Babu Banarasi Das University, Lucknow

Department of Electronics and Communication

School of Engineering
Master of Technology

Wireless Communication & Sensor Networks

Evaluation Scheme (Full Time) (w.e.f Session 2019-20)

SEMESTER I									
Course Category	**Course Code**	**Course Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	MAS3002	Linear algebra and random process	4	0	0	40	60	100	4
C	MEC3101	Advance Wireless Communication Systems	4	0	0	40	60	100	4
C	MEC3102	Data Communication	4	0	0	40	60	100	4
C	MEC3103	Digital Communication Techniques	4	0	0	40	60	100	4
GE		Generic Elective-I	4	0	0	40	60	100	4
C	MEC3151	Advance Wireless Communication Laboratory	0	0	2	40	60	100	1
C	MEC3152	Seminar	0	0	2	100	-	100	1
C	MEC3153	Technical Paper Presentation *	0	0	2	100	-	100	1
	Total		20	0	6	440	360	800	23

SEMESTER II									
Course Category	**Course Code**	**Course Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	MEC3201	Wireless MIMO Communications	4	0	0	40	60	100	4
C	MEC3202	Introduction to Mobile Computing	4	0	0	40	60	100	4
C	MEC3203	Wireless Sensor Networks	4	0	0	40	60	100	4
GE		Generic Elective-II	4	0	0	40	60	100	4
GE		Generic Elective-III	4	0	0	40	60	100	4
C	MEC3251	MIMO Wireless Communication Lab	0	0	2	40	60	100	1
C	MEC3252	Mini Project	0	0	2	100	-	100	1
C	MEC3253	Research Methodology & Practices **	0	0	2	100	-	100	1
	Total		20	0	6	440	360	800	23

SEMESTER III									
Course Category	**Course Code**	**Course Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	MEC3351	State of Art Seminar ***	-	-	-	200	-	200	4
C	MEC3352	Thesis –I #	-	-	-	400	-	400	16
	Total					600		600	20

SEMESTER IV									
Course Category	**Course Code**	**Course Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	MEC3451	Thesis –II ##	-	-	-	200	800	1000	28
	Total					200	800	1000	28

* Technical paper presentation provides a platform for the student to do some original research that has not been done before, have a latest research paper (for reference) published in a refereed journal, and then give a presentation.

** The mission of the course is to impart research skills to the beginners and help them to improve the quality of Research. The student is expected to develop the most appropriate methodology for their Research Studies, and then give a presentation on research overview and its methodologies. This may include various steps to conduct the research.

*** The student needs to perform a literature survey and will give a state of art presentation and will submit a synopsis clearly mentioning the problem statement. The presentation and synopsis will be evaluated internally within two months of the start of the semester and the result will be intimated to the students so as to proceed for Thesis-I.

The student will develop a workable model for the problem they have proposed in synopsis.

This is in continuation with Thesis-I. The required experimental/mathematical verification of the proposed model will be done in this semester.

Generic Elective – I		
1.	GE35411	Advance Digital Signal Processing
2.	GE35412	Modelling and Simulation of Wireless Communication Systems
3.	GE35413	Mobile Satellite Communication
4.	GE35414	Global Positioning System

Generic Elective – II		
1.	GE35421	Smart Antennas
2.	GE35422	Advance Optical Communication
3.	GE35423	Multimedia Communication Systems
4.	GE35424	CDMA and OFDM for Wireless Communication

Generic Elective – III		
1.	GE35431	Statistical Signal Processing
2.	GE35432	Spread Spectrum communication
3.	GE35433	Cooperative Communication
4.	GE35434	Cognitive Radio Communication

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Evaluation Scheme (Full Time) (w.e.f Session 2019-20)

Course Category	Semester						Total Credits	%age
	I	II	III	IV	V	VI		
F								
C	19	15	20	28			82	87.23
GE	4	8					12	12.77
Total	23	23	20	28			94	100

Course Category	Semester						Total Credits	%age
	I	II	III	IV	V	VI		
Basic Sciences	4						4	4.25
Professional Subject – Core	13	13					26	27.65
Professional Subject – Generic Elective	4	8					12	12.77
Project Work, Seminar and/or Internship in Industry or elsewhere/GP	2	2	20	28			52	55.32
Total	23	23	20	28			94	100

MEC3101-Advance Wireless Communication Systems

Course Objective:

1. The main objective of this course is to build an understanding about the basic cellular concept, system interference and system capacity.
2. It provides the knowledge about the various fading effect and models.
3. It introduces the concept of error probability in different fading channel like AWGN.

