To implement multirate signal processing.
- To interpret the use of LMS/RLS algorithm in the design of adaptive filters

LIST OF EXPERIMENTS

1. Generation of standard discrete time sequences (Unit Impulse, Unit Step, Unit Ramp,

Sinusoidal and exponential signals) and carrying out of arithmetic operations and plot the results.

2. Generation of random sequences satisfying the given probability distributions such as Uniform, Gaussian, Rayleigh and Rician.
3. Design of FIR filters for the given specification and plot the frequency response of the designed filter.
4. Design of IIR filters for the given specification and plot the frequency response of the designed filter.
5. Analysis of finite word length effects of FIR filter coefficients.
6. Estimation of power spectrum of the given random sequence using Nonparametric methods (Bartlett, Welch and Blackman Tukey).
7. Estimation of power spectrum of the given random sequence using parametric methods (AR, MA and ARMA).
8. Up-sampling the discrete time sequence by L times and plot the spectrum of both the given sequence and up-sampled sequence.
9. Down-sampling the discrete time sequence by M times and plot the spectrum of both the given sequence and down-sampled sequence.
10. Design an adaptive filter to extract a desired signal from the given noisy signal by Cancelling the noise using LMS algorithm.
11. Design an adaptive filter to extract a desired signal from the given noisy signal by Cancelling the noise using RLS algorithm.
12. Implementation of digital filter banks for the given specifications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Generate deterministic/Random sequences using simulation tool.

CO2: Design and analyze the frequency response of FIR/IIR digital filters for the given specifications.

CO3: Estimate power spectrum of the given random sequence using parametric / nonparametric estimation methods.

CO4: Implement adaptive filters using LMS/RLS algorithm.

CO5: Analyze the discrete time systems at various sampling rates.

SEMESTER II

21CM107	MIC AND RF SYSTEM DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn about the fundamentals of microwave integrated circuits.
- To know the concepts of passive microwave components.
- To be familiar with microwave amplifiers and oscillators.
- To design integrated antennas and the relevant measurement techniques.
- To introduce the MMIC inspired systems.

UNIT I	INTRODUCTION TO MICROWAVE INTEGRATED CIRCUITS	9

MMIC technology - advantages and applications- Active device technologies- design approaches- multichip module technology substrates.

UNIT II	PASSIVE COMPONENTS	9

Inductors – Capacitors – Resistors - Micro-strip components - Coplanar circuits - Multilayer techniques –Micro machined passive components , Switches & Attenuators- Filter design.

UNIT III	AMPLIFIERS & OSCILLATORS	9

AMPLIFIERS: Stability & gain analysis - matching techniques - reactively matched amplifier design-LNA. OSCILLATORS: Design principles - active device CAD techniques for large signal oscillators design- phase noise - MMIC VCO - Mixers.

UNIT IV	INTEGRATED ANTENNAS AND MEASUREMENT TECHNIQUES	9

Integrated antenna selection- photonic band gap antennas - micro machined antenna - micro electro mechanical system antennas - test fixture measurements - probe station measurements -thermal and cryogenic measurements- experimental field probing techniques.

UNIT V	SYSTEM DESIGN USING MMIC TECHNOLOGY	9

Analysis of MMIC Technology and design issues in Phased array radar, Satellite transponder -Integrated electronic warfare T/R modules - Avionic systems integration.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Impart the knowledge of microwave integrated circuits for multichip designing.

CO2: Familiarize about passive microwave components and the principles.

CO3: Demonstrate the operation of microwave amplifiers and oscillators.

CO4: Design integrated antennas.

CO5: Analyse the performance of MMIC inspired systems.

REFERENCES:

1. Ravender Goyal, "Monolithic MIC; Technology & Design", 1st Edition, Artech House, 1989.
2. Hoffman R.K, "Handbook of Microwave Integrated Circuits", 1st Edition, Artech House, Boston, 1987.
3. Ulrich L. Rohde and David P.N, "RF / Microwave Circuit Design for Wireless Applications", 2nd Edition, John Wiley, 2012.
4. C. Gentili, "Microwave Amplifiers and Oscillators", 1st Edition, North Oxford Academic, 1987.
5. Samuel. Y. Liao, "Microwave Circuit Analysis and Amplifier Design", 1st Edition, Prentice Hall, Inc., 1987.
6. Matthew N.O. Sadiku, "Numerical Techniques in Electromagnetics", 1st Edition, CRC Press, 2009.

21CM108	OPTICAL NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the working principles of optical system components.
- To be familiar with transmission system engineering.
- To know the development of optical network architectures.
- To study about wavelength division multiplexing.
- To learn about various optical topologies.

UNIT I	OPTICAL NETWORK COMPONENTS	9

Introduction to Optical Networks: Telecommunications Networks Architecture, Services, circuit switching and packet switching, Optical Networks: Multiplexing Techniques, Second generation Optical Networks, Optical Packet Switching, Transmission Basics: Wavelength, frequencies, and channel spacing, Wavelength standards, Optical power and loss, Network Evolution, Nonlinear Effects: Self-phase Modulation, Cross-phase Modulation, Four Wave mixing, Solitons. Components: Couplers, Isolators and Circulators, Multiplexers and Filters,

Optical Amplifiers, Transmitters, Detectors, Switches, Wavelength Converters.		
UNIT II	**TRANSMISSION SYSTEM ENGINEERING**	**9**
Transmission System Engineering: System Model, Power Penalty, Transmitter, Receiver, Optical Amplifiers, Crosstalk, Dispersion, Wavelength Stabilization, Overall Design Considerations. Optical Internets: Migration to IP optical networking, IP and Optical backbone, IP Routing table, MPLS and optical cross connect table, Protocol stack Alternatives, Internetworking SS7 and Legacy Transport, Internet transport network protocol stack.		
UNIT III	**NETWORK ARCHITECTURE**	**9**
SONET, SDH and Optical Transport Networks (OTNs): SONET and SDH: SONET multiplexing hierarchy, Frame structure, Functional Component, problem detection, concatenation. Architecture of Optical Transport Networks (OTNs): Digital wrapper, in-band and out-ofband control signalling, Importance of Multiplexing and multiplexing hierarchies, SONET multiplexing hierarchies, SDH multiplexing hierarchies, New Optical Transport, OTN layered Model, Generic Framing Procedure (GFP).		
UNIT IV	**WDM**	**9**
WDM, Network topologies, MPLS and Optical Networks: WDM: WDM operation, Dense Wavelength Division Multiplexing (DWDM), Erbium-doped Fiber (EDF), WDM amplifiers, Add-Drop Multiplexers, Wavelength Continuity Property, Higher dispersion for DWDM, Tunable DWDM Lasers.		
UNIT V	**TOPOLOGIES**	**9**
Network topologies and protection schemes: Robust networks, Line and path protection switching, Types of topology, Point to point topology, bi-directional line-switched ring (BLSR), meshed topology, Passive optical networks, Metro optical networks , MPLS and Optical Networks: IS label switching, Forwarding equivalence class (FEC), Types of MPLS nodes, Label distribution and binding, label swapping and traffic forwarding, MPLS support of Virtual Private Networks (VPN), MPLS traffic engineering, Multi protocol Lambda switching (MPLS).		
		TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain about the optical components used in optical networks.

CO2: Interpret optical network routing algorithms and transmission system.

CO3: Analyze the optical network architecture.

CO4: Illustrate the performance of wavelength division multiplexing.

CO5: Identify and formulate different networking topologies.

REFERENCES:

1. Rajiv Ramaswami and Kumar Sivarajan, "Optical Networks – Practical Perspective", 3rd Edition, Morgan - Kaufmann Publishers, 2008.
2. Uyless Black, "Optical Networks, Third Generation Transport Systems", 2nd Edition, Pearson Ed, 2003.

21CM109	SIGNAL DETECTION AND ESTIMATION THEORY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the concepts of detection and estimation.
- To learn the basics of multi-user detection theory.
- To understand the theory behind various estimation techniques.
- To familiarize with Wiener filter and Kalman filter in detail.
- To characterize multipath fading channels.

UNIT I	REVEIW OF PROBABILITY AND STOCHASTICPROCESS	9

Conditional probability, Bayes' theorem , Random variables, Conditional distributions and densities, moments and distribution of random variables., Stationary Processes, Cyclo stationary processes, Averages and Ergodicity, Autocorrelation function, Power spectral density, Discrete time stochastic processes, Spatial stochastic processes, Random signals, Relationship of power spectral density and autocorrelation function.

UNIT II	SINGLE AND MULTIPLE SAMPLE DETECTION	9

Hypothesis testing and the MAP criterion, Bayes criterion, Minimax criterion, Neyman-Pearson criterion, Sequential detection, Optimum digital detector in additive gaussian noise , Performance of binary receivers in AWGN.

UNIT III	FUNDAMENTALS OF ESTIMATION THEORY	9

Formulation of the general parameter estimation problem, Relationship between detection and estimation theory, Types of estimation problems, Properties of estimators, Bayes estimation, Minimax estimation, Maximum-Likelihood estimation, Comparison of

estimators of parameters.

UNIT IV	WIENER AND KALMAN FILTERS	9

Orthogonality principle, Autoregressive techniques, Discrete Wiener filter, Continuous Wiener filter, Generalization of discrete and continuous filter representations , Linear least-squares methods, Minimum-Variance weighted Least-Squares methods, Minimum-variance, Least Squares, Kalman algorithm - Computational considerations, Signal estimation, Continuous Kalman filter, Extended Kalman filter.

UNIT V	APPLICATIONS	9

Detector structures in non-Gaussian noise , Examples of noise models, Receiver structures, and Error-rate performance, Estimation of non-gaussian noise parameters, Fading-multipath channel models, Receiver structures with known channel parameters, Receiver structures without knowledge of phase, Receiver structures without knowledge of amplitude or phase, receiver structures and performance with no channel knowledge.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Make use of detection and estimation theory to solve communication problems.

CO2: Utilize probability and stochastic process concepts in detection and estimation.

CO3: Illustrate estimation models.

CO4: Interpret Wiener and Kalman filters to solve linear estimation problems.

CO5: Outline Multipath fading channels.

REFERENCES:

1. Harry L. Van Trees, "Detection, Estimation and Modulation Theory", Part I, 1st Edition, John Wiley and Sons, New York, 2004.
2. Ludeman and Lonnie C., “Random processes: filtering, estimation, and detection”, 1st Edition, John Wiley & Sons, Inc., 2003.
3. Sergio Verdu, “Multi User Detection” Cambridge University Press, 1998.
4. Steven M. Kay, "Fundamentals of Statistical Processing, Volume I: Estimation Theory”, 1st Edition, Prentice Hall Signal Processing Series, Prentice Hall, 1993.
5. Thomas Schonhoff, "Detection and Estimation Theory”, 3rd Edition, Prentice Hall, New Jersy, 2007.

21CM110	ADVANCED DIGITAL IMAGE PROCESSING	L	T	P	C
		3	2	0	4

COURSE OBJECTIVES:

- To learn about the fundamental image processing methods.
- To know about different mathematical transforms for image enhancement and restoration.
- To be familiar with segmentation and morphological processing.
- To discuss about the need of image classification algorithms.
- To study about the different image registration and visualization methods.

UNIT I	DIGITAL IMAGE PROCESSING FUNDAMENTALS	12

Elements of visual perception, brightness, contrast, hue, saturation, mach band effect, 2D image transforms-DFT, DCT, KLT, SVD. Image enhancement in spatial and frequency domain, Review of Morphological image processing.

UNIT II	IMAGE SEGMENTATION TECHNIQUES	12

Edge detection, Thresholding, Region growing, Fuzzy clustering, Watershed algorithm, Active contour models, Texture feature based segmentation, Graph based segmentation, Wavelet based Segmentation - Applications of image segmentation.

UNIT III	FEATURE EXTRACTION	12

First and second order edge detection operators, Phase congruency, Localized feature extraction - detecting image curvature, shape features, Hough transform, shape skeletonization, Boundary descriptors, Moments, Texture descriptors- Autocorrelation, Co-occurrence features, Run length features, Fractal model based features, Gabor filter, wavelet features.

UNIT IV	REGISTRATION AND IMAGE FUSION	12

Registration - Preprocessing, Feature selection - points, lines, regions and templates Feature correspondence - Point pattern matching, Line matching, Region matching, Template matching. Transformation functions - Similarity transformation and Affine Transformation. Re-sampling – Nearest neighbour and Cubic splines. Image Fusion - Overview of image fusion, pixel fusion, wavelet based fusion -region based fusion.

UNIT V	3D IMAGE VISUALIZATION	12

Sources of 3D Data sets, Slicing the Data set, Arbitrary section planes, The use of color,

Volumetric display, Stereo Viewing, Ray tracing, Reflection, Surfaces, Multiple connected surfaces, Image processing in 3D, Measurements on 3D images.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Outline the fundamentals of image processing.

CO2: Analyse various segmentation algorithms.

CO3: Describe various feature extraction techniques for image analysis.

CO4: Discuss the concepts of image registration and fusion.

CO5: Explain 3D image visualization.

REFERENCES:

1. Ardeshir Goshtasby, " 2D and 3D Image registration for Medical, Remote Sensing and Industrial Applications", John Wiley and Sons, 2005.
2. Anil K. Jain, Fundamentals of Digital Image Processing', Pearson Education, Inc., 2002.
3. John C.Russ, "The Image Processing Handbook", CRC Press, 2007.
4. Mark Nixon and Alberto Aguado, "Feature Extraction and Image Processing", Academic Press, 2008.
5. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing', Pearson, Education, Inc., 2nd Edition, 2004.
6. Rick S.Blum and Zheng Liu, "Multisensor image fusion and its Applications", 1st Edition, Taylor & Francis, 2006.

21CM111	PRODUCT DEVELOPMENT LABORATORY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To develop their own innovative prototype of ideas.
- To train the students in preparing mini project reports and examination.

Individual student works on a topic approved by the head of the department and develops the prototypes using the available packages and prepares a comprehensive project report after completing the work to the satisfaction. The progress of the project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is

evaluated based on oral presentation and the mini project report jointly by external and internal examiners constituted by the Head of the Department.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

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

- Take up their Project Work Phase –I and Phase -II and find solution by formulating proper methodology.

21CM112	TECHNICAL PAPER WRITING AND SEMINAR PRESENTATION	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

- To build the concept of advanced engineering developments.
- To introduce literature survey.
- To outline the technical reports presentation.
- To extend presentation and technical skill.
- To make use of various teaching aids such as overhead projectors, power point presentation and demonstrative models.

METHOD OF EVALUATION:

During the seminar session, each student is expected to prepare and present a topic on engineering/ technology, for duration of about 8 to 10 minutes. In a session of three periods per week and all the students are expected to present the seminar. Each student is expected to present at least twice during the semester and the student is evaluated based on that. At the end of the semester, he / she can submit a report on his / her topic of seminar and marks are given based on the report. A faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also. Evaluation is 100% internal.

TOTAL : 30 PERIODS

COURSE OUTCOMES:

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

CO1: Extent motivation for any topic of interest and develop a thought process for technical presentation.

CO2: Outline a detailed literature survey and build a document with respect to technical publications.

CO3: Analyze the comprehensive proof-of-concept and related data.

CO4: Develop presentation and technical skill.

CO5: Make use of new and recent technology (e.g. Latex) for creating technical reports.

PROFESSIONAL ELECTIVES

21CMP01	MACHINE LEARNING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basic concepts and techniques of Machine Learning.
- To learn about Supervised and Unsupervised Learning Techniques.
- To study the various Probability Based Learning Techniques.
- To understand Dimensionality Reduction and Evolutionary Models.
- To interpret the Graphical Models.

UNIT I	INTRODUCTION	9

Learning – Types of Machine Learning – Supervised Learning – The Brain and the Neuron –Design a Learning System –Perspectives and Issues in Machine Learning – Concept Learning Task–Concept Learning as Search–Finding a Maximally Specific Hypothesis–Version Spaces and the Candidate Elimination Algorithm — Linear Discriminants — Perceptron — Linear Separability—Linear Regression.

UNIT II	LINEAR MODELS	9

Multi-layer Perceptron – Going Forwards – Going Backwards: Back Propagation Error – Multi-layer Perceptron in Practice — Examples of using the MLP — Overview — Deriving Back Propogation— Radial Basis Functions and Splines—Concepts—RBF Network—Curse of Dimensionality–Interpolations and Basis Functions–SupportVectorMachines.

UNIT III	TREE AND PROBABILISTIC MODELS	9

Learning with Trees – Decision Trees – Constructing Decision Trees – Classification and Regression Trees – Ensemble Learning – Boosting – Bagging – Different ways to Combine Classifiers – Probability and Learning – Data into Probabilities – Basic Statistics – Gaussian Mixture Models – Nearest Neighbor Methods – Unsupervised Learning – K means Algorithms – Vector Quantization – Self Organizing Feature Map

UNIT IV	DIMENSIONALITY REDUCTION AND EVOLUTIONARY MODELS	9

Dimensionality Reduction – Linear Discriminant Analysis – Principal Component

Analysis – Factor Analysis – Independent Component Analysis – Locally Linear Embedding – Isomap – Least Squares Optimization – Evolutionary Learning – Genetic algorithms – Genetic Offspring: - Genetic Operators – Using Genetic Algorithms – Reinforcement Learning – Overview – Getting Lost Example – Markov Decision Process

UNIT V	GRAPHICAL MODELS	9

Markov Chain- Monte Carlo methods – Sampling – Proposal distribution – Markov Chain- Monte Carlo – Graphical models – Bayesian networks – Markov Random Fields – Hidden Markov models – Tracking methods

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, learners will be able to:

CO1: Utilize the appropriate machine learning strategy for any given problem.

CO2: Identify supervised, unsupervised and semi-supervised learnings.

CO3: Interpret the role of Probabilistic models in learning.

CO4: Develop dimensionality reduction algorithms.

CO5: Illustrate the graph models of machine learning.

REFERENCES:

1. Ethem Alpaydin, "Introduction to Machine Learning (Adaptive Computation and Machine Learning Series)", 3rd Edition, MIT Press, 2014.
2. Jason Bell, "Machine learning- Hands on for Developers and Technical Professionals", 1stEdition, Wiley, 2014.
3. Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", 1stEdition, Cambridge University Press, 2012.
4. Stephen Marsland, "Machine Learning – An Algorithmic Perspective", 2nd Edition, Chapman and Hall/ CRC Machine Learning and Pattern Recognition Series, 2014.
5. Tomm Mitchell, "Machine Learning", 1st Edition, McGraw Hill Education, 2013.

21CMP02	WAVELET TRANSFORMS AND ITS APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the fundamental concepts of wavelet transforms.
- To study about multi resolution concepts.
- To learn wavelet system design.
- To be familiar with the different wavelet families and applications.
- To interpret the applications of various wavelets.

UNIT I	INTRODUCTION TO WAVELETS	9

Introduction to multi-rate signal processing- Decimation and Interpolation, Quadrature mirror filters, Sub-band coding, Limitations of Fourier transform, Short time Fourier transform and its drawbacks, Continuous wavelet transform, Time frequency representation, Wavelet system and its characteristics, Orthogonal & Orthonormal functions and function space.

UNIT II	MULTI RESOLUTION CONCEPT AND DISCRETE WAVELET TRANSFORM	9

Multi resolution formulation of wavelet systems- signal spaces, scaling function, wavelet function and its properties, Multiresolution analysis, Haar scaling and wavelet function, Filter banks-Analysis and Synthesis, 1D and 2D Discrete wavelet transform, Wavelet packets, Tree structured filter bank, Multichannel filter bank, Undecimated wavelet transform.

UNIT III	WAVELET SYSTEM DESIGN	9

Refinement relation for orthogonal wavelet systems, Restrictions on filter coefficients, Design of Daubechies orthogonal wavelet system coefficients, Design of Coiflet and Symlet wavelets.

UNIT IV	WAVELET FAMILIES	9

Continuous Wavelets- Properties of Mexican hat wavelet, Morlet, Gaussian and Meyer wavelets. Orthogonal wavelets- Properties of Haar wavelets, Daubechies wavelets, Symlets, Coiflets and Discrete Meyer wavelets. Properties of Biorthogonal wavelets, Applications of wavelet families.

UNIT V	APPLICATIONS	9

Denoising of Signals and Images, Image enhancement, Edge detection, Image fusion, Image

compression, Wavelet based feature extraction, Analysis of phonocardiogram signals, Analysis of EEG signals, Speech enhancement for hearing aids.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Relate the vector concepts and signal concepts.

CO2: Outline multi resolution process.

CO3: Infer knowledge about wavelet systems.

CO4: Experiment with continuous and discrete wavelet transforms.

CO5: Identify the wavelets to specific applications.

REFERENCES:

1. C.Sidney Burrus, Ramesh Gopinath and Haito Guo, "Introduction to wavelets and Wavelet Transform", 16th Edition, Prentice Hall, 1998.
2. G.Strang and T.Nguyen, "Wavelet and filter banks" 1st Edition, Wesley and Cambridge Press, 2008.
3. P.P.Vaidyanathan, "Multi-rate systems and filter banks", 8th Edition, Prentice Hall 1993
4. Raguveer M Rao and Ajith S. Bopardikar, "Wavelet transforms – Introduction to theory and applications", 6th Edition, Addison Wesley, 1998
5. S.Mallet, "A Wavelet tour of Signal Processing", 1st Edition, Academic Press 1998
6. K.P.Soman and KL Ramachandran, "Insight into wavelets from theory to practice", 20th Edition, PHI, 2008

21CMP03	ADVANCED SATELLITE COMMUNICATION AND NAVIGATION SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To study about the orbital mechanics.
- To learn M2M developments and satellite applications.
- To know about satellite communication in Ipv6 environment.
- To be familiar with various navigational systems.
- To impart knowledge about different deep space missions.

UNIT I	OVERVIEW OF SATELLITE COMMUNICATION	9

Overview of satellite communication and orbital mechanics link budget parameters, Link-budget calculations, Auxiliary equations, Performance calculations.		
UNIT II	**M2M DEVELOPMENTS AND SATELLITE APPLICATIONS**	**9**
Overview of Internet of Things and M2M- M2M applications, examples and Satellite support- Satellite roles context and applications- Antennas for satellite M2M applications- M2M Market opportunities for satellite operators- Ultra HD Video/TV and satellite implications- High Throughput Satellites (HTS) and Ka/Ku Spot beam technologies- Aeronautical, Maritime and other mobility services.		
UNIT III	**SATELLITE COMMUNICATION IN IPV6 ENVIRONMENT**	**9**
Overview of IPv6 and its benefits for Satellite networks - Migration and Coexistence- Implementation scenarios and support- Preparations for IPv6 in Satellite communication- Satellite specific protocol issues in IPv6 – Impact of IPv6 on Satellite network architecture and services-Detailed transitional plan- IPv6 demonstration over satellites - Key results and recommendations.		
UNIT IV	**SATELLITE NAVIGATION AND GLOBAL POSITIONING SYSTEM**	**9**
Overview of radio and satellite navigation, GPS principles, Signal model and codes, satellite signal acquisition, Mathematical model of GPS observables, Methods of processing GPS data, GPS receiver operation and Differential GPS. IRNSS, GAGAN, GLONASS and Galileo.		
UNIT V	**DEEP SPACE NETWORKS AND INTERPLANETARY MISSIONS**	**9**
Introduction – Functional description - Design procedure and performance criterion-Mars exploration Rover- Mission and space craft summary-Telecommunication subsystem overview-Ground Subsystem-Telecom subsystem and Link performance Telecom subsystem Hardware and software Chandrayaan-1 Mission - Mission and space craft summary-Telecommunication subsystem overview- Ground subsystem-Telecom subsystem and Link performance. Mangalyaan mission - Mission and space craft summary-Telecommunication subsystem overview- Ground Subsystem -Telecom subsystem and Link performance.		
TOTAL: 45 PERIODS		
COURSE OUTCOMES: At the end of the course, learners will be able to CO1: Explain about orbital mechanics and link budget calculations		

CO2: Outline the various applications of Satellite

CO3: Explain the concept of IPv6 Protocols in Satellite communication

CO4: Illustrate satellite navigation and principles of global positioning system

CO5: Outline Deep space networks and Inter planetary missions

1. Adimurthy.V, "Concept design and planning of India's first interplanetary mission", Current Science, Vol. 109, No. 6, 2015.
2. Anil K.Maini and Varsha Agrawal, "Satellite Technology: Principles and Applications", 3rd Edition, Wiley, 2014.
3. DanielMinoli, "Innovations in Satellite Communication and SatelliteTechnology" ,3rd Edition, Wiley, 2015.
4. Hofmann-Wellenhof B., Lichtenegger H., and Elmar Wasle, "Global Navigational Satellite Systems" 1st Edition, Springer-Verlag, 2008.
5. Jim Taylor, "Deep Space Communications", 2ndEdition, John Wiley & Sons,2016.
6. Louis J. Ippolito, Jr. "Satellite Communications Systems Engineering: Atmospheric Effects, Satellite Link Design and System Performance", 1st Edition, Wiley, 2017.

21CMP04	MIMO OFDM SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamental concepts of wireless channel modeling techniques.
- To study the basic principle of OFDM technique.
- To know about the various MIMO techniques including MIMO channel capacity, Antenna diversity and space-time codes.
- To learn the spatial characteristics of wireless channel using various estimation techniques.
- To interpret the technical background of signal detection technique for spatially multiplexed MIMO systems.

UNIT I	SAMPLED SIGNAL AND MULTIPATH FADING CHANNEL MODELS	9

Physical scattering models- Extended channel models signal model for SISO, SIMO, MISO

and MIMO ITU channel models- 3GPPP channel models - Extended ITU models- Spatial channel model SCM extension channel model, WINNER channel model.		
UNIT II	**CAPACITY ANALYSIS & BIT ERROR RATE ANALYSIS**	**9**
Capacity in frequency flat fading channel, Capacity in frequency selective fading channel - Transmit beam forming - Receiver selection combining- Receiver equal combining- Receiver maximal ratio combining.		
UNIT III	**SPATIAL DIVERSITY AT TRANSMITTER AND RECEIVER**	**9**
Diversity gain- Transmit and receive antenna diversity- Diversity order and performance- Combined space and path diversity- Indirect transmit diversity-space time coding for frequency flat channels- frequency selective channels - Receivers for SISO, SIMO and MIMO.		
UNIT IV	**CHANNEL ESTIMATION AND TIMING & FREQUENCY SYNCHRONIZATION**	**9**
MIMOLS estimation- MMSE estimation- Robust MMSE estimation-coarse time synchronization- Fine time synchronization- Coarse frequency synchronization- Fine frequency synchronization.		
UNIT V	**OFDM AND SPREAD SPECTRUM MODULATION**	**9**
SISO-OFDM- MIMO OFDM- SISO SS modulation- MISO SS modulation, Model, capacity and receiver gain of MIMO MAC, MIMO BC and MIMO MU.		
	TOTAL: 45 PERIODS	

COURSE OUTCOMES:

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

CO1: Explain the concepts of MIMO OFDM Wireless communication systems.

CO2: Demonstrate the multiple access extension and PAPR reduction techniques of OFDM.

CO3: Determine the capacity and bit error rate of MIMO OFDM system for a given power delay profile of the MIMO channel.

CO4: Estimate the channel Impulse response coefficients of the SISO, SIMO, MISO and MIMO Systems.

CO5: Detect signals for spatially multiplexed MIMO Systems using various techniques.

REFERENCES:

1. A. Paulraj, R. Nabar and D Gore, "Introduction to Space-Time Wireless Communications", 1st Edition, Cambridge University Press, 2008.

2. D.Tse and P.Viswanath, "Fundamentals of Wireless Communications", 1st Edition, Asian Edition, Cambridge University Press, 2006.
3. Stefania Sesia, Issam Toufik and Matthew Baker, "LTE - The UMTS Long Term Evolution: From Theory to Practice", 2nd Edition, Wiley, 2011.
4. Y.S.Cho, J.Kim,Won Young Yang and Chung G. Kang, " MIMO OFDM Wireless Communications with MATLAB", 1st Edition, John Wiley & sons(Asia) private Ltd, 2010.
5. L. Hanzo, Y.A. Li Wang, M. Jiang, "MIMO-OFDM for LTE, Wi-Fi and WiMAX", 1st Edition, John Wiley & Sons Ltd, 2010.
6. E. Biglieri, R. Calderbank, A. Constantinides, A. Goldsmith and A. Paulraj, "MIMO Wireless Communications", 1st Edition, Cambridge University Press, 2010.

21CMP05	ANALOG AND MIXED SIGNAL VLSI DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To study the MOS characteristics, large signal model /small signal model and its analysis
- To interpret the submicron circuit, its process flow and delay elements
- To understand the characteristics and architectures of different types of data converters.
- To learn SNR and filters for data converters.
- To study about the switched capacitor amplifier circuits

UNIT I	INTRODUCTION AND BASIC MOS DEVICES	9

Challenges in analog design-Mixed signal layout issues- MOSFET structures and characteristics- large signal and small signal model of single stage Amplifier-Source follower- Common gate stage – Cascode stage – large and small signal analysis of differential amplifier with active load, pole-zero estimation, zero value time constant method, frequency response of CS, cascade amplifiers.

UNIT II	SUBMICRON CIRCUIT DESIGN	9

Submicron CMOS process flow, Capacitors and Resistors, Current mirrors, Digital circuit design, Delay elements – Adders- Op-amp parameters and design.

UNIT III	DATA CONVERTERS	9

Static and dynamic errors in DAC and ADC – Architectures & Characteristics of Sample and Hold- Digital to Analog Converters- DAC- R-2R, weighted DAC, multiplying DAC, segmented DAC and sigma delta DAC. ADC – Flash ADC, pipelined ADC, successive approximation ADC, sigma delta ADC.

UNIT IV	SNR IN DATACONVERTERS	9

Overview of SNR of Data converters- Clock Jitters- Improving techniques-averaging – Decimating Filters for ADC- Band pass and High Pass Sinc Filters- Interpolating filters for DAC.

UNIT V	SWITCHED CAPACITOR CIRCUITS	9

Resistors, First order low pass circuit, Switched capacitor amplifier, Switched capacitor integrator – Design of flip around sample and hold circuit – pipelined ADC.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Outline the characteristics and model of MOS circuits.

CO2: Relate the Submicron circuits and its delay elements.

CO3: Explain the characteristics and architectures of different types of data converters.

CO4: Compare the SNR of data converters.

CO5: Develop switched capacitor circuits.

REFERENCES:

1. J. Jacob Wikner, Mikael Gustavsson and Nianxiong Tan "CMOS Data Converters for Communications", 1st Edition, Springer, 2000.
2. Van de Plassche and Rudy J., "CMOS Integrated Analog-to-Digital and Digital-to-Analog Converters", 2nd Edition, Springer, 2003.

21CMP06	ELECTROMAGNETIC METAMATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the concepts of left handed materials.
- To design metamaterial transmission lines.
- To learn about the structure of metamaterials.
- To design metamaterial antennas.
- To interpret the applications of metamaterials.

UNIT I	LEFT HANDED MATERIALS AND THEIR PROPERTIES	9

Left-Handedness from Maxwell's equations, Entropy conditions in dispersive media, Boundary conditions, Reversal of Doppler effect, Reversal of Snell's law: Negative refraction, Focusing by a "Flat LH Lens", Reversal of Goos-Haenchen effect, Reversal of convergence and divergence in Convex and Concave lenses, Sub-wavelength diffraction, Fresnel coefficients.

UNIT II	METAMATERIAL TRANSMISSION LINES	9

Ideal homogeneous CRLH TLs- equivalent MTM constitutive parameters, Balanced and Unbalanced resonances, LC network implementation: Transmission matrix analysis, Input impedance, Cutoff frequencies, Analytical dispersion relation, Bloch impedance. Experimental transmission characteristics, Conversion from transmission line to constitutive parameters.

UNIT III	METAMATERIAL STRUCTURE ANALYSIS	9

Real distributed 1D CRLH structures: General design guidelines, Microstrip implementation, and parameters extraction, Two-dimensional MTMs: Eigen value problem, Negative Refractive Index (NRI) effects: Negative phase velocity, Negative refraction, Negative focusing, RH-LH interface surface plasmons. Distributed 2D structures: Description of possible structures, Dispersion and Propagation characteristics, Parameter extraction, Distributed implementation of the NRI slab reflectors with unusual properties.

UNIT IV	METAMATERIAL ANTENNAS	9

Fundamental aspects of Leaky-Wave structures, Principle of leakage radiation, Uniform and periodic Leaky-Wave structures, Uniform LW structures, Periodic LW structures, Metamaterial Leaky-Wave structures. Backfire-to Endfire (BE) Leaky-Wave (LW) antenna, Electronically scanned BE LW antenna: Electronic scanning principle, Electronic

beamwidth ccntrol principle, Analysis of the structure and results, Two-Dimensional structures: Two Dimensional LW radiation, Conical-Beam antenna, Full-Space scanning antenna, Dual-Band CRLH-TL resonating ring antenna, "Meta-Interfaces", Heterodyne phased array, Nonuniform Leaky-Wave radiator.

UNIT V	APPLICATION AND ADVANCES IN METAMATERIALS	9

"Real-Artificial" Materials: Homogenization, Quasi-Optical NRI lenses and devices, Three-dimensional Isotropic LH MTMs, Optical MTMs, 'Magnetless' magnetic MTMs, Terahertz magnetic MTMs, Surface plasmonic MTMs, Antenna radomes and Frequency selective surfaces, Nonlinear MTMs, Active MTMs.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Illustrate the properties of metamaterials.

CO2: Construct metamaterial transmission lines.

CO3: Design the metamaterial structures.

CO4: Demonstrate the metamaterial inspired antennas.

CO5: Select the metamaterials for advanced applications.

REFERENCES:

1. Christophe Caloz and Tatsuo Itoh, "Electromagnetic Metamaterials: Transmission Line Theory and Microwave Applications", 1st Edition, A John Wiley & Sons, Inc., Publication, 2006
2. Tie Jun Cui, David Smith and Ruopeng Liu, "Metamaterials: Theory, Design, and Applications", 1st Edition, Springer, 2009
3. Douglas H. Werner and Do-Hoon K, "Transformation Electromagnetics and Metamaterials", 1st Edition, Springer-Verlag London, 2014

21CMP07	ADVANCED ANTENNA DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn various types of printed antennas.
- To understand about wearable antennas.
- To gain the knowledge about active integrated antennas.
- To be familiar with the reconfigurability function in antenna design.

- To study about metamaterials and metasurfaces.

UNIT I	PRINTED ANTENNAS	9

Concepts of Printed antennas, Broadband microstrip patch antennas, Circularly polarized planar antennas, Enhanced gain patch antennas, Wideband compact patch antennas, Microstrip slot antennas, Microstrip planar monopole antenna, Patch antennas for multiband applications.

UNIT II	WEARABLE ANTENNAS	9

Overview of wearable systems and its characteristics, Antennas for wearable devices, Design requirements, Modeling and Characterization of wearable antennas, WBAN radio channel characterization and Effect of wearable antennas, Domains of operation, Sources on the human body, Compact wearable antenna for healthcare sensors.

UNIT III	ACTIVE INTEGRATED ANTENNAS	9

Active wearable antenna modules-Features, Electromagnetic characterization of fabrics and Flexible foam materials, Matrix-Pencil two-line method, Small-Band inverse planar antenna Resonator method, Active antenna modules for wearable textile systems, Substrate integrated waveguide technology.

UNIT IV	RECONFIGURABLE ANTENNAS	9

Reconfigurable methodologies, Design considerations for reconfigurable systems, Reconfigurable planar/printed antenna configurations, Active reconfigurable systems.

UNIT V	METAMATERIALS AND METASURFACES	9

Double negative properties, Structures, Design of metamaterial antennas, Multi-surface - Metasurface antennas, Metahorns, Metalenses, Analysis of metasurfaces.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Evaluate the performance of different printed antennas.

CO2: Analyse the properties of wearable antennas.

CO3: Apply EM characterization to analyse active integrated antennas.

CO4: Design reconfigurable antennas.

CO5: Develop metamaterials and metasurfaces.

REFERENCES:

1. Debatosh Guha and Yahia M.M. Antar, "Microstrip and Printed Antennas", 1st Edition, John Wiley & Sons, 2011.

2. Taming the Borg, "Moving Wearables into the Mainstream", 1st Edition, Springer, 2008.
3. Eng Hock Lim and Kwok Wa Leung, "Compact Multifunctional Antennas for Wireless Systems", 2nd Edition, John Wiley & Sons, 2012.
4. Zhi Ning Chen, "Antennas for Portable Devices", 3rd Edition, John Wiley & Sons, 2007.
5. Warren L Stutzman and Gary A.Thiele, "Antenna Theory and Design", 3rd Edition, John Wiley & Sons, 2013.

21CMP08	MILLIMETER WAVE COMMUNICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn about the characteristics and applications of millimeter wave.
- To understand the fundamentals of millimeter wave devices and circuits.
- To know the various components of millimeter wave communications system.
- To interpret the concepts of millimeter wave MIMO systems.
- To study about antenna design at millimeter wave frequencies.

UNIT I	INTRODUCTION	9

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

UNIT II	MM WAVE DEVICES AND CIRCUITS	9

Millimeter wave generation and amplification: Peniotrons, Ubitrons, Gyrotrons and Free electron lasers. HEMT, models for mm wave Transistors, transistor configurations, Analog mm wave components: Amplifiers, Mixers, VCO, PLL. Metrics for analog mm wave devices, Consumption factor theory, Trends and architectures for mm wave wireless, ADC's and DAC's.

UNIT III	MM WAVE COMMUNICATION SYSTEMS	9

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

wave design considerations.		
UNIT IV	**MM WAVE MIMO SYSTEMS**	**9**
Massive MIMO communications, Spatial diversity of antenna arrays, Multiple antennas, Multiple transceivers, Noise coupling in MIMO system, Potential benefits for mm wave systems, Spatial, Temporal and Frequency diversity, Dynamic spatial, frequency and modulation allocation.		
UNIT V	**ANTENNAS FOR MM WAVE SYSTEMS**	**9**
Antenna beamwidth, polarization, advanced beam steering and beam forming, mm wave design consideration, On-chip and In package mm wave antennas, Techniques to improve gain of on-chip antennas, Implementation for mm wave in adaptive antenna arrays, Device to Device communications over 5G systems, Design techniques of 5G mobile.		
TOTAL: 45 PERIODS		

COURSE OUTCOMES:

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

CO1: Illustrate the characteristics of millimeter wave.

CO2: Infer the properties of millimeter wave devices and circuits.

CO3: Explain about the usage of millimeter wave communication systems.

CO4: Outline the characteristics of millimeter wave MIMO systems.

CO5: Design antenna for millimeter wave frequencies.

REFERENCES:

1. K.C. Huang and Z. Wang, "Millimeter Wave Communication Systems", 2nd Edition, Wiley-IEEE Press, March 2011.
2. Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport and Murdock, "Millimeter Wave Wireless Communication", 4th Edition, Prentice Hall, 2014.
3. Xiang, W; Zheng, K and Shen, X.S; "5G Mobile Communications", 2nd Edition, Springer, 2016.

21CMP09	MULTIMEDIA COMPRESSION TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn the basic ideas of compression algorithms related to multimedia components such as text, speech, audio, image and video.
- To know about the principles and standards in text compression.
- To infer the use of image compression in multimedia processing applications.
- To study about audio compression.
- To explore the video compression and its applications.

UNIT I	FUNDAMENTALS OF COMPRESSION	9

Introduction to multimedia – Graphics, Image and Video representations – Fundamental concepts of video, digital audio – Storage requirements of multimedia applications – Need for compression – Taxonomy of compression algorithms - Elements of information theory – Error free compression – Lossy compression.

UNIT II	TEXT COMPRESSION	9

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

UNIT III	IMAGE COMPRESSION	9

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

UNIT IV	AUDIO COMPRESSION	9

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

UNIT V	VIDEO COMPRESSION	9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the requirement of compression in different real time applications.

CO2: Select relevant techniques for text compression.

CO3: Experiment various image compression algorithms.

CO4: Compare the performance of audio compression techniques.

CO5: Illustrate the different standards applicable for video compression.

REFERENCES:

1. David Solomon, "Data Compression – The Complete Reference", 4th Edition, Springer Verlog, New York, 2006.
2. Darrel Hankerson, Greg A Harris and Peter D Johnson, "Introduction to Information Theory and Data Compression", 2nd Edition, Chapman and Hall, CRC Press, 2003.
3. Khalid Sayood, "Introduction to Data Compression", Morgan Kauffman Harcourt India, 3rd Edition, 2010.
4. Mark S. Drew and Ze-Nian Li, "Fundamentals of Multimedia", 1st Edition, PHI, 2009.
5. Peter Symes, "Digital Video Compression", 1st Edition, McGraw Hill Publishers, 2004.
6. Yun Q.Shi and Huifang Sun, "Image and Video Compression for Multimedia Engineering, Algorithms and Fundamentals", CRC Press, 2003.

21CMP10	COGNITIVE RADIO NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce to the concepts of cognitive radio.
- To understand the cognitive radio architecture.
- To learn spectrum sensing and dynamic spectrum access.
- To be familiar with MAC layer and network layer design for cognitive radio.
- To know how cognitive radio relates with internet of things and M2M technologies.

UNIT I	INTRODUCTION TO SOFTWARE-DEFINED RADIO AND COGNITIVE RADIO	9

Evolution of software defined radio and cognitive radio: goals, benefits, definitions,

architectures, relations with other radios, issues, enabling technologies, radio frequency spectrum and regulations.		
UNIT II	**COGNITIVE RADIO ARCHITECTURE**	**9**
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, Architecture and Overview of IEEE 802.22 standard for broadband wireless access in TV bands.		
UNIT III	**SPECTRUM SENSING AND DYNAMIC SPECTRUM ACCESS**	**9**
Introduction – Primary user detection techniques – energy detection, feature detection, matched filtering, cooperative detection , Bayesian Approach, Neyman Pearson fusion rule for spectrum sensing, Optimum spectrum sensing –KullbackLeibler divergence and other approaches, Fundamental tradeoffs in spectrum sensing, Spectrum sharing models of dynamic spectrum access - Unlicensed and licensed spectrum sharing, Fundamental limits of cognitive radio.		
UNIT IV	**MAC AND NETWORK LAYER DESIGN FOR COGNITIVE RADIO**	**9**
MAC for cognitive radios – Multichannel MAC - slotted ALOHA – CSMA, Network layer design – routing in cognitive radios, flow control and error control techniques.		
UNIT V	**ADVANCED TOPICS IN COGNITIVE RADIO**	**9**
Cognitive radio for Internet of Things - Features and applications – Enabling technologies and protocols – M2M technologies - Data storage and analysis techniques - Requirement and challenges of IoT – Energy efficiency– MIMO Cognitive radio – Power allocation algorithms.		
TOTAL: 45 PERIODS		

COURSE OUTCOMES:

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

CO1: Summarize the benefits, evolution and implications of software defined radio.

CO2: Explain the techniques and functions of cognitive radio architecture.

CO3: Outline the basics of various spectrum sensing techniques and algorithms.

CO4: Interpret the functions of MAC layer and network layer and its various protocols.

CO5: Outline cognitive radio for internet of things and M2M technologies.

REFERENCES:

1. Alexander M. Wyglinski, Maziar Nekovee and Thomas Hou, "Cognitive

Radio Communications and Networks", Academic Press, Elsevier, 2010.
2. Bruce Fette, "Cognitive Radio Technology", Newnes, 2006.
3. Kwang-Cheng Chen and Ramjee Prasad, "Cognitive Radio Networks", 1st Edition, John Wiley and Sons, 2009.
4. Huseyin Arslan, "Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems", Springer, 2007.
5. S.Shanmugavel, M.A.Bhagyaveni, R.Kalidoss, "Cognitive Radio-An Enabler for Internet of Things", 1st Edition, River Publishers, 2017.

SEMESTER III

21CMP11	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basics of electromagnetic interference and compatibility.
- To study about EMI Coupling Principles.
- To know the methods to mitigate EMI.
- To be familiar with the EMI Standards and Regulations.
- To learn about the EMI testbeds.

UNIT I	BASIC THEORY	9

Introduction to EMI and EMC, Intra and inter system EMI, Elements of Interference, Sources and Victims of EMI, Conducted and Radiated EMI emission and susceptibility, Case histories, Radiation hazards to humans, Various issues of EMC, EMC Testing categories EMC engineering application.

UNIT II	COUPLING MECHANISM	9

Electromagnetic field sources and Coupling paths, Coupling via the supply network, Common mode coupling, Differential mode coupling, Impedance coupling, Inductive and Capacitive coupling, Radioactive coupling, Ground loop coupling, Cable related emissions and coupling, Transient sources, Automotive transients.

UNIT III	EMI MITIGATION TECHNIQUES	9

Working principle of shielding and Murphy's law, LF magnetic shielding, Apertures and

shielding effectiveness, Choice of materials for H, E, and free space fields, Gasketting and sealing, PCB level shielding, Principle of grounding, Isolated grounds, Grounding strategies for large systems, Grounding for mixed signal systems, Filter types and operation, Surge protection devices, Transient protection.

UNIT IV	STANDARD AND REGULATION	9

Need for standards, Generic/General standards for residential and industrial environment, Basic standards, Product standards, National and International EMI standardizing organizations; IEC, ANSI, FCC, AS/NZS, CISPR, BSI, CENELEC, ACEC. Electro magnetic emission and susceptibility standards and specifications, MIL461E standards.

UNIT V	EMI TEST METHODS AND INSTRUMENTATION	9

Fundamental considerations, EMI shielding effectiveness tests, Open field test, TEM cell for immunity test, Shielded chamber , Shielded anechoic chamber, EMI test receivers, Spectrum analyzer, EMI test wave simulators, EMI coupling networks, Line impedance stabilization networks, Feed through capacitors, Antennas, Current probes, MIL -STD test methods, Civilian STD test methods.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Outline the basics of Interferences.

CO2: Utilize various EMI coupling principles to achieve compatibility.

CO3: Explain the Electromagnetic compatible PCBs for EMI mitigation techniques.

CO4: Illustrate the EMI standards and regulation.

CO5: Demonstrate various EMI / EMC testbeds.

REFERENCES:

1. Bemhard Keiser, “Principles of Electromagnetic Compatibility”, 3rd Edition, Artech House, Norwood, 1986.
2. Clayton Paul, “Introduction to Electromagnetic Compatibility”, 1st Edition, Wiley Interscience, , 2006.
3. Daryl Gerke and William Kimmel, “EDN's Designer's Guide to Electromagnetic Compatibility”, Elsevier Science & Technology Books, 2002.
4. Henry W. Ott, “Electromagnetic Compatibility Engineering”, 3rd Edition, John Wiley & Sons Inc, Newyork, 2009.
5. V Prasad Kodali, “Engineering Electromagnetic Compatibility”, IEEE Press,

Newyork, 2001.

21CMP12	FREQUENCY SELECTIVE SURFACES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals of FSS.
- To be familiarize with the periodic structures.
- To design the layered radomes.
- To analyze the geometries of FSS.
- To explain the operation surface iIntegrated waveguide.

UNIT I	INTRODUCTION TO FSS	9

Periodic structures - Surface waves unique to finite periodic structures - Complementary arrays - passive versus active arrays - dipole versus slot arrays - Applications of periodic structures: Hybrid radomes, Bandstop filters, Dichroic reflectors, Circuit analog absorbers, Meanderline polarizer.

UNIT II	TYPES OF ELEMENTS	9

Center connected or N-Poles: Unloaded tri-pole array, Square spiral element - Loop types: three legged and four-legged loaded element - Solid interior types - combination of elements – Common misconceptions about elements - Comparison of elements - Evaluation of periodic structures.

UNIT III	FSS RADOME MODELING	9

Modeling of an N-layered hybrid radome - Determination of the transmission coefficient for an N - layered hybrid radome - analysis of the hybrid radome – Honeycomb and thick screen radomes - Reflection: image lobes - Luebbers' anomaly - Calculation of scattering from N arrays of dipoles - Matching in the band-pass region.

UNIT IV	ANALYSIS OF FSS	9

Estimating the resonant frequency of a single periodic surface: Effect of dielectric material, Bandwidth - Extension to arrays of wide flat elements - Filter geometries and equivalent circuits - Matrix methods - Derivation of cascading matrix.

UNIT V	SUBSTRATE INTEGRATED WAVEGUIDES	9

Substrate integrated waveguides – Circuits and Components - SIW and FSS - Modeling and design considerations – Applications – Merits and demerits.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Analyze the structure of frequency selective surfaces.

CO2: Explain the characteristics of periodic structures.

CO3: Design layered radomes.

CO4: Develop the equivalent circuits of FSS.

CO5: Illustrate the structure of substrate integrated waveguide.

REFERENCES:

1. Ben A Munk, "Frequency Selective Surfaces-Theory and Design", 1st Edition, John Wiley, 2000.
2. Ben A Munk, "Finite Antenna Arrays and FSS", Wiley-IEEE Press, July 2003
3. Salvatore Celozzi, "Electromagnetic Shielding", 2nd Edition, Wiley Interscience Publication, 2008.
4. E.A.Parker, "The Gentleman's Guide to Frequency Selective Surfaces", 17th Q.M.W. Antenna Symposium, London, April 1991.
5. M. Bozzi, F. Xu, D. Deslandes, and K. Wu, "Modeling and design considerations for substrate integrated waveguide circuits and components," in Int. Telecomm. Modern Satellite, Cable, Broadcast. Serv.Conf., Sep. 2007, pp. 7–16.
6. Benjamin Hooberman, "Everything You Ever Wanted to Know About Frequency-Selective Surface Filters but Were Afraid to Ask", May 2005.

21CMP13	SOFT COMPUTING TECHNIQUES	L	T	P	C
		3	2	0	4

COURSE OBJECTIVES:

- To understand Artificial Intelligence and Production Systems.
- To familiarize with architecture and algorithms involved in Neural Networks.
- To gain the knowledge about different types of perceptions.
- To explain Fuzzy Logic, Various fuzzy systems and their functions.
- To learn the s applications and advances of Genetic Algorithms.

UNIT I	INTRODUCTION TO SOFTCOMPUTING	9

Introduction to soft computing, soft computing vs. hard computing, Types of soft computing techniques, Sequential and Parallel Computing. Applications of soft computing: Healthcare, Remote Sensing and Communication Systems.

UNIT II	ARTIFICIAL INTELLIGENCE	9

Introduction, Various types of production systems, characteristics of production systems. Search Techniques: Breadth first search, Depth first search, Hill Climbing, Best first search. A* and AO* Algorithms and control strategies. Knowledge representation issues, Prepositional and predicate logic, monotonic and non monotonic reasoning, forward and backward reasoning, Strong slot and weak slot filler structure.

UNIT III	NEURAL NETWORKS	9

Biological neuron, artificial neuron, definition of ANN, Taxonomy of neural net, Difference b/w ANN and human brain, characteristic and applications of ANN, single layer network.

Perceptron training algorithm, Linear separability, Widrow & Hebb's learning rule/Delta rule, ADALINE, MADALINE. Introduction of MLP, activation functions, Error calculation, back propagation algorithm, momentum, limitation, characteristics and application of EBPA.

UNIT IV	FUZZY LOGIC AND FUZZY SYSTEMS	9

Fuzzy set theory, Fuzzy set versus crisp set, Crisp relation & fuzzy relations, Fuzzy systems: crisp logic, fuzzy logic, features of membership functions.

Fuzzy propositions, formation, decomposition & aggregation of fuzzy Rules, fuzzy reasoning, fuzzy inference systems, fuzzy decision making & Applications of fuzzy logic.

UNIT V	GENETIC ALGORITHM AND APPLICATIONS	9

Fundamental, basic concepts, working principle, encoding, fitness function, reproduction, Genetic modeling: Inheritance operator, cross over, inversion & deletion, mutation operator, Bitwise operator ,Generational Cycle, Convergence of GA, Differences & similarities between GA and other traditional methods, Applications & advances in GA.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course , learners should be able to

CO1: Learn about soft computing techniques and their applications.

CO2: Analyze various neural network architectures.

CO3: Familiarize with perceptrons and counter propagation networks.

CO4: Define the fuzzy systems.

CO5: Analyze the genetic algorithms and their applications.

REFERENCES:

1. S.N. Sivanandam and S.N. Deepa, "Principles of Soft Computing", 2nd Edition, Wiley Publications, 2011.
2. S. Rajasekaran and G.A. Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic & Genetic Algorithms, Synthesis & applications", 1st Edition, PHI Publication, 2009.
3. N.K.Bose and Ping Liang, "Neural Network fundamental with Graph, Algorithms & Applications", 1st Edition, TMH, 1998.
4. Bart Kosko, "Neural Network & Fuzzy System", 1st Edition, PHI Publication, 2009.
5. Rich E and Knight K, "Artificial Intelligence", 3rd Edition, TMH, 2012.
6. George J Klir and Bo Yuan, "Fuzzy sets & Fuzzy Logic, Theory & Applications", 1st Edition, PHI Publication, 2009.

21CMP14	SPACE TIME WIRELESS COMMUNICATION	L	T	P	C
		4	0	0	3

COURSE OBJECTIVES:

- To understand the concepts and derive the expressions of signals; channel model for various multiple antenna techniques.
- To learn channel capacity and spatial diversity of various multiple antenna systems.
- To study transmit diversity concept under various channel constraints.
- To demonstrate various receiver structure of multiple antenna configuration.
- To understand receiver structures and spread spectrum concepts of multiple antenna systems.

UNIT I	SPACE TIME SIGNAL & CHANNEL MODEL	9

Space time signal model: SISI, SIMO, MISO and MIMO, Space time channel model: SISO, SIMO, MISO and MIMO, Extended channel models: Spatial fading correlation, LOS component, Cross-polarized antennas and Degenerate channels, Statistical properties of channel: Singular value and Squared Frobenius norm.

UNIT II	CAPACITY OF SPACE TIME WIRELESS CHANNELS	9

Frequency flat fading channel with perfect CSIT, Frequency flat fading channel in the absence of CSIT, Frequency selective fading channel with perfect CSIT, Frequency selective fading channel in the absence of CSIT, Random MIMO channel, Correlated MIMO channel.

UNIT III	SPATIAL DIVERSITY	9

Diversity gain: Coding gain vs diversity gain, Spatial diversity vs time/frequency diversity, Transmit antenna diversity: Channel unknown to the transmitter – MISO, Channel known to the transmitter – MISO, Channel unknown to the transmitter – MIMO, Channel known to the transmitter - MIMO, Receive diversity: Selection, Threshold, Equal gain and Maximal ratio combining.

UNIT IV	**RECEIVER STRUCTURES**	**9**

Maximum likelihood receiver, Zero forcing receiver, Minimum mean square error, Decision feedback error, D-BLAST and V- BLAST.

UNIT V	**SPACE TIME OFDM & SPREAD SPECTRUM**	**9**

SISO – OFDM, MIMO – OFDM modulation, Signaling and receivers for MIMO – OFDM: Spatial diversity coding for MIMO – OFDM, SM for MIMO – OFDM and Space-frequency coded MIMO – OFDM, SISO – SS modulation: Frequency flat channel, Frequency selective channel, MIMO – SS modulation, Signaling and receivers for MIMO – SS: Spatial diversity coding for MIMO-SS, SM for MIMO-SS.

Total Periods: 45

COURSE OUTCOMES:

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

CO1: Obtain signal and channel model for SISO, SIMO, MISO and MIMO systems for specified muti-antenna configuration.

CO2: Determine the capacity of SISO, SIMO, MISO and MIMO systems for the frequency flat and frequency channel models.

CO3: Analyze SIMO and MIMO transmit diversity techniques under the assumptions of known and unknown CSI at the transmitter.

CO4: Analyze MISO and MIMO receiver diversity using various combining techniques.

CO5: Apply zero-forcing, ML, MMSE and DFE techniques to find error probability of space-time receivers.

REFERENCES:

1. D.Tse and P. Viswanath, "Fundamentals of Wireless Communications", 1st Edition, Cambridge University Press, 2005.
2. A.B.Gershman, N.D.Sidiropoulos, "Space Time Processing for MIMO Communications", 4th Edition, John Wiley, 2005.
3. Erik. G. Larsson, "Space Time Block Coding for Wireless Communications", 2nd

Edition, Cambridge University Press, 2003.

21CMP15	SYSTEM ON CHIP ARCHITECTURE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basic processor designing techniques.
- To classify data types.
- To apply hardware system prototyping tools.
- To acquire the knowledge of ARM system control processor.
- To design system in package.

UNIT I	INTRODUCTION TO PROCESSOR DESIGN	9

Abstraction in hardware design, MUO a simple processor, Processor design trade off, Design for low power consumption. ARM Processor as system-on-chip: Acorn RISC Machine –Architecture inheritance – ARM programming model – ARM development tools – 3 and 5 stage pipeline ARM organization – ARM instruction execution and implementation – ARM co-processor interface.

UNIT II	ARM ASSEMBLY LANGUAGE PROGRAMMING	9

ARM instruction types – data transfer, data processing and control flow instructions – ARM instruction set – Co-processor instructions. Architectural support for high level language: Data types – abstraction in software design – Expressions – Loops – Functions and Procedures –Conditional statements – Use of memory.

UNIT III	MEMORY HIERARCHY	9

Memory size and speed – On-chip memory – Caches – Cache design- an example –memory management. Architectural support for system development: Advanced microcontroller bus architecture – ARM memory interface – ARM reference peripheral specification – Hardware system prototyping tools – Armulator –Debug architecture.

UNIT IV	ARCHITECTURAL SUPPORT FOR OPERATING SYSTEM	9

An introduction to operating systems – ARM system control coprocessor – CP15 protection unit registers – ARM protection unit – CP15 MMU registers – ARM MMU architecture – Synchronization – Context switching input and output.

UNIT V	SYSTEM IN PACKAGE DESIGN	9

Advantages and disadvantages between SoC, SiC and board level design; SiP design flow,

System planning, Chip-package co-design, System optimization; SiP design layout, simulation, verification, Gaps in SiP design, Power optimization tools, Parasitic extraction tools, Signal integrity. Examples of SiP.

	TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Design system in package.
2. Apply hardware system prototyping tools.
3. Classify data types.
4. Design Arm MMU architecture.
5. Model arm system control processor.

REFERENCES:

1. Steve Furber, "ARM System on Chip Architecture", 2nd Edition, Addison Wesley Professional, 2000.
2. Ricardo Reis, "Design of System on a Chip: Devices and Components", 1st Edition, Springer, 2004.
3. Jason Andrews and Newnes, "Co-Verification of Hardware and Software for ARM System on Chip Design (Embedded Technology)",1st Edition, 2005
4. Prakash Rashinkar, Peter Paterson and Leena Singh L ,Kluwer, "System on Chip Verification – Methodologies and Technique"s, Academic Publishers, 1st Edition, 2002.

21CMP16	**WEARABLE ELECTRONICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand the role of wearable devices.
- To explain the types and application of wearable sensor.
- To study about smart textiles.
- To describe the working of energy harvesting.
- To learn the properties of wearable antennas.

UNIT I	**INTRODUCTION TO WEARABLE TECHNOLOGY**	**9**

World of Wearable (WOW), Role of wearable, The emerging concept of big data, The Ecosystem enabling digital life, Smart mobile communication devices, Attributes of

wearables, Taxonomy for wearables, Advancements in wearables, Textiles and clothing, Applications of wearables.

UNIT II	WEARABLE BIO AND CHEMICAL SENSORS	9

Introduction, System design, Microneedle technology, Sampling gases, Types of sensors, Challenges in chemical biochemical sensing, Sensor stability, Interface with the body, Textile integration, Power requirements, Applications: Personal health, Sports performance, Safety and Security, Case studies.

UNIT III	SMART TEXTILE	9

Conductive fibres for electronic textiles: an overview, Types of conductive fibre, Applications of conductive fibres, Bulk conductive polymer yarn, Bulk conductive polymer yarn, Techniques for processing CPYs, Wet-spinning technique, Electro spinning technique, case studies, Hands on project in wearable textile: Solar Backpack, LED Matrix wallet.

UNIT IV	ENERGY HARVESTING SYSTEMS	9

Introduction, Energy harvesting from Temperature gradient, Thermoelectric generators, DC-DC Converter topologies, DC-DC Converter design for Ultra-Low input voltages, Energy harvesting from Foot motion, AC-DC converters, Wireless energy transmission, Energy harvesting from light, Case studies.

UNIT V	WEARABLE ANTENNAS	9

Introduction, Background of textile antennas, Design rules for embroidered antennas, Integration of embroidered textile surfaces onto polymer substrates, Characterizations of embroidered conductive, textiles at radio frequencies, RF performance of embroidered textile antennas, Applications of embroidered antennas.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Analyse measurable quantities and working principles of wearable electronic devices.

CO2: Describe different types of wearable sensors.

CO3: Determine and interpret the outcome of the smart textiles and solve the design challenges.

CO4: Analyse and evaluate the energy harvesting systems.

CO5: Design the customised wearable antennas.

REFERENCES:

1. Edward Sazonov, Michael R., "Wearable Sensors: Fundamentals, Implementation and Applications",1st Edition, Neuman Academic Press, 2014.
2. Tilak Dias, "Electronic Textiles: Smart Fabrics and Wearable Technology", 1stEdition,Woodhead Publishing; ISBN-13: 978-0081002018.
3. Hal Rodriguez and Sahrye Cohen, "Make It, Wear It: Wearable Electronics for Makers, Crafters, and Cosplayers", 1st Edition, McGraw-Hill Education, 2018.
4. Gang Wang, Chengyi Hou, Hongzhi Wang, "Flexible and Wearable Electronics for Smart Clothing: Aimed to Smart Clothing", 1st Edition, Wiley, 2020
5. SenentxuLanceros-Méndez, Carlos MiguelCosta, "Printed Batteries: Materials, Technologies and Applications", 1st Edition, Wiley, 2018.

21CMP17	NETWORK ROUTING ALGORITHMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To expose to the layered architecture for communication networks and the specific functionality of the network layer.
- To study the basic principles of routing and the implementation in conventional networks.
- To understand the evolving routing algorithms based on internetworking requirements, optical backbone and the wireless access part of the network.
- To study the specifications and functionalities of various protocols/standards of mobile networks.
- To be familiarize with Adhoc networks concepts and its routing protocols.

UNIT I	INTRODUCTION	9

ISO OSI Layer Architecture, TCP/IP Layer Architecture, Functions of network layer, General Classification of routing, Routing in telephone networks, Dynamic non hierarchical routing (DNHR), Trunk status map routing (TSMR), real-time network routing (RTNR), Distance vector routing, Link state routing, Hierarchical routing.

UNIT II	INTERNET ROUTING	9

Interior protocol: Routing Information Protocol (RIP), Open Shortest Path First (OSPF), Bellman Ford Distance Vector Routing. Exterior Routing Protocols: Exterior Gateway Protocol (EGP) and Border Gateway Protocol (BGP). Multicast routing: pros and cons of

multicast and multiple Unicast routing, Distance vector multicast routing protocol (DVMRP), Multicast Open Shortest Path First (MOSPF), MBONE, Core based tree routing.

UNIT III	ROUTING IN OPTICAL WDM NETWORKS	9

Classification of RWA algorithms, RWA algorithms, Fairness and admission control, Distributed control protocols, Permanent routing and wavelength requirements, Wavelength rerouting- Benefits and issues, Light path migration, Rerouting schemes, algorithms- AG, MWPG.

UNIT IV	MOBILE - IP NETWORKS	9

Macro-mobility protocols, Micro-mobility protocol: Tunnel based : Hierarchical mobile IP, Intra domain mobility management, Routing based: Cellular IP, Handoff wireless access internet infrastructure (HAWAII).

UNIT V	MOBILE AD –HOC NETWORKS	9

Internet-based mobile ad-hoc networking communication strategies, Routing algorithms – Proactive routing: destination sequenced distance vector routing (DSDV), Reactive routing: Dynamic Source Routing (DSR), Ad hoc On-Demand Distance Vector Routing (AODV), Hybrid Routing: Zone Based Routing (ZRP).

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the various layers of communication networks and the functionalities of the network layer.

CO2: Outline the concepts of internet routing and its protocols.

CO3: Summarize the different routing algorithms for optical WDM networks.

CO4: Interpret the functionalities of various protocols/standards of mobile IP networks.

CO5: Infer the different routing protocols for mobile Ad-hoc networks.

REFERENCES:

1. A.T Campbell et al., “Comparison of IP Micromobility Protocols”, IEEE Wireless Communications Feb.2002, pp 72-82.
2. C.E Perkins, “Ad Hoc Networking”, Addison – Wesley, 2001.
3. M. Steen Strub, “Routing in Communication network”, Prentice Hall International, Newyork, 1995.
4. S. Keshav, “An engineering approach to computer networking”, 1st Edition, Addison Wesley 1999.

5. William Stallings, "High speed Networks TCP/IP and ATM Design Principles", 4th Edition, Prentice Hall, New York, 1995.
6. William Stallings, "High speed networks and Internets Performance and Quality of Service", 2nd Edition, Pearson Education Asia. Reprint India 2002.

21CMP18	5G TECHNOLOGIES AND ITS APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn fundamentals of 5G wireless propagation channels.
- To understand the transmission and design techniques for 5G deployment.
- To be familiar with D2D and M2M communications.
- To understand the concepts of millimeter wave communications.
- To design smart antennas for 5G communication.

UNIT I	5G WIRELESS PROPAGATION CHANNELS	9

Overview of 5G requirements, Regulations for 5G, Spectrum analysis and sharing for 5G. Channel modeling requirements, propagation scenarios and challenges in 5G modeling, Channel models for mm wave MIMO systems.

UNIT II	TRANSMISSION AND DESIGN TECHNIQUES FOR 5G	9

Modulation techniques – Orthogonal frequency division multiplexing (OFDM), generalized frequency division multiplexing (GFDM), filter bank multi-carriers (FBMC) and universal filtered multi-carrier (UFMC), Multiple access techniques – orthogonal frequency division multiple accesses (OFDMA), generalized frequency division multiple accesses (GFDMA), non-orthogonal multiple access (NOMA).

UNIT III	DEVICE-TO-DEVICE (D2D) COMMUNICATIONS	9

Device-to-device (D2D) and machine-to-machine (M2M) type communications – Extension of 4G D2D standardization to 5G, radio resource management for mobile broadband D2D, multihop and multi-operator D2D communications. Applications of D2D and M2M communications.

UNIT IV	MILLIMETER WAVE COMMUNICATIONS	9

Millimeter-wave communications – spectrum regulations, deployment scenarios, beam-forming, physical layer techniques, interference and mobility management, Massive MIMO propagation channel models, Channel estimation in massive MIMO, Massive MIMO with

imperfect CSI, Multi-cell Massive MIMO, Pilot contamination, Spatial Modulation (SM). Applications of millimeter wave communication.		
UNIT V	**ANTENNAS FOR 5G COMMUNICATION**	**9**
Smart antenna configurations, fixed side lobe canceling, Retro directive arrays. Diversity techniques, Angle diversity, Maximum ratio combining, Adaptive beamforming, Fixed multiple beams versus adaptive beamforming. Angle of arrival and direction of arrival estimation techniques.		
	TOTAL: 45 PERIODS	

COURSE OUTCOMES:

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

CO1: Explain the advancements and benefits of 5G technology and channel modeling constraints.

CO2: Analyse the transmission and design strategies related to 5G communications.

CO3: Implement device to device and machine to machine communication.

CO4: Understand millimeter wave communications and massive MIMO propagation.

CO5: Design smart antennas for 5G communication.

REFERENCES

1. Jonathan Rodriguez, "Fundamentals of 5G Mobile Networks", 1st Edition, John Wiley & Sons.
2. Amitabha Ghosh and Rapeepat Ratasuk, "Essentials of LTE and LTE-A", Cambridge University Press.

21CMP19	ADVANCED WIRELESS NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To study about advanced wireless network, LTE, 4G and evolutions from LTE to LTE.
- To learn about wireless IP architecture, packet data protocol and LTE network architecture.
- To discuss about adaptive link layer, hybrid ARQ and graphs routing protocol.
- To study about mobility management, cellular network, and micro cellular

networks.

- To understand about the quality of service wireless IP networks.

UNIT I	INTRODUCTION	9

Introduction to 1G/2G/3G/4G terminology. Evolution of public mobile services -Motivation for IP based wireless networks -Requirements and targets for long term evolution (LTE)-Technologies for LTE- 4G advanced features and roadmap evolutions from LTE to LTE-wireless standards. Network model- Network connectivity-Wireless network design with small world properties.

UNIT II	WIRELESS IP NETWORK ARCHITECTURES	9

3GPP packet data networks-Network architecture-Packet Data Protocol(PDP), Context configuring PDP addresses on mobile stations - Accessing IP networks through PS domain LTE network architecture-Roaming architecture-Protocol architecture-Bearer establishment Procedure -Inter-Working with other RATs.

UNIT III	ADAPTIVE LINK ANDNETWORK LAYER	9

Link layer capacity of adaptive air interfaces-Adaptive transmission in AdHoc networks Adaptive hybrid ARQ schemes for wireless links-Stochastic learning link layer protocol, Infrared link access protocol-Graphs and routing protocols-Graph theory-Routing with topology aggregation-Network and aggregation models.

UNIT IV	MOBILITY MANAGEMENT	9

Cellular networks-Cellular systems with prioritized handoff-Cell residing time distribution Mobility prediction in Pico- and micro-cellular networks.

UNIT V	QUALITY OF SERVICE	9

QoS challenges in wireless IP networks - QoS in 3GPP - QoS architecture, Management and classes -QoS attributes - Management of end-to-end IP QoS - EPS bearers and QoS in LTE networks.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Demonstrate their understanding on the latest 4G networks and LTE.

CO2: Explain the wireless IP and LTE network architectures.

CO3: Outline the adaptive link layer and network layer graphs and protocols.

CO4: Demonstrate their comprehension on mobility management and cellular network.

CO5: Explain the quality of service architecture of wireless IP network and its

challenges.

REFERENCES:

1. Ayman ElNashar, Mohamed El-saidny, Mahmoud Sherif, "Design, Deployment and Performance of 4G-LTE Networks: A Practical Approach", 3rd Edition, John Wiley & Sons, 2014.
2. Crosspoint Boulevard, "Wireless and Mobile All-IP Networks", 2nd Edition, Wiley Publication, 2005.
3. Jyh-Cheng Chen and Tao Zhang, "IP-Based Next-Generation Wireless Networks Systems, Architectures, and Protocols", 3rd Edition, John Wiley & Sons, Inc.Publication,2006.
4. SavoGlisic," Advanced Wireless Networks-4G Technologies", 2nd Edition, John Wiley & Sons, Ltd, 2006.
5. StefaniaSesia, IssamToufik and Matthew Baker, "LTE – The UMTS Long Term Evolution from Theory to Practice", 2nd Edition, John Wiley & Sons, Inc. Publication, 2011.

21CMP20	IOT FOR HEALTH CARE APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn the fundamentals of embedded systems and IoT.
- To understand the hardware platforms and sensor interfaces.
- To learn about the web and cloud servers.
- To be familiarize with the real time needs of IOT.
- To study the case specific issues.

UNIT I	INTRODUCTION TO IOT	9

Introduction to embedded systems-an overview, features. Networked embedded system - types and overview, wireless communication standards-zigbee, bluetooth & Wi-Fi. Introduction to smart objects or things. IoT and its applications in health care systems-Patient monitoring & diagnostics, home healthcare, personal care and fitness.

UNIT II	IOT HARDWARE PLATFORM AND SENSOR INTERFACE	9

Introduction to CC3100 Wi-Fi booster pack: overview & features. Introduction to CC3100

SDK: understand the important APIs. Getting started with energia Wi-Fi libraries. Sensor interface: temperature sensor, pressure sensor, light sensor, and IR sensor.		
UNIT III	**EMBEDDED WEB-SERVER AND IOT CLOUD SERVICES**	**9**
Embedded web server: basic introduction, its importance and role in IoT. Design of a simple embedded web server: HTTP. HTML basics overview of different IoT cloud services.		
UNIT IV	**APPLICATION DESIGN**	**9**
Application design: Design of IoT based pulse oximeter, block diagram, concepts of analog front end, signal process and Wi-Fi integration.		
UNIT V	**CASE STUDIES**	**9**
Case Study 1: Wireless patient monitor system. Case Study 2: Wearable fitness and activity monitor. Case Study 3: Safety monitoring.		
TOTAL: 45 PERIODS		

COURSE OUTCOMES:

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

CO1: Outline the basic concepts of IoT in healthcare.

CO2: Relate the existing hardware platforms and sensor interfaces for various healthcare based applications.

CO3: Compare the ways of communication between the client and the server in IoT.

CO4: Illustrate the various services available in IoT.

CO5: Build various applications in healthcare using IoT based approach and substantiate the same with appropriate case studies.

REFERENCES:

1. CunoPfister, "Getting Started with Internet of Things", O'Relly, 1st Edition, 2011
2. J. P Vasseur, Adam Dunkels, "Interconnecting Smart Objects with IP", Elsevier, 2010

21CMP21	**NUMERICAL TECHNIQUES FOR ELECTROMAGNETIC FIELDS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To study the quasistatic field analysis.
- To understand finite difference methods.
- To learn about variational methods.

- To be familiarize with method of moments.
- To formulate finite element methods.

UNIT I	QUASISTATIC FIELD ANALYSIS	9

Introduction to Electro quasi-statics and Magneto-quasi-statics, Laws of Maxwell, Lorentz, and Newton, Quasi-static laws, Conditions for fields to be quasi-static, Quasi-static systems, Applications, Quasi-static differential laws in free space.

UNIT II	FINITE DIFFERENCE METHODS	9

Finite differencing of parabolic PDEs, Finite differencing of hyperbolic PDEs, Finite differencing of elliptic PDEs, Band matrix method, Accuracy and Stability of FD solutions, Practical applications: Guided structures - Transmission lines, Waveguides, Wave scattering analysis using FDTD, Yees finite difference algorithm, Accuracy and Stability, Lattice truncation conditions, Initial fields, Programming aspects, Absorbing boundary conditions for FDTD, Finite differencing for nonrectangular systems, Spherical coordinates, Numerical integration for discrete data - Eulers rule, Trapezoidal rule, Simpson's rule, Newton-Cotes rules, Gaussian rules, Multiple integration.

UNIT III	VARIATIONAL METHODS	9

Inhomogeneous equations, Operators in linear spaces, Calculus of variations, Construction of functional from PDEs, Rayleigh Ritz method, Weighted residual method, Collocation method, Sub domain method, Least Squares method, Eigen value problems, Practical applications.

UNIT IV	METHOD OF MOMENTS	9

Integral equations, Connection between differential and integral equations, Greens functions - For free space, For domain with conducting boundaries, Applications –Quasi-static problems, Scattering problems - Scattering by conducting cylinder, Scattering by an Arbitrary array of parallel wires, Radiation problems - Hallens integral equation, Pocklingtons integral equation, EM absorption in the human body, Derivation of integral equations, Transformation to matrix equation discretization, Evaluation of matrix elements, Solution of the matrix equation.

UNIT V	FINITE ELEMENT METHOD	9

Typical finite elements, Solution of Laplace equation, Element governing equations, Assembling of all elements, Solution of Poisson's equation, Wave equation, Automatic mesh generation - Rectangular domains, Arbitrary domains, Definition of blocks, Subdivision of each block, Connection of individual blocks, Bandwidth reduction, Higher

order elements, Pascal triangle, Local coordinates, Shape functions, Three dimensional elements, Finite element methods for exterior problems, Boundary element method.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Make use of the numerical methods for various EM problems.

CO2: Identify the solution for any EM problem using finite difference method.

CO3: Select the applications of variational methods to real world problems.

CO4: Illustrate the performance of the antenna or waveguides using method of moments.

CO5: Compare the performance of finite element methods with other methods.

REFERENCES:

1. Matthew N.O.Sadiku, "Numerical Techniques in Electromagnetics with MATLAB", 3rd Edition, CRC Press, 2009.
2. BharathiBhat, and ShibanK.Koul, "Stripline-like Transmission Lines for Microwave Integrated Circuits", 4th Edition, New Age International, 2007.
3. DraganPoljak, "Advanced Modeling in Computational Electromagnetic Compatibility", Wiley, 2007.
4. Jian-Ming Jin, "Theory and Computation of Electromagnetic Fields", 2ndEdition Wiley IEEE Press, 2015.
5. David B. Davidson, "Computational Electromagnetics for RF and Microwave Engineering", 2nd Edition, Cambridge, 2010.
6. Silvester and Ferrari, "Finite Elements for Electrical Engineers", 3rd Edition, Cambridge, 1996.

21CMP22	DEEP LEARNING TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the concept of deep learning and fundamental mathematics required for deep learning.
- To study the modern practical deep networks and their applications.
- To understand the research methods of deep learning.

- To know about the various deep generative models.
- To learn the applications of deep learning networks.

UNIT I	INTRODUCTION AND PREREQUISITE MATHEMATICS	9

Introduction – Historical trends in deep learning - Linear algebra – Scalars – Vectors – Matrices and Tensors – Linear dependence and span - Probability and information theory – The chain rule of conditional probability - Bayes rule – Machine learning basics – Supervised and Unsupervised learning algorithms – Stochastic gradient descent.

UNIT II	MODERN PRACTICAL DEEP NETWORKS	9

Deep feed forward networks – Gradient based learning – Back propagation and other differentiation algorithms – Regularization for deep learning: Parameter norm penalties – Norm penalties as constrained optimization – Challenges in training deep models – Convolution networks operation – Pooling – Recurrent neural networks – Bidirectional RNNs – Deep recurrent networks – Recursive neural networks.

UNIT III	DEEP LEARNING RESEARCH	9

Probabilistic PCA and factor analysis - Independent Component Analysis (ICA) –Auto encoders - Representation learning- Greedy layer-Wise unsupervised pretraining - Transfer learning and Domain adaptation - Semi-supervised disentangling of causal factors - Structured probabilistic models for deep learning -The challenge of unstructured modeling - Using graphs to describe model structure - Sampling from graphical models - Learning about dependencies - Inference and approximate inference.

UNIT IV	DEEP GENERATIVE MODELS	9

Boltzmann machines - Restricted Boltzmann machines - Deep belief networks – Deep boltzmann machines - Boltzmann machines for real valued data - Convolutional Boltzmann machines - Boltzmann machines for structured or sequential outputs - other Boltzmann machines – Back propagation through random operations - Directed generative nets - Drawing samples from auto encoders - Generative stochastic networks -Other generation schemes - Evaluating generative models.

UNIT V	APPLICATION AND VISUALIZATION	9

Large scale deep learning – Computer vision – Speech recognition – Natural language processing – Other applications - Visualizations - Visual data analysis techniques - Interaction techniques – Social network analysis – Collective inferencing.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Make use of mathematical fundamentals of deep learning algorithms.

CO2: Identify a suitable optimization strategy for deep learning implementation.

CO3: Outline the research modes of deep learning.

CO4: Illustrate suitable deep learning models with suitable justification.

CO5: Choose a suitable visualization technique for the deep learning applications.

REFERENCES:

1. Ian Good fellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016.
2. Yusuke Sugomori, "Java Deep Learning Essentials", PACKT, 2016.
3. Timothy Masters, "Deep Belief Nets in C++ and CUDA C: Volume 1: Restricted Boltzmann Machines and Supervised Feed Forward Networks", 2015.
4. Jeff Heaton, Artificial Intelligence for Humans, Volume 3: Deep Learning and Neural Networks, Heaton Research, 2015.
5. Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012

21CMP23	WIRELESS ADHOC AND SENSOR NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNIT I	MAC & TCP IN AD HOC NETWORKS	9

Fundamentals of WLANs – IEEE 802.11 Architecture - Self configuration and Auto configuration-Issues in Ad-hoc wireless networks – MAC protocols for Ad-hoc wireless

networks – Contention based protocols - TCP over Ad-hoc networks-TCP protocol overview - TCP and MANETs – Solutions for TCP over Ad-hoc networks.

UNIT II	ROUTING IN AD HOC NETWORKS	9

Routing in Ad-hoc networks- Introduction-topology based versus position based approaches-Proactive, Reactive, Hybrid Routing Approach-Principles and Issues – Location services - DREAM – Quorums based location service – Grid – Forwarding strategies – Greedy packet forwarding – Restricted directional flooding- Hierarchical Routing- Issues and Challenges in providing QoS.

UNIT III	MAC, ROUTING & QOS IN WIRELESS SENSOR NETWORKS	9

Introduction – Architecture - Single node architecture – Sensor network design considerations – Energy efficient design principles for WSNs – Protocols for WSN – Physical Layer : Transceiver design considerations – MAC layer protocols – IEEE 802.15.4 Zigbee – Link layer and Error control issues - Routing protocols – Mobile nodes and Mobile robots - Data centric and Contention based networking – Transport protocols & QOS – Congestion control issues – Application layer support.

UNIT IV	SENSOR MANAGEMENT	9

Sensor management - Topology control protocols and Sensing mode selection protocols - Time synchronization - Localization and positioning – Operating Systems and Sensor Network programming – Sensor network simulators.

UNIT V	SECURITY IN AD HOC AND SENSOR NETWORKS	9

Security in Ad-hoc and Sensor networks – Key distribution and management – Software based anti-tamper techniques – watermarking techniques– Defense against routing attacks - Secure Adhoc routing protocols – Broadcast authentication WSN protocols – TESLA – Biba – Sensor network security protocols – SPINS.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Identify different issues in wireless Ad-hoc and sensor networks.

CO2: Explain protocols developed for Ad-hoc and sensor networks.

CO3: Identify and address the security threats in Ad-hoc and sensor networks.

CO4: Build a sensor network environment for different type of applications.

CO5: Develop security protocols.

REFERENCES:

1. Feng Zhao and Leonidas Guibas, ”Wireless Sensor Networks: an information processing approach”, Elsevier publication, 2004.
2. Charles E. Perkins, “Ad Hoc Networking”, Addison Wesley, 2000.
3. I.F. Akyildiz, W. Su, Sankarasubramaniam and E. Cayirci, “Wireless sensor networks: a survey”, Computer networks, Elsevier, 2002, PP: 394 - 422.

21CMP24	REAL TIME SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn the internal architecture and programming of an embedded processor.
- To introduce interfacing I/O devices to the process.
- To introduce the evolution of internet of things (IoT).
- To build a small low-cost embedded and IoT system using arduino/Raspberry Pi/open platform.
- To apply the concept of internet of thing.

UNIT I	8-BIT EMBEDDED PROCESSOR	9

8-bit Microcontroller – Architecture – Instruction set and Programming – Programming parallel ports – Timers and Serial port – Interrupt handling.

UNIT II	EMBEDDED C PROGRAMMING	9

Memory and I/O Devices interfacing – Programming embedded systems in C – Need for RTOS – Multiple tasks and processes – Context switching – Priority based scheduling policies.

UNIT III	IoT AND ARDUINO PROGRAMMING	9

ARM processor – Introduction to the concept of IoT devices – IoT devices versus computers – IoT configurations – Basic components – Introduction to arduino – Types of arduino – arduino toolcchain – arduino programming structure – Sketches – Pins – Input/Output from Pins using sketches – Introduction to arduino Shields – Integration of sensors and actuators with arduino.

UNIT IV	IoT COMMUNICATION AND OPEN PLATFORMS	9

IoT Communication models and APIs – IoT communication protocols – Bluetooth – WiFi – ZigBee – GPS –GSM modules – Open platform (like Raspberry Pi) – Architecture – Programming – Interfacing – Accessing GPIO Pins – Sending and Receiving signals using GPIO pins – Connecting to the cloud.

UNIT V	**APPLICATIONS DEVELOPMENT**	**9**

Complete design of embedded systems – Development of IoT applications – Home automation – Smart agriculture – Smart cities – Smart healthcare

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Outline the architecture and programming of an embedded processor.

CO2: Summarize the interfacing of I/O devices and programming the embedded systems.

CO3: Explain IoT configurations and arduino programming structure.

CO4: Illustrate the models, communication protocols and open platforms in IoT.

CO5: Build IoT based applications for the benefit of the society.

REFERENCES:

1. Muhammed Ali Mazidi, Janice GillispieMazidi and Rolin D. McKinlay, "The 8051 Microcontroller and Embedded Systems", 2nd Edition, Pearson Education, 2014.
2. Adrian McEwen and Hakim Cassimally, "Designing the Internet of Things", 1st Edition, John Wiley &Sons, 2014.
3. Michael J. Pont, "Embedded C", 3rd Edition, Pearson Education, 2007.
4. Robert Barton, Patrick Grossetete, David Hanes, Jerome Henry and Gonzalo Salgueiro, "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", CISCO Press, 2017.
5. Andrew N Sloss, D. Symes and C. Wright, "Arm System Developers Guide", Morgan Kauffman/ Elsevier, 2006.
6. ArshdeepBahga and Vijay Madisetti, "Internet of Things: A Hands-on Approach", VPT, 2014.

21CMP25	TESTING OF VLSI CIRCUITS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To know about the basic testing process.
- To understand the generation of test input.
- To design the testability.
- To know the test patterns.
- To get knowledge about fault diagnosis.

UNIT I	BASICS OF TESTING AND FAULT MODELLING	9

Introduction to testing – Faults in digital circuits – Modeling of faults – Logical fault models – Fault detection – Fault Location – Fault dominance – Logic simulation – Types of simulation – Delay models – Gate level event – Driven simulation.

UNIT II	TEST GENERATION FOR COMBINATIONAL AND SEQUENTIAL CIRCUITS	9

Test generation for combinational logic circuits – Testable combinational logic circuit design – Test generation for sequential circuits – Design of testable sequential circuits.

UNIT III	DESIGN FOR TESTABILITY	9

Design for testability – Ad-hoc design – generic scan based design – classical scan based design – system level DFT approaches.

UNIT IV	SELF TEST AND TEST ALGORITHMS	9

Built-In self Test – test pattern generation for BIST – Circular BIST – BIST architectures – Testable memory design – Test algorithms – Test generation for embedded RAMs.

UNIT V	FAULT DIAGNOSIS	9

Logical level diagnosis – Diagnosis by UUT reduction – Fault diagnosis for Combinational circuits – Self checking design – System level diagnosis.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Understand the basic testing process and faults in digital circuits.
2. Identify the test generation techniques for combinational and sequential circuits.
3. Explain the design for testability.

4. Build the testing algorithms.
5. Infer the fault diagnosis for combinational circuits.

REFERENCES:

1. M.Abramovici, M.A.Breuer and A.D. Friedman, "Digital systems and Testable Design", Jaico Publishing House, 1st Edition, 2002.
2. P.K. Lala, "Digital Circuit Testing and Testability", Academic Press, 1st Edition, 2002.
3. M.L.Bushnell and V.D.Agrawal, "Essentials of Electronic Testing for Digital,
4. Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers, 1st Edition, 2002.
5. A.L.Crouch, "Design Test for Digital IC's and Embedded Core Systems", Prentice Hall International, 1st Edition, 2002.

21CM201	PROJECT WORK PHASE I	L	T	P	C
		0	0	12	6

COURSE OBJECTIVES:

- To improve the skills in literature survey and to extract the relevant information by vast reading.
- To obtain necessary exposure on the latest developments in the relevant field and to use the current field of work in the research work.
- To develop the abilities for identifying and defining correct problem formulation in their chosen field.
- To acquire required knowledge for analysis and solving the given problem independently.
- To enhance the presentation and documentation skills in order to disseminate solution to the real world challenges.

METHOD OF EVALUATION:

Student should work on a topic approved by the Head of the Department under the guidance of a faculty member and prepares a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is to be sumbitted at the end of the semester. The project work is evaluated based

on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.
TOTAL: 300 PERIODS

COURSE OUTCOMES:

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

CO1: Solve any challenging practical problems and find solution by formulating proper methodology.

CO2: Demonstrate a sound technical knowledge of their selected project topic.

CO3: Examine problem identification, formulation and solution.

CO4: Design engineering solutions to complex problems utilizing a systems approach.

CO5: Interpret with engineers and the community at large in written and oral forms.

SEMESTER IV

21CM202	PROJECT WORK PHASE II	L	T	P	C
		0	0	24	12

COURSE OBJECTIVES:

- To improve the skills in literature survey and to extract the relevant information by vast reading.
- To obtain necessary exposure on the latest developments in the relevant field and to use the current field of work in the research work.
- To develop the abilities for identifying and defining correct problem formulation in their chosen field.
- To acquire required knowledge for analysis and solving the given problem independently.
- To enhance the presentation and documentation skills in order to disseminate solution to the real world challenges.

METHOD OF EVALUATION:

Student should work on a topic approved by the Head of the Department under the guidance of a faculty member and prepares a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three

reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.
TOTAL: 600 PERIODS
COURSE OUTCOMES:
At the end of the course, learners will be able to CO1: Solve any challenging practical problems and find solution by formulating proper methodology. CO2: Demonstrate a sound technical knowledge of their selected project topic. CO3: Examine problem identification, formulation and solution. CO4: Design engineering solutions to complex problems utilising a systems approach. CO5: Interpret with engineers and the community at large in written an oral forms.

AUDIT COURSES

21AC101	ENGLISH FOR RESEARCH PAPER WRITING *(Common to all PG Programmes)*	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES:

- To explain writing skills and level of readability.
- To outline content writing in each section.
- To summarize the skills needed for framing a title.
- To demonstrate the skills needed for writing the conclusion.
- To compare the quality of paper with plagiarism report.

UNIT I	INTRODUCTION TO RESEARCH PAPER WRITING	6
Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.		
UNIT II	**PRESENTATION SKILLS**	**6**
Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction.		
UNIT III	**TITLE WRITING SKILLS**	**6**
Key skills –Title, Abstract, Introduction, Review of the Literature, Methods, Results, Discussion and		

Conclusions.		
UNIT IV	**RESULT WRITING SKILLS**	**6**
Skills -Methods, Results, Discussion and Conclusions.		
UNIT V	**VERIFICATION SKILLS**	**6**
Useful phrases, checking Plagiarism, ensuring quality paper submission.		
		TOTAL: 30 PERIODS

COURSE OUTCOMES:

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

CO1:Explain the writing skills and level of readability

CO2: Outline the contents of research paper in each section

CO3:Classify the skills needed for writing a title

CO4: Summarize the content for presenting research conclusion note.

CO5: Illustrate the quality of paper by checking plagiarism.

TEXT BOOKS:

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

REFERENCES

1. Stephen Howe and Kristina Henriksson, "Phrase Book for Writing Papers and Research in English", 4th Edition, Create Space Independent Publishing Platform, 2007.
2. Adrian Wallwork ,"English for Research: Usage, Style, and Grammar", Springer,2012.
3. John Flowerdew and Pejman Habibie, "Introducing English for Research Publication Purposes", 1st Edition, Routledge, ,2021.
4. Wendy Laura Belcher, Writing Your Journal Article in Twelve Weeks: A Guide to Academic Publishing Success, 1stEdition, SAGE Publications, Inc., 2009

21AC102	**CONSTITUTION OF INDIA** *(Common to all PG Programmes)*	**L**	**T**	**P**	**C**
		2	**0**	**0**	**0**

COURSE OBJECTIVES:

- To Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional Role and entitlement to civil and economic rights as well as the emergence nationhood in the early years of Indian nationalism
- To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.
- To understand the importance of local body administration
- To know the role and function of election commission

UNIT I	**HISTORY AND PHILOSOPHY OF THE INDIAN CONSTITUTION**	**6**

History - Drafting Committee - (Composition & Working)- Philosophy - Preamble, Salient Features

UNIT II	**CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES**	**6**

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

UNIT III	**ORGANS OF GOVERNANCE**	**6**

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

UNIT IV	**LOCAL ADMINISTRATION**	**6**

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

UNIT V	**ELECTION COMMISSION**	**6**

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

TOTAL: 30 PERIODS

COURSE OUTCOMES:

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

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

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

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

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

CO5: Understand the basic Structure and functions of Election Commission.

REFERENCES:

1. Dr. S. N. Busi, "Dr. B. R. Ambedkar, Framing of Indian Constitution", 1st Edition, Ava Publishers, 2016.
2. M.P. Jain, "Indian Constitution Law", 7th Edition, Lexis Nexis, 2014.
3. D.D. Basu, "Introduction to the Constitution of India", 26th Edition, Lexis Nexis, 2022.