SETHU INSTITUTE OF TECHNOLOGY
Pulloor, Kariapatti – 626 115

MASTER OF ENGINEERING IN COMMUNICATION SYSTEMS

REGULATION 2021 - CURRICULUM

Revision 01 (Recommended After BOS 28.03.2024)

OVERALL COURSE STRUCTURE

Category	Total No. of Courses	Credits	Credit Percentage (%)
PROGRAM CORE (PC)	**9**	**26**	**37**
PROGRAM ELECTIVE (PE)	**6**	**18**	**25.71**
OPEN ELECTIVE (OE)	**1**	**3**	**4.28**
PROJECT WORK (PW)	**3**	**20**	**28.61**
MANDATORY COURSE (MC)	**1**	**3**	**4.28**
AUDIT COURSE (AC)	**2**	**-**	**-**
TOTAL	**22**	**70**	**100**

SEMESTER-WISE COURSE STRUCTURE – NUMBER OF COURSES

Semester	PC	PE	OE	PW	MC	AC	TOTAL
I	4	2	-	-	1	1	**8**
II	5	2		1	-	-	**8**
III	-	2	1	1	-	1	**5**
IV	-	-	-	1	-	-	**1**
TOTAL	**9**	**6**	**1**	**3**	**1**	**2**	**22**

SEMESTER-WISE COURSE STRUCTURE – CREDITS

Semester	PC	PE	OE	PW	MC	AC	TOTAL
I	12	6	-	-	3	-	**21**
II	14	6	-	2	-	-	**22**
III	-	6	3	6	-	-	**15**
IV	-	-	-	12	-	-	**12**
TOTAL	**26**	**18**	**3**	**20**	**3**	**-**	**70**

REGULATION – 2021
CURRICULUM I TO IV SEMESTERS (FULL TIME)

SEMESTER I

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	**21PCM101**	Adaptive Signal processing	**3**	**1**	**0**	**4**
2.	**21PCM105**	Advanced Digital Communication	**3**	**1**	**0**	**4**
3.	**-**	Program Elective I	**3**	**0**	**0**	**3**
4.	**-**	Program Elective II	**3**	**0**	**0**	**3**
5.	**-**	Audit Course I	**3**	**0**	**0**	**0**
6.	**21PGM701**	Research Methodology and IPR (Mandatory course)	**3**	**0**	**0**	**3**
PRACTICAL						
7.	**21PCM104**	Adaptive Signal processing Laboratory	**0**	**0**	**4**	**2**
8.	**21PCM106**	Advanced Digital Communication Laboratory	**0**	**0**	**4**	**2**
Total			**18**	**0**	**10**	**21**
Total Number of Credits: 21						

SEMESTER II

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	**21PCM204**	Fiber Optic Networks	**3**	**0**	**0**	**3**
2.	**21PCM207**	Advanced Radiating Systems	**3**	**0**	**0**	**3**
3.	**21PCM208**	AI for Communication	**3**	**0**	**0**	**3**
4.	**21PCM209**	Advanced Wireless Communication	**3**	**0**	**0**	**3**
5.	**-**	Program Elective III	**3**	**0**	**0**	**3**
6.	**-**	Program Elective IV	**3**	**0**	**0**	**3**
PRACTICAL						
7.	**21PCM210**	Advanced Radiating Systems Laboratory	**0**	**0**	**4**	**2**
8.	**21PCM206**	Term Paper and Seminar	**0**	**0**	**4**	**2**
Total			**18**	**0**	**8**	**22**
Total Number of Credits: 22						

SEMESTER III

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	**-**	Program Elective V	**3**	**0**	**0**	**3**
2.	**-**	Program Elective VI	**3**	**0**	**0**	**3**
3.	**-**	Audit Course II	**3**	**0**	**0**	**0**
4.	**-**	Open Elective	**3**	**0**	**0**	**3**
PRACTICAL						
5.	**21PCM301**	Dissertation Phase – I	**0**	**0**	**12**	**6**
Total			**12**	**0**	**12**	**15**
Total Number of Credits: 15						

SEMESTER IV

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1.	**21PCM401**	Dissertation Phase – II	**0**	**0**	**24**	**12**
Total			**0**	**0**	**24**	**12**
Total Number of Credits: 12						

TOTAL NO. OF CREDITS: 70

SEMESTER I

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	**21PCM101**	Adaptive Signal processing	**3**	**1**	**0**	**4**
2.	**21PCM105**	Advanced Digital Communication	**3**	**1**	**0**	**4**
3.		Program Elective I	**3**	**0**	**0**	**3**
4.		Program Elective II	**3**	**0**	**0**	**3**
5.	**-**	Audit Course I	**3**	**0**	**0**	**0**
6.	**21PGM701**	Research Methodology and IPR (Mandatory course)	**3**	**0**	**0**	**3**
PRACTICAL						
7.	**21PCM104**	Adaptive Signal processing Laboratory	**0**	**0**	**4**	**2**
8.	**21PCM106**	Advanced Digital Communication Laboratory	**0**	**0**	**4**	**2**
Total			**18**	**0**	**10**	**21**
Total Number of Credits: 21						

21PCM101	ADAPTIVE SIGNAL PROCESSING	L	T	P	C
		3	1	0	4

OBJECTIVES:(Min three)

- To impart the fundamental concepts of discrete random signal processing and spectrum estimation.
- To explain the concept of multi-rate digital signal processing and adaptive filters.
- To give an outline about advanced transform techniques.

UNIT I	DISCRETE RANDOM SIGNAL PROCESSES	9+3

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

UNIT II	MULTIRATE DIGITAL SIGNAL PROCESSING	9+3

Multi rate DSP, Decimators and Interpolators, Sampling rate conversion, multistage decimator & interpolator, poly phase filters, QMF, digital filter banks, Applications in sub-band coding.

UNIT III	ADAPTIVE FILTERS	9+3

Principles of adaptive filter - FIR adaptive filter - Newton's Steepest descent algorithm - Derivation of first order adaptive filter - LMS adaptation algorithms - Adaptive noise cancellation, Adaptive equalizer, Adaptive echo cancellers.

UNIT IV	SPECTRUM ESTIMATION	9+3

Estimation of Spectra from Finite-Duration Observations of Signals, Nonparametric Methods for Power Spectrum Estimation, Parametric Methods for Power Spectrum Estimation, Minimum-Variance Spectral Estimation, Eigen analysis Algorithms for Spectrum Estimation.

UNIT V	ADVANCED TRANSFORM TECHNIQUES	9+3

2-D Discrete Fourier transform and properties - Applications to image smoothing and sharpening - Continuous and Discrete wavelet transforms - Multi resolution Analysis - Application to signal compression.

TOTAL: 45(L)+ 15(T) PERIODS

COURSE OUTCOMES:

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

CO1	Explain the fundamental concepts of adaptive signal processing	**Understand**
CO2	Design adaptive filters for various applications	**Apply**
CO3	Design sampling rate converters and analyze its frequency response	**Apply**
CO4	Investigate the performance of adaptive signal processing algorithms in radar and communication systems applications using simulation software and submit a report	**Analyze**
CO5	Analyze the various transformation techniques used in different applications	**Analyze**
CO6	Design a signal processing algorithm for a practical application	**Evaluate**

REFERENCES:

1. J.G.Proakis and D.G.Manolakis“Digital signal processing: Principles, Algorithm and Applications”, 4th Edition, Prentice Hall, 2007.
2. M. H. Hayes, “Statistical Digital Signal Processing and Modeling”, John Wiley & Sons Inc.,2002.
3. S.Haykin, “Adaptive Filter Theory”, 4th Edition, Prentice Hall, 2001.
4. D.G.Manolakis, V.K. Ingle and S.M.Kogon, “Statistical and Adaptive Signal Processing”, McGraw Hill, 2000.

Course Designer: Mr. A. Manoj Prabaharan AP/ECE

21PCM105	ADVANCED DIGITAL COMMUNICATION	L	T	P	C
		3	1	0	3

OBJECTIVES:(Min three)

- To understand the basic principles of signal space analysis and digital transmission.
- To enhance the knowledge of coherent and non-coherent communication receivers.
- To enable the students to learn channel coding techniques and multi-carrier modulation systems.

UNIT I	COHERENT AND NON-COHERENT COMMUNICATION	9+3

Coherent receivers, Optimum receivers in WGN, IQ modulation & 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

UNIT II	EQUALIZATION TECHNIQUES	9+3

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

UNIT III	BLOCK CODED DIGITAL COMMUNICATION	9+3

Architecture and performance – Binary block codes; Orthogonal; Biorthogonal; Trans orthogonal – Shannon's channel coding theorem; Channel capacity; Matched filter; Concepts of Spread spectrum communication, Applications 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+3

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+3

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

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1	Describe the process involved in designing of digital communication systems	**Understand**
CO2	Apply the knowledge of mathematical concept to develop digital modulation and equalization techniques.	**Apply**
CO3	Apply the knowledge of Multicarrier and Multiuser communications	**Apply**
CO4	Analyze the operation of channel coding techniques	**Analyze**
CO5	Analyze the performance of different coded digital communication systems	**Analyze**
CO6	Develop a digital communication system using modern engineering tools	**Evaluate**

REFERENCES:

1. Bernard Sklar., “Digital Communications”, Pearson Education, 3rd Edition, 2001.
2. John G. Proakis., “Digital Communication”, Mc Graw Hill Publication, 5th Edition, 2001.
3. M.K.Simon, S.M.Hinedi and W.C.Lindsey, “Digital communication techniques; Signal Design and Detection”, Prentice Hall of India, New Delhi, 2002.
4. Stephen G. Wilson, “Digital Modulation and Coding”, First Indian Reprint, Pearson Education, 2003.

Course Designer: Dr. K.A.Shahul Hameed., Prof./ECE

21PGM701	RESEARCH METHODOLOGY AND IPR	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide an overview on selection of research problem based on the Literature review.
- To enhance knowledge on the Data collection and Analysis for Research design.
- To outline the importance of ethical principles to be followed in Research work and IPR.

UNIT I	FORMULATION OF RESEARCH PROBLEM	9

Meaning of research problem, Sources of research problem, Criteria- good research problem, and selecting a research problem, Scope and objectives of research problem. Defining and formulating the research problem - Necessity of defining the problem – Types of Literature Review- Sources for Literature Review - Identifying gap areas from literature review.

UNIT II	RESEARCH DESIGN AND ETHIC	9

Research Design – Different Research designs- Sampling design- Types of sampling, Methods of Data collection- primary data, secondary data Plagiarism, Application of results and ethics - Environmental impacts - Ethical issues - ethical committees.

UNIT III	DATA ANALYSIS AND TESTING OF HYPOTHESES	9

Data Processing and Analysis strategies -Types of Analysis- Statistics in Research - Measures of Central Tendency - Measures of Dispersion - Measures of Asymmetry (Skewness) -Measures of Relationship - Simple Regression Analysis - Multiple Correlation and Regression Testing of Hypotheses- Chi-square test, Taguchi and ANOVA

UNIT IV	REPORT AND RESEARCH PROPOSAL WRITING	9

Significance of Report Writing - Different Steps in Writing Report - Layout of the Research Report - Types of Reports - Oral Presentation - Mechanics of Writing a Research Report - Bibliography, types of referencing, citations. Format of research proposal -Research Proposal writing - assessment by a review committee.

UNIT V	INTELLECTUAL PROPERTY AND PATENT RIGHTS	9

Nature of Intellectual Property – Patents- Designs, Trade and Copyright- Geographical Indications. Process of Patenting and Development – Patent Search- Invention, Innovation-Documents for Patent filing - Examination- Grant of Patent. Scope of Patent Rights - Case Studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After successful completion of this course, the students will be able to:

CO1	Design suitable research methodology to pursue the research in scientific and systematic procedure with statistical / IT Tools.	**Apply**
CO2	Apply ethical principles in research and reporting to promote healthy scientific practice.	**Apply**
CO3	Analyze the literature to identify the research gap in the given area of research.	**Analyze**
CO4	Analyze and synthesize the data using research methods and knowledge to provide scientific interpretation and conclusion.	**Analyze**
CO5	Conduct patent database search in various countries for the research problem identified.	**Analyze**

CO6	Prepare research reports and proposals by properly synthesizing, arranging the research documents to provide comprehensive technical and scientific.	**Organize**

REFERENCES

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes.
3. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
4. Wadehra, B.L. 2000. Law relating to patents, trademarks, copyright designs and geographical indications. Universal Law Publishing.

ADDITIONAL READING

1. Anthony, M., Graziano, A.M. and Raulin, M.L., 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
2. Carlos, C.M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed Books, New York.
3. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
4. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
5. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
6. Leedy, P.D. and Ormrod, J.E., 2004 Practical Research: Planning and Design, Prentice Hall.
7. Satarkar, S.V., 2000. Intellectual property rights and Copy right. Ess Ess Publications.

21PCM104	ADAPTIVE SIGNAL PROCESSING LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To impart the knowledge on various simulation tools used in communication engineering.
- To train the students about digital filter realizations for communication.

LIST OF EXPERIMENTS:

1. Stability analysis using Hurwitz Routh Criteria
2. Sampling of Input Sequence using FFT
3. State Space Matrix from Differential Equation
4. Normal Equation using Levinson Durbin
5. Decimation and Interpolation using Rationale Factors
6. Maximally Decimated Analysis DFT Filter
7. Chebyshev Type I, II Filter
8. Cascade Digital IIR Filter Realization
9. Estimation of PSD
10. Design and Simulate Adaptive Filter Algorithms
11. Generation of DTMF signals
12. Auto correlation and Cross Correlation
13. Radar Pulse Compression

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1	Analyze the stability of various signal processing algorithms for the given specification	**Analyze**
CO2	Analyze the different digital filters using Modern Tools.	**Analyze**
CO3	Apply various transforms in time and frequency domain to realize digital filters	**Apply**
CO4	Apply appropriate software tools to make measurements of physical quantities.	**Apply**
CO5	Demonstrate proficiency in using discipline-specific tools.	**Apply**
CO6	Function effectively as an individual for efficiently executing the given task.	**Organize**

21PCM106	ADVANCED DIGITAL COMMUNICATION LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To impart the knowledge on various simulation tools used in communication engineering.
- To train the students about digital filter realizations for communication.

LIST OF EXPERIMENTS:

1. Generation & detection of binary digital modulation techniques using SDR
2. Digital modulation and Demodulation techniques – ASK, PSK and FSK (Hardware and
3. Software simulation) and Bit Error Rate analysis.
4. Spread Spectrum communication system-Pseudo random binary sequence generation- Baseband DSSS.
5. Time Division Multiplexing and Demultiplexing of two band limited signals
6. Simulate the QPSK and DPSK transmitter and receiver
7. Simulate NRZ, RZ, half-sinusoid and raised cosine pulses and generate eye diagram for binary polar signalling.
8. BER performance Analysis of M-ary digital Modulation Techniques (coherent & non
9. 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. Channel Coder/decoder design (block codes / convolutional codes/ turbo codes)
13. MIMO system transceiver design using MATLAB/SCILAB/LABVIEW

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1	Calculate the power and bandwidth requirements of modern communication systems, including those employing ASK, PSK, FSK modulation formats	**Apply**
CO2	Analyze the performance of digital design in the communication systems.	**Analyze**
CO3	Apply various transforms in time and frequency domain to realize digital filters	**Apply**
CO4	Analyze the performance of optimization algorithms for equalizing the channel or noise/echo cancellation	**Analyze**
CO5	Demonstrate proficiency in using discipline-specific tools.	**Apply**
CO6	Design synchronization algorithm for Digital Communication systems	**Organize**

SEMESTER II

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	**21PCM204**	Fiber Optic Networks	**3**	**0**	**0**	**3**
2.	**21PCM207**	Advanced Radiating Systems	**3**	**0**	**0**	**3**
3.	**21PCM208**	AI for Communication	**3**	**0**	**0**	**3**
4.	**21PCM209**	Advanced Wireless Communication	**3**	**0**	**0**	**3**
5.	**-**	Program Elective III	**3**	**0**	**0**	**3**
6.	**-**	Program Elective IV	**3**	**0**	**0**	**3**
PRACTICAL						
7.	**21PCM210**	Advanced Radiating Systems Laboratory	**0**	**0**	**4**	**2**
8.	**21PCM206**	Term Paper and Seminar	**0**	**0**	**4**	**2**
Total			**18**	**0**	**8**	**22**
Total Number of Credits: 22						

21PCM204	FIBER OPTIC NETWORKS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concept of optical networks in optical communication systems.
- To introduce optical networks and its enabling technologies such as transmitters, optical receivers, filters, optical amplifiers,
- To discuss WDM network elements and their designs.
- To learn about Free space optics and its use in making optical networks
- To gain knowledge on Control and management, network survivability, optical TDM and CDM networks.