Learning Outcome:

1. The students will understand the cellular system design fundamentals such as frequency reuse, cell coverage and handoff strategies.
2. Students will understand the error performance of digital modulation technique over AWGN and Fading channels.
3. Students will be able to find the capacity of wireless channel and learn about different diversity techniques.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Cellular Concepts – System Design Fundamentals** Cellular concept**,** Channel reuse**,** Channel assignment strategies**,** Handoff strategies**,** Interference and system capacity**,** Improving capacity in cellular system, Coverage of cellular systems	30 Hours	1
II	**Mobile Radio Propagation** Large Scale Path Loss: Free space propagation model-Basic propagation mechanisms (Reflection, diffraction and Scattering)-ground reflection model-Diffraction Model-Practical link budget design-Outdoor and indoor propagation models, Small scale fading and multipath: Small scale multipath propagation-Impulse response model of a multipath channel-Small scale multipath measurements parameters of mobile multipath channels-Types of small scale fading	30 Hours	1
III	**Performance of digital modulation over wireless channels** Error Probability for BPSK and QPSK over AWGN channel, Error Probability for M- ary PSK over AWGN channel, Error Probability for M-ary PAM and M-ary QAM over AWGN channel, Error Probability for FSK over AWGN channel, Error Probability for MSK and GMSK over	30 Hours	1

	AWGN channel, Outage and error probability analysis in Fading channels		
IV	**Capacity of Wireless Channels and Diversity Techniques** Capacity in AWGN, Capacity of Flat Fading Channel, Channel Distribution Information (CDI) known, Channel Side Information at Receiver, Channel Side Information at Transmitter and Receiver, Capacity of Frequency Selective Fading channels, Introduction to Diversity Techniques: Time diversity-Frequency diversity-Space diversity-Polarization diversity	30 Hours	1

Text/ Reference Books:

1. Andrea Goldsmith, "Wireless Communications," Cambridge University Press, 2007.
2. T.S. Rappaport, "Wireless Communications," Pearson Education, 2008.
3. Raj Pandya, "Mobile and Personal Communication Systems and Services," Prentice Hall of India, 2002.
4. William C.Y. Lee, "Wireless and Cellular Telecommunications," 3rd edition, Tata McGraw Hill, 2006.

MEC3102-Data communication

Course Objective:

1. Describe the components of a data communications system. Identify key considerations in selecting various transmission media in networks.
2. Explain the role of line codes in a data communications network.
3. Explain the role of digital communications devices in a data communications network.
4. Describe the various types of signals and their features.
5. Describe the features and functions of multiplexing and modulation.
6. Describe the various error detection and correction schemes.

Learning Outcome:

1. After completion of the subject, the students will understand Data Communications System and its components.
2. Students will be able to identify the different types of network topologies, protocols and different types of network devices and their functions within a network.
3. Students will learn the basic protocols of computer networks, and how they can be used to assist in network design and implementation.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** A Communication model, Data Communications, Data Communication Networking, Need for Protocol Architecture, A Simple Protocol Architecture, OSI Model, The TCP/IP Protocol Architecture	30 Hours	1
II	**Data Communications and Signal Encoding Techniques:** Concepts, Analog and Digital Data Transmission, , Transmission Impairments, Channel Capacity, Guided Transmission Media, , Wireless Transmission, Wireless Propagation, Line-of Sight Transmission, Signal Encoding Techniques	30 Hours	1
III	**Digital Data Communication Techniques, Multiplexing and Spread Spectrum** Asynchronous and Synchronous Transmission, Types of Errors, Error Detection, Error correction, Line Configurations, Interfacing, Data Link Control: Flow control-Error Control-High-Level Data Control , Multiplexing: Multiplexing using Frequency Division-Synchronous Time Division-Statistical Time Division-Asymmetric Digital	30 Hours	1

	Subscriber Line Xdsl, Spread Spectrum: The Concept of Spread Spectrum-Frequency Hoping-Direct Sequence Spread Spectrum-Code-Division Multiple Access		
IV	**WAN and LAN** WAN: Circuit Switching and Packet Switching, Switching Networks, Circuit Switching Networks, Circuit-Switching Concepts, Control Signaling, Soft switch Architecture, Packet Switching Principles, X-25, Frame Relay, Asynchronous Transfer Mode: Protocol Architecture-ATM Logical Connections-ATM Cell-Transmission of ATM Cells-ATM Service Categories-ATM Adaptation Layer, LAN: Background Topologies and Transmission Media-LAN Protocol Architecture-Bridges-Layer 2 and Layer 3 Switches	30 Hours	1

Text/ Reference Books:

1. W Stallings, Data and Computer Communications, Prentice Hall of India, 1997,PearsonEdu.
2. Data Communication by FOROUZAN TMCG & NETWORKING.
3. M Deprycker, ATM-solutions for Broadband ISDN, Prentice-Hall of USA,1995.
4. R.G Gallager and D Bertsekas, Data Networks, Prentice Hall of India, 1992.

MEC3103-Digital Communication Techniques

Course Objective:

1. To understand the building blocks of digital communication system.
2. To prepare mathematical background for communication signal analysis.
3. To understand and analyze the signal flow in a digital communication system.
4. To analyze error performance of a digital communication system in presence of noise and other interferences.
5. It gives the insight view of different modulation technique those are used in digital communication.
6. It introduces various channel coding techniques to combat with fluctuating channel Conditions. It also provides the idea about the network synchronization.

Learning Outcome:

1. Student will be able to gain the knowledge about the architecture of digital communication systems.
2. They will learn about the Equalization techniques, used to remove the ISI.
3. Students will gain the knowledge about different modulation and coding techniques.
4. Students will learn about the link budget in which they will learn how to calculate the losses at every possible point in the communication link.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Functional Architecture of digital communication systems** Functional Architecture of digital communication systems, Definition and Characterization of band limited Channel, Optimum pulse shape Design, Equalization techniques, Gram-Schmidt Orthogonalisation Procedure, Shannon's capacity theorem, Shannon Limit	30 Hours	1
II	**Formatting and Base Band Modulation** Base Band Systems, Formatting Textual Data, Co-Relation Receiver, Coherent Detection: Coherent Detection of ASK-Sampled Matched Filter, Non-Coherent Detection: Detection Of Differential PSK, Error Performance for Binary Systems: Probability of Bit Error for coherently Detected BPSK-Probability of Bit Error for coherently Detected DPSK-Probability of Bit Error for coherently Binary Detected Binary Orthogonal FSK-Probability of Bit Error for Non coherently Detected Binary Orthogonal FSK-Probability of Bit Error for Binary DPSK-Comparison of Bit Error	30 Hours	1

	Performance for various Modulation Types, M-Array Signaling, Symbol Error Performance For M-array System: Probability of Symbol Error for MPSK-Probability of Symbol Error for MFSK-Bit Error probability versus Symbol Error probability For orthogonal Signals-Bit Error probability versus Symbol Error probability For multiple phase signaling		
III	**Communication Link Analysis (Link Budget)** Meaning of link budget: Need and Significance of link budget, Received Signal Power and noise power: Power range Equation-Noise Figure, Noise Temperature, Repeaters: regenerative Repeaters-Non-regenerative Repeaters	30 Hours	1
IV	**Channel Coding and Synchronization** Error correction coding and trade-offs: Coding Gain and performances-Linear Block Codes-Systemaic Linear Block Codes, Convolution Encoding: Convolution Encoder Representation, Polynomial Representation: State Representation and State Diagram-The Tree Diagram-The Trellis Diagram, Reed Solomon Codes, Interleaving: Block Interleaving-Convolution Interleaving, Concatenated Codes, Turbo Codes, Synchronization: Receiver Synchronization-Network Synchronization	30 Hours	1

Text/ Reference Books:

1. Bernard Sklar, "Digital Communication, Fundamentals and Application", Pearson Education Asia, 2nd Edition, 2001
2. John G. Proakis, "Digital Communication", McGraw Hill Inc 2001
3. Simon, Hinedi, Lindsey, "Digital Communication Techniques, Signal Design and Detection ",Prentice Hall of India Private Limited, New Delhi - 11, 1999
4. Simon Haykin, "Digital Communications", John Wiley and Sons, 1998
5. B.P. Lathi, "Modern Digital and Analog and communication systems", 3rd Edition Oxford university press 1998

MEC3151-Advance Wireless Communication Laboratory

List of Experiments

1. Modeling of free space propagation model
2. Modeling of two- ray ground reflection model.
3. Modeling of Knife-edge diffraction model.
4. Modeling of Log-normal shadowing in land mobile communication
5. Performance of digital modulation scheme in Gaussian channel.
6. Modeling of Okumura-Hata propagation model.
7. Performance of digital modulation scheme in Rayleigh channel.
8. Generation of Rayleigh & Exponentially distributed random variable with the help of Gaussian distributed random variable.
9. Generation of Rayleigh fading channel with the help of Matlab function.

MEC-3201Wireless MIMO Communications

Course Objective:

1. The main objective of this course is to give the comprehensive idea about the basic concept of fading channels, their Probability of Error/Outage Probability and Different Diversity Technique.
2. To impart the knowledge about MIMO Channel Modeling, Capacity and Orthogonal Space Time Block Coding.

Learning Outcome:

1. At the end of the course student will be able understand the fading channels and calculate Error Probability and Outage Probability.
2. Students will be able to calculate the average SNR at the output of the combiner and Error/Outage Probability.
3. Students will be able to model a MIMO Channel and find its capacity.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Basic Concept Of Fading Channels** Wireless Channels**,** Error/ Outage probability over fading channels**,** Diversity techniques**,** Diversity Combining Scheme**:** Maximal Ratio Combining (MRC)-Equal Gain Combining (EGC)-Selection Combining (SC)-Generic Selection Combining (GSC)-Switch and Stay Combining (STC) diversity**,** Multiple antennas in wireless communications.	30 Hours	1
II	**Capacity of MIMO channels** Capacity and Information rates of noisy, AWGN and fading channels, Capacity of MIMO channels, Capacity of non-coherent MIMO channels, Constrained signaling for MIMO communications.	30 Hours	1
III	**MIMO Channel Coding** Transmit diversity with two antennas: The Alamouti scheme, Orthogonal and Quasi-orthogonal space-time block codes, Linear dispersion codes, Generic space-time trellis codes, Basic space-time code design principles, Representation of space-time trellis codes for PSK constellation, Performance analysis for space-time trellis codes, Comparison of space-time block and trellis codes, Development of concatenated codes, Concatenated codes for AWGN and MIMO channels, Turbo coded modulation for MIMO channels, Concatenated space-time block coding.	30 Hours	1

IV	**MIMO frequency-selective channels and MIMO OFDM** MIMO frequency-selective channels, Capacity and Information rates of MIMO Frequency Selective fading channels, Space-time coding and Channel detection for MIMO Frequency Selective channels, MIMO OFDM systems.	30Hours	1

Text/ Reference Books:

1. Tolga M. Duman and Ali Ghrayeb, "Coding for MIMO Communication systems", John Wiley &Sons, West Sussex, England, 2007
2. M. Janakiraman, "Space-time codes and MIMO systems", Artech House, 2004
3. E.G. Larsson and P. Stoica, "Space-time block coding for Wireless communications", Cambridge University Press, 2003
4. H. Jafarkhani, "Space-time coding: Theory & Practice", Cambridge University Press, 2005
5. A.B. Gershman and N.D. Sidiropoulus, "Space-time processing for MIMO communications", Wiley, Hoboken, NJ, USA, 2005

MEC3202-Introduction to Mobile Computing

Course Objective:

1. The main objective of this course is to give the comprehensive idea about various mobile generation technologies their usage and network scenarios.
2. It gives the knowledge about mobile languages, its Future advancements and Wireless Application Protocol.

Learning Outcome:

1. At the end of the course students will have clear understanding of UMTS, HSPA, LTE, Wi MAX, Wi Fi, mobile radio link and its air interfaces.
2. They will learn about per-user throughput in Downlink and Uplink.
3. They will learn about Developing Mobile Computing applications and J2ME.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Evolution:** Evolution from 2G over 3G to 4G & 5G, Beyond 3G Network Architectures: UMTS, HSPA and HSPA+-LTE-Wi-MAX-Wi-Fi	30 Hours	1
II	**Network Capacity and Usage Scenarios** Usage in Developed Markets and Emerging Economies, Measuring Mobile Usage from a Financial Point of View, Cell Capacity in Downlink, Current and Future Frequency Bands for Cellular Wireless, Cell Capacity in Uplink, Per-user Throughput in Downlink, Per-user Throughput in the Uplink, Traffic Estimation Per User, Overall Wireless Network Capacity	30 Hours	1
III	**Mobile Computing and Overview** Mobile Computing, Developing Mobile Computing applications, Mobile Computing Architectures , Mobile Computing through Telephony, Short Message Service, Wireless Application Protocol	30 Hours	1
IV	**Introduction to Mobile Language and Future Advancements** J2ME**,** Voice over Internet Protocol and Convergence**,** Security Issues in Mobile Computing**,** Next Generation Networks (NGN): Concept and Overview.	30 Hours	1

Text/ Reference Books:

1. Martin Sauter “Beyond 3G: Bringing Networks, Terminals and the Web together”, Wiley.
2. Hasan Ammed “Mobile Computing”, McGraw Hill.

MEC3203-WIRELESS SENSOR NETWORKS

Course Objective:

1. The main objective of this course is to introduce the basic concepts and applications of Wireless Sensor Networks.
2. To provide the idea about the fundamentals of wireless communication system used in wireless sensor network with relevant protocols and design issues.

Learning Outcome:

1. At the end of the course students will have clear understanding of WSN network architectures, its characteristics, critical design factors, and constraints.
2. They will gain the understanding of various medium access control (MAC) protocols for WSNs.
3. Students will learn about various routing protocols and the challenges of transport layer solutions. They will understand localization and its challenges.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Overview Of Wireless Sensor Networks** