Scheme for Master of Technology

in

Electronics and Communication Engineering

(COMMUNICATION SYSTEMS)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY, KURUKSHETRA

MISSION AND VISION OF THE INSTITUTION:

VISION

To be a role-model in technical education and research, responsive to global challenges.

MISSION

To impart technical education that develops innovative professionals and entrepreneurs and to undertake research that generates cutting-edge technologies and futuristic knowledge, focusing on the socio-economic needs.

VISION AND MISSION OF THE DEPARTMENT

VISION

To impart state-of-the-art Electronics and Communication Engineering Education and Research responsive to global challenges.

MISSION

M1: To prepare students with strong theoretical and practical knowledge by imparting quality education.

M2: To produce comprehensively trained and innovative graduates in Electronics and Communication Engineering through hands on practice and research to encourage them for entrepreneurship.

M3: To inculcate team work spirit and professional ethics in students.

VISION AND MISSION OF THE PROGRAM

VISION

To become a center of education and research in Electronics and Communication Engineering with the capability to meet future challenges of the society.

MISSION

M1: To impart excellent education in Electronics and Communication Engineering for professional roles in a dynamic and challenging technological world.

M2: To advance knowledge through quality research in emerging areas.

M3: To build a strong relationship with industry, academia and society.

PROGRAM OUTCOMES (POs)

Electronics and Communication Engineering (Communication Systems)

Graduates of the Programme:

PO1 : shall be able to utilize domain knowledge required for analyzing and resolving problems of Communication systems.

PO2 : shall have the ability to write and present a substantial technical report of the comprehended problem and its recommended solution.

PO3 : shall demonstrate a definite higher degree of mastery in the comprehension and analysis of Communication Engineering problems.

PO4 : shall be equipped with theoretical and practical skills to investigate and undertake complex projects of inter-disciplinary nature with wide impact.

PO5 : shall imbibe social and environmental ethics, readily adapting to ever changing and transforming technical requirements and working towards sustainable development of the society.

PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

The postgraduate students of the Electronics and Communication Engineering **(Communication Systems)** Program will

PEO1: Possess fundamental as well as advanced knowledge with research initiatives in the field of **Communication Systems**.

PEO2: Be able to design solutions for electronic system for real world applications which are technically feasible and economically viable leading to social benefits.

PEO3: Possess team spirit, have communication skills, ethical and professional attitude for lifelong learning

Electronics and Communication Engineering (Communication Systems)

Master of Technology Electronics & Communication Engineering (Communication Systems)

Proposed Course Structure for Two-Year M.Tech. ECE program

Semester-I

Subject Code	Course Title	L-T-P	Credits
MEC1C01	Stochastic Processes	3-0-0	3
MEC1C03	Advanced Digital Signal Processing	3-0-0	3
MEC1C05	Advanced Digital Communication	3-0-0	3
	Departmental Elective I	3-0-0	3
	Departmental Elective-II	3-0-0	3
	Departmental Elective-III	3-0-0	3
MEC1L07	Communication Lab	0-0-2	1
	Total	**18-0-3=21**	**19**

Weight age for Theory Courses:

During Semester Evaluation Weightage – 50%
End Semester Examination Weightage - 50%

Weightage for Lab. Courses:

During Semester Evaluation Weightage -60%
End Semester Examination Weightage - 40%

List of Departmental **Electives**:

MEC1E31 Wireless Networks

MEC1E33 Image Processing

MEC1E35 Microwave Theory and Devices

MEC1E37 Statistical Signal Processing

MEC1E39 Satellite and Space Communication

MEC1E41 Computer Networks

MEC1E43 Introduction to Soft Computing and Machine Learning

MEC1E45 Modeling and Synthesis with Verilog HDL

MEC1E47 Internet of Things (IoT)

Electronics and Communication Engineering (Communication Systems)

Semester-II

Subject Code	Course Title	L-T-P	Credits
MEC1C02	Emerging Wireless Technologies	3-0-0	3
MEC1C04	Detection and Estimation	3-0-0	3
MEC1C06	Information and Network Security	3-0-0	3
	Departmental Elective-I	3-0-0	3
	Open Elective/Departmental Elective	3-0-0	3
MEC1P08	Minor Project Work	0-0-4	2
MEC1L10	Simulation lab	0-0-2	1
	Total	**15-0-7=22**	**18**
MEC1T12	Summer Training /Term Course	_	_

Weight age for Theory Courses:

During Semester Evaluation Weightage – 50%
End Semester Examination Weightage - 50%

Weight age for Lab. Courses:

During Semester Evaluation Weightage -60%
End Semester Examination Weightage- 40%

List of Departmental Electives:

MEC1E30 Research Analysis for Engineering

MEC1E32 Wireless Sensor Networks

MEC1E34 System Modeling and Simulation

MEC1E36 Mobile Computing

MEC1E38 Speech Processing

MEC1E40 Digital Signal Processors and Applications

MEC1E42 Adaptive Signal Processing

MEC1E44 Error Control Coding

MEC1E46 MIMO Wireless Communications

MEC1E48 Selected Topics in Communication Engineering

List of Open Electives:

MEC1O72 Sensors Technology

MEC1O74 Cyber Physical System

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Semester-III

Subject Code	Course Title	Credits
MEC1D/P/I09	Dissertation/project work/internship -I	14

Semester –IV

Subject Code	Course Title	Credits
MEC1D/P/I10	Dissertation/project work/internship-II	14

Electronics and Communication Engineering (Communication Systems)

SEMESTER-I

MEC1C01 STOCHASTIC PROCESSES

L T P
3 0 0

Credits : 3
Time : 3 Hours

Course-Objectives:

The primary objective of this course is:

- To provide students with a good understanding of the concepts and methods of linear algebra.
- To introduce students to the basic methodology of "probabilistic thinking" and to apply it to problems;
- To provide mathematical background and sufficient experience so that the student can read, write, and understand sentences in the language of probability theory, as well as solve probabilistic problems in signal processing and Communication Engineering.
- To understand basic concepts of probability theory and random variables, how to deal with multiple random variables, Conditional probability and conditional expectation, joint distribution and independence, mean square estimation.
- Analysis of random process and application to the signal processing in the communication system.

Syllabus:

UNIT-I:

Probability and Random Variable: Basics of Probability and Random Variable.

Linear Algebra: Systems of linear equations, Matrices, Elementary row operations, Row-reduced echelon matrices, Vector spaces, Subspaces, Bases and dimension, Ordered bases and coordinates, Linear transformations, Rank-nullity theorem, Algebra of linear transformations, Matrix representation, Transpose of a linear transformation, Characteristic values and characteristic vectors of linear transformations, Minimal polynomial of a linear transformation, Cayley-Hamilton theorem, Orthonormal bases, and Gram-Schmidt process.

UNIT -II:

Distribution & Density Functions: Distribution and Density functions and their Properties - Binomial, Poisson, Uniform, Gaussian, Exponential, Rayleigh, Rician and Conditional Distribution, Methods of defining Conditional Events, Conditional Density and Properties.

Operation on One Random Variable – Expectations: Introduction, Expected Value of a Random Variable, Function of a Random Variable, Moments about the Origin, Central Moments, Variance and Skew, Chebychev's Inequality, Characteristic Function, Moment Generating Function, Transformations of a Random Variable: Monotonic Transformations for a Continuous Random Variable, Non-monotonic Transformations of Continuous Random Variable, Transformation of a Discrete Random Variable

UNIT-III:

Multiple Random Variables: Vector Random Variables, Joint Distribution Function, Properties of Joint Distribution, Marginal Distribution Functions, Conditional Distribution and Density–Point Conditioning, Conditional Distribution and Density–Interval conditioning, Statistical Independence, Sum of Two Random Variables, Sum of Several Random Variables, Central Limit Theorem, Unequal Distribution, Equal Distributions.

Operations on Multiple Random Variables: Expected Value of a Function of Random Variables: Joint Moments about the Origin, Joint Central Moments, Joint Characteristic Functions, Jointly Gaussian

Random Variables: Two Random Variables case, N Random Variable case, Properties, Transformations of Multiple Random Variables, Linear Transformations of Gaussian Random Variables.

UNIT-IV:

Stochastic Processes– Temporal Characteristics: The Stochastic Process Concept, Classification of Processes, Deterministic and Nondeterministic Processes, Distribution and Density Functions, Concept of Stationary and Statistical Independence, First-Order Stationary Processes, Second-Order and Wide-Sense Stationarity, Time Averages and Ergodicity, Mean-Ergodic Processes, Correlation-Ergodic Processes, Autocorrelation Function and its Properties, Cross-Correlation Function and its Properties, Covariance and its Properties, Linear System Response of Mean and Mean-squared Value, Autocorrelation Function, Cross-Correlation Functions, Gaussian Random Processes, Poisson Random Process, Power Spectrum: Properties, Relationship between Power Spectrum and Autocorrelation Function.

TEXT BOOKS:

1. Probability, Random Variables & Random Signal Principles - Peyton Z. Peebles, TMH.
2. Probability and Random Processes – Scott Miller, Donald Childers, Elsevier.

REFERENCE BOOKS:

1. Probability, Random Variables and Stochastic Processes – Athanasios Papoulis and S. Unnikrishna Pillai., TMH.
2. Theory of Probability and Stochastic Processes- Pradip Kumar Gosh, University Press
3. Probability and Random Processes with Application to Signal Processing – Henry Stark and John W. Woods, PE
4. Probability Methods of Signal and System Analysis - George R. Cooper, Clave D. MC Gillem, Oxford.
5. Statistical Theory of Communication - S.P. Eugene Xavier, New Age Publications.