UNIT – 1	BASICS OF OPTICAL NETWORKS	9

Telecommunications Network Architecture, Services, Circuit Switching and Packet Switching, Optical Networks, The Optical Layer, Transparency and All Optical Networks, Optical Packet Switching, Transmission Basics, Network Evolution.

UNIT – 2	TRANSMISSION SYSTEM ENGINEERING	9

Modulation and Demodulation, spectral efficiency, Error detection and correction, System model, Transmitter and receiver, Power penalty and amplifiers, Crosstalk, dispersion and nonlinearities, Wavelength stabilization, Overall design considerations.

UNIT – 3	COMPONENTS OF FIBER OPTIC NETWORKS	9

Passive components, Switches and functional modules of fiber optic networks, Test and measuring instruments: OTDR, Optical spectrum analyser (OSA), Fiber optic sensors and their applications in various fields: Measurement of pressure, temperature, current and voltage, liquid level and strain

UNIT – 4	OPTICAL NETWORK SYSTEM SCHEMES	9

Optical Line Terminals, Optical Line Amplifiers, Optical Add/Drop Multiplexers, Optical Cross connects, Cost Trade–offs, LTD and RWA Problems, Dimensioning Wavelength Routing Networks, Statistical Dimensioning Models, Maximum Load Dimensioning Models, Passive Optical Networks (PONs).Free Space Optics: Introduction to Free Space Optics, Fundamentals of FSO Technology, Factors Affecting FSO, Integration of FSO in Optical Networks, The FSO Market..

UNIT – 5	NETWORK SURVIVABILITY	9

Optical Safety. Basic Concepts, Protection in SONET/SDH, Protection in IP Networks, Optical Layer Protection Schemes. Optical TDM and CDM Networks: Optical TDM Networks, Optical CDM Networks.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Ability to understand optical communication networks	**Understand**
CO2	Apply the concept of data communication network to study optical transmission systems and management.	**Apply**
CO3	Ability to interpret sensor designs	**Apply**
CO4	Ability to analyze different network management schemes	**Analyze**
CO5	Ability to analyse protection in optical networks	**Analyze**

CO6	Evaluate multiplexing in optical networks	**Evaluate**

References:

1. Ramaswami Rajiv, Kumar N. Sivarajan, Optical Networks: A Practical Perspective, Morgan Kaufmann Publishers, Elsevier(2004).
2. Mukherjee, Biswanath, Optical WDM Networks, Springer (2006).
3. Maier, Marti, Optical Switching Networks, Cambridge University Press (2008).
4. Sivalingam, Krishna M., Subramaniam, Suresh, Emerging Optical Networks Technologies: Architectures, Protocols, and Performance, Springer (2004).
5. Mohammad Ilyas, Hussein T. Mouftah, “Handbook of Optical Communication Networks”, Taylor and Francis, First edition, 2007.

COURSE DESIGNER: Dr. P. MAHALAKSHMI, ASP/ECE

21PCM207	ADVANCED RADIATING SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the basic concepts of antenna design and technologies.
- To summarize the performance characteristics of various antenna arrays, micro-strip antennas and its radiation analysis.
- To analyze the printed antenna design in terms of ground plane effect.

UNIT I	INTRODUCTION TO ANTENNA TECHNOLOGIES	9

Antenna fundamental parameters, Antenna array techniques, Broadband antenna technologies, Mobile phone antenna- base station, hand set antenna, Impedance matching techniques, Introduction to numerical techniques.

UNIT II	MICROSTRIP ANTENNA	9

Radiation Mechanism from patch; Excitation techniques; Microstrip dipole; Rectangular patch, Circular patch, and Ring antenna – radiation analysis from cavity model; input impedance of rectangular and circular patch antenna; Microstrip array and feed network; Application of Microstrip array antenna.

UNIT III	ANTENNA MINIATURIZATION TECHNIQUES	9

Miniaturization via shaping- slot, bending and folding , Meander line antennas, Miniaturization via Material loading-Dielectric material ,Poymer ceramic material, Miniaturization Using Magnetic Photonic crystals-Dipole performance within photonic crystals.

UNIT IV	PRINTED ANTENNA DESIGN	9

“Swan” Antenna with Reduced Ground Plane Effect, Diversity Antenna, Printed Slot and Band-Notched UWB Antenna- Wide-Slot UWB Antenna, Monopole-Like Slot UWB Antenna, Band-Notched UWB Antennas.

UNIT V	ADVANCEMENT IN ANTENNA TECHNOLOGY	9

Antennas for Cellular Base station, Antennas in Automobile RADAR, Antennas in Access points of WLAN/WiFi, Antennas in wireless charging systems, Antennas in Radio telescope system.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Describe the concept of antenna and its advancement.	**Understand**
CO2	Apply the knowledge of antenna shaping and material loading to design a miniaturized antenna.	**Apply**
CO3	Determine the radiation characteristics of various antennas	**Apply**
CO4	Analyze the performance of Microstrip patch antennas	**Analyze**
CO5	Analyze the characteristics of printed antenna in terms of its effects in ground plane.	**Analyze**
CO6	Design various antennas using simulation software	**Evaluate**

REFERENCES:

1. K.D Prasad, —Antennas and Wave Propagation‖, Sathya Prakasan Publications, 4th Edition, 2009.

2. Constantine A. Balanis, —Antenna Theory Analysis and Design, John Wiley India‖, 4th Edition, 2016.

3. E.C.Jordan and Balmain,—Electromagnetic waves and Radiating systems, Pearson Education, 2015.

4. John D.Kraus, Ronald J.Marhefka and Ahmad S.Khan —Antennas and wave Propagation, Tata MCGraw- Hill Book company, 4th Edition, 2010

5. Debatosh Guha, Yahia M.M. Antar," Microstrip and printed antennas- New trends, Techniques and applications", 1st edition, Wiley, 2011.

Course Designer: Dr.M.Pandimadevi, ASP/ECE

21PCM208	AI for COMMUNICATION	L	T	P	C
		3	0	0	3

OBJECTIVE:

- To understand the role of AI in enhancing communication systems.
- To explore the integration of AI in wireless communication technologies.
- To design and implement AI-driven communication networks.

UNIT I	INTRODUCTION TO AI IN COMMUNICATION SYSTEMS	9

Overview of AI and Machine Learning-Evolution and milestones in AI-Importance of AI in Communication Systems-Basic Concepts in Communication Systems-Overview of signal processing and modulation techniques-AI in telecommunications-AI-driven optimization techniques for communication systems.

UNIT II	MACHINE LEARNING TECHNIQUES FOR COMMUNICATION SYSTEMS	9

Supervised Learning Fundamentals: Regression, classification, and neural networks- Algorithms: Linear regression, logistic regression, decision trees, and support vector machines Unsupervised Learning Fundamentals: Clustering and dimensionality reduction- Algorithms: K-means clustering, principal component analysis (PCA)- Applications in dynamic spectrum management and adaptive modulation.

UNIT III	SIGNAL PROCESSING AND OPTIMIZATION USING AI	9

Signal filtering and noise reduction techniques-AI techniques for signal enhancement-Noise cancellation and interference management using ML algorithms-Linear and non-linear optimization-AI for resource allocation and scheduling in communication networks

UNIT IV	AI FOR WIRELESS COMMUNICATION SYSTEMS	9

Role of AI in 5G network optimization-AI for beamforming, MIMO systems, and massive MIMO-Cognitive Radio Network: Spectrum sensing and management using AI -Dynamic spectrum access and sharing with AI techniques-Network Security: AI-based intrusion detection and prevention systems- Securing communication channels using AI

UNIT V	PRACTICAL APPLICATIONS AND FUTURE TRENDS	9

Practical Applications and Future Trends: Self-organizing networks (SON), Predictive maintenance and fault detection using AI-AI in Internet of Things (IoT) and smart cities-Edge AI and its impact on communication systems- AI for 6G and future wireless technologies-Ethical considerations and challenges in implementing AI in communication systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Describe the fundamental concepts of AI and Machine Learning	**Understand**
CO2	Apply machine learning algorithms in signal processing for communication systems.	**Apply**
CO3	Apply optimization methods for resource allocation and scheduling in communication networks.	**Apply**
CO4	Analyze the impact of AI on network management and security.	**Analyze**
CO5	Analyze the role of AI in optimizing wireless communication systems	**Analyze**
CO6	Evaluate the performance of AI techniques in signal processing tasks	**Evaluate**

TEXT BOOKS:

1. Stuart Russell and Peter Norvig "Artificial Intelligence: A Modern Approach", 4th Edition, Pearson, 2020.
2. Samuel O. Agbo "Principles of Modern Communication Systems", 2nd Edition, McGraw-Hill Education, 2021.

3. F. Richard Yu, Yang Xiao, Song Guo "AI for Wireless Communication Systems", 1st Edition, Springer, 2020.
4. Syed Omar Faruk Towaha, Ashwin Pajankar "AI and IoT for Smart City Applications", 1st Edition, Apress, 2021.

REFERENCES:

1. Kevin P. Murphy "Machine Learning: A Probabilistic Perspective", 2nd Edition, MIT Press, 2022.
2. Wen Tong, Peiying Zhu "6G: The Next Horizon: From Connected People and Things to Connected Intelligence", 1st Edition, Cambridge University Press, 2021.
3. 5. John G. Proakis and Dimitris G. Manolakis "Digital Signal Processing: Principles, Algorithms and Applications", 5th Edition, Pearson, 2022.

COURSE DESIGNER: J. JUDITH AP/ECE

21PCM209	ADVANCED WIRELESS COMMUNICATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the importance of improving capacity of wireless channel using MIMO
- To enable understanding of channel impairment mitigation using space-time block and Trellis codes.
- To teach advanced MIMO system like layered space time codes, MU-MIMO System and MIMO-OFDM systems.

UNIT I	WIRELESS CHANNEL PROPAGATION AND MODEL	9

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

UNIT II	CAPACITY OF WIRELESS CHANNELS	9

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

UNIT III	DIVERSITY	9

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

UNIT IV	MIMO COMMUNICATIONS	9

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

UNIT V	MULTIUSER SYSTEMS	9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Understand the concept of the capacity calculation under different channel conditions and diversity combining methods	**Understand**
CO2	Apply the knowledge of channel characteristics to compute the different parameters of multipath channels	**Apply**
CO3	Apply the concept of MIMO Communications and identify the performance of multipath propagation	**Apply**
CO4	Analyze the wireless channel characteristics and identify appropriate channel models	**Analyze**
CO5	Analyze multiple access techniques and identify their use in different multi-user scenarios.	**Analyze**
CO6	Evaluate the impact of multipath fading and interference and mitigate the impairments on wireless communication systems.	**Evaluate**

REFERENCES:

1. Andrea Goldsmith, Wireless Communications, Cambridge University Press,2007.

2. Andreas.F.Molisch,“WirelessCommunications”,JohnWiley,India,2006.
3. Simon Haykin& Michael Moher, “Modern Wireless Communications”, Pearson Education, 2007.
4. Rappaport.T.S., “Wireless communications”, Pearson Education, 2003.
5. UpenaDalal, “Wireless Communication”, Oxford Higher Education, 2009.

Course Designer: Mrs. S. Ramya AP/ECE

21PCM210	ADVANCED RADIATING SYSTEMS LAB	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To understand the basic concepts of antenna design.
- To impart the knowledge on various antenna simulation tools used in Communication engineering.

LIST OF EXPERIMENTS:

1. Design a half wave dipole antenna using simulation software
2. Design a dipole antenna and simulate its radiation pattern.
3. Design a microstrip patch antenna and simulate the numerical evaluation of its parameters.
4. Design a loop antenna using given specifications.
5. Design a slot antenna using simulation software.
6. Design an array antenna and simulate its radiation pattern.
7. Simulation of different types of patch antenna using same operating frequency and analyze its parameters.
8. Analyze a patch antenna in terms of its bending effects.
9. Design a monopole antenna using given specifications.
10. Measurement of reflection co-efficient of an antenna.
11. Analyze the signal strength parameters of an antenna using Spectrum analyzer.
12. Measurement of gain of an antenna using Spectrum Analyzer.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1	Design and simulate an antenna for the given specifications.	**Apply**
CO2	Analyze the radiation pattern of various antennas.	**Analyze**
CO3	Analyze the various parameters of patch antenna.	**Analyze**
CO4	Apply appropriate software tools to make measurements of physical quantities.	**Apply**
CO5	Demonstrate proficiency in using discipline-specific tools.	**Apply**
CO6	Function effectively as an individual for efficiently executing the given task.	**Organize**

Course Designer: Dr.M.Pandimadevi ASP/ECE

21PCM206	TERM PAPER AND SEMINAR	L	T	P	C
		0	0	4	2

OBJECTIVE:

- To inculcate the importance of communication skills
- To familiarize with the concepts in emerging engineering field

DESCRIPTION:

This course is introduced to enrich the communication skills of the student and to create awareness on recent development in Electrical and Electronics Engineering through Technical presentation. In this course, a student has to present at least two technical papers or recent advances in Engineering / Technology that will be evaluated by a committee constituted by the Head of the Department. Students should work on a small research problem. Students have to carry out the project under the guidance of faculty member using the knowledge of subjects that he/she has learned. The student should submit the report at the end of the semester. The product should be demonstrated at the time of examination.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

CO1	Understand the basic concept of core subject.	**Understand**
CO2	Analyze the problem identification, formulation and Solution to solve the innovative ideas.	**Apply**
CO3	Develop innovative ideas to solve research problems.	**Apply**
CO4	Analyze and review research literature to solve the proposed innovative idea.	**Apply**
CO5	Implement the novelty in technical reports with seminars.	**Apply**
CO6	Write effective reports and make clear presentations.	**Organize**

SEMESTER III

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
6.	**-**	Elective III	**3**	**0**	**0**	**3**
7.	**-**	Elective IV	**3**	**0**	**0**	**3**
8.	**-**	Elective V	**3**	**0**	**0**	**3**
9.	**-**	Audit Course II	**3**	**0**	**0**	**0**
10.	**-**	Open Elective	**3**	**0**	**0**	**3**
PRACTICAL						
11.	**21PCM301**	Dissertation Phase – I	**0**	**0**	**12**	**6**
Total			**15**	**0**	**12**	**18**
Total Number of Credits: 18						

21PCM301	DISSERTATION PHASE-I	L	T	P	C
		0	0	12	6

DESCRIPTION:

- Every candidate shall be permitted to undertake a research-based project work of his/her choice related to his/her discipline/ interdisciplinary / multidisciplinary in consultation with the Head of the Department. The project shall be supervised by faculty members of the department in which the candidate registered a course.
- In case of a project work at Industrial/research organization, the project work shall be jointly supervised by the faculty supervisor and an expert from the organization.
- He/she shall be required to undergo three reviews in a semester to assess the progress of the project work. The project work shall be evaluated based on the project report submitted by the candidate and viva-voce examination conducted by a committee consisting of an external examiner, internal examiner and the supervisor of the candidate.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

CO1	Apply the knowledge gained from theoretical and practical courses in solving problems with innovative solutions and by planning organizing and coordinating for the execution of the project work	**Apply**
CO2	Analyze and interpret the data/information from various literature sources and synthesize the information to provide valid conclusions about the problem identification, formulation and solution of the project	**Analyze**
CO3	Design, model and develop optimal solutions for problems being investigated	**Create**
CO4	Demonstrate professionalism with ethics; present effective communication skills and relate engineering issues to broader societal context [Psychomotor Domain]	**Apply**
CO5	Engage in learning for effective project implementation in the broadest context of technological change with consideration for public health, safety, cultural and societal needs.	**Analyze**
CO6	Write effective reports and make clear presentation to the engineering community and society.	**Organize**

SEMESTER IV

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1.	**21PCM401**	Dissertation Phase – II	**0**	**0**	**24**	**12**
Total			**0**	**0**	**24**	**12**
Total Number of Credits: 12						

TOTAL NO. OF CREDITS: 70

21PCM401	DISSERTATION PHASE-II	L	T	P	C
		0	0	12	6

DESCRIPTION:

- Every candidate shall be permitted to undertake a research-based project work of his/her choice related to his/her discipline / interdisciplinary / multidisciplinary in consultation with the Head of the Department. The project shall be supervised by faculty members of the department in which the candidate registered a course.
- In case of a project work at Industrial/research organization, the project work shall be jointly supervised by the faculty supervisor and an expert from the organization.
- He/she shall be required to undergo three reviews in a semester to assess the progress of the project work. The project work shall be evaluated based on the project report submitted by the candidate and viva-voce examination conducted by a committee consisting of an external examiner, internal examiner and the supervisor of the candidate.

TOTAL: 120 PERIODS

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to

CO1	Analyze and review the research literature critically and evolve suitable methodologies for solving the complex engineering problem	**Analyze**
CO2	Analyze the complex engineering problem critically to provide optimal solution after considering public health, safety, ethical, societal and environmental factors	**Analyze**
CO3	Design, model and develop optimal solutions for problems being investigated	**Create**
CO4	Utilize modern engineering and IT tools, techniques including prediction and modeling for complex engineering activities and augment the effectiveness of the solution with an understanding of the limitations	**Apply**
CO5	Write effective reports and make clear presentation to the engineering community and society	**Analyze**
CO6	Engage in learning for effective project implementation with a commitment to improve knowledge and competence in context of technological updation	**Organize**

COURSE CATEGORY: PROGRAM ELECTIVES

S.No	Course Code	Course Title	L	T	P	C
1.	**21PCM501**	Space Time Wireless Communication	**3**	**0**	**0**	**3**
2.	**21PCM502**	Quantum Communication	**3**	**0**	**0**	**3**
3.	**21PCM503**	Radar Signal Processing	**3**	**0**	**0**	**3**
4.	**21PCM504**	Millimeter wave Communication	**3**	**0**	**0**	**3**
5.	**21PCM505**	Communication Network Security	**3**	**0**	**0**	**3**
6.	**21PCM506**	Satellite Communication	**3**	**0**	**0**	**3**
7.	**21PCM507**	IoT Protocols	**3**	**0**	**0**	**3**
8.	**21PCM508**	Speech and audio Signal Processing	**3**	**0**	**0**	**3**
9.	**21PCM509**	Ultra wide band Communication	**3**	**0**	**0**	**3**
10.	**21PCM510**	High Performance Communication Networks	**3**	**0**	**0**	**3**
11.	**21PCM511**	Pattern Recognition and Application	**3**	**0**	**0**	**3**
12.	**21PCM512**	Microelectronics and VLSI Technology	**3**	**0**	**0**	**3**
13.	**21PCM513**	Mobile and Social Computing	**3**	**0**	**0**	**3**
14.	**21PCM514**	Network management System	**3**	**0**	**0**	**3**
15.	**21PCM515**	Global Positioning System	**3**	**0**	**0**	**3**
16.	**21PCM516**	DSP Processor Architecture and Programming	**3**	**0**	**0**	**3**
17.	**21PCM517**	Medical imaging Techniques	**3**	**0**	**0**	**3**
18.	**21PCM518**	Network Routing Algorithm	**3**	**0**	**0**	**3**
19.	**21PCM519**	Telematics for Health	**3**	**0**	**0**	**3**
20.	**21PCM520**	Advanced Big Data Analytics	**3**	**0**	**0**	**3**
21.	**21PCM521**	Wireless Sensor Networks	**3**	**0**	**0**	**3**
22.	**21PCM522**	RF Circuits and Microwave Systems	**3**	**0**	**0**	**3**
23.	**21PCM523**	MIMO System	**3**	**0**	**0**	**3**
24.	**21PCM524**	VLSI Device Modeling	**3**	**0**	**0**	**3**
25.	**21PCM525**	Ubiquitous Computing	**3**	**0**	**0**	**3**
26.	**21PCM526**	Soft Computing Techniques	**3**	**0**	**0**	**3**
27.	**21PCM527**	Machine Learning	**3**	**0**	**0**	**3**
28.	**21PCM528**	Optimization Techniques	**3**	**0**	**0**	**3**
29.	**21PCM529**	Data Compression Techniques	**3**	**0**	**0**	**3**
30.	**21PCM530**	Cognitive Radio Networks	**3**	**0**	**0**	**3**
31.	**21PCM531**	5G Mobile Communication Technology	**3**	**0**	**0**	**3**

COURSE CATEGORY: OPEN ELECTIVE

S.No	Course Code	Course Title	L	T	P	C
1.	**21PCD601**	Industrial Safety	**3**	**0**	**0**	**3**
2.	**21PCS602**	Business analytics	**3**	**0**	**0**	**3**
3.	**21PCM603**	IoT for Smart Applications	**3**	**0**	**0**	**3**
4.	**21PPE604**	Bio Energy from Waste	**3**	**0**	**0**	**3**
5.	**21PSE605**	Smart City Technologies	**3**	**0**	**0**	**3**

COURSE CATEGORY: AUDIT COURSES

S.No	Course Code	Course Title	L	T	P	C
1.	**21PGM801**	Pedagogy Studies	**3**	**0**	**0**	**0**
2.	**21PGM802**	English for Research Paper Writing	**3**	**0**	**0**	**0**

21PCM501	SPACE TIME WIRELESS COMMUNICATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the concept of multiple antenna propagation, transmitter and receiver diversity technique.
- To impart the knowledge of capacity of a frequency flat deterministic MIMO channel
- To analyze the concept of micro multi user detection.

UNIT 1	MULTIPLE ANTENNA PROPAGATION AND ST CHANNEL CHARACTERIZATION	9

Wireless channel – Scattering model in macrocells – Channel as a ST random field – Scattering functions, Polarization and field diverse channels – Antenna array topology – Degenerate channels – reciprocity and its implications – Channel definitions – Physical scattering model -Extended channel model – Channel measurements – sampled signal model – ST multiuser and ST interference channels – ST channel estimation.

UNIT II	CAPACITY OF MULTIPLE ANTENNA CHANNEL	9

Capacity of frequency flat deterministic MIMO channel: Channel unknown to the transmitter -Channel known to the transmitter – capacity of random MIMO channels – Influence of ricean fading – fading correlation – XPD and degeneracy on MIMO capacity – Capacity of frequency selective MIMO channels.

UNIT III	SPATIAL DIVERSITY	9

Diversity gain – Receive antenna diversity – Transmit antenna diversity – Diversity order and channel variability – Diversity performance in extended channels – Combined space and path diversity – Indirect transmit diversity – Diversity of a space-time – frequency selective fading channel

UNIT IV	MULTIPLE ANTENNA CODING AND RECEIVER	9

Coding and interleaving architecture, ST coding for frequency flat channels, ST coding for frequency selective channels, Receivers (SISO, SIMO, MIMO), Iterative MIMO receivers, Exploiting channel knowledge at the transmitter: linear pre-filtering, optimal pre-filtering for maximum rate, optimal pre filtering for error rate minimization, selection at the transmitter, Exploiting imperfect channel knowledge

UNIT V	ST OFDM, SPREAD SPECTRUM AND MIMO MULTIUSER DETECTION	9

SISO - OFDM modulation, MIMO - OFDM modulation - Signaling and receivers for MIMO - OFDM - SISO - SS modulation - MIMO - SS modulation - Signaling and receivers for MIMO - S. MIMO - MAC - MIMO - BC - Outage performance for MIMO - MU - MIMO - MU with OFDM - CDMA and multiple antennas

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	To explain the concept of multiple antenna propagation	**Understand**
CO2	Apply the concept of multiple antenna coding and receivers	**Apply**
CO3	Analyze the various MIMO multiuser detection techniques.	**Analyze**
CO4	Analyze the capacity of random MIMO channel.	**Analyze**
CO5	Analyze the channel characterization for various channel models.	**Analyze**
CO6	Analyze the order diversity and channel variability of the channel.	**Analyze**

TEXT BOOKS:

1. Sergio Verdu, Multi User Detection, Cambridge University Press, 2011
2. A. Paulraj, Rohit Nabar, Dhananjay Gore, Introduction to Space Time Wireless Communication Systems, Cambridge University Press, 2008

REFERENCES

1. Jonathan Rodriguez, “Fundamentals of 5G Mobile Networks ”, John Wiley and Sons, New York, 2015.
2. Afif Osseiran, Jose F. Monserrat and Patrick Marsch, ” 5G Mobile and Wireless Communications Technology”, Cambridge University Press 2016
3. Holger Claussen, David Lo´pez-Pe´rez, Lester Ho, Rouzbeh Razavi and Stepan Kucera, “Small Cell Networks”, John Wiley and Sons, New York, 2017.

21PCM502	QUANTUM COMMUNICATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To Introduce basic postulates of Boolean algebra.
- To outline the formal procedures for the analysis and design of combinational and sequential circuits.
- To introduce the concept of memories, programmable logic devices, synchronous and asynchronous circuits.

UNIT 1	VECTOR AND HILBERT SPACES	9

Introduction, Vector Spaces, Inner-Product Vector Spaces, Definition of Hilbert Space, Linear Operators, Eigenvalues and Eigenvectors, Outer Product. Elementary Operators, Hermitian and Unitary Operators.

UNIT 2	QUANTUM MECHANICS	9

The Environment of Quantum Mechanics, On the Statistical Description of a Closed Quantum System, Dynamical Evolution of a Quantum System, Quantum Measurements, Generalized Quantum Measurements (POVM), Composite Quantum Systems.

UNIT 3	QUANTUM DECISION THEORY	9

Analysis of a Quantum Communications System, Analysis and Optimization of Quantum Binary Systems, Binary Optimization with Pure States, System Specification in Quantum Decision Theory, State and Measurement Matrices with Pure States, State and Measurement Matrices with Mixed States, Formulation of Optimal Quantum Decision, Holevo's Theorem, Numerical Methods for the Search for Optimal Operators, Kennedy's Theorem.

UNIT 4	QUANTUM COMMUNICATIONS SYSTEMS	9

Constellations of Coherent States, Parameters in a Constellation of Coherent States, Theory of Classical Optical Systems, Analysis of Classical Optical Binary Systems, Quantum Decision with Pure States, Quantum Binary Communications Systems, Quantum Systems with OOK, QAM, PSK, BPSK Modulation.

UNIT 5	QUANTUM INFORMATION	9

Introduction to Quantum Information, Fundamentals of Continuous Variables, Classical and Quantum Information Theory, Applications of Quantum Information.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Explain the basic concepts for quantum communication.	**Understand**
CO2	Classify the types of measurements in quantum mechanics.	**Apply**
CO3	Apply the knowledge of Numerical methods to formulate the Quantum Decision.	**Apply**
CO4	Analyze the Classical Channels and Quantum channels in quantum informatics.	**Analyze**
CO5	Analyze the various Data Compression techniques in quantum communications.	**Analyze**
CO6	Analyze the various quantum binary communication systems.	**Analyze**

REFERENCES:

1. Cariolaro, Gianfranco. Quantum communications. Berlin: Springer, 2015.
2. Imre, Sandor, and Laszlo Gyongyosi. Advanced quantum communications: an engineering approach. John Wiley & Sons, 2012.
3. Sergienko, Alexander V., ed. Quantum communications and cryptography. CRC press, 2018.

21PCM503	RADAR SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

PRE-REQUISITE: Digital Signal Processing

OBJECTIVES:

- To study about different radar signal processing techniques such as matched filtering, modelling, signal detection etc.
- To familiarise the concept of matched filter techniques to identify the moving targets.
- To study the Pulsed RADAR signals for sampling and quantization.

UNIT I	RADAR SYSTEMS AND SIGNAL MODELS	9

Basic RADAR functions, Elements of a RADAR system, Components of RADAR signal, simple point target, RADAR cross section for meteorological targets, statistical description, clutter. Swerling model, Frequency and Spatial models.

UNIT II	SAMPLING AND QUANTIZATION OF PULSED RADAR SIGNALS	9

Domains and criteria for sampling RADAR signals, sampling in fast time dimension, sampling in slow time-selecting the pulse repetition interval, quantization, I/Q Imbalance and Digital I/Q.

UNIT III	RADAR WAVEFORMS	9

The waveform matched filter, matched filtering for moving targets, the Ambiquity function, The pulse burst waveform, frequency modulated-pulse compressed waveform, Range side lobe control for FM waveforms, costas frequency codes.

UNIT IV	DOPPLER PROCESSING	9

Moving Target Indication(MTI),Pulse Doppler Processing, Pulse pair processing, Additional Doppler Processing issues, clutter mapping and moving target detector, MTI for moving platforms.

UNIT V	CONSTANT FALSE ALARM RATE (CFAR) DETECTION	9

The effect of unknown Interference power on False Alarm probability, cell-averaging CFAR, Analysis of CFAR, order statistics CFAR, limitations-target masking, clutter images. Applications of RADAR signal Processing: Semi-Automatic Ground Environment (SAGE) Air Defense System, Ground Penetrating RADAR (GPR) technology.

TOTAL: 45 Periods

COURSE OUTCOMES

After completion, the student will be able to

CO1	Explain the basic concept of Radar systems	**Understand**
CO2	Compare the various techniques to process the RADAR signals	**Understand**
CO3	Apply the knowledge of sampling concepts to process the pulsed RADAR signals.	**Apply**
CO4	Apply the knowledge of matched filter techniques to identify the moving targets	**Apply**
CO5	Apply the concept of detection techniques to identify the unknown interference.	**Apply**
CO6	Analyze the performance of radar system both in search and track modes.	**Analyze**

REFERENCE BOOKS:

1. Mark.A.Richards,"Fundamentals of RADAR signal Processing",Mc Graw Hill,2005.
2. Vyacheslav Tuzlukov," Signal Processing in RADAR systems",CRC press,2013.
3. Harry L.Van Trees,"Detection,Estimation and Modulation Theory –RADAR,SONAR signal processing and Gaussian signals in noise",2001.

21PCM504	MILLIMETER WAVE COMMUNICATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the fundamentals of Millimeter wave devices and circuits.
- To describe the various components of Millimeter wave Communications system.
- To know the antenna design at Millimeter wave frequencies.

UNIT I	INTRODUCTION	9

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

UNIT II	MM WAVE DEVICES AND CIRCUITS	9

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

UNIT III	MM WAVE COMMUNICATION SYSTEMS	9

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

UNIT IV	MM WAVE MIMO SYSTEMS	9

Massive MIMO Communications, Spatial diversity of Antenna Arrays, Multiple Antennas, Multiple Transceivers, Noise coupling in MIMO system, Potential benefits for mm wave systems, Spatial, Temporal and Frequency diversity, Dynamic spatial, frequency and modulation allocation.

UNIT V	ANTENNAS FOR MM WAVE SYSTEMS	9

Antenna beam width, 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 the student will be able to:

CO1	Describe the characteristics and wave propagation for mm wave.	**Understand**
CO2	Explain Millimeter devices and circuits.	**Understand**
CO3	Apply the knowledge of Millimeter wave technology in MIMO systems.	**Apply**
CO4	Analyze the various modulations for millimeter wave technology.	**Analyze**
CO5	Analyze the various modulations for millimeter wave technology.	**Analyze**
CO6	Design and implement an antenna for Millimeter wave frequencies.	**Create**

REFERENCE BOOKS:

1. Behrouz Forouzan.A , "Cryptography and Network security", Tata McGraw- Hill, 2008.
2. William Stallings, "Cryptography and Network security: principles and practice", Prentice Hall of India, 2nd Edition, New Delhi, 2002.
3. Atul Kahate, "Cryptography and Network security", Tata McGraw- Hill, 2nd Edition, 2008.
4. Yang.H, "Security in Mobile Ad Hoc Networks: Challenges and Solution", IEEE Wireless Communications, 2004.

21PCM505	COMMUNICATION NETWORK SECURITY	L	T	P	C
		3	0	0	3

Security Attack issues specific to Wireless systems: Worm hole, Tunneling, DoS. WEP for Wi-Fi network, Security for 4G networks: Secure Ad hoc Network, Secure Sensor Network Projects for Teaching cryptography and network security. Research projects, Programming projects reading report assignment.

OBJECTIVES:

- To introduce the concept of security and explain symmetric and asymmetric key algorithms
- To impart knowledge on integrity, authentication and key management.
- To outline the concept of network security and wireless network security.

UNIT I	INTRODUCTION ON SECURITY	9

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

UNIT II	SYMMETRIC & ASYMMETRIC KEY ALGORITHMS	9

Substitution Ciphers, Transposition Ciphers, Stream and Block Ciphers, Data Encryption Standards (DES), Advanced Encryption Standard (AES), RC4, principle of asymmetric key algorithms, RSA Cryptosystem , Shamir's secret sharing and BE, Identity-based Encryption (IBE), Attribute-based Encryption (ABE). Introduction to Quantum Cryptography, Block chain, Bit coin and Crypto currency.

UNIT III	INTEGRITY, AUTHENTICATION AND KEY MANAGEMENT	9

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

UNIT IV	NETWORK SECURITY, FIREWALLS AND WEB SECURITY	9

Introduction on Firewalls, Types of Firewalls, Firewall Configuration and Limitation of Firewall. IP Security Overview, IP security Architecture, authentication Header, Security payload, security associations, Key Management. Web security requirement, secure sockets layer, transport layer security, secure electronic transaction, dual signature. Side-channel attack, Pretty Good Privacy (PGP).

UNIT V	WIRELESS NETWORK SECURITY	9

Security Attack issues specific to Wireless systems: Worm hole, Tunneling, DoS. WEP for Wi-Fi network, Security for 4G networks: Secure Ad hoc Network, Secure Sensor Network Projects for Teaching cryptography and network security. Research projects, Programming projects reading report assignment.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Describe the basic concepts in communication network security	**Understand**
CO2	Identify the various network security services and mechanism	**Apply**
CO3	Apply the knowledge of mathematical theory to develop different network security algorithms	**Apply**
CO4	Apply the concepts of digital signature to secure communication networks	**Apply**
CO5	Analyze the performance of different encryption techniques	**Analyze**

CO6	Analyze and resolve security issues in networks	**Analyze**

REFERENCES:

1. Behrouz Forouzan.A , “Cryptography and Network security”, Tata McGraw- Hill, 2008.
2. William Stallings, “Cryptography and Network security: principles and practice”, Prentice Hall of India, 2nd Edition, New Delhi, 2002.
3. Atul Kahate, “Cryptography and Network security”, Tata McGraw- Hill, 2nd Edition, 2008.
4. Yang.H, “Security in Mobile Ad Hoc Networks: Challenges and Solution”, IEEE Wireless Communications, 2004.

21PCM506	SATELLITE COMMUNICATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce about the elements of satellite Communication.
- To explain the modulation and multiple access schemes.
- To summarize about satellites and its applications

UNIT I	ELEMENTS OF SATELLITE COMMUNICATION	9

Satellite Systems, Orbital description and Orbital mechanics of LEO, MEO and GSO, Placement of a Satellite in a GSO, Satellite – description of different Communication subsystems, Bandwidth allocation.

UNIT II	TRANSMISSION, MODULATION, MULTIPLE ACCESS	9

Phased arrays for satellite communications, satellite laser communications, Features of RF and optical space communication systems, wireless standards in satellite networking, Tracking and Data Relay Satellite K (TDRS-K) , Multiple Access Techniques – DMA, TDMA, CDMA, and DAMA.

UNIT III	SATELLITE LINK DESIGN	9

Basic link analysis, Interference analysis, Rain induced attenuation and interference, Ionospheric characteristics, Link Design with and without frequency reuse.

UNIT IV	SATELLITE NAVIGATION AND GLOBAL POSITIONING SYSTEM	9

Radio and Satellite Navigation, GPS Position Location Principles, GPS Receivers and Codes, Satellite Signal Acquisition, GPS Receiver Operation and Differential GPS.

UNIT V	SERVICES AND APPLICATIONS	9

Mixed and mobile services - Multimedia satellite services - Advanced applications based on satellite platforms - INTELSAT series, Remote Sensing - Special services, E-mail, Video conferencing and Internet connectivity, Mission Chandrayan and Mission Mangalyaan.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Describe the fundamental concepts of satellite communication	**Understand**
CO2	Apply various modulation techniques and interference involved in satellite communication.	**Apply**
CO3	Apply the knowledge of GPS to analyze the satellite Navigation.	**Apply**
CO4	Design real time applications for satellite communication.	**Apply**
CO5	Apply the knowledge of various services in satellite communication.	**Apply**
CO6	Analyze the various interference in satellite link design.	**Analyze**

REFERENCES:

1. Timothy Pratt, Charles Bostian.W, “Satellite Communications”, John Wiley and Sons, 2010.
2. Roddy.D, “Satellite Communication”, McGrawHill, 2008.
3. Tri T Ha, “Digital Satellite Communication”, McGraw Hill, 2009.
4. Wilbur Pritchard.L, Suyderhoud.H.D, RobertNelson.A, “ Satellite Communication Systems Engineering ”, Prentice Hall, New Jersey, 2006.

21PCM507	IOT PROTOCOLS	L	T	P	C
		3	0	0	3

PRE-REQUISITE: Data communication networks

COURSE OBJECTIVES:

- To explain about Internet of Things.
- To impart basic knowledge of RFID Technology, Sensor Technology.
- To make students aware of resource management and security issues in Internet of Things.

UNIT I	INTRODUCTION TO IOT	9

Genesis of IoT-IoT and Digitization-IoT Impact-Convergence of IT and OT-IoT - Challenges-IoT Network Architecture and Design: Drivers Behind New Network Architectures-Comparing IoT Architectures-A Simplified IoT Architecture-The Core IoT Functional Stack-IoT Data Management and Compute Stack

UNIT II	IOT NETWORKS	9

Smart Objects: The ―Things‖ in IoT: Sensors, Actuators, and Smart Objects, Sensor Networks Connecting Smart Objects: ―Communications Criteria‖ -Range, Frequency Bands, Power Consumption, Topology, Constrained Devices, Constrained-Node Networks. ―IoT Access Technologies‖- IEEE 802.15.4, IEEE 802.15.4g and IEEE 802.15.4e, IEEE 1901.2a, LoRaWAN, NB-IoT and Other LTE Variations

UNIT III	IOT PROTOCOLS	9

IP as the IoT Network Layer: The Business Case for IP, The Need for Optimization, Optimizing IP for IoT, Optimizing IP for IoT- Application Protocols for IoT: The Transport Layer, IoT Application Transport Methods

UNIT IV	DATA ANALYTICS AND SECURITY FOR IOT	9

Data and Analytics for IoT: An Introduction to Data Analytics for IoT, Machine Learning, Big Data Analytics Tools and Technology, Edge Streaming Analytics, Network Analytics Securing IoT: Common Challenges in OT Security, How IT and OT Security Practices and Systems Vary, Formal Risk Analysis Structures, The Phased Application of Security in an Operational Environment

UNIT V	IOT IN INDUSTRY &APPLICATIONS	9

Manufacturing: An Introduction to Connected Manufacturing, An Architecture for the Converged Factor, Industrial Automation Control Protocols, Connected Factory Security Smart and Connected Cities: An IoT Strategy for Smarter Cities, Smart City IoT Architecture, Smart City Use-Case Examples-Transportation: Transportation and Transports, Transportation Challenges, IoT Use Cases for Transportation, An IoT Architecture for Transportation-Public Safety: Overview of Public Safety, An IoT Blueprint for Public Safety, Emergency Response IoT Architecture, Emergency Response IoT Architecture, School/college Bus Safety-IoT use cases in agriculture: Monitoring of climate conditions, Crop management, Precision farming, Agricultural drones, Predictive analytics for smart farming, End-to-end farm management system.

TOTAL: 45 Periods

COURSE OUTCOMES

After completion, the student will be able to

CO1	Explain the concepts of IoT technology	**Understand-K2**
CO2	Apply the knowledge of IoT for practical applications	**Apply-K3**
CO3	Apply the knowledge of communication protocols to develop IoT applications	**Apply-K3**
CO4	Analyze the impact of IoT in various sectors	**Analyze-K4**
CO5	Analyze the performance of IoT applications using simulation software	**Analyze-K4**
CO6	Design IoT based real life applications	**Create-K6**

REFERENCES:

1. IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, Cisco Press, 2017.

2. Internet of Things – A hands-on approach, Arshdeep Bahga, Vijay Madisetti, Universities Press, 2015.
3. Vijay Madisetti, Arshdeep Bahga, Internet of Things A Hands-On- Approach II,2014.
4. Architecting the Internet of Things,Dieter Uckelmann, Mark Harrison, Michahelles and Florian (Eds), Springer,2011.

21PCM508	SPEECH AND AUDIO SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the basics of speech signal, speech production mechanisms.
- To explore time domain and frequency domain analysis of speech signal.
- To impart LPC based characterization applications of speech signal processing.

UNIT I	MECHANICS OF SPEECH	9

Speech production mechanism - Nature of Speech signal - Discrete time modelling of Speech production - Representation of Speech signals - Classification of Speech sounds - Phones - Phonemes - Phonetic and Phonemic alphabets - Articulatory features. Music production - Auditory perception - Anatomical pathways from the ear to the perception of sound - Peripheral auditory system - Psycho acoustics.

UNIT II	TIME DOMAIN METHODS FOR SPEECH PROCESSING	9

Time domain parameters of Speech signal - Methods for extracting the parameters Energy - Average Magnitude - Zero crossing Rate - Silence Discrimination using ZCR and energy - Short Time Auto Correlation Function - Pitch period estimation using Auto Correlation Function.

UNIT III	FREQUENCY DOMAIN METHOD FOR SPEECH PROCESSING	9

Short Time Fourier analysis - Filter bank analysis - Formant extraction - Pitch Extraction - Analysis by Synthesis - Analysis synthesis systems- Phase vocoder - Channel vocoder Homomorphic speech analysis: Cepstral analysis of Speech - Formant and Pitch Estimation Speech enhancement techniques in time domain - Homomorphic vocoder

UNIT IV	LINEAR PREDICTIVE ANALYSIS OF SPEECH	9

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

UNIT V	APPLICATION OF SPEECH & AUDIO SIGNAL PROCESSING ALGORITHMS	9

Spectral Estimation, dynamic time warping – Hidden Markov model – Music analysis – Pitch Detection– Feature analysis for recognition – Music synthesis – Automatic Speech Recognition – Feature Extraction for ASR – Deterministic sequence recognition – Statistical Sequence recognition – ASR systems – Speaker identification and verification – Voice response system ,Voice activity detection for speech coding-simulation of audio coding techniques.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Understand Speech and audio signal production and perception mechanisms.	**Understand**
CO2	Apply speech processing solutions based on filter banks.	**Apply**
CO3	Analyze speech and audio signals in the time and frequency domains.	**Analyze**
CO4	Analyze speech signals using LPC coder	**Analyze**
CO5	Analyze speech recognition, speaker identification and speech synthesis schemes.	**Analyze**
CO6	Analyze various applications of Automatic speech recognition algorithms.	**Analyze**

REFERENCES:

1. L.R.Rabiner and R.W. Schaffer., Digital Processing of Speech signals - Prentice Hall - 1978.

2. Ben Gold and Nelson Morgan, Speech and Audio Signal Processing, John Wiley and Sons Inc., 2004.
3. Quatieri ,Discrete-time Speech Signal Processing , Prentice Hall, 2001.
4. J.L.Flanagan ,Speech analysis: Synthesis and Perception ,Berlin,1972.
5. I.H. Witten, Principles of Computer Speech – Academic Press, 1982.

21PCM509	ULTRA WIDEBAND COMMUNICATION	L	T	P	C
		3	0	0	3

OBJECTIVE:

- To give fundamental concepts related to Ultra wide band
- To impart knowledge about the channel model and signal processing for UWB.
- To acquire knowledge about UWB antennas and regulations.

UNIT I	INTRODUCTION TO UWB	9

History, Definition, FCC Mask, UWB features, Antenna Requirements, Radiation Mechanism of the UWB Antennas, Link Budget for UWB System Taking into Account the UWB Antennas, Short Range Analysis of UWB Antennas.

UNIT II	ULTRA WIDE BAND WIRELESS CHANNELS AND INTERFERENCE	9

Impulse Response Modeling of UWB Wireless Channels, Modified Impulse Response Method, The IEEE UWB Channel Model, Frequency Modeling of UWB Channels, Comparison of Time and Frequency Models, UWB Interference.

UNIT III	UWB SIGNAL PROCESSING AND TECHNOLOGIES	9

Modulation, BER of Modulation Schemes, Rake Receiver, Transmit-Reference (T-R) Technique, UWB Range- Data Rate Performance, UWB Channel Capacity, Impulse Radio, Pulsed Multiband, Multiband OFDM, Comparison of UWB Technologies.

UNIT IV	UWB WIRELESS LOCATIONING	9

Position Locationing Methods, Time of Arrival Estimation, NLOS Location Error, Locationing with OFDM.

UNIT V	UWB APPLICATIONS AND REGULATIONS	9

Wireless Ad hoc Networking, UWB Wireless Sensor, RFID, Consumer Electronics and Personal, Asset Location, Medical applications, UWB Regulation and standards in various countries, UWB Regulation in ITU, IEEE Standardization, Magnet (My Personal Adaptive Global NET), Magnet Beyond, Pulsers (Pervasive Ultra-Wideband Low Spectral Energy Radio Systems)

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

CO1	Explain the fundamental concepts in UWB.	**Understand**
CO2	Classify UWB regulations in various countries.	**Understand**
CO3	Apply the knowledge of UWB antennas to develop UWB applications.	**Apply**
CO4	Analyze the various signal processing methods in UWB.	**Analyze**
CO5	Analyze the various UWB wireless locationing methods.	**Analyze**
CO6	Assess the performance of UWB models.	**Evaluate**

REFERENCES:

1. Homayoun Nikookar and Ramjee Prasad, “Introduction to Ultra Wideband for Wireless Communications”1st Edition, Springer Science Business Media BV2010.
2. Thomas Kaiser, Feng Zheng “Ultra-Wideband Systems with MIMO”, 1st Edition, JohnWiley&SonsLtd, New York,2010.
3. W.Palm Siriwong pairatand KJ.Ray Liu, “Ultra-Wideband Communications Systems: Multiband OFDM approach” John Wiley and IEEEpress,NewYork2008**.**

21PCM510	HIGH PERFORMANCE COMMUNICATION NETWORKS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on Fundamentals of computer networks and wireless networks.
- To learn the architecture and uniqueness of high-performance networks.
- To familiarize the students on the network design and management

UNIT 1	INTRODUCTION COMMUNICATION NETWORKS	9

Telephone and computer networks - cable television networks - wireless networks - networking principles - digitalization - traffic characterization and QoS - network services - network elements - network mechanisms - layered architecture - network bottlenecks.

UNIT II	BROADBAND WIRELESS NETWORKS	9

Evolution of Broadband wireless - fixed broadband wireless - mobile broadband wireless - MANET architecture - mobile adhoc routing protocols - modeling and simulation tools for MANET - performance of MANET routing protocols - routing modeling - mathematical analysis.

UNIT III	INTERNET AND TCP/IP NETWORKS	9

Technology trends in IP networks - IP packet communications in mobile communication networks - TCP and UDP - performance of TCP/ IP networks - Circuit Switched Networks: SONET - DWDM - fiber to the home - DSL - Intelligent Network (IN) scheme - comparison with conventional systems - merits of the IN scheme - CATV and layered network - services over CATV.

UNIT IV	ATM NETWORKS	9

ATM reference model - Addressing - Signaling - Routing - ATM Adaptation Layer (AAL) – ATM Traffic and service parameterization - ATM traffic management - Switching in ATM - ATM Network Interfaces and Architecture - Multiprotocol over ATM.

UNIT V	HIGH PERFORMANCE NETWORKS	9

WiMAX overview - WIMAX physical layer - Overview of MAC Layer - Network Reference Model - Overview of LTE - Overview of LTE-A - Uplink transmission scheme and frame structure - Downlink multi antenna techniques - Transmission modes.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Explain the concepts of the various network topologies.	**Understand**
CO2	Design ATM Networks using different protocols	**Apply**
CO3	Design routing networks and virtual topology.	**Apply**
CO4	Select the most appropriate wireless broadband network and analyze its structure	**Analyze**
CO5	Analyze the various advanced high-performance networks.	**Analyze**
CO6	Analyze the various network services.	**Analyze**

TEXT BOOKS:

1. Jean Warland and Pravin Varaiya, “High Performance Communication Networks”, 2nd Edn. (onwards), Harcourt and Morgan Kanffman Publishers, London, 2008.
2. Sumit Kasera and Pankaj Sethi, “ATM Networks: Concepts and Protocols”, Tata McGraw Hill, 2007.
3. Jeffrey G. Andrews, Arunabha Ghosh and Rias Muhamed, “Fundamentals of WiMAX Understanding Broadband Wireless Networking”, Prentice Hall of India, 2008.

21PCM511	PATTERN RECOGNITION AND APPLICATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce statistical theory in pattern recognition.
- To give knowledge on parametric and nonparametric models.
- To explain the various clustering algorithms and fuzzy based classification in Pattern Recognition.

UNIT – 1	INTRODUCTION	9

Introduction: Basics of pattern recognition – Design principles of pattern recognition system – Learning and adaptation – Pattern recognition approaches. Mathematical foundations: Linear algebra – Probability theory – Expectation – Mean and Covariance – Normal distribution – Multivariate normal densities – Chi square test of hypothesis.

UNIT – 2	STATISTICAL PATTERN RECOGNITION	9

Bayesian Decision Theory – Classifiers- linear and nonlinear classifiers – Normal density and discriminant functions.

UNIT – 3	GENERATIVE METHODS	9

Maximum-Likelihood and Bayesian Parameter Estimation -Maximum-Likelihood estimation – Bayesian Parameter estimation – Dimension reduction methods – Principal Component Analysis (PCA) – Fisher Linear Discriminant analysis – Expectation – maximization (EM) – Hidden Markov Models (HMM) – Gaussian mixture models. Nonparametric Techniques-Density Estimation.

UNIT – 4	DISCRIMINATIVE METHODS	9

Distance-based Method - Nearest neighbor Classification ,Metrics and Tangent Distance, Fuzzy Linear Discriminant Functions - Geometry, Gradient, Minimum, Support, Artificial Neural Networks - Biological Motivation and Back-Propagation.

UNIT – 5	UNSUPERVISED LEARNING AND CLUSTERING	9

Criterion functions for clustering - Clustering Techniques: Iterative square - Error partitional clustering - K-Means - agglomerative hierarchical clustering - Cluster validation, SVM, CNN, RNN algorithms.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1	Describe the basic principles of pattern recognition	**Understand**
CO2	Apply clustering techniques for pattern recognition applications	**Apply**
CO3	Apply classification algorithms for pattern recognition applications	**Apply**
CO4	Analyze various supervised and unsupervised learning methods	**Analyze**
CO5	Compare the performance of the generative and discriminative methods	**Analyze**
CO6	Develop various pattern recognition techniques to solve real world problems	**Evaluate**

TEXT BOOKS:

1. Richard O. Duda, Peter E. Hart, David G. Stork, “Pattern Classification”, John Wiley, 2nd Edition, 2006.
2. Bishop Christopher M, “Pattern Recognition and Machine Learning”, Springer, 1st Edition, 2009.
3. Theodoridis S, Koutroumbas K, “Pattern Recognition”, Academic Press, 4th Edition, 2009.

REFERENCES:

1. Keinosuke Fukunaga, “Introduction to Statistical Pattern Recognition”, Academic Press, 2nd Edition, 2003.
2. Statistics and the Evaluation of Evidence for Forensic Scientists by C. Aitken and F. Taroni, Wiley, 2004.

21PCM512	MICROELECTRONICS AND VLSI TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVE:

- To Impart Knowledge on physics of semiconductors and quantitative models.
- To understand the basics of semiconductor crystal properties, IC fabrication and automation.
- To identify the issues at various stages of VLSI physical design involved in fabrications.

UNIT I	PHYSICS OF SEMICONDUCTORS	9

Review of semiconductor physics –quantum foundations -Semiconductor band structure, Simplified band structure models, Carrier concentration –non equilibrium –quasi Fermi levels -drift and diffusion –mobility –generation and recombination –continuity equation.

UNIT II	BASICS OF SEMICONDUCTOR CRYSTAL PROPERTIES	9

Material properties, crystal structure, lattice, basis, planes, directions, angle between different planes, phase diagram and solid solubility, Crystal growth techniques, Epitaxy, Clean room and safety requirements. Oxidation: wet and dry oxidation, Deal-Grove model, Diffusion process, Ion implantation, modeling of Ion implantation, statistics of ion implantation, rapid thermal annealing, SIMS.

UNIT III	ADVANCED METHODS IN FABRICATIONS	9

Deposition & Growth: Various deposition techniques CVD, PVD, evaporation, sputtering, spin coating, LPCVD, MBE, ALCVD, Growth of High k and low k dielectrics, Etching -wet and dry etch, plasma and RIE etch, Photolithography: Positive photo resist, negative photo resist, comparison of photo resists, components of a resist, light sources, exposure, resolution, depth of focus, numerical aperture sensitivity, contrast, proximity and projection lithography, step and scan, optical proximity correction.

UNIT IV	PHYSICAL DESIGN AUTOMATION	9

Introduction to digital IC design - custom and semicustom flow, combinational logic synthesis - Technology independent and technology dependent optimization - Binary decision diagrams - High level synthesis-Scheduling and allocation - Physical design - terminology - graph algorithms - heuristic algorithms - Basic Unix/Linux commands - introduction to C shell/Perl scripting.

UNIT V	NANO –ELECTRONICS	9

Nano-scale electronics; Foundation of nano-electronics – low dimension transport, quantum confinement, Coulomb blockade and quantum dot; Ballistic transport and Quantum interferences; Landauer formula, quantization of conductance, example of Quantum point contact.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1	Outline the basics of semiconductor crystal properties.	**Understand**
CO2	Build an idea on nano-electronics and its technology.	**Understand**
CO3	Apply the semiconductor phenomena relevant to the field of electronics.	**Apply**
CO4	Apply the VLSI technology into IC circuits.	**Apply**
CO5	Analyze the various advanced methods involved in deposition and photolithography.	**Analyze**
CO6	Analyze the various applications of nanometer technology.	**Analyze**

REFERENCES:

1. S.M. Sze& Kwok K. Ng, Physics of Semiconductor Devices, 3rdEdition, Wiley, 2007.
2. B.L. Anderson & R. L. Anderson, Fundamentals of Semiconductor Devices, McGraw-Hill, 2005.

21PCM513	MOBILE AND SOCIAL COMPUTING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on social network structures.
- To give knowledge on mobile computing application.
- To give knowledge on social media in the public sector and business use.

UNIT 1	INTRODUCTION TO MOBILE COMPUTING	9

Mobile Computing – Mobile Computing Vs wireless Networking – Mobile Computing Applications- Characteristics of Mobile computing – Structure of Mobile Computing Application. MAC Protocols – Wireless MAC Issues. Fixed Assignment Schemes – Random Assignment Schemes – Reservation Based Schemes.

UNIT 2	MOBILE PLATFORMS AND APPLICATIONS	9

Mobile Device Operating Systems – Special Constrains and Requirements of Mobile OS- Commercial Mobile Operating Systems: Windows Mobile- Palm OS- Symbian OS- iOS, Android- BlackBerry- Mobile Application Development and Protocols: Mobile Devices as Web clients-WAP-J2ME-Android application Development.

UNIT 3	BASIC SOCIAL NETWORKS STRUCTURES	9

Introduction - Analyzing the social web - A brief history of the social web-Websites discussed-Tools used. Basics of network structure- Representing networks-Basic network structures and properties-Social Networks - Basic Structure and Measures- Network Visualization.

UNIT 4	BUILDING SOCIAL NETWORKS AND ITS PROPAGATION	9

Modeling networks- Sampling methods- Egocentric network analysis- Link Prediction-Entity resolution- Incorporating network data-Case study- Topic Models-Epidemic models - Threshold models-The firefighter problem -Stochastic models -Applications of epidemic models to social media.

UNIT 5	CASE STUDY - SOCIAL MEDIA IN THE PUBLIC SECTOR, BUSINESS USE & ITS PRIVACY	9

Analyzing public-sector social media –Case study- Measuring success- Broadcast example-Interaction and monitoring example- Social media failure example- Privacy policies and settings-Aggregation and data mining- Data ownership and maintaining privacy online - Respecting privacy in social media analysis- Case Study: Social Network Strategies for Surviving the Zombie Apocalyps.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Explain the basic concepts of mobile computing under various system aspects.	**Understand**
CO2	Describe the basic concepts of social networking with different datasets.	**Apply**
CO3	Apply Level: Apply various mobile platforms for implementing different applications.	**Apply**
CO4	Analyze Level: Analyze the social media data with different topic models.	**Analyze**
CO5	Analyze Level: Analyze different social networking structures for the given problem specifications.	**Evaluate**
CO6	Analyze social networking concepts for various public sector problems.	**Create**

TEXT BOOKS:

1. Prasant Kumar Pattnaik, Rajib Mall, “Fundamentals of Mobile Computing”,2nd Edition, PHI Learning Pvt. Ltd, New Delhi – 2015.
2. Cioffi-Revilla, Claudio. Introduction to Computational Social Science, Springer, 2014**.**
3. Jennifer Golbeck, Analyzing the social web, Morgan Kaufmann, 2013.

REFERENCES:

1. Jochen H. Schller, “Mobile Communications”, Second Edition, Pearson Education, New Delhi, 2007.
2. 2.Matthew A. Russell. Mining the Social Web: Data Mining Facebook, Twitter, Linkedin, Google+, Github, and More, 2nd Edition, O'Reilly Media, 2013.
3. 3. Robert Hanneman and Mark Riddle. Introduction to social network methods. Online Text Book, 2005.

21PCM514	NETWORK MANAGEMENT SYSTEM	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the principles of network management, different standards and protocols used in managing complex networks.
- To explain the automation of network management operations and making use of readily available network management systems.
- To explain the concept of Broadband Access Networks.

UNIT 1	DATA COMMUNICATION AND NETWORK MANAGEMENT	9

Analogy of Telephone Network Management, Distributed computing environments, TCP/IP based Networks: The INTERNET AND INTRANETS, Communications Protocols and Standards, Case Histories on Networking and Management, Network Management Architecture and Organization**.**

UNIT 2	STANDARDS, MODELS, AND LANGUAGES	9

Network Management Standards, Network Management Models, Organization Model, Information Model, Communication Model, Functional Model, Abstract Syntax Notation One (ASN.1) Encoding Structure.

UNIT 3	SNMPV1 NETWORK MANAGEMENT	9

Managed Network, Organization Model, Information Model, SNMP Communication Model, Functional Model SNMP Management, Remote Monitoring system RMON1, Remote Monitoring system RMON2

UNIT 4	BROADBAND ACCESS NETWORKS	9

Broadband Access Technology, Cable Modem Technology, HFC Management, DSL Technology, Asymmetric Digital Subscriber Line Technology, ADSL Management, MIB Integration with Interfaces Groups in MIB-2.

UNIT 5	NETWORK MANAGEMENT APPLICATIONS	9

Configuration Management, Fault Management, Performance Management, Event Correlation Techniques, Security Management, Report Management, Policy- Based Management.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Describe the network topologies and its components used in computer networks	**Understand**
CO2	Apply the concepts of network management standards to manage practical networks	**Apply**
CO3	Acquire the knowledge about various network management tools and the skill to use them in monitoring a network	**Apply**
CO4	Apply the knowledge of network topologies in network management systems	**Apply**
CO5	Analyze the challenges faced by Network managers.	**Analyze**
CO6	Evaluate various commercial network management systems and open network management systems	**Evaluate**

TEXT BOOKS:

1. Network Management – Principles and Practice" by Mani Subramanian, Addison Wesley Pub Co, First Edition, 2000.

REFERENCES:

1. Salah Aiidarous,Thomas Plevayk,"Telecommunications Network Management Technologies and Implementations ", IEEE press, Eastern Economy Edition, New Delhi, 1998.

2. BehrouzA.Forouzan, “Data Communications and Networking”, Tata McGraw Hill, 2nd Edition, 2003.
3. “SNMP, SNMPv2, SNMPv3, AND RMON 1and 2” by William Stallings, Addison Wesley, Third Edition, 1999.

21PCM515	GLOBAL POSITIONING SYSTEM	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart the fundamental concepts of GPS.
- To give an idea about the GPS Navigation and Satellite.
- To understand the fundamentals of GPS Receiver.

UNIT 1	GPS FUNDAMENTALS	9

Introductory GPS System, Description and Technical Design, History of Satellites, Launches, Initial Testing, Applications OF GPS, Pioneers of the GPS.

UNIT II	GPS NAVIGATION DATA	9

Introduction, Detailed Description of the Navigation Data Time, Satellite Clocks and Clock Errors, Satellite Orbit and Position, Ionosphere Correction Using Measured Data.

UNIT III	GPS SATELLITE AND PAYLOAD	9

Spacecraft and Navigation Payload Heritage, Navigation Payload Requirements, Block IIR Space Vehicle Configuration, Block IIR Payload Design, Characteristics of the GPS L-Band Satellite Antenna, Future performance Improvements.

UNIT IV	FUNDAMENTALS OF SIGNAL TRACKING THEORY	9

GPS User Equipment - System Architecture, Delay lock loop Receivers for Signal tracking, Coherent and Non coherent Delay lock loop, Vector Delay lock loop, Processing of GPS signals - Quasi optimal and channel Capacity.

UNIT V	GPS RECEIVER	9

Generic Receiver Description, Technology Evolution, System Design Details, Receiver Software signal Processing, Bit synchronization.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Explain the fundamental concepts of GPS.	**Understand**
CO2	Identify the Navigation datas used for satellite positioning	**Apply**
CO3	Apply the knowledge of Navigation Payload to compute various parameters of GPS.	**Apply**
CO4	Apply the knowledge of the GPS Receiver used in different applications	**Apply**
CO5	Analyze the various types of Signals in GPS communication.	**Analyze**
CO6	Develop an application using GPS.	**Create**

Reference Books:

1. Parkinson.B, Spilker.J,“GPS: Theory and Applications ”, Vol.I&Vol.II, AIAA,370 L'Enfant Promenade SW, Washington, DC 20024, 1996.
2. Hoffman.B, Wellenhof, Lichtenegger.H and Collins.J, “GPS: Theory and Practice”, Springer, Wein, 4th revised edition, New York, 1997.
3. Leick.A, “GPS Satellites Surveying”, John Wiley & Sons, 2nd edition, NewYork, 1995.

21PCM516	DSP PROCESSOR ARCHITECTURE AND PROGRAMMING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Basics of programmable Digital Signal Processor
- Various DSP processor and programming skills
- Advanced DSP architectures and some applications

UNIT – I	INTRODUCTION TO PROGRAMMABLE DSPS	9

Overview: Multirate Signal Processing- Discrete wavelet transform- Adaptive filters-Image Data Compression -Linear Predictive Coder and Speech Compression - Multiplier and Multiplier accumulator – Modified Bus Structures and Memory access in P-DSPs – Multiple access memory – Multi-port memory – VLIW architecture- Pipelining – Special Addressing modes in P-DSPs – On chip Peripherals.

UNIT – II	TMS320C5X PROCESSOR	9

Architecture – Assembly language syntax - Addressing modes – Assembly language Instructions - Pipeline structure, Operation – Block Diagram of DSP starter kit – Application Programs for processing real time signals.

UNIT – III	TMS320C6X PROCESSOR	9

Architecture of the C6x Processor - Instruction Set - DSP Development System: Introduction– DSP Starter Kit Support Tools- Code Composer Studio - Support Files - Programming Examples to Test the DSK Tools – Application Programs for processing real time signals.

UNIT – IV	ADSP PROCESSORS	9

Architecture of ADSP-21XX and ADSP-210XX series of DSP processors- Addressing modes and assembly language instructions – Application programs –Filter design, FFT calculation.

UNIT – V	PROGRAMMABLE DIGITAL SIGNAL PROCESSORS	9

Architecture of TMS320C54X: Pipe line operation, Addressing modes, Instruction Set, Code Composer studio - Implementation of Basic DSP Algorithms: The Q-notation, FIR Filters, IIR Filters, interpolation Filters, Decimation filters, Adaptive Filters, 2-D Signal Processing. Implementation of FFT Algorithms.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1	Describe the architecture details and instruction sets of various DSP processors	**Understand**
CO2	Apply the knowledge of programming skills to develop code for processing real time signals.	**Apply**
CO3	Design and implement DSP algorithm using code composer studio.	**Apply**
CO4	Analyze various DSP algorithms for real time application.	**Analyze**
CO5	Compare and evaluate various DSP algorithms.	**Evaluate**
CO6	Design DSP based system for real time applications.	**Create**

TEXT BOOKS:

1. Venkataramani.B, Bhaskar.M, " Digital Signal Processors – Architecture, Programming and Applications ", Hill Publishing Company Limited, 2003.
2. Avtar Singh and S. Srinivasan, Digital Signal Processing – Implementations using DSPMicroprocessors with Examples from TMS320C54xx, Cengage Learning India Private Limited,Delhi 2012.

REFERENCES:

1. RulphChassaing and Donald Reay, Digital Signal Processing and Applications with theC6713 and C6416 DSK, John Wiley & Sons, Inc., Publication, 2012 (Reprint).
2. Peter Pirsch ,"Architectures for Digital Signal Processing", John Weily, 2007
3. User guides: Texas Instrumentation, Analog Devices, Motorola.

21PCM517	MEDICAL IMAGING TECHNIQUES	L	T	P	C
		3	0	0	3

OBJECTIVE:

- Explain the principles of the gamma camera, SPET and PET.
- Understand how Doppler and echo information can be combined in an ultrasound image.
- Describe magnetic resonance imaging.
- Understand the distinction between anatomical functional imaging.

UNIT I	ULTRASONIC IMAGING	9

Ultra Sound In Medicine - Introduction, production of ultra sound - properties principles of image formation, Capture and display - principles of A -mode, B-mode and M-mode display - Doppler Ultra sound and Colour flow mapping - Applications of diagnostic ultra sound.

UNIT II	CT IMAGING	9

X-Ray computed tomography - Principles of sectional imaging - scanner configuration - data acquisition system -image formation principles - conversion of x-ray data in to scan image - 2D image reconstruction techniques -Iteration and Fourier methods. Types of CT scanners.

UNIT III	MAGNETIC RESONANCE IMAGING	9

Magnetic Resonance Imaging - Principles of MRI pulse sequence- image acquisition and reconstruction techniques MRI instrumentation magnets gradient system RF coils - receiver system Functional MRI - Application of MRI.

UNIT IV	NUCLEAR MEDICINE IMAGING	9

Radio isotope imaging - Rectilinear scanners, linear scanners - SPECT - PET Gamma Camera Radio nuclides for imaging, Emission Computed Tomography.

UNIT V	IMAGE FORMATION AND IMAGE PROCESSING	9

Relation between object and Image – General Image Processing Problem – Discrete Fourier Representation and the models foe Imaging system – General Theory of Image Restoration – Image Sampling – Iterative Image Processing.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After successful completion of this course the students will be able to :

CO1	Explain the basic concepts of various imaging modalities	**Understand**
CO2	Apply the physical principles of image formation to obtain various imaging	**Apply**
CO3	Develop and simulate various techniques used for improving the quality of image in spatial domain for different clinical applications.	**Apply**
CO4	Develop mathematical modeling for an image processing system in various imaging modalities.	**Apply**
CO5	Analyze the efficiency of specified imaging modalities, image quality assurance and diagnostic decision making	**Analyze**
CO6	Design and develop any algorithm using modern tools for specific application.	**Create**

REFERENCES:

1. S Webb, Adam Highler, Bristol, " The Physics of Medical Imaging ", IEEE Press New York, 1998.
2. A C Kak, " Principle of Computed Tomography ", IEEE Press New York.
3. G A Hay, " Medical Image Formation Perception and Measurement" .
4. William R. Hendee and Russell Ritenour. E. Woods, " Medical Imaging Physics", A John Wiley & Sons, Inc. publications, 2002.
5. Atam.P. Dhawan, "Medical Image Analysis", Second Edition, John Wiley and Sons, 2011.
6. Jacob Beutel and M. Sonka, "Handbook of Medical Imaging", SPIE press 2000.

21PCM518	NETWORK ROUTING ALGORITHM	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the concepts of routing in network and various routing protocols.
- Give knowledge on optical and mobile IP networks.
- To summarize the various routing in mobile Ad-HOC network.

UNIT 1	INTRODUCTION	7

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 2	INTERNET ROUTING	10

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 3	ROUTING IN OPTICAL WDM NETWORKS	10

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 4	ROUTING ALGORITHM FOR 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 5	ROUTING ALGORITHM FOR 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 the student will be able to:

CO1	Describe the fundamental concepts of various routing techniques.	**Understand**
CO2	Explain the various mobile IP protocols.	**Understand**
CO3	Apply the various routing techniques in mobile adhoc networks.	**Apply**
CO4	Analyze performance of various routing protocols.	**Analyze**
CO5	Analyze different issues of routing in optical networks.	**Analyze**
CO6	Design and implement a network routing protocol.	**Create**

TEXT BOOKS:

1. D.Medhi and K.Ramasamy, “Network Routing: Algorithms, Protocols and Architectures”, Morgan Kaufmann Publishers, First Edition 2007.
2. Steen Strub M, “Routing in Communication networks”, Prentice Hall International, 1995.
3. S. Keshav, “An engineering approach to computer networking”, Addison Wesley, 1999.

REFERENCES:

1. William Stallings, “High speed networks and Internets Performance and Quality of Service”, Pearson Education Asia, IInd Edition, Reprint India, 2002.
2. William Stallings, “High speed Networks TCP/IP and ATM Design Principles”, PrenticeHall, New York, 1995.
3. Jean Walrand and PravinVaraiya, “High-Performance Communication Networks”, Second Edition, 2000.
4. C.E Perkins, “Ad Hoc Networking”, Addison – Wesley, 2001.

21PCM519	TELEMATICS FOR HEALTH	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To expertise on telematics in the field of healthcare.
- To explain the Role of Telehealth and Telemedicine in Homes and Communities.
- To summarize the telematics for telehealth applications.

UNIT 1	INTRODUCTION	9

Shifts in meaning of health, the use of telematics in Health care, health choices, telehealth and telemedicine: A case Study.

UNIT II	TELEHEALTH AND ADOLESCENTS	9

E Zoot, Handynet, Alarm systems, Video telephony, electronic town meetings, community television: Case Study.

UNIT 3	PROMOTING GOOD PRACTICES	9

Services for women with high risk pregnancies, Services for adolescents, services for disabled people, elderly people: social support for independent living.

UNIT 4	TELEHEALTH TECHNOLOGIES	9

Telehealth citizens and public policy making the technologies, health choices, policies for health. policy making.

UNIT V	APPLICATIONS	9

Telematics applications for- women, elderly people, neonatal, case study in various countries- Europe, USA and German

Total Hours - 45

COURSE OUTCOMES:

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

CO1	Explain the basic concepts of telematics.	**Understand**
CO2	Explain the telematics concepts for the healthcare.	**Understand**
CO3	Apply the knowledge of telematics to formulate health cycle.	**Apply**
CO4	Analyze the various case studies for healthcare applications	**Analyze**
CO5	Analyze the various performance of telehealth in telematics.	**Analyze**
CO6	Apply telematics to develop the Real time applications.	**Create**

Text Books:

1. Marjorie Gott, Telematics for Health: The Role of Telehealth and Telemedicine in Homes and Communities, 1995, 1st edition.

21PCM520	ADVANCED BIG DATA ANALYTICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To expertise on data science and big data analytics.
- To explain the concepts of big data ecosystem.
- To summarize the basic data analytic methods using R.

UNIT 1	INTRODUCTION	7

Big Data Overview, Data Structures, Analyst Perspective on Data Repositories,State of the Practice in Analytics,BI Versus Data Science, Current Analytical Architecture, Drivers of Big Data, Emerging Big Data Ecosystem and a New Approach to Analytics, Key Roles for the New Big Data Ecosystem.

UNIT II	DATA ANALYTICS LIFECYCLE	10

Data Analytics Lifecycle Overview, Discovery, Data Preparation, Model Planning, Model Building, Communicate Results, Operationalize, Case Study: Global Innovation Network and Analysis (GINA).

UNIT 3	REVIEW OF BASIC DATA ANALYTIC METHODS USING R	10

Introduction to R, R Graphical User Interfaces, Statistical Methods for Evaluation, Hypothesis Testing, Difference of Means, Wilcoxon Rank-Sum Test, Type I and Type II Errors, Power and Sample Size.

UNIT 4	ADVANCED ANALYTICAL THEORY AND METHODS	9

Overview of Clustering, K-means, Apriori Algorithm, Evaluation of Candidate Rules, Applications of Association Rules, Transactions in a Grocery Store, Transactions in a Grocery Store, Validation and Testing, Linear Regression, Logistic Regression.

UNIT V	ADVANCED ANALYTICS	9

Analytics for Unstructured Data, The Hadoop Ecosystem, SQL Essentials, In-Database Text Analysis, Advanced SQL, Communicating and Operationalizing an Analytics Project.

Total Hours - 45

COURSE OUTCOMES:

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

CO1	Explain the basic concepts of big data analytics.	**Understand**
CO2	Explain the data science concepts for the advanced analytics.	**Understand**
CO3	Apply the knowledge of data analytics to formulate life cycle.	**Apply**
CO4	Analyze the big data analytic methods using R.	**Analyze**
CO5	Analyze the various performance of SQL in analytics.	**Analyze**
CO6	Develop Real time application using Big Data Analytics.	**Create**

TEXT BOOKS:

1. Radha Shankarmani, M. Vijayalakshmi, “Big Data Analytics”, 2nd Edition, Wiley, 2017.
2. EMC Education Services , “Data Science and Big Data Analytics”, Discovering, Analyzing, Visualizing and Presenting Data, Wiley,2015.

21PCM521	WIRELESS SENSOR NETWORKS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To expertise on sensor networks and their Applications, localization and positioning.
- To explain the concepts of routing protocols and topology control.
- To summarize the Operating Systems and Programming Concepts for WSNs.

UNIT 1	INTRODUCTION	9

Wireless Sensor Networks - Characteristics requirements- -Unique Constraints and Challenges - Difference between Mobile adhoc and Sensor Networks- Advantages of sensor networks - Sensor Node Architecture - Sensor Network Architecture - Sensor Networks Applications: Environmental Monitoring, Industry Automation, Disaster Management, Mobile Crowd Sensing Applications -Smart Cities, Road Transportation, Health Care and Well-Being, Marketing/Advertising.

UNIT II	LOCALIZATION AND POSITIONING	9

Properties of localization and positioning procedures, Possible approaches, Mathematical basics for the lateration problem, Single-hop localization, Positioning in multi hop environments, Impact of anchor placement.

UNIT III	ROUTING PROTOCOLS FOR WIRELESS SENSOR NETWORK	9

Medium Access Control - The S-MAC Protocol- IEEE 802.15.4 Standard and ZigBee - General Issues **-** Geographic, Energy-Aware Routing - Unicast Geographic Routing - Routing on a Curve-Energy-Minimizing Broadcast - Energy-Aware Routing to a Region - Attribute-Based Routing - Directed Diffusion - Rumor Routing - Geographic Hash Tables .

UNIT IV	TOPOLOGY CONTROL	9

Topology Control - Clustering - Time Synchronization - Clocks and Communication Delays - Interval Methods - Reference Broadcasts - Localization and Localization Services -Ranging Techniques - Range-Based Localization Algorithms - Other Localization Algorithms - Location Services.

UNIT V	OPERATING SYSTEMS AND PROGRAMMING WSN	9

Operating Systems for WSNs: Introduction, Architecture, Execution Model Case Study: Popular Operating Systems-TinyOS, Contiki, MagnetOS, Mantis OS. Programming WSNs: Simulation Tools-TOSSIM, COOJA, Castalia, NS-3 Case study: Performance comparison of energy efficient cluster based routing protocols.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1	Describe the advantages and applications of sensor networks.	**Understand**
CO2	Discuss the different methods of localization and positioning methods.	**Understand**
CO3	Apply the knowledge of sensor network to design different network architecture.	**Apply**
CO4	Analyze the flat and hierarchical network topology control.	**Apply**
CO5	Analyze the various routing protocols in sensor networks.	**Analyze**
CO6	Develop Energy efficient protocols for wireless sensor networks.	**Evaluate**

REFERENCES:

1. Feng Zhao Feng Zhao Leonidas Guibas Leonidas Guibas, Wireless Sensor Networks,"An Information Processing Approach, 1st Edition, 2004, Elsevier.
2. Holger Karl And Andreas Willig, " Protocols and Architectures for Wireless Sensor Networks ", John Wiley & Sons, 2005.
3. KazemSohraby, Daniel Minoli, &TaiebZnati, "Wireless Sensor Networks-s Technology, Protocols, And Applications ", John Wiley, 2007.
4. Nandini Mukherjee SarmisthaNeogySarbani Roy, Building Wireless Sensor Networks Theoretical & Practical Perspectives, CRC Press, 2016.
5. John R. Vacca, Handbook of Sensor Networking Advanced Technologies and Applications, CRC Press, 2015.

21PCM522	RF CIRCUITS AND MICROWAVE SYSTEMS	L	T	P	C
		3	0	0	3

PRE-REQUISITE: MICROWAVE ENGINEERING

COURSE OBJECTIVES:

- To familiarize the concept of filters and RF amplifier design.
- To familiarize with the usage of active and passive components of microwave systems.
- To know the various microwave measurements and its effect on different applications.

UNIT I	RF TRANSISTOR AMPLIFIER DESIGN	9

RF Components: Diodes, BJT, FET, Characteristics of Amplifiers-Amplifiers Power relations-Stability Considerations-Constant Gain-Noise Figure Circles-Constant VSWR circles-Broadband High Power and Multistage Amplifiers.

UNIT II	RF FILTER DESIGN	9

Generalization-Basic Resonator and Filter configurations: Low pass, High Pass, Band Pass and Band stop type Filters-Special filter Realizations-Filter Implementations using unit element and kuroda`s identities-Coupled Filters.

UNIT III	RF OSCILLATORS AND MIXERS	9

Basic Oscillator Model, High-Frequency Oscillator Configuration, Dielectric Resonator Oscillators, YIG-Tuned Oscillator, Basic Characteristics of Mixers, Single-Ended Mixer Design, Single-Balanced Mixer, Double-Balanced Mixer.

UNIT IV	INTRODUCTION TO MICROWAVE SYSTEMS	9

Wireless Communications system, Radar Systems, Radiometer Systems, Satellite Communication, Remote sensing, Radio Navigation and Global Positioning Systems, Microwave Propagation, Microwave Antennas.

UNIT V	MICROWAVE MEASUREMENTS	9

Power, Frequency and impedance measurement at microwave frequency, Network Analyzer and measurement of scattering parameters, Spectrum Analyzer and measurement of spectrum of a microwave signal, Noise at microwave frequency and measurement of noise figure, Measurement of Microwave antenna parameters.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion, the student will be able to

CO1	Explain the basic concept of RF circuits and microwave systems.	**Understand**
CO2	Apply the knowledge of active components to design the RF devices.	**Apply**
CO3	Apply the knowledge of spectrum analyzer to measure the spectrum of a microwave signal.	**Apply**
CO4	Analyze the performance parameters of filters used for RF circuits.	**Analyze**
CO5	Analyze the RF signals using the various measurement techniques.	**Analyze**
CO6	Design a circuit using RF and Microwave components for wireless communication system.	**Analyze**

REFERENCE BOOKS:

1. Reinhold .Ludwig and Pavel Bretshko, “RF Circuit Design”, Pearson Education, 2006.
2. Joseph J. Carr, “RF Components and Circuits”, Newnes, 2002.
3. AnanjanBasu “An Introduction to Microwave Measurements”, CRC Press July 2017.
4. Kai chang, “RF and Microwave Wireless Systems” wiley edition 2000.

21PCM523	MIMO SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge about MIMO Channel modeling and system architecture.
- To introduce space time block codes and space time trellis codes.
- To explain the practical applications of MIMO systems.

UNIT I	SPATIAL MULTIPLEXING AND CHANNEL MODELING	9

Review of SISO fading communication channels- Multiplexing capability of deterministic MIMO, Physical modeling of MIMO Channels, Modeling of MIMO fading channels, MIMO wireless communication, MIMO channel and signal model, A fundamental trade-off, MIMO transceiver design, MIMO in wireless networks, MIMO in wireless standards.

UNIT II	CAPACITY AND MULTIPLEXING ARCHITECTURES	9

The V-BLAST architecture, Fast fading MIMO channel. Receiver architectures, Slow fading MIMO channel, D-BLAST: an outage-optimal architecture.

UNIT III	DIVERSITY–MULTIPLEXING TRADEOFF AND SPACE TIME BLOCK CODES	9

Diversity–multiplexing tradeoff, Space time block codes on real and complex orthogonal designs, Code design criteria for quasi-static channels (Rank, determinant and Euclidean distance), Quasi-orthogonal designs and Performance analysis.

UNIT IV	SPACE TIME TRELLIS CODES	9

Representation of STTC, shift register, generator matrix, state-transition diagram, trellis diagram, Code construction, Delay diversity as a special case of STTC and Performance analysis.

UNIT V	MULTIUSER COMMUNICATION	9

Access protocols: duty-cycle, scheduled, random access, polling-based, Uplink with multiple receive antennas, MIMO uplink, Downlink with multiple transmit antennas, MIMO downlink, MIMO in 4G (LTE, LTE-Advanced and WiMAX) and 5G, Antenna partitioning technique for MIMO-CDMA systems.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1	Describe the concepts of mathematical model for the design of MIMO channels	**Understand**
CO2	Design a space time MIMO wireless communication architecture for the given specifications	**Apply**
CO3	Analyze and Design various space time block codes.	**Apply**
CO4	Analyze the wireless channel characteristics and identify appropriate channel models.	**Analyze**
CO5	Analyze the performance of MIMO systems in various applications.	**Analyze**
CO6	Design space time trellis codes for a given specification and develops skills to solve engineering problems	**Evaluate**

TEXT BOOKS:

1. Nei David Tse and Pramod Viswanath, “Fundamentals of Wireless Communication ”, Cambridge University Press 2005, Press 2005.
2. Hamid Jafarkhani, , “ Space-Time Coding: Theory and Practice ”, Cambridge University, Press 2005.

REFERENCES:

1. Paulraj, R. Nabar and D. Gore, “Introduction to Space-Time Wireless Communications ”, Cambridge University, Press 2005.
2. E.G. Larsson and P. Stoica,“Space-Time Block Coding for Wireless Communications ”, Cambridge University, Press 2008.
3. M. Janakiraman,“Space-time codes and MIMO systems ”, Artech House, 2004.
4. Ezio Biglieri , Robert Calder bank et al, “ MIMO Wireless Communications ”, Cambridge University, Press 2007.

21PCM524	VLSI DEVICE MODELLING	L	T	P	C
		3	0	0	3

OBJECTIVES

- To impart the knowledge of MOS models and their second order effects.
- To describe the methods for analyzing MOSFET scaling.
- To introduce the concept of Quantum phenomena in MOS transistors.

UNIT 1	MOS MODELS	9

MOS operation, Equivalent circuit representation of MOS Transistor, Types of Compact Model, Basic modeling, Advanced MOSFET modeling, RF modeling of MOS transistors- Charge model, Quasi and non-Quasi static model.

UNIT II	MOS SECOND ORDER EFFECT	9

Review of MOSFET Current Equation - MOSFET Channel Mobility- MOSFET capacitances and Inversion- Layer Capacitance effect - Short Channel MOSFETs

UNIT III	MOSFET SCALING	9

Constant-Field scaling – Generalized Scaling – Non scaling Effects- Threshold-Voltage Requirement – Channel Profile Design – Non-uniform Doping – Quantum Effect on Threshold Voltage – Discrete Dopant Effects on Threshold Voltage- MOSFET Channel Length.

UNIT IV	QUANTUM PHENOMENA IN MOS TRANSISTORS	9

Carrier Energy Quantization in MOS capacitor-2-D Density of States- Electron Concentration Distribution-Approximate Methods- Quantization Correction in Compact MOSFET Models- Quantum Tunneling-Gate Current Density-Compact Gate Current Models-Gate Induced Drain Leakage (GIDL)

UNIT V	NON CLASSICAL MOSFET STRUCTURE	9

Silicon-On-Insulator Devices – SOI CMOS – Partially Depleted SOI MOSFETs – Fully Depleted SOI MOSFETs- Dual Material Gate MOSFETs, Surrounding Gate MOSFETs - Multigate MOSFETs- FINFETs-TFETs – HEMTs – Silicon Nanowires – Junction less FETs.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1	Explain in detail about the different modeling of MOS transistor	**Understand**
CO2	Apply the concept of quantum phenomena in MOS Transistors models	**Apply**
CO3	Apply the technologies used in non-classical MOSFET structure in real time applications	**Apply**
CO4	Apply the concept of device modeling to differentiate Non-classical and Multigate MOSFET.	**Apply**
CO5	Analyze the different types of MOSFET Scaling	**Analyze**
CO6	Analyze long channel and short channel MOSFET devices	**Analyze**

REFERENCES:

1. Y. Taur and T. H. Ning, “Fundamentals of Modern VLSI Devices”, Cambridge University Press, Cambridge, UnitedKingdom, 2015
2. A.B.Bhattacharyya , “ Compact MOSFET Models for VLSI Design”, John Wiley & Sons Ltd,2009.
3. Trond Ytterdal, Yuhua Cheng and Tor A. Fjeldly Wayne Wolf, “Device Modeling for Analog and RF CMOS Circuit Design”, John Wiley & SonsLtd.
4. Snowden C. M., Introduction to Semiconductor Device Modeling, World Scientific Press, Singapore, 1986.
5. J.P.Colinge “FinFETs and other MultigateTransistors”, 2007.

21PCM525	UBIQUITOUS COMPUTING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES :

- To impart some of the fundamental concepts of ubiquitous computing.
- To explore the high level facilities, system architecture and protocols of the ubiquitous system
- To familiarize the students on Smart Devices and Services in the network design and management.

UNIT I	INTRODUCTION	9

Overview- Founding Contributions to Ubiquitous Computing, Ubicomp Systems and Challenges, Creating Ubicomp Systems, Evaluating and Documenting Ubicomp Systems, and Networking Basics: NFC, Wireless LAN.

UNIT II	UBIQUITOUS COMMUNICATION	9

Introductions, Audio Networks, Data Networks, Wireless Data Networks, Universal and Transparent Audio, Video and Alphanumeric Data Network Access, Ubiquitous Networks, Further Network Design Issues, Service Oriented Networks.

UNIT III	CONTEXT AWARE COMPUTING	9

Modelling Context Aware Systems, Mobility Awareness, Spatial Awareness, Temporal Awareness: Coordinating and Scheduling, ICT System Awareness.

UNIT IV	SMART DEVICES AND SERVICES	8

Introduction, Service Architecture Models, Service Provision Life Cycle, Service Invocation, Virtual Machines and Operating Systems.

UNIT V	SMART MOBILES,CARDS AND DEVICE NETWORKS	10

Smart Phones, Smart Cards and related hardware / software concepts (OS included),select case studies, connectivity through Gateway services: the OSGi Human–Computer, Hidden UI Via Basic Smart Devices, Human Centred Design (HCD), User Models: Acquisition and Representation.

TOTAL: 45 Periods

COURSE OUTCOMES:

After completion, the student will be able to

CO1	Describe the fundamental concepts of ubiquitous computing and its performance.	**Understand**
CO2	Apply the knowledge of networking to facilitate next generation computing.	**Apply**
CO3	Design and implement ubiquitous computing in various smart devices.	**Apply**
CO4	Apply the knowledge of networking concepts to propose solutions for security and privacy issues.	**Apply**
CO5	Analyze the various devices in ubiquitous computing systems.	**Analyze**
CO6	Design real time application using ubiquitous computing.	**Create**

REFERENCES:

1. John Krumm, Ubiquitous Computing Fundamentals, CRC Press, 2010.
2. StefenPoslad: Ubiquitous Computing: Smart Devices, Environments and Interactions, iley, London, 2009, Indian reprint, 2014.

21PCM526	SOFT COMPUTING TECHNIQUES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce soft computing concepts.
- To explain the concepts of artificial neural network and fuzzy logic.
- To impart knowledge on optimization and genetic algorithms.

UNIT I	ARTIFICIAL NEURAL NETWORK I	9

Fundamental concept – Evolution of Neural Networks – Basic Models of Artificial Neural Networks– Important Terminologies of ANNs– McCulloch-Pitts Neuron–Linear Separability, Hebb Network- Supervised Learning Network: Perceptron Networks – Adaline – Back-Propagation Network – Radial Basis Function Network.

UNIT II	ARTIFICIAL NEURAL NETWORK- II	9

Associative Memory Networks: Training Algorithms for Pattern Association – Auto associative Memory Network – Hetero associative Memory Network – Bidirectional Associative Memory – Hopfield Networks – Iterative Auto associative Memory Networks – Temporal Associative Memory Network -Learning Networks: Fixed weight Competitive Nets, Unsupervised – Kohonen Self-Organizing Feature Maps – Learning Vector Quantization-Counter propagation Networks-Adaptive Resonance Theory Networks-Special Networks.

UNIT III	FUZZY SET THEORY I	9

Introduction to Classical Sets - Fuzzy sets – Classical Relations - Fuzzy Relations – Tolerance and Equivalence Relations – Non interactive Fuzzy sets – Membership Functions- Fuzzification – Methods of Membership Value Assignments – Defuzzification – Lambda-Cuts for Fuzzy sets and Fuzzy Relations – Defuzzification Methods.

UNIT IV	FUZZY SET THEORY II	9

Fuzzy Arithmetic and Fuzzy Measures: Fuzzy Rule Base and Approximate Reasoning: Truth values and Tables in Fuzzy logic – Fuzzy Propositions – Formation of Rules – Decomposition and Aggregation of rules – Fuzzy Reasoning – Fuzzy Inference Systems (FIS) – Fuzzy Decision Making.

UNIT V	GENETIC ALGORITHMS	9

Genetic Algorithms- Basic Operators and Terminologies in Gas-Simple GA- General Genetic Algorithms – the Scheme Theorem—Classification of Genetic Algorithms-Holland Classifier systems-Genetic programming and applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Explain the difference between learning and programming and explore practical applications of Neural Networks.	**Understand**
CO2	Apply the concept of mathematical theory to design the FIS	**Apply**
CO3	Apply the optimization methods for its use in computer engineering fields and other domains	**Apply**
CO4	Apply the traditional genetic algorithms for various applications.	**Apply**
CO5	Simulate AI algorithms for real time applications.	**Apply**
CO6	Analyze the applications which can use fuzzy logic.	**Analyze**

TEXT BOOKS:

1. S.N. Sivanandan and S.N. Deepa, Principles of Soft Computing, Wiley India, 2007.ISBN: 10: 81-265-1075-7.
2. J.S.R.Jang,C.T.Sun,E.Mizutani,Neuro-Fuzzy and Soft Computing,Prentice Hall Inc., 1997

REFERENCES:

1. TimothyJ.Ross, Fuzzy Logic with Engineering Applications, McGraw-Hill,1997.
2. J.S.R.Jang, C.T.S.un and E.Mizutani, Neuro-Fuzzy and Soft Computing, PHI,2004, PearsonEducation.
3. S. Rajasekaran and G.A.V.Pai, “Neural Networks, Fuzzy Logic and Genetic Algorithms”, PHI2010.

21PCM527	MACHINE LEARNING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge about the concepts of machine learning.
- To introduce the fundamental concepts of distributed nature of operating system, network, data and processes.
- To enable the students to understand the concepts of computing environment where computations do not take place at one system and accordingly enable them to solve related problems.

UNIT I	INTRODUCTION TO MACHINE LEARNING	9

Brief Introduction to Machine Learning Supervised Learning, Unsupervised Learning, Reinforcement Learning.

UNIT II	PROBABILITY AND STATISTICAL DECISION THEORY	9

Probability Basics Linear Algebra Statistical Decision Theory – Regression & Classification Bias – Variance Linear Regression Multivariate Regression.

UNIT III	DIMENSIONALITY REDUCTION	9

Dimensionality Reduction Subset Selection, Shrinkage Methods, Principle Components Regression Linear Classification, Logistic Regression, Linear Discriminant Analysis Optimization, Classification-Separating Hyper planes Classification.

UNIT IV	ARTIFICIAL NEURAL NETWORK	9

Artificial Neural Networks (Early models, Back Propagation, Initialization, Training & Validation) Parameter Estimation (Maximum Likelihood Estimation, Bayesian Parameter Estimation) Decision Trees Evaluation Measures, Hypothesis Testing Ensemble Methods, Graphical Models

UNIT V	CLUSTERING AND MIXTURE MODELS	9

Clustering, Gaussian Mixture Models, Spectral Clustering Ensemble Methods Learning Theory, Reinforcement Learning

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1	Understand machine learning techniques and computing Environment that are suitable for the applications under consideration.	**Understand**
CO2	Apply the knowledge of artificial neural network to formulate different methods of machine learning	**Apply**
CO3	Implement various ways of selecting suitable model parameters for different machine learning techniques.	**Apply**
CO4	Analyze various algorithms to obtain suitable solutions.	**Analyze**
CO5	Solve problems associated with batch learning and online learning, and the big data characteristics such as high dimensionality, dynamically growing data and in particular scalability issues.	**Analyze**
CO6	Develop scaling up machine learning techniques and associated computing techniques and technologies for various applications.	**Create**

REFERENCES:

1. T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, Springer, 2008.
2. Christopher Bishop. Pattern Recognition and Machine Learning. 2e. Springer, 2006.
3. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning with application in R, Springer, 2017.
4. Ethem Alpaydin, Machine Learning: The new AI, MIT press, 2016.

21PCM528	OPTIMIZATION TECHNIQUES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn linear and non -linear programming problem.
- To understand the concept of queuing model, simulation and decision theory.
- Learn efficient computational procedures to solve optimization problems.

UNIT I	INTRODUCTION TO OPTIMIZATION	9

Definition-Classical Optimization Technics- Linear and Non- Linear Programming, Formulation of optimization problem- Simplex Method - Big M Method - Two phase method - Dual Simplex method - Integer Programming- Gomory All Integer cutting plane Method-Gomory Mixed Integer Method-Branch and Bound Method

UNIT II	LINEAR PROGRAMMING	9

Introduction – Unconstrained and Constrained Optimization- Kuhn Tucker conditions- Relative Maximum and Minimum values- Method of Lagrangian Multipliers- Hessian Matrix- Quadratic programming- Wolfe's Modified Simplex Method – Problems

UNIT III	PROGRAMMING	9

Recursive relationship - Solution to recursive equation - Dynamic Programming Algorithm - Principle of Optimality - Maximum and minimum values - Solution of LPP by Dynamic Programming - Multi stage problem

UNIT IV	NETWORKS	9

Introduction to Concept of Queuing Models - Single Server - Multiple server Models - Problems - Pollaczek Khinchine theorem. Theoretical concepts of Open queuing networks (Theory) - Closed Queuing Networks (Theory) - Queues in series (Theory).

UNIT V	ANALYSIS AND SIMULATION	9

Introduction to Decision Making process – Elements – Decision making under uncertainty – Maximin and Maximax criteria- Hurwitz criterion – Laplace criterion – Minimax Regret criterion – Decision tree analysis- Problems - Simulation - Nature and need for simulation - Monte Carlo method – Applications to Queuing systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Describe the fundamental concepts of design space, constraint surfaces and objective function.	**Understand**
CO2	Apply the Knowledge of Differential calculus to find the maxima and minima of functions of several variables.	**Apply**
CO3	Apply the Knowledge of objective function to solve Real-life problems with Linear Programming	**Apply**
CO4	Apply the Knowledge of objective function to solve the Linear Programming models using graphical and simplex methods.	**Apply**
CO5	Analyze the various travelling salesman concepts to find the optimum solution using transportation algorithms	**Analyze**
CO6	Analyze the Queuing model for effective customer satisfaction	**Analyze**

REFERENCES:

1. T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, Springer, 2008.
2. Christopher Bishop. Pattern Recognition and Machine Learning. 2e. Springer, 2006.
3. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning with application in R, Springer, 2017.
4. Ethem Alpaydin, Machine Learning: The new AI, MIT press, 2016.

21PCM529	DATA COMPRESSION TECHNIQUES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the concepts of compression techniques.
- Give knowledge on text compression and audio compression.
- To impart the concepts of image and video compression techniques.

UNIT 1	INTRODUCTION	9

Compression Techniques - Lossless compression - Lossy compression - Measures of performance- A brief introduction to Information theory - Models - Physical, Probability, Markov, Composite source model - Coding - uniquely Decodable codes, Prefix Codes - Huffman coding

UNIT 2	CONTEXT-BASED COMPRESSION	9

Arithmetic Coding - Dictionary techniques - The basic algorithm, the escape symbol, Length of context, the Exclusion principle - The Burrows - Wheeler transform - Move to front coding

UNIT 3	LOSSLESS IMAGE COMPRESSION	9

The Old JPEG Standard - CALIC - JPEG-LS - Multi resolution Approaches - Scalar quantization - Adaptive Quantization, non uniform Quantization - Vector quantization - Structured Vector Quantizers, Variations on the Theme

UNIT 4	AUDIO AND VIDEO COMPRESSION	9

MPEG advanced audio coding - MPEG-2 AAC, MPEG-4 AAC - Dolby AC3 (Dolby Digital) - Speech Compression - The MPEG-1 Video Standard - The MPEG-2 Video Standard - MPEG-4 Part 10, Advanced Video Coding - Packet Video

UNIT 5	ADVANCED TECHOLOGIES	9

CALIC - CCSDS - JPEG 2000 - EBCOT - LZ77 - LZ78- LZSS algorithm - Multi-Layer Perceptron (MLP) based Compression - Dee Coder- Deep Neural Network Based Video Compression - Convolutional Neural Network (CNN) based compression

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Explain the various compression techniques.	**Understand**
CO2	Apply the knowledge of various data compression algorithms to compute the data efficiency in terms of speed and compression ratio for various applications	**Apply**
CO3	Analyze different compression techniques and standards for image	**Analyze**
CO4	Compare various video compression standards for real time applications.	**Analyze**
CO5	Analyze basic compression algorithms using various modern tools.	**Analyze**
CO6	Evaluate the performance of coding techniques for real time applications.	**Evaluate**

TEXT BOOKS:

1. Khalid Sayood, " Introduction to Data Compression ", Morgan Kauffman Harcourt India, 3rd Edition, 2011.
2. David Salomon, " Data Compression – The Complete Reference ", Springer Verlag, 4th Edition, New York, 2011.

REFERENCES:

1. Yun Q.Shi, Huifang Sun, " Image and Video Compression for Multimedia Engineering - Fundamentals, Algorithms & Standards ", CRC press, 2003.
2. Mark S.Drew, Ze-Nian Li, " Fundamentals of Multimedia ", PHI, 1st Edition, 2004.

21PCM530	COGNITIVE RADIO NETWORKS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce the basic concept of Cognitive Radio Networks.
- To impart the knowledge of Cognitive Radio and Networks
- To introduce the different Dynamic Spectrum Access of Cognitive radio.

UNIT 1	INTRODUCTION TO COGNITIVE RADIO NETWORKS (CRN)	9

Software-defined radio - Cognitive radio features and capabilities - Research challenges in cognitive radio - Cognitive radio architectures for Next Generation (XG) networks - Cognitive radio standardization - Limitations with Cognitive Radio Network Applications - Architectural Descriptions of Cognitive Radio Networks - Cognitive Radio Networks as Heterogeneous Systems - Technologies to Drive Cognitive Radio Network.

UNIT 2	SPECTRUM SENSING IN COGNITIVE RADIO NETWORKS	9

Energy Detection Techniques - Matched Filter Detection Techniques - Cyclo-stationary Feature Detection Techniques - Waveform-Based Sensing Techniques - Radio Identification Sensing Techniques - Techniques that Employ Multiple Antennas - Problems Associated with Spectrum Sensing in CRN - Determining Sensing Accuracy- Cooperative Spectrum Sensing in Cognitive Radio Networks - Spectrum Prediction for Cognitive Radio Network Applications - Spectrum Sensing for Cognitive OFDMA Systems - Spectrum Sensing for Cognitive Multi-Radio Networks.

UNIT 3	RESOURCE MANAGEMENT IN COGNITIVE RADIO NETWORKS	9

Interference Management - Users' Distributions Modeling in Cognitive Radio Networks - Analysis of the Signal-to-Interference Plus Noise Ratio - Introducing Machine and Deep Learning into Cognitive Radio Networks - Training a Deep Learning Model- Application of Deep Learning in Spectrum Management - Deep Reinforcement Learning - The Role of Cognitive Radio Networks in Fifth-Generation Communication.

UNIT 4	DYNAMIC SPECTRUM ACCESS OF COGNITIVE RADIO	9

Spectrum access models - Dynamic spectrum access architecture - Medium access control for dynamic spectrum access - Open issues in dynamic spectrum access - Centralized dynamic spectrum access - Distributed dynamic spectrum access: cooperative and non-cooperative approaches.

UNIT 5	TRUSTED COGNITIVE RADIO NETWORKS	9

Framework of Trust in CRN - Trusted Association and Routing - Trust with Learning - Security in CRN - Spectrum Management of Cognitive Radio Networks: Spectrum Sharing - Spectrum Pricing - Mobility Management of Heterogeneous Wireless Networks - Regulatory Issues and International Standards - Public safety and cognitive radio.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Explain the concept of Cognitive Radio Networks	**Understand**
CO2	Apply appropriate techniques for the Spectrum Sensing in Cognitive Radio Networks	**Apply**
CO3	Apply the Cognitive Radio design methodologies for wireless applications.	**Apply**
CO4	Analyze the Spectrum Access of Cognitive Radio	**Analyze**
CO5	Analyze the different cognitive radio techniques for spectrum holes detection	**Analyze**
CO6	Compare the various sensing techniques in cognitive radio networks using modern tools	**Analyze**

TEXTBOOKS:

1. Bodhaswar TJ Maharaj, Babatunde Seun Awoyemi, Developments in Cognitive Radio Networks: Future Directions for Beyond 5G, Springer, 2022.
2. Ekram Hossain, Dusit Niyato, Zhu Han, Dynamic Spectrum Access and Management in CognitiveRadio Networks, Cambridge University Press 2009.
3. Kwang-Cheng Chen, Ramjee Prasad, Cognitive Radio Networks, John Wiley &Sons Ltd., 2009.

REFERENCES:

1. Alexander M. Wyglinski, Maziar Nekovee, And Y. Thomas Hou, “Cognitive Radio Communications and Networks - Principles And Practice”, Elsevier Inc., 2010.
2. Bruce Fette, Cognitive Radio Technology - Second Edition, Elsevier, 2009.
3. Huseyin Arslan, Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems, Springer, 2007.

21PCM531	5G MOBILE COMMUNICATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce 5G fundamentals
- To impart knowledge on the techniques and technologies used in 5G.
- To describe the applications of 5G**.**

UNIT 1	5G STANDARDIZATION	9

Historical Trend of Wireless Communications – Evolution of LTE Technology to Beyond 4G – 5G Roadmap – 10 Pillars of 5G – 5G in North America – 5G in Asia – 5G Architecture – The 5G Internet: Internet of Things and Context-Awareness – Networking Reconfiguration and Virtualization Support.

UNIT–2	SPECTRUM USAGE AND MANAGEMENT	9

Introduction – Spectrum for 5G – Spectrum Authorization and Usage Scenarios – Spectrum Bandwidth Demand Determination – Frequency Bands for 5G – Spectrum Usage Aspects at High Frequencies – Channel Modeling: Core Features of New Channel Models – Additional Features of New Channel Models.

UNIT–3	COGNITIVE RADIO AND SON FOR 5G WIRELESS NETWORKS	9

Introduction – Overview of Cognitive Radio Technology in 5G Wireless – Spectrum Optimization using Cognitive Radio –Energy-Efficient Cognitive Radio Technology – Key Requirements and Challenges for 5G Cognitive Terminals - SON in UMTS and LTE – The Need for SON in 5G – Evolution towards Small-Cell Dominant HetNets.

UNIT–4	RF TECHNOLOGIES AT MM-WAVE FREQUENCIES	9

LTE/NR Dual-Connectivity–LTE/NR Coexistence–ADC and DAC Considerations–LO generation and Phase Noise Aspects–Power Amplifier Efficiency in Relation to Unwanted Emission–Receiver Noise Figure, Dynamic Range, and Bandwidth Dependencies – Green Flexible RF for 5G

UNIT–5	mm WAVE AND TERAHERTZ SPECTRUM FOR 6G WIRELESS	9

Introduction to mmWave and THz Spectrum – Propagation at the mmWave and THz Frequencies – Channel Measurement Efforts – Propagation at mmWave and THz Frequencies – Beamforming and Antenna Patterns – Channel Models – The mmWave Communications Systems – The THz Communications Systems – Standardization Efforts

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Describe the function of next generation technology	**Understand**
CO2	Apply the knowledge of 5G techniques to solve the existing problems in communication.	**Apply**
CO3	Analyze the performance of 4G and 5G system.	**Analyze**
CO4	Analyze the factors affecting deployment of 5G in Indian scenario	**Analyze**
CO5	Evaluate the Spectral efficiency for various frequency bands.	**Evaluate**
CO6	Generate and evaluate the performance of the 5G uplink and downlink model using MATLAB	**Evaluate**

REFERENCES:

1. Fundamentals of 5G Mobile Networks, Jonathan Rodriguez,John Wiley &sons, 2015.
2. 5G System Design Architectural and Functional Considerations and Long Term Research Patrick Marsch,Deutsche Bahn AG, ÖmerBulak, John Wiley &sons, 2018.
3. 5G NR: The Next Generation Wireless Access Technology, Erik Dahlman, Stefan Parkvall, Johan Skold.Elsevier 2018.
4. 5G Mobile Communications, Wei Xiang ,KanZheng,Xuemin (Sherman) Shen, Springer International Publishing Switzerland 2017.
5. Towards 5G Wireless Networks, A Physical Layer Perspective, HosseinKhaleghiBizaki, Intech open book series 2016.

COURSE CATEGORY: OPEN ELECTIVE

S.No	Course Code	Course Title	L	T	P	C
1.	**21PCD601**	Industrial Safety	**3**	**0**	**0**	**3**
2.	**21PCS602**	Business analytics	**3**	**0**	**0**	**3**
3.	**21PCM603**	IoT for Smart Applications	**3**	**0**	**0**	**3**
4.	**21PPE604**	Bio Energy from Waste	**3**	**0**	**0**	**3**
5.	**21PSE605**	Smart City Technologies	**3**	**0**	**0**	**3**

COURSE CATEGORY: AUDIT COURSES

S.No	Course Code	Course Title	L	T	P	C
1.	**21PGM801**	Pedagogy Studies	**3**	**0**	**0**	**0**
2.	**21PGM802**	English for Research Paper Writing	**3**	**0**	**0**	**0**

OPEN ELECTIVE

21PCM603	IOT FOR SMART APPLICATIONS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To obtain and analyze data from things (devices).
- To learn the architecture of IoT Protocol standards.
- To design and implement Smart IoT applications.

UNIT 1	M2M AND IOT- INTRODUCTION	9

The Vision-Introduction, From M2M to IoT, M2M towards IoT-the global context, A use case example, Differing Characteristics.

UNIT II	M2M AND IOT TECHNOLOGY FUNDAMENTALS	9

Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service (XaaS), M2M and IoT Analytics, Knowledge Management.

UNIT III	IOT REFERENCE ARCHITECTURE	9

IoT Architecture -State of the Art – Introduction, State of the art, Architecture Reference Model-Introduction, Reference Model and architecture, IoT reference Model, IoT Reference Architecture-Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views.

UNIT IV	SENSORS AND SMART APPLICATIONS	9

Principles, Classification, Parameters, Characteristics, Environmental Parameters (EP), Characterization. Mechanical and Electromechanical Sensors: Introduction, Resistive Potentiometer, Strain Gauge, Resistance Strain Gauge, Semiconductor Strain Gauges, Inductive Sensors-Sensitivity and Linearity of the Sensor, Types- Capacitive Sensors, Electrostatic Transducer, Force/Stress Sensors using Quartz Resonators, Ultrasonic Sensors, Introduction, On-board Automobile Sensors (Automotive Sensors), Home Appliance Sensors, Aerospace Sensors, Sensors for Manufacturing, Sensors for environmental Monitoring.

UNIT V	INTERNET OF THINGS –PRIVACY, SECURITY AND GOVERNANCE	9

Introduction, Overview of Governance, Privacy and Security Issues, Smartie Approach. Data Aggregation for the IoT in Smart Cities and Security issues**.**

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1	Describe the IoT communication protocol Standards and its challenges	**Understand**
CO2	Describe the concept of M2M & IoT	**Understand**
CO3	Apply the concept of IoT fundamentals to differentiate various IoT architecture	**Apply**
CO4	Apply knowledge of IoT technology for developing smart IoT applications	**Apply**
CO5	Apply the knowledge of IoT technology to select the appropriate sensors for developing real-time applications	**Apply**
CO6	Analyze the security and privacy issues in IoT.	**Analyze**

REFERENCES:

1. Kao-Cheng Huang and Zhaocheng Wang, “Millimeter Wave communication From Machine-to-Machine to the Internet of Things Introduction to a New Age of Intelligence,Jan Ho ̈ller, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle, Academic Press,2014
2. Vijay Madisetti and Arshdeep Bahga, “Internet of Things (A Hands-on-Approach)”, 1st Edition, VPT, 2014.
3. Francis da Costa, “Rethinking the Internet of Things: A Scalable Approach to Connecting Everything”, 1stEdition, A press Publications, 2013.
4. Cuno Pfister, “Getting Started with the Internet of Things”, O Reilly Media, 2011.
5. McEwen, H. Cassimally, “Designing the Internet of Things”, Wiley, 2013.
6. Samuel Green guard, “Internet of things”, MIT Press, 2015.

AUDIT COURSES

COURSE CATEGORY: AUDIT COURSES

S.No	Course Code	Course Title	L	T	P	C
1.	**21PGM801**	Pedagogy Studies	**3**	**0**	**0**	**0**
2.	**21PGM802**	English for Research Paper Writing	**3**	**0**	**0**	**0**

21PGM801	PEDAGOGY STUDIES	L	T	P	C
		3	0	0	0

OBJECTIVES:

- To make the students understand a range of cognitive capacities in human learners.
- To explain the outcome-based education system.
- To describe the curriculum design process.

UNIT – 1	EDUCATIONAL PSYCHOLOGY AND ENGINEERING EDUCATION	4

Learning process, motivation and engagement, ICT in learning and teaching, Facilitating the learners, Engineering education and recent trends, Research in Engineering education, General maxims of teaching, Teacher-centered, learner-centered and learning-centered approaches, Becoming a reflective teacher, Disruptive Innovation in Education.

UNIT – 2	OUTCOME BASED EDUCATION	4

Outcome Based Education: A broad context for quality teaching and learning, planning for quality teaching and learning, Necessity for learning outcomes - Course Outcomes and Program Outcomes, Defining learning outcomes, learning outcomes in the cognitive domain, learning outcomes in the affective domain, learning outcomes in the psychomotor domain, Program Outcomes, Graduate Attributes, Program Educational Objectives, linking learning outcomes to teaching and assessment.

UNIT – 3	CURRICULUM DESIGN	4

Curriculum design cycle, curriculum structure, credit and academic load, need assessment – feedback from stakeholders, concept of “Constructive alignment”, the two loop approach of ABET, tuning approach of curriculum design, CDIO concept of curriculum design and implementation, Industry relevant curriculum design and implementation, concept mapping, Instructional design and delivery.

UNIT – 4	TEACHING AND ASSESSMENT STRATEGIES	4

Direct instruction as teaching strategy, co-operative learning, problem-solving, industry relevant teaching, role-play, case study, technology enabled teaching, research orientation, measurement and evaluation of students’ achievement, assessment of learning outcomes - assessment tools: direct and indirect assessment tools, rubrics for assessment, attainment analysis, corrective action-curriculum updation, improvement in pedagogy, innovative assessment methods.

TOTAL : 16 PERIODS

COURSE OUTCOMES:

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

CO1	Write learning outcomes and link learning outcomes to appropriate assessments.	**Understand**
CO2	Design syllabus and lesson plans that align with learning outcomes.	**Apply**
CO3	Use technology to enhance teaching and learning.	**Apply**
CO4	Choose teaching-learning strategies appropriate to the needs of the learners.	**Apply**
CO5	Develop pedagogical expertise through an introduction to theoretically-based teaching methods and strategies.	**Create**

REFERENCES:

1. Dr.Sue Duchesne, Anne McMaugh, Sandra Bochner, Kerri-Lee Krause, “Educational Psychology for Learning and Teaching”, Cengage Learning, 4th Edition, 2019.

2. Lisa R. Lattuca, Patrick T. Terenzini, J. Fredericks Volkwein, and George D. Peterson, “The Changing Face of Engineering Education” The Bridge, National Academy of Engineering, Summer 2006.
3. Anderson, L. & Krathwohl, D. A Taxonomy for Learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. New York: Longman, 2001.
4. Blumberg, P. Developing learner-centred teaching: A practical guide for faculty. San Francisco: Jossey-Bass, 2017.
5. Teaching Support Services. Learning objectives. University of Guelph, Guelph, Ontario. Retrieved from http://www.uoguelph.ca/tss/resources/idres/learningobjectives1.pdf.
6. O.V. Boev, N.Gruenwald and G.Heitmann, “Engineering Curriculum Design aligned with Accrediation Standards”, Hochschule Wismar Publishers, 2013.
7. Fink, D. L. Integrated course design. Manhattan, KS: The IDEA Center, 2005. Retrieved from http://www.theideacenter.org/sites/default/files/Idea_Paper_42.pdf

21PGM802	ENGLISH FOR RESEARCH PAPER WRITING	L	T	P	C
		3	0	0	0

OBJECTIVES:

- To give and exposure on writing skills and readability.
- To impart the knowledge of each section of the paper.
- To enhance the student to write the good quality Research paper.

UNIT I	INTRODUCTION TO RESEARCH	9

Introduction to Research Paper, Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs, Clarity and Removing Redundancy, Highlighting the Findings, Hedging and Criticizing, Paraphrasing and Plagiarism - Useful idioms & phrases.

UNIT II	STRUCTURE OF RESEARCH PAPER	6

Types of the Research papers, Regular Research Paper - Review Research Paper – Case Study Research Paper – Research Letters - Sections of a Paper, Title, Author names and affiliations - Corresponding author - Abstracts, Keywords, Highlights, Graphical Abstract - Introduction, Methods, Results, Discussion, Conclusions, Acknowledgment - the First Draft.

UNIT III	METHODOLOGY, RESULTS & DISCUSSION AND CONCLUSION	9

Introduction - Writing preview of Research work - Review of literature – assimilating the points - Logical flow - Research gap - Writing the Methodology - Sequence - Specification - Explaining results - Interpretation and plotting - Discussion of the salient findings - Critical analysis - Writing the Conclusion.

UNIT IV	SUBMISSION OF RESEARCH PAPER	6

References – Citations and Checking the Citations – Various forms of Citation – Guidelines for authors –Manuscript submission – Conflict of Interest - Authors reply for Reviewer comments – Point by Point Explanation – Resubmission – Acceptance – Copyright – Proof reading and final submission.

TOTAL : 30 PERIODS

COURSE OUTCOMES:

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

CO1	Write research paper effectively with improved standard of language.	**Understand**
CO2	Explain the different sections of the Research paper	**Understand**
CO3	Formulate the Acceptable Research Manuscript	**Apply**

REFERENCES :

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

ADDITIONAL READING :

1. MLA Handbook for Writers of Research Papers, The Modern Language Association of America, New York 2009.