Course-Outcomes:

CO1: Illustrate and formulate fundamental probability distribution and density functions, as well as functions of random variables
CO2: Explain the concepts of expectation and conditional expectation, and describe their properties.
CO3: Analyze continuous and discrete-time random processes.
CO4: Explain the concepts of stationary and wide-sense stationarity, and appreciate their significance.
CO5: Apply the theory of stochastic processes to analyze linear systems.
CO6: Apply the above knowledge to solve basic problems in filtering, prediction and smoothing

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MEC1C03 ADVANCED DIGITAL SIGNAL PROCESSING

L T P	Credits : 3
3 0 0	Time : 3 Hours

Course Objective:

The primary objective of this course is to provide a thorough understanding and working knowledge of design, implementation and analysis DSP systems.

Syllabus:

UNIT – I
Discrete Fourier Transform: Frequency domain sampling and reconstruction of discrete time signals, the DFT, symmetry properties of DFT, multiplication of two DFTs, and circular convolution, linear filtering methods based on DFT, frequency analysis of signals using DFT, DCT. Divide and conquer Approach to computation of DFT, radix-2 and radix-4 DFT algorithms.

UNIT –II
Multirate DSP: Decimation and interpolation, Digital filter banks, interconnection of building blocks, noble identifies, polyphase representation, polyphase implementation of uniform DFT filter banks, fractional decimation, PR systems, multirate implementation. Applications of multiage systems, PR QMF bank. Two channel and M Channel QMF banks and polyphase representations, tree structured filter banks.

UNIT-III
Optimum Linear Filters: Innovation representation of stationary random process. Forward and Backward linear prediction optimum reflection coefficients for the lattice forward and backward predictors. Levinson Durbin algorithm, AR Lattice and ARMA lattice ladder filters, FIR and IIR wiener filter, for filtering and prediction.

UNIT-IV
Cepstrum Analysis and Homomorphic Deconvolution: Complex cepstrum and its properties, complex and real cepstrums for exponential, periodic, minimum phase and maximum phase sequences, computation of complex cepstrum, homomorphic systems, deconvolution, homomorphic deconvolution. Complex cepstrum for simple multipath model and speech model.

REFERENCES:

1. J.G. Proakis and D.G. Manolakis Digital Signal Processing
2. AV Oppenheim and RW Schafer Discrete time signal processing

Course outcomes:

At the end of the course, the students will be able to:

CO1: Interpret, represent and process discrete/digital signals and sytems
CO2: Thorough understanding of frequency domain analysis of discrete time signals.
CO3: Ability to design & analyze DSP systems like FIR and IIR Filter etc.
CO4: Practical implementation issues such as computational complexity, hardware resource limitations as well as cost of DSP systems or DSP Processors.
CO5: Understanding of spectral analysis of the signals

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MEC1C05 ADVANCED **DIGITAL COMMUNICATION**

L T P		Credits	: 3
3 0 0		Time	: 3 Hours

Course Objectives:
This subject aims to give in depth knowledge in digital communication systems. It introduces latest technologies like Multichannel, Multicarrier communication, and Multi user communication systems.

Syllabus

UNIT-I
Characterization of Communication Signals & Systems
Representation of Band Pass Signal and System: Response of a band pass system to band pass signal, Representation of band pass stationary stochastic processes. Representation of digitally modulated signals**:** memory less modulation methods, Linear modulation with memory, Nonlinear modulation methods with memory. Spectral Characteristics of Digitally Modulated Signals**:** Power spectra of Linearly modulated Signals, CPFSK and CPM Signals, Modulated Signals with memory.

UNIT-II
Band pass Modulation & Demodulation
Digital Band Pass Modulation techniques, Detection of signals in Gaussian noise. Coherent Detection**:** Coherent Detection of PSK, MPSK and FSK and its error performance, Sampled Matched Filter. Non Coherent detection**:** Detection of DPSK, FSK, Binary Differential PSK and their error performance, required tone spacing for non coherent orthogonal FSK. Comparison of bit error performance of various modulation techniques. **M**-ary Signaling & Performance, Symbol Error Performance for M-ary Systems; MPSK and MFSK, Bit Error probability versus symbol error probability.

UNIT-III
Digital Signaling Over a Channel With Intersymbol Interference
Signal design for band limited channels. Communication through Band limited Linear Filter Channels: optimum demodulation for ISI and additive white Gaussian noise**,** Linear equalization, Decision-Feedback equalization: Coefficient Optimization, Performance Characteristics. Adaptive equalization

UNIT-IV
Multichannel and Multicarrier Systems:
Multichannel Digital Communication in AWGN Channels, Multicarrier Communication, and Multi user communication.

REFERENCES:

1. Simon Haykin: Communication System, Wiley Eastern Limited.
2. J.Dass, SK Mullick & PK Chatterjee: Principle of Digital Communication, Wiley Eastern Limited.
3. Martin S. Roden: Digital and Data Communication System P.H.Inc, London, .
4. Viterbi, A.J. and J.K. Omura: Principles of Digital Communication, Mc-Graw Hill Book Company, New York.
5. Bernard Sklar: Digital Communications, Fundamentals & Applications, Pearson
6. J.G. Proakis," Digital Communication".

Course outcomes:
At the end of the course, the students will be able to:

CO1: Characterize the band pass signals and systems.

Electronics and Communication Engineering (Communication Systems)

CO2: Calculate different parameters like power spectrum density, probability of error for different modulation techniques.
CO3: Design pulse shape for minimizing the ISI.
CO4: Analyze the performance of different equalizer.
CO5: Use concept of Spread Spectrum & Multicarrier Communication techniques.

MEC1E31 WIRELESS NETWORKS

L T P	Credits	: 3
3 0 0	Time	: 3 Hours

Course Objectives:

- To gain an understanding and knowledge about different layers of wireless communication protocol stacks and standards
- To analyze the requirements of wireless applications and services and identify the suitable wireless networks
- To plan and design wireless networks for given user data base and quality of service.

Syllabus

UNIT-I:

WLANs: Architecture and services, MAC, VCS, NAV, ARQ, Backoff with DCF, Physical layer and Rate adaptation, power savings mechanism, performance analysis- channel event analysis, throughput and delay. Gigabit WLAN

UNIT-II:

LTE, LTE-Advanced, LTE-Advanced Pro, Spectrum regulations and standardization, 3GPP & ITU-R, LTE Radio access- transmission schemes, scheduling, multi-antenna system, spectrum flexibility, Radio interface architecture

UNIT-III:

5G NR: design principle, features, NR multi-antenna transmission, synchronisation, random access, standards for 5G NR radio access technology, coexistence and interworking with LTE

UNIT-IV:

Advanced topics: Machine Type Communication, Device to Device Communication, License assisted access, full dimension MIMO, small cell enhancement

References:

1. Evan Marsic, “Wireless Networks, Local and Ad hoc networks, Rutger University
2. Erik Dahlman, Stefan Parkvall, Johan Skold, “4G LTE Advanced Pro and the Road to 5G” Academic Press.

Course Outcomes:

CO1: The students will be able to comprehend the architecture and technical features of different wireless networks including cellular networks and standards, WLAN, and broadband wireless access networks.
CO2: Ability to plan and design cellular and wireless local area networks
CO3: Ability to develop wireless application and services
CO4: Ability to use concepts of 5G technologies

MEC1E33 IMAGE PROCESSING

L T P	Credits	: 3
3 0 0	Time	: 3 Hours

Course Objectives

The student should be able to understand and apply the various concepts of Digital Image Processing.

Syllabus

UNIT – I:
Introduction: The Origin of Digital Image Processing, Problems and Applications, Fundamental steps in image processing, Components of an image processing system. Transforms and their properties. Two Dimensional DFT, DCT. Hadamard, Slant, Haar and KL, Transforms and their properties, Arnold, Wavelet and Contourlet transforms.
Image Perception: Image models, sampling & quantization, neighbors of a pixel, connectivity, labeling of connected components.

UNIT – II:
Intensity Transformation and Spatial Filtering: Basic intensity transformation functions, Histogram processing, spatial filters, homomorphic filtering, generation of spatial marks, Fuzzy techniques for Intensity Transformation and Spatial Filtering.
Image Restoration and Reconstruction: Noise models, Restoration in the presence of Noise only, Frequency domain filtering, Inverse filtering, Wiener filtering, Geometric mean filtering, Image reconstruction from projections.
Image Compression: Redundancy models, error free compression, Lossy compression, Some basic compression methods, Image compression standards.

UNIT – III:
Color Image Processing: Color Models, Pseudocolor Image Processing, Bacics of full color image processing, color transformations, segmentation, smoothing and sharpening, Noise in color Images. VMF,VDF,etc.
Morphological Image Processing: Erosion, Dialation, Opening, Closing, Some basic morphological algorithms, Gray scale morphology.

UNIT – IV:
Image Segmentation: Detection of Discontinuity, Edge detection, Boundary detection, Thresholding, Regional oriented segmentation uses of motion in segmentation.
Representation and Description: Representation, Regional descriptors, Boundary descriptors, Image analysis, Pattern and their classes, Decision theoretical methods, Structural methods, Interpretation
Image forensic: Image forgery detection types and its applications.

REFERENCES:

1. Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, Pearson.
2. Anil K. Jain, Fundamentals of Digital Image Processing, Pearson.
3. Kenneth R. Castleman, Digital Image Processing, Pearson.
4. Rafael C. Gonzalez, Richard E. Woods, Steven Eddins, 'Digital Image Processing using MATLAB', Pearson Education, Inc..
5. Hany Farid, 'Photo Forensics' The MIT Press.

Course outcomes

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

Electronics and Communication Engineering (Communication Systems)

CO1: Understand and apply the Image filtering, Restoration, segmentation etc.
CO2: Apply the vector approach to handle the color images.
CO3: Apply the 'Morphological operation' for various applications.
CO4: Develop the understanding about digital image forensics.

MEC1E35 MICROWAVE THEORY AND DEVICES

L T P Credits : 3
3 0 0 Time : 3
Hours

Course Objectives
Students will try to learn:
- To design and analyze microwave filters.
- To design and implement Microwave Amplifiers
- To design and implement Microwave Oscillators.
- To design and understand microwave systems.

Unit-I:
MICROWAVE FILTERS: Periodic Structure, Filter Design by the Image Parameters Method, Filter Design by the Insertion Loss Method, Filter Transformations, Filter Implementations, Stepped-Impedance Low-Pass Filters, Coupled Line Filters, Filters Using Coupled Resonators.

Unit-II:
MICROWAVE AMPLIFIER DESIGN: Two-Port Power Gains, Stability, Single stage Transistor Amplifier Design, Broadband amplifier design, Power amplifiers.

Unit-III:
MICROWAVE OSCILLATORS: Transistor Oscillators, Dielectric Resonator Oscillators, Oscillator Phase Noise, Representation of Phase Noise, Leeson's Model for Oscillator Phase Noise, Frequency Multipliers.

Unit-IV:
INTRODUCTION TO MICROWAVE SYSTEMS: Wireless Communication Systems, Radar Systems, Radiometer Systems, Microwave Propagation, Microwave Heating, Biological Effects and Safety.

REFERENCES:
1. D.M. Pozar- Microwave Engineering
2. R.E. Collins, Microwave Circuits, McGraw Hill
3. Samuel Y. Liao, Microwave Devices and Circuits, Prentice-Hall of India.
4. I. J. Bahl and P. Bhartia- Microwave Solid State Circuit Design

Course Outcomes
At the end of the course student will be able to:
1. Design and implement microwave filters.
2. Design and implement Microwave Amplifiers
3. Design and implement Microwave Oscillators.
5. Design and understand microwave systems.

MEC1E37 STATISTICAL SIGNAL PROCESSING

L T P Credits : 3

Electronics and Communication Engineering (Communication Systems)

3 0 0 Time : 3 Hours

Course objective: To understand and study the basic concepts of Random processes, Signal modeling, Wiener and Kalman filtering and Spectrum estimation.

Syllabus

UNIT-I: Random Processes
Introduction, Random variables, Averages, Joint distributions, Joint moments, Correlation, covariance, Linear Mean Square Estimation, Parameter Estimation, Random Processes, Gaussian Processes, stationary Processes, Autocorrelation and Auto Covariance matrices, Ergodicity, Filtering Random processes, Spectral Factorization, MA, AR and ARMA Processes, Harmonic Processes

UNIT-II: Signal Modeling
Least Squares, Pade approximation and Prony's methods, Finite data records, Autocorrelation and Covariance methods, Stochastic models, Levinson-Durbin Algorithm

UNIT-III: Wiener and Kalman Filtering
The Wiener filter, filtering, linear prediction, noise cancellation. Lattice structure for FIR Wiener filter, causal and non-causal IIR Wiener filters, Kalman filters. Wold's decomposition

UNIT-IV: Spectrum Estimation
Non parametric methods and their performance comparison, minimum variance spectrum estimation, the maximum entropy method, frequency estimation, principal components spectrum estimation

REFERENCES:

1. Monson H Hayes, Statistical Digital Signal Processing and Modelling Wiley
2. T. Chonavel, Statistical Signal Processing, Springer

Course outcomes:
At the end of the course, students will be able to:

CO1: To understand the characterization of the Random processes.
CO2: To gain knowledge about Signal modeling.
CO3: To learn Wiener and Kalman filtering.
CO4: To gain knowledge about Spectrum estimation

Electronics and Communication Engineering (Communication Systems)

MEC1E39 **SATELLITE AND SPACE COMMUNICATION**

L T P		Credits	: 3
3 0 0		Time	: 3 Hours

Course Objectives:
To understand the concepts and issues related to earth and space segments of satellite communication, analyse the performance of satellite links, and learn about the future space technologies.

Syllabus

UNIT-I
Review of satellite physics: Types of satellite orbits, Kepler's & Newton's Law, orbital parameters, the earth's orbit, earth-satellite geometry, perturbations of orbits.
Empirical/statistical satellite channel models, physical-statistical modelling, satellite diversity, modeling of land mobile satellite (LMS) channel, modelling of satellite to indoor propagation channel. Challenges for electronic circuits in space applications.

UNIT-II
Configuration of a link, antenna parameters, radiated power, received signal power, individual link performance, mitigation of atmospheric impairments, overall link performance with transparent satellite and regenerative satellite, link performance with multi-beam antenna coverage. Earth station organization, radio frequency characteristics, antenna subsystem, RF subsystem, communication subsystems, network interface subsystems, monitoring and control.

UNIT-III
Characteristics of the payload, transparent and regenerative repeaters, multi-beam antenna payload, antenna coverage and characteristics, Attitude control, propulsion subsystem, telemetry, tracking and command (TTC) and on-board data handling (OBDH). The space environment: mechanical environment, radiation, flux of high energy particles, environment during installation.

UNIT-IV
Application satellites - Remote-sensing satellite, Meteorological satellites, Global positioning satellite, Scientific research satellites, Communication satellites: satellite orbits and structure, frequency bands and broadband access, VSAT system, satellite services. Future space technologies: Non-rocket space launch, satellites and cyberattacks, photonics in space. Signal processing elements in satellite communications.

REFERENCES

1. G. Maral, and M. Bousquet, "Satellite Communications Systems: Systems, Techniques and Technologies," Wiley.
2. Lous J. Ippolito Jr., "Satellite Communication System Engineering," Wiley.
3. A.G. Kanatas, A.D. Panagopoulos, "Radio Wave Propagation and Channel Modeling for Earth-Space Systems," CRC Press.
4. M. Razani, "Commercial Space Technologies and Applications," CRC Press.
5. Brice R. Elbert, "Introduction to Satellite Communication," Artech House.

Course Outcomes:

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At the end of the course, students will be able to:

- CO1: Understand the configuration of the satellite communication system and satellite orbits.
- CO2: Analyze the satellite link performance under different conditions.
- CO3: Learn about various subsystems of earth station and satellite.
- CO4: Comprehend the techniques for TTC, OBDH and challenges of space environment.
- CO5: Analyze the requirements of satellites for different fields of applications.

MEC1E41 COMPUTER NETWORKS

Electronics and Communication Engineering (Communication Systems)

L T P	Credits : 3
3 0 0	Time : 3 Hours

Course Objectives

The objective of this subject is to provide a fundamental understanding of principles involved in Computer Networks and to provide insight into some of the new principles that are evolving for future networks.

Syllabus

UNIT-I

Interconnections, packet switching, virtual circuits, internetworking, bridges, switches, routers, gateways, address structure, area routing hierarchy, address classes, IPv6.

Layered network architecture-OSI and TCP/IP reference models, data link layer-framing and error detection, Retransmission algorithms.

UNIT-II

Carrier sensing-CSMA, slotted aloha, Pseudo-Bayesian stabilization for CSMA aloha, CSMA un-slotted aloha, FCFS splitting algorithms for CSMA.

Multiaccess reservations- Satellite reservation systems, LAN-CSMA/CD, Ethernet, slotted CSMA/CD, unslotted CSMA/CD, High speed LAN-distributed queue dual bus.

Unit-III

Routing, shortest path routing, distributed routing algorithms, optimal routing, Virtual path routing-on demand routing, minimum interference routing, multiprotocol label switching, routing of stream type sessions-quality of service routing, flow control-window and credit schemes, rate based schemes.

Unit-IV

Networks of queues- closed networks, open networks, estimating parameters, and distributions, computational methods for queuing network solutions, Security issues in Internet architecture.

REFERENCES:

1. Bertsekas, Dimitri, Robert Gallager, “Data Networks”, Upper Saddle river, NJ Prentice Hall.
2. Andrew S. Tanenbaum, “Computer Networks. Pearson Education Asia.
3. James F. Kurose, Keith W. Ross, “Computer Networking: A Top-Down Approach”, Pearson.

Course outcomes:

After studying this course, the student will be able to:

CO1: Understand basic principles of Networking.
CO2: Analyze underlying concepts.
CO3: Develop the queueing theory and use it for analyzing Multi access Schemes.
CO4: Gain an insight into subject of routing.

MEC1E43 INTRODUCTION TO SOFT COMPUTING AND MACHINE LEARNING

L T P	Credits	: 3
3 0 0	Time	: 3 Hours

Course Objectives:

- The primary objective of this course is to provide an introduction to the basic principles, techniques, and applications of soft computing and machine learning.
- Provide the mathematical background for carrying out the optimization associated with neural network learning.
- Aim of this course is to develop some familiarity with current research problems and research methods in Soft Computing by working on a research or design projects

Syllabus

UNIT-I

Introduction to Soft Computing, Evolution of Computing, Soft Computing Constituents – From Conventional AI to Computational Intelligence, soft computing vs. hard computing, various types of soft computing techniques, Fuzzy Computing, Neural Computing, Genetic Algorithms, Associative Memory, Adaptive Resonance Theory, Classification, Clustering, Bayesian Networks, Probabilistic reasoning, applications of soft computing.

UNIT – II

Introduction to Fuzzy Logic and inference systems, Classical and Fuzzy Sets: Overview of Classical Sets, Membership Function, Fuzzy rule generation. Operations on Fuzzy Sets, Fuzzy Arithmetic, Fuzzy Equations, Fuzzy inference systems and its types, Rough set and possibility theory.

UNIT – III

Fundamentals of Artificial Neural Network: Introduction, Model of Artificial Neuron, Architectures, Learning Methods, Deep learning, Taxonomy of ANN Systems, SingleLayer ANN System, Supervised Learning Neural Networks, Perceptrons, Adaline, Backpropagation, Mutilayer Perceptrons, Recurrent Neural Networks, Applications of ANN in research.

Fundamentals of hybrid intelligent systems, evolutionary computing, Genetic Algorithm (GA) processes and swarm intelligence

UNIT – IV

Introduction to machine learning systems and methodologies, regression & classification techniques, introduction to SVM, probabilistic learning models and Markov models.

REFERENCES:

1. S. Kaushik and S. Tiwari, Soft computing, TMH
2. Padhy and Simon, Soft Computing, Oxford University Press
3. S. N. Sivanandam & S. N. Deepa, Principles of Soft Computing, Wiley India Pvt. Ltd..
4. Goldberg D. E., Genetic Algorithms in Search, Optimization, and Machine Learning, Pearson Education.
5. Haykin, Neural networks: a comprehensive foundation, Pearson Education.
6. Mitchell M., An Introduction to Genetic Algorithms, Prentice-Hall.
7. Klir G.J. & Yuan B., Fuzzy Sets & Fuzzy Logic, PHI.
8. J.S.R. Jang, C.T.Sun and E.Mizutani, “Neuro-Fuzzy and Soft Computing”, PHI, Pearson Education.
9. Elaine Rich, Kevin Knight, Artificial Intelligence TMH.
10. 1.Timothy J.Ross, “Fuzzy Logic with Engineering Applications”, McGraw-Hill.
11. Davis E.Goldberg, “Genetic Algorithms: Search, Optimization and Machine Learning”, Addison Wesley, N.Y..

12. S. Rajasekaran and G.A.V.Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms", PHI, R.Eberhart, P.Simpson and R.Dobbins, "Computational Intelligence - PC Tools", AP Professional, Boston.
13. Dan W. Patterson, Introduction to AI and Expert System, PHI.

Course Outcomes:

After studying this course, the student will be able to:

CO1: Upon successful completion of the course, students will be able to

CO2: Understand the concepts of Soft Computing and machine learning

CO3: Apply Artificial Neural Networks, Fuzzy Logic and Genetic Algorithms for solving complex engineering problems.

CO4: Initiate into the field of machine learning

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MEC1E45 MODELLING AND SYNTHESIS WITH VERILOG HDL

L T P	Credits	: 3
3 0 0	Time	: 3 Hours

Course Objectives

- To design combinational, sequential circuits using Verilog HDL.
- To understand behavioral and RTL modelling of digital circuits
- To verify that a design meets its timing constraints, both manually and through the use of computer aided design tools
- To simulate, synthesize, and program their designs on a development board
- To analyze the steps involved in synthesis of HDL code

Syllabus

UNIT-I

Hardware modelling with the Verilog HDL. Encapsulation, modelling primitives, different types of description: Gate level, Dataflow, Behavioural Modelling.

UNIT-II

Delay modelling & Advanced modelling techniques: Event based and level sensitive timing control, memory initialization, conditional compilation, time scales for simulation. Static timing analysis, delay, switch level modelling, user defined primitive (UDP), memory modelling.

UNIT-III

Logic synthesis: Logic synthesis of HDL construct, technology cell library, design constraints, synthesis of Verilog/VHDL constructs. Synthesis of combinational logic and Sequential Logic: HDL-based synthesis -technology-independent design, styles for synthesis of combinational and sequential logic, synthesis of finite state machines, synthesis of gated clocks, design partitions and hierarchical structures.

UNIT-IV

Simulation and Verification: Functional verification; test-bench; boundary scan-chains; fault simulation and testing; timing analysis.

Text Books

1. M.D.Ciletti, "Modelling, Synthesis and Rapid Prototyping with the Verilog HDL", PHI.
2. S. Palnitkar, "Verilog HDL –A Guide to Digital Design and Synthesis", Pearson.

REFERENCES:

1. J Bhaskar, "A Verilog HDL Primer (3rdedition)", Kluwer.
2. M.G.Arnold, "Verilog Digital –Computer Design", Prentice Hall (PTR).
3. Recent literature in Modelling and Synthesis with Verilog HDL.

Course outcomes

Electronics and Communication Engineering (Communication Systems)

At the end of the course student will be able

- CO1: understand the basic concepts of Verilog HDL
- CO2: model digital systems in Verilog HDL at different levels of abstraction
- CO3: understand the design flow from simulation to synthesizable version
- CO4: Synthesize RTL models to standard cell libraries and FPGAs
- CO5: generate Test bench and verify digital systems

__Electronics and Communication Engineering (Communication Systems)__

MEC1E47 MEC1E47I NTERNET OF THINGS (IoT)

L T P	Credits : 3
3 0 0	Time : 3 Hours

Course Objectives:

Students should be able to understand the basic concepts of Internet of Things and should be able to build applications based on IoT.

Syllabus

UNIT-I
Introduction to IoT, Characteristics of IoT, Physical design of IoT, Logical design of IoT, Functional blocks of IoT, Communication models & APIs, IoT enabling technologies like wireless sensor networks, cloud computing, big data analytics, communication protocols, Machine to Machine, Difference between IoT and M2M, Software define Network

UNIT-II
Wireless medium access issues, MAC protocol survey, Survey routing protocols, Sensor deployment & Node discovery, Data aggregation & dissemination, Design challenges, Development challenges, Security challenges, Other challenges

UNIT-III
Home automation, Industry applications, Energy Systems, Retails, Logistics, Agriculture, Health and Lifestyle, Environment, Surveillance applications, Other IoT applications

UNIT-IV
Introduction to Python, Introduction to different IoT tools, python data types and data structures, Control flow, functions, modules and packages, developing applications through IoT tools, developing sensor based application through embedded system platform, Implementing IoT concepts with python

REFERENCES:

1. Vijay Madisetti, Arshdeep Bahga, “Internet of Things: A Hands-On Approach”
2. Designing the Internet of Things , Adrian McEwen (Author), Hakim Cassimally
3. Waltenegus Dargie, Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice."
4. Recent research/white papers

Course Outcomes:

After the course, students should be able to

CO1: Understand the basic concepts related Internet of Things
CO2: Visualize the basic protocols in wireless sensor network
CO3: Design applications based on IoT for solving different problems
CO4: Implement basic IoT applications on embedded platform

MEC1L07 COMMUNICATION LAB

L T P — Credits : 3
0 0 2 — Time : 2 Hours

Course Objective:

- To explore digital communications.
- To understand the building blocks of digital communication system
- To prepare mathematical background for communication signal analysis
- To understand and analyse the signal flow in a digital communication system
- To analyse error performance of a digital communication system in presence of noise and other interferences
- To understand concept of spread spectrum communication system
- The lab will cover, analog to digital conversion, modulation, pulse shaping, and noise analysis

List of Experiments:

1. (a) To study kinds of signal sampling and their reconstruction.
   (i) Natural sampling
   (ii) Sample and hold
   (iii) Flat top sampling
   (b) To study the effect of different sampling frequencies on the sampling and reconstruction signal.
   (i) Study the effect of different sampling frequencies.
   (ii) Study the effect of duty cycles.
2. To study Time Division Multiplexing and De-multiplexing of analog signals using various receiver synchronization techniques.
   (i) Direct synchronization technique
   (ii) Clock recovery through Phase Locked Loop
   (iii) Clock recovery through Threshold Detector
3. To study the Pulse Code Modulation and Demodulation using different techniques.
4. To study the effect of parities and Hamming code on PCM data.
   (a) None Parity
   (b) Even Parity
   (c) Odd Parity
   (d) Hamming Code
5. To study various data encoding and decoding techniques.
   (a) NRZ-I, NRZ-M, NRZ-S, BIO-L, BIO-M, BIO-S, URZ
   (b) AMI Encoding and Decoding
   (c) Unipolar to Bipolar
   (d) Bipolar to Unipolar
6. To study Delta Modulation and Demodulation.
7. To study Adaptive Delta Modulation and Demodulation.
8. To study ASK Modulation and Demodulation.
9. To study PSK Modulation and Demodulation.
10. To study FSK Modulation and Demodulation.

ADDITIONAL EXPERIMENTS

11. To simulate a simple single-mode optical fiber that is optimized for use in the 1310 wavelength region.
12. To design a communication link using optical fiber at 1550 nm and to plot its parameters.

Course Outcome:

Electronics and Communication Engineering (Communication Systems)

After successfully completing the course students will be able to:

CO1: Analyze the performance of a baseband and pass band digital communication system in terms of error rate and spectral efficiency
CO2: Perform the time and frequency domain analysis of the signals in a digital communication system
CO3: Select the blocks in a design of digital communication system
CO4: Analyze Performance of spread spectrum communication system
CO5: Appreciate the importance of synchronization in communication systems

SEMESTER-II

MEC1C02 EMERGING WIRELESS TECHNOLOGIES

L T P		Credits	: 3
3 0 0		Time	: 3 Hours

Course Objectives:

- To gain an understanding and knowledge about different wireless technologies
- To analyze the application requirements of wireless applications and services
- To plan and design specific technology based wireless applications

Syllabus

UNIT-I:
Massive MIMO: system model, random matrix theory, channel estimation, spectral efficiency, energy efficiency and hardware efficiency, practical deployment consideration

UNIT-II:
Smart antenna and beamforming: Eigen-combining, robust adaptive beamforming, random array theory, collaborative beamforming

UNIT-III:
Cognitive radio: software defined radio, spectrum management, spectrum access, cognitive radio architecture

UNIT-IV:
Cooperative Communication, Near-field communication, Gi-Fi, Low power WLAN, Bluetooth, ZigBee

Text Books

1. Emil B., Jakob H., Luca S., “Massive MIMO Networks,” nowpublishers.com
2. Chen Sun, Jun Cheng, Takashi Ohira, “Handbook on advancements in smart antenna technologies for wireless networks”, Information science reference
3. Brute Fette, “Cognitive Radio Technology”, Elsevier.

Course Outcomes:

At the end of the course, students will be able to:

CO1: The students will be able to comprehend the capabilities and potential of the emerging wireless technologies

CO2: Ability to perform performance evaluation of technologies

CO3: Ability to develop use cases of recent wireless technologies

CO4: Use concepts of emerging wireless technologies.

MEC1C04 DETECTION AND ESTIMATION

L T P   Credits : 3
3 0 0   Time : 3 Hours

Course Objectives

To learn about various classical and Bayesian estimation methods; understand techniques for detection of signal with known and unknown parameters and apply them for practical applications.

Syllabus

UNIT-I
Importance of estimation in signal processing. Unbiased estimators, minimum variance criterion, existence of minimum variance unbiased estimators. Cramer-Rao lower bound, general CRLB for signals in WGN, CRLB for transformations. Linear models, concept of sufficient statistics, Neyman-Fisher factorization theorem, using sufficiency to find the MVU estimators.

UNIT-II
Maximum likelihood estimation, MLE for transformed parameters, numerical determination of MLE. Least squares approach for estimation of parameters, geometrical interpretation, sequential LS, constrained LS, signal processing examples. Bayesian philosophy of estimation, risk functions, MMSE and MAP estimators. Kalman filters, dynamic signal models, Kalman versus Wiener filters.

UNIT-III
Detection theory in signal processing, Neyman –Pearson theorem, Receiver operating characteristics, minimum probability of error, Bayes risk, multiple hypothesis testing. Matched filters for detection of deterministic signals, generalized matched filters. Detection of multiple signals. Techniques for detection of random signals.

UNIT-IV
Composite hypothesis testing, Bayesian approach, generalized likelihood ratio test, performance of GLRT for large data records. Detection of signals with unknown parameters, GLRT and Bayesian approaches for detection of signals with unknown parameters, signal processing examples. Detection of random signals with unknown parameters, weak signal detection.

REFERENCES:

1. S. M. Kay, "Fundamentals of Statistical Signal Processing: Estimation Theory," Pearson.
2. S. M. Kay, "Fundamentals of Statistical Signal Processing: Detection Theory," Pearson.
3. H. V. Poor, "An Introduction to Signal Detection and Estimation," Springer.
4. H. L. Van Trees, Detection, Estimation and Modulation Theory, Parts 1 and 2, John Wiley Inter-Science.
5. E. L. Lehman, Testing Statistical Hypothesis, John Wiley.

Course Outcomes:

At the end of the course, students will be able to:

CO1: Analyze the estimator properties such as Bias, Efficiency, Linearity and CR bound.
CO2: Use classical estimation techniques such as MLE and LS for estimation of parameters.
CO3: Apply Bayesian estimation approaches in various applications.
CO4: Comprehend methods of detection of signals with known and unknown parameters.
CO5: Apply estimation and detection methods to real engineering problems.

MEC1C06 INFORMATION AND NETWORK SECURITY

L T P   Credits : 3

Electronics and Communication Engineering (Communication Systems)

3 0 0 Time : 3 Hours

Course Objectives

The aim of the course is to make students understand about various network vulnerabilities, security algorithms to mitigate them, key management and distribution techniques. Students will learn to design security applications in the field of Information technology.

Syllabus

UNIT-I
Introduction to General security concepts, basic terminologies, issues, network and security models. Symmetric and asymmetric cryptography, Key management and Distribution, RSA Algorithm, Diffie Hellman Key Exchange, Elliptic Curve Cryptography. Message Authentication and Hash Functions: Authentication Requirements, Authentication Functions, weak and strong authentication, Zero knowledge protocol, Message Authentication Codes, Hash Functions, Digital Signatures.

UNIT-II
Security standards and protocols, Kerberos protocol: public key infrastructure (PKI); security protocols for different network layers, secure IPsec, SSL and TL), Protocols for E-Commerce. Web and Email Security Important security issues with the Web (both the server and the client sides), building and maintaining secure web sites.
Risks and issues associated with the uses of electronic email, privacy, message integrity and authenticity, technologies for secure email systems, PEM (Privacy Enhanced Email), S/MIME, PGP secure mail protocol.

UNIT-III
Wireless network Security, important security issues of 802.11 standard, Security in future wireless networks; IoT, 5G, Cloud security

UNIT-V
Security Systems and Management Issues, Security systems in the real world, firewalls, security in software systems, main security features of some well-known systems and their weaknesses. Security policies, management strategies and policies for enterprise information security, management issues relevant to information security.

REFERENCES:

1. Cryptography and Network Security by Behrouz A. Forouzan, TATA McGraw hill.
2. Charlie Kaufman, Radia Perlman, Mike Specincer: Network Security – private communication in a public world, Prentice Hall.
3. Newman, Robert C: Enterprise Security, Prentice Hall.
4. Cryptography and Network Security, William Stalling, Prentice hall

Course Outcomes:
At the end of the course, students will be able to:

CO1: Analyze the data vulnerabilities and hence be able to design a solution to secure the data.
CO2: Identify the security issues in the network and resolve it.
CO3: Evaluate and analyze various security mechanisms
CO4: Compare and Contrast different IEEE standards and network security issues

MEC1E30 RESEARCH ANALYSIS FOR ENGINEERING

L T P Credits : 3
3 0 0 Time : 3 Hours

Electronics and Communication Engineering (Communication Systems)

Course objective:

- Provide students with fundamental knowledge of research analysis and design used in engineering.
- Guide and mentor students in developing, completing, writing, and presenting a valid and ethical research report.
- Learn to focus on a research problem using scientific methods and to devise and design an experimentation set-up
- Learn parameter estimation and related modeling methods to understand research problem formulation.

Syllabus

UNIT-I:

Introduction to Engineering Research, Research questions, Engineering Ethics, Research proposal, questions, design and Research tools.

Literature survey, types of publications, measuring research impact, keywords, online literature survey and document retrieval.

UNIT-II:

Introduction to statistical analysis, sources of error and uncertainty, one/two/multi-dimensional statistics, Null hypothesis testing, Basic instrumentation, Static and dynamic characteristics of instruments used in experimental set up, Data collection using a digital computer system, Linear scaling for receiver and fidelity of instrument, Role of DSP in conditioning the collected data

Regression and variance analysis, level of significance and confidence interval, Introduction to optimization techniques, two/multi parameter optimization methods, cost function

UNIT-III:

Outline of problem solving, creative thinking, theory and practice, creative thinking techniques Scheduling, organization and procrastination, tools of time management: rules of time management, setting assessing and achieving goals, Oral communication: voice production, informative speech, audio-visual materials, writing a research proposal and research paper/thesis using various tools such as LaTex, word processing softwares etc.; process of reporting, plagiarism/similarity related issues, referencing and standard report formats, measuring research contents and outcomes

UNIT-IV:

Ethics in Engineering research, Introduction to IPR, Patents, Copyright, Trademark, Industrial design, product development, Individual and Institutional research project proposals and funding agencies

REFERENCES:

1. David V. Thiel, “Research methods for engineers”, Cambridge University Press.
2. Sameer Phanse, “Research Methodology: Logic, methods and cases”, Oxford University Press.
3. Anthony M. Graziano and Michael L. Raulin, “Research Methods”, Pearson.
4. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”, JUTA.
5. Research Methodology: Methods and Techniques: C.R. Kothari
6. Research Methodology and Introductions for Science and Engineering:Melville and Goddard
7. Developing Effective Research Proposals: Punch
8. Applied Research Design: Leonard Bickma
9. W. R. Cornish, Intellectual Property: Patents, Copyright, Trademarks and Allied Rights (Sweet and Max Well London).
10. Trochim, W.M.K., Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
11. Coley, S.M. and Scheinberg, C. A., "Proposal Writing", Sage Publications.
12. Leedy, P.D. and Ormrod, J.E., Practical Research: Planning and Design, Prentice Hall.

Electronics and Communication Engineering (Communication Systems)

Course outcome:

At the end of the course, students will be able to:

- CO1: At the end of this course students will critically analyze research analysis methodologies for solving engineering problems
- CO2: Collect, analyze and interpret the data/statistical information for setting up various simulations/experimentation along with comparison and validation of results
- CO3: Apply techniques for creative thinking and problem solving and learn various techniques for self and resource management
- CO4: Familiarize with various methods/means of presentations and skill themselves in communicating and preparing various reports on their research work
- CO5: The students will be able to differentiate between various types of IPRs. And they will feel confident in writing and publishing their research papers and research projects.

Electronics and Communication Engineering (Communication Systems)

MEC1E32 WIRELESS SENSOR NETWORKS

L T P	Credits : 3
3 0 0	Time : 3 Hours

Course objective:

The objective of this course is to make the students

- To Understand the basic WSN technology and supporting protocols, with emphasis placed on standardization basic sensor systems and provide a survey of sensor technology
- Understand the medium access control protocols and address physical layer issues
- Learn key routing protocols for sensor networks and main design issues
- Learn transport layer protocols for sensor networks, and design requirements
- Understand the Sensor management, sensor network middleware, operating systems.

Syllabus

UNIT-I:

Introduction, data acquisition, classification, sensor platforms, standards, applications, single hop, multi-hop, design constraints, energy modeling, distributed estimation, multi sensor estimation, estimation theory for wireless sensor networks

UNIT-II:

Routing-challenges, Hooding, gossip protocol, sensor protocol for information via negotiation, SPIN-EC, hierarchical routing, LEACH, PEGASIS. TEEN, geographic routing protocols-MECN, greedy forwarding, distance based blacklisting, PRR based routing, PRADA, application to Internet of things (IoT), WSN for Cloud computing.

UNIT-III:

Data aggregation techniques-energy efficiency, network lifetime, data accuracy, flat networks, hierarchical networks, cluster based networks, chain based data aggregation, power efficient data gathering protocol for sensor information systems, tree based data aggregation, energy aware data aggregation tree, energy harvesting, grid based data aggregation, QoS aware protocols, trade-offs in data aggregation protocols-capacity-energy tradeoff

UNIT-IV:

Localization: ranging techniques-received signal strength, time of arrival, time difference arrival, angle of arrival, range based localization protocols-, triangulation, multilateration, ad-hoc positioning system, range free localization-approximate point in triangualiton, security issues in WSNs

REFERENCES:

1. E W. Dargie, C. Poellabauer, " Fundamentals of wireless sensor networks: Theory and practice"
2. I.F. Akyildiz, M.C. Vuran, “Wireless sensor networks".

Course Outcomes:

At the end of the course, students will be able to:

Electronics and Communication Engineering (Communication Systems)

CO1: Understand the building blocks of wireless sensor network design.
CO2: Identify the requirements for the specific applications in wireless sensor networks.
CO3: Analyze the routing protocols, algorithms and data aggregation techniques.
CO4: Comprehend the variety of localization strategies.

MEC1E34 SYSTEM MODELING AND SIMULATION

L T P	Credits	: 3
3 0 0	Time	: 3 Hours

Course objective:

The aim of this course is to introduce various system modeling and simulation techniques, and highlight their applications in different areas. It includes modeling, design, simulation, planning, verification and validation. After learning the simulation techniques, the students are expected to be able to solve real world problems which cannot be solved strictly by mathematical approaches. This course begins by demonstrating the usefulness of simulation as a tool for problem solving in business, industry, government, and society.

Syllabus

UNIT-I:
Systems, models, simulation, discrete event simulation, steps in a simulation study, review of random variables, stochastic processes, means, variance, correlation, confidence intervals, hypothesis tests

UNIT-II:
Model validity and credibility, statistical procedures- inspection approach, confidence approach, time series approach, selection of input probability distribution, continuous distribution, discrete distribution, empirical distribution, assessing sample independence, histograms, quantile summaries, estimation of parameters, goodness of fit tests, multivariate distributions

UNIT-III:
Random numbers generators- linear congruential generators, composites generators, testing random number generators- empirical tests, theoretical tests, generating random variates-inverse transform, convolution, acceptance- rejection, generating- continuous random variates, discrete random variates, random vectors, correlated random variates and stochastic processes

UNIT-IV:
Simulation of queuing systems- Poisson arrival processes, exponential distribution, service times, normal distribution, queuing disciplines, simulation of single and two server queue application of queuing theory in computer systems, introduction to simulation languages-GPSS, SIMSCRIPT

REFERENCES:

1. Averill M Law, " Simulation Modeling and Analysis" MGH.
2. Jerry Banks, John S Carson, Barry L Nelson, David M Nicol, " Discrete-event system simulation".

Course outcome:
At the end of the course, students will be able to:

Electronics and Communication Engineering (Communication Systems)

CO1: Understand different methods for random number generation
CO2: Have a clear understanding of the need for the development process to initiate the real problem.
CO3: Be able to describe the components of continuous and discrete systems and simulate them
CO4: Be able to model any system from different fields
CO5: Be able to implement numerical algorithm to meet simple requirements, expressed in English

MEC1E36 MOBILE COMPUTING

L T P	Credits	: 3
3 0 0	Time	: 3 Hours

Course objective:

To impart fundamental concepts in the area of mobile computing, to provide a computer systems perspective on the converging areas of wireless networking, embedded systems, and software, and to introduce selected topics of current research interest in the field.

Syllabus:

UNIT I:
Introduction to Mobile Communications and Computing: Mobile Computing (MC): Introduction to MC. novel applications, limitations, and architecture. GSM: Mobile services. System architecture, Radio interface, Protocols, Localization and calling. Handover, Security and new data services, soft computing tools for Mobile networks.

UNIT II:
(Wireless) Medium Access Control: Motivation for a specialized MAC (Hidden and exposed terminals, near and far terminals), SDMA, FDMA. TDMA, CDMA. Mobile Network Layer: Mobile IP packet delivery, agent advertisement and discovery, registration, tunneling and encapsulation, optimizations, DHCP. Mobile Transport Layer: Traditional TCP, Indirect TCP, Snooping TCP, Mobile TCP, Fast retransmit/fast recovery, Transmission /time-out freezing, Selective retransmission, Transaction oriented TCP.

UNIT III:
Database Issues: Hoarding techniques, caching invalidation mechanisms, client server computing with adaptation, power-aware and context-aware computing, transactional models, query processing, recovery, and quality of service issues. Data Dissemination: Communications asymmetry, classification of new data delivery mechanisms, push-based mechanisms, pull-based mechanisms, hybrid mechanisms, selective tuning (indexing) techniques.

UNIT IV:
Mobile Ad hoc Networks (MANETs): Overview, Properties of a MANET, spectrum of MANET applications, routing and various routing algorithms, security in MANETs, Protocols and Tools: Wireless Application Protocol-WAP. Bluetooth, security, link management)

REFERENCES:

1. Jochen Schiller, Mobile Communications, Addison-Wesley.
2. Stojmenovie and Cacute, Handbook of Wireless Networks and Mobile Computing, Wiley.

Course Outcomes:
At the end of the course, students will be able to:

CO1:	Investigate the structure and components for Mobile IP and Mobility Management.
CO2:	Analyze challenges related to mobile network and transport layer
CO3:	Develop efficient caching mechanisms for power/context aware computing & QoS.
CO4:	Design WAP based tools for networking & security issues in MANETs & Bluetooth.

MEC1E38 SPEECH PROCESSING

L T P	Credits	: 3
3 0 0	Time	: 3 Hours

Course Objectives:

Aim of this course is to introduce the students with models for speech signal in Time-domain and Frequency-domain. Student will also be familiarized with Homomorphic Speech processing system.

UNIT-I
Digital models for speech signals:
Mechanism of speech production & acoustic phonetics, the acoustic theory of speech production, lossless tube models, and digital models for speech signals.

UNIT-II
Time Domain Models and Digital Representation of Speech:
Time dependent processing of speech, short time energy and average magnitude, short time average zero crossing rate, discrimination between speech & silence, pitch period estimation using parallel processing, short time autocorrelation function & AMDF, pitch period estimation using autocorrelation function, Median Smoothing and Speech Processing. Sampling speech signals, Review of the statistical model for speech, Instantaneous Quantization, Adaptive Quantization, General Theory of Differential Quantization, DPCM, Direct Digital Code Conversion.

UNIT-III
Short Time Fourier analysis of Speech Signal:
Definition and properties, Design of digital filter banks, Implementation of filter bank summation method using FFT, Spectrographic displays, Pitch detection, Analysis by synthesis, Analysis-Synthesis systems.

UNIT-IV
Homomorphic Speech processing and Linear Predictive Coding of Speech: Homomorphic systems for convolution, Complex cepstrum of speech, Pitch detection, Formant estimation, The Homomorphic vocoder, Basic principles of linear predictive analysis, Computation of the gain for the model, Solution of LPC equations, Comparisons between the methods of solution of the LPC analysis equations, The prediction error signal, Frequency domain interpretation of linear predictive analysis, relation of linear predictive analysis to lossless tube models, Relations between the various speech parameters, Synthesis of speech from linear predictive parameters, application of LPC parameters.

REFERENCES:

1. Digital Processing of Speech Signals by L.R. Rabiner and R.W. Schafer,Pearson
2. Discrete-Time Speech Signal Processing Principles and Practices by Thomas F. Quatieri, Pearson
3. Chris Rowden: Speech Processing McGraw Hill.

Course outcomes

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

CO1: qualitatively describe the mechanisms of human speech production and how the articulation mode of different classes of speech sounds determines their acoustic characteristics,

CO2: apply MatLab tools to analyse speech signals in the time and frequency domains, and in terms of the parameters of a source-filter production model,

CO3: solve given problems regarding parameter estimation in source-filter production models and regarding speech analysis and synthesis using these models,

CO4: describe and implement methods and systems for efficient quantization and coding of speech signals, and solve given problems regarding these methods,

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CO5: describe and implement methods for speech enhancement, and solve given problems regarding these methods,

MEC1E40 DIGITAL SIGNAL PROCESSORS AND APPLICATIONS

L T P		Credits	: 3
3 0 0		Time	: 3 Hours

Course Objectives:
To deal with the architecture and programming of DSP processors and the design of real-time DSP systems. To understand the interfacing of memory & I/O peripherals to the DSP processors and used as a desktop reference to develop real-time applications at work.

UNIT-I
Introduction: A Digital signal-processing system, sampling process, Discrete time sequences, Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT), Linear time-invariant systems, Digital filters, Decimation and interpolation, Analysis and Design tool for DSP Systems MATLAB, Computational Accuracy in DSP Implementations: Number formats for signals and coefficients in DSP systems, Dynamic Range and Precision, Sources of error in DSP implementations, DSP Computational errors.

UNIT-II
An overview of real-time DSP systems and applications, processor architectures, software and hardware development issues, and system-design considerations. Architecture, instruction set, programming, and system-design issues for several fixed-point and floating-point DSP processors, Strengths and weaknesses of each processor.

UNIT-III
Applications: Designing and implementing FIR, IIR filters, implementing Fast Fourier transforms, adaptive filtering using fixed-point and floating-point DSP processors, Low-Power Reconfigurable DSP Architecture.

UNIT-IV:
Interfacing Memory & I/O Peripherals to Programmable DSP Devices: Memory space organization, External bus interfacing signals, Memory interface, parallel I/O interface, Programmed I/O, Direct Memory access(DMA), A Multichannel buffered serial port, a CODEC interface circuit, CODEC programming.

TEXT BOOKS:
1. S. Salivahanan, A. Vallavaraj, & C. Gnanpriya, “Digital signal processing,” -TMH.
2. Venkataramani, “Digital Signal Processors: Architecture, Programming & Applications,” TMH.
3. S. M. Kuo, W.-S. Gan, “Digital Signal Processors: Architectures, Implementations, and Applications,” Pearson Education.

REFERENCES:
1. S. K. Mitra, “Digital signal processing: A Computer based approach,” TMH.
2. J. G. Proakis, “Digital signal processing principles–algorithms and applications,” PHI.

Course outcomes
At the end of the course, the students will be able to:

CO1: Understand the fixed-point and floating-point processors.
CO2: Understand the in depth knowledge of DSP processors & their architectures.
CO3: Understand implementation of DSP algorithms on different processors
CO4: Acquire knowledge about programming language techniques, integration of DSP programmable devices with memories & I/O peripherals.

MEC1E42 ADAPTIVE SIGNAL PROCESSING

L T P		Credits	: 3
3 0 0		Time	: 3 Hours

Electronics and Communication Engineering (Communication Systems)

Course objective:
To understand and study the basic concepts of Discrete random processes, linear prediction, Digital Wiener filtering, Least mean squares adaptive filter, Orthogonalized adaptive filters, least squares adaptive filters, Other adaptive filtering techniques, Blind adaptive filtering.

UNIT-I
Discrete random processes
Random variables, random processes, filtered random processes, Ensemble averages, correlation, covariance, power spectrum, cross power spectrum, Ergodicity, time averages, biased & unbiased estimators, consistent estimators.
Linear prediction
Direct form linear prediction filtering, Normal equations for linear prediction filtering. Levinson algorithm, Linear prediction lattice filtering.

UNIT-II
Digital Wiener filtering
Wiener smoothing and prediction filters, Application of Wiener smoothing to noise cancelling. Application of Wiener prediction filters. Constrained, linear MMSE filtering, minimum variance beam forming
Least mean squares adaptive filter
Frequency domain adaptive filters, Adaptive lattice filters

UNIT-III
Orthogonalized adaptive filters
Frequency domain adaptive filters, Adaptive lattice filters
Least squares adaptive filters
Godard algorithm Lattice

UNIT-IV
Other adaptive filtering techniques
Neural networks and multi-layer perceptrons, Adaptive IIR filtering, The constant modulus algorithm
Blind adaptive filtering
Cost functions. Higher-order statistics

REFERENCES:

1. Fundamentals of Adaptive Filtering, Ali H. Sayed, John Wiley.
2. Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, D. Manolakis, V. Ingle, S. Kogan, McGraw Hill.
3. Adaptive Signal Processing, B. Widrow, S. Stearns, Prentice-Hall.
4. Theory and Design of Adaptive Filters, J. Triechler, C. Johnson, M. Larimore Prentice-Hall.
5. Adaptive Filtering: Algorithms and Practical Implementation, P. Diniz, Kluwer.
6. Adaptive Filters: Structures, Algorithms and Applications, M. Honig, D. Messerschmitt, Kluwer.
7. Adaptive Signal Processing, L. Sibul, Ed., IEEE Press.
8. Time Series Analysis: Forecasting and Control, G. Box, G. Jenkins, Holden- Day.
9. Time Series, D. Brillinger, Holt-Reinhart-Wilson.
10. Signal Processing: The Modern Approach, J. Candy, McGraw Hill.
11. Signal Processing: The Model Based Approach, J. Candy, McGraw Hill.
12. Digital Spectral Analysis, S. Marple, Prentice-Hall.
13. Blind Deconvolution, S. Haykin, ed., Prentice-Hall,.

Course outcomes:

CO1: To learn Discrete random processes and linear prediction.
CO2: To gain knowledge about Digital Wiener filtering and Least mean squares adaptive filters.
CO3: To learn Orthogonalized adaptive filters and least squares adaptive filters.

CO4: To gain knowledge about Other adaptive filtering techniques and Blind adaptive filtering.

MEC1E44 ERROR CONTROL CODING

L T P Credits : 3
3 0 0 Time : 3 Hours

Course Objectives:
To demonstrate competence in analyzing and evaluating the practice of different error correcting coded in digital communication system.

UNIT-I
Coding for Reliable Digital Transmission & Storage: Introduction, Types of codes, modulation & demodulation, Maximum likelihood decoding, types of errors, error control strategies, selection of coding scheme.

UNIT-II
Convolutional & Linear Block Codes: Encoding of convolutional codes, structural & distance properties of convolutional codes, Introduction to linear block codes, syndrome & error detection, minimum distance of a block codes, error-detecting & error-correcting capabilities of block code, standard array & syndrome decoding, hamming codes.

UNIT-III
Cyclic Codes: Description of cyclic codes, Generator & parity-check matrices of cyclic codes, encoding of cyclic codes, syndrome computation & error detection, decoding of cyclic codes, cyclic hamming codes, shortened cyclic codes, DSP 56002 Instruction Set: Instruction Formats Parallel move operating parallel move types, instructions set move arithmetic logic, bit manipulation, loop, programmer control instructions.

UNIT-IV
BCH Codes: Description of the codes, decoding of the BCH codes, implementation of Galois field arithmetic, implementation of error correction, non-binary BCh codes & reed- solomon codes, weight distribution & error detection of binary BCH codes, LPDC, Turbo, Trellis.
Multistage Coding: Introduction, serial concatenation, serial concatenation using inner block code, maximal length codes, orthogonal codes, reed muller codes, high rate codes with soft-decision decoding.

TEXT BOOKS:
1. S. Lin, D. J. Costello Jr., “Error Control Coding: Fundamentals & Applications,” Prentice–Hall.
2. P. Sweeney, “Error Control Coding From Theory to Practice,” John Wiley & Sons Ltd..
3. C. W. Huffman & V. Pless, “Fundamentals of Error-Correcting Codes,” Cambridge University Press.

REFERENCES:
1. J. G. Proakis, “Digital Communications,” McGraw Hill.
2. S. Haykin, “Communication Systems,” John Wiley & Sons.
3. M. Bossert, “Channel Coding for Telecommunications,” John Wiley & Sons.

Course outcomes
At the end of the course, the students will be able to
CO1: Understand the importance of error correcting methods for reliable digital transmission.
CO2: Understand the strengths and weaknesses of various errors correcting code for a given application.
CO3: Understand different error correcting codes for appraise of reaching data rate to Shannon limit
CO4: Acquire knowledge about multistage coding.

MEC1E46 MIMO Wireless Communications

L T P Credits : 3

Electronics and Communication Engineering (Communication Systems)

3 0 0 Time : 3 Hours

Course Objectives

The student should be able to understand and apply the various concepts of MIMO System in Wireless Communication.

UNIT-I

Introduction to multi antenna communications

Space lime wireless channels for multi antenna systems, Overview of Diversity techniques of SIMO, MISO and MIMO systems, Shannon's capacity formula, Extended Capacity formula for MIMO channels. Capacity of SIMO- MISO channels.

UNIT-II

Introduction to Space time coding

Space Time Coding (STC): System model, pairwise error probability, space time block code design. Space Time Block Codes (STBC): Alamouti space time codes, generalization of space time block coding, decoding of space time block codes, space time trellis codes. Spatial Multiplexing, Spatial Modulation.

UNIT-III

Feedback Techniques and Antenna Selection in MIMO Systems

Feedback Techniques introduction, Limited feedback MIMO: System Description, channel quantization, quantized signal adaptation, Quantized signal Adaptation algorithms. Antenna Selection: Optimum Antenna Selection Technique, Complexity Reduced Antenna Selection, Antenna Selection for OSTBC, Antenna selection with spatial correlation.

UNIT-IV

Multi User MIMO Systems

Mathematical Model for Multi-User MIMO System, Channel capacity of Multi-user MIMO system. Transmission methods for broadcast channel: Channel Inversion, Block Diagonalization, Dirty Paper Coding, Tomlinoson-Harashima Precoding.

Introduction to Massive MIMO Systems

Favorable Propagation and Deterministic Channels, Favorable Propagation and Random Channels, Finite Dimensional Channels, Pilot Contamination and Pilot Assignment, Massive MIMO with FDD Operation, Cell Free Massive MIMO.

REFERENCES:

1. George Tsoulos," MIMO System Technology for wireless communications", Taylor & Francis Group.
2. Claude Oestges & Bruno Clerckx," MIMO wireless communications: from real world propagation to space time coding design", Elsevier

Course outcomes

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

CO1: Understand the importance of error correcting methods for reliable digital transmission.

CO2: Understand the strengths and weaknesses of various errors correcting code for a given application.

CO3: Understand different error correcting codes for appraise of reaching data rate to Shannon limit

CO4: Acquire knowledge about multistage coding.

MEC1E48 SELECTED TOPICS IN COMMUNICATION ENGINEERING

L T P	Credits : 3
3 0 0	Time : 3 Hours

Course Objectives:
This subject aims to introduce upcoming technologies for wireless communication like OMA, NOMA, D2D Communication and Millimeter wave communication.

Syllabus

UNIT-I
Review of wireless channels:
Background and quick review of wireless channels: propagation losses, multipath propagation, time-variant channels, Time domain equalization (MLSE, DFE, other linear equalization techniques), Frequency domain equalization Orthogonality and interference in communication systems.

UNIT-II
Orthogonal and Non orthogonal multiple access:
Orthogonal and Non orthogonal multiple access: Introduction to OMA and NOMA, state of the art in OMA and NOMA. Advantages and disadvantages of OMA and NOMA. State of the art in OMA and NOMA. Research issues.

Unit-III
D2D Communication:
D2D Communication: Introduction of D2D communication, state of the art, Limitations and research issues in D2D Communication.

Unit-IV
Millimeter wave communication:
Millimeter wave communication: Introduction of mm wave communication, state of the art, Limitations and research issues in mm wave communication.

REFERENCES:

1. Theodore S Rappaport- "Wireless Communications- Principles And Practice," (Review of wireless propagation models).
2. Lingyang Song , Dusit Niyato, Zhu Han, Ekram Hossain-" Wireless Device-to-Device Communications and Networks", Cambridge University Press.
3. Chen Xu, Lingyang Song, and Zhu Han,- "Resource Management for Device-to-Device Underlay Communication", Springer Publishing Company.
4. Kao-Cheng Huang Zhaocheng Wang-"Millimeter Wave Communication Systems", John Wiley & Sons.
5. Recent literature on 5G technologies.

Course outcomes:

At the end of the course, the students will be able to:

CO1: Understand the Time domain equalization and Frequency domain equalization.
CO2: Understand the concept of OMA and NOMA systems.
CO3: Understand the concept D2D communication and Research issues in D2D communication.
CO4: Understand the basic concept of Millimeter wave communication.

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MEC1O72 SENSORS TECHNOLOGY

L T P	Credits	: 3
3 0 0	Time	: 3 Hours

Course Objectives:

Course will provide the understanding of the right sensors for a given application and design basic circuit building blocks. Also help students to simulate, synthesize, and layout a complete sensor and sensor system.

Syllabus

UNIT-I
DATA ACQUISITION: Sensors, Signals and Systems, Sensors types and classification, Sensor Characteristics.
PHYSICAL PRINCIPLE OF SENSING: electric charges, field and potential, capacitance, magnetism and induction, resistance, piezoelectric effect, hall effect, temperature and thermal properties of materials, heat transfer.

UNIT-II
Nature of Semiconductor Sensor Output: Sensor Output Characteristics, Sensing Technologies, Digital Output Sensors, Noise/Interface Aspects, Low Power Low Voltage Sensors, Analysis of Sensitivity Improvement. Getting Sensor Information into the Microcontroller, Amplification and Signal Conditioning, Digital Conversion

UNIT-III
Communications for Smart Sensors: Automotive Protocols, Industrial Networks, Wireless Sensors and its Applications, Wireless Sensing Networks, Telemetry, Modeling and simulation of microsensors and actuators, Sensors and smart structures. Micro-opto-electro-mechanical sensors and system, Interworking with IoT

UNIT-IV
SENSORS IN DIFFERENT APPLICATION AREAS: Sensor Fusion concept, Automotive Sensors, Home appliance Sensors, Aerospace Sensors, Sensors for manufacturing, Medical Diagnostic Sensors, Sensors for Environmental Monitoring, Recent Trends in Sensor Technology.

REFERENCES:

1. J. Fraden, Handbook of Modern Sensors:Physical, Designs, and Applications, AIP Press, Springer.
2. D. Patranabis, Sensors and Transducers, PHI Publication, New Delhi
3. Randy Frank, Smart Sensors, Artech House.
4. Sze S.M “Semiconductor Sensors”, John Wiley, New York.
5. Ristic L,“Sensor Technology and Devices”, Artech House, London.
6. Gerard Meijer, Kofi Makinwa, “Smart Sensor Systems: Emerging Technologies and Applications”, ISBN: 978-0-470-68600-3.

Course outcome:
After studying this course, the student will be able to:

CO1: Understand the concept of sensors and its characteristics.

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CO2: Understand the practical approach in design of technology based on different sensors.
CO3: Learn various sensor materials and technology used in designing sensors
CO4: Synthesis and analyze wireless sensors for advanced applications
CO5: Understand the software and hardware designing aspects of sensors co-existing with other systems
CO6: Propose new applications for sensors.

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MEC1O74 Cyber Physical System

L T P	Credits	: 3
3 0 0	Time	: 3 Hours

Course Objectives:

The objective of this course is to introduce students to cyber-physical systems modeling, analysis and design. Students should be able to: Define embedded systems and cyber-physical systems (CPS) and give examples.
The student should be able to develop an explanation of the challenges in implementing a cyber-physical system from a computational perspective, but based equally on the principles of automated control.
The course aims to representation the student to real world problems in this domain and provide a walk through the design and validation problems for such systems.

Syllabus

UNIT-I
Introduction: What is a Cyber-Physical System, Key Features of Cyber-Physical Systems, Application, and Sidebar: About the Term "Cyber-Physical Systems, Motivating Example, The Design Process.

UNIT-II
Modeling Dynamic Behaviors
Continuous Dynamics, Discrete Dynamics, Hybrid Systems, Composition of State Machines, Concurrent Models of Computation.

UNIT-III
Design of Embedded Systems
Embedded Processors, Memory Architectures, Input and Output, Multitasking, Scheduling.

UNIT-IV
Analysis and Verification
Invariants and Temporal Logic, Equivalence and Refinement, Reach ability Analysis and Model Checking, Quantitative Analysis.

REFERENCES:

1. E.A. LEE & S.A. SESHIA: Introduction to Embedded Systems, A Cyber-Physical Approach, UC Berkeley.
2. Alur, Rajeev: Principles of Cyber-Physical Systems. MIT Press.
3. Wolf, Marilyn: High-Performance Embedded Computing, Applications in Cyber-Physical Systems and Mobile Computing, Elsevier.

Course outcome:
After studying this course, the student will be able to:

CO1: Understand various modeling formalisms for CPS, such as hybrid automata, state-space methods, etc.
CO2: Learn the categorize the essential modeling formalisms of Cyber-Physical Systems (CPS).
CO3: Understanding the concept of Internet of Things (IoT) for pervasive computing.
CO4: The course provides students with a basic understanding of state-of-the-art in the area of cyber physical systems.

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MEC1L10 SIMULATION LAB

L T P	Credits	: 3
0 0 2	Time	: 2 Hours

Learning Objectives:

- To provide background and fundamentals of MATLAB tool for the analysis and processing of communication signals, and make students able to design the required algorithms for their research work using MATLAB.
- To provide an overview of signal transmission through linear systems, convolution and correlation of signals and sampling, and also understand the practical importance and importance of Fourier and Z-Transforms using MATLAB.
- To design a network, simulate and analyze the performance of an IoT system, wireless routers, switches and wireless interconnects, etc. through NetSim tool.
- To use Wireless InSite tool to design wireless links, optimize antenna coverage, assess key channel and signal characteristics for RF and millimeter wave frequency bands.
- To understand, analyze and design the antenna, filters, complex radio frequency circuit and transmission lines using HFSS tools.

Course Outcomes:

Upon completion of this course, students will able to :

CO1: Analyze the generation of various signals and sequences in MATLAB, including the operations on Signals and Sequences.

CO2: Verification of Sampling Theorem, Linearity and Time Invariance Properties of a given Signals/ Systems.

CO3: Analyze the Fourier Transform of a given signal and plotting its magnitude and phase spectrum and also plot Pole-Zero Maps in Z-Plane.

CO4: Analyze the wireless interconnects, switches, routers, and a wireless design through NetSim.

CO5: Able to properly analyze the EM wave flow and properties, analyzing the antenna coverage and capacity, designing and simulating mesh networks through Wireless InSite tool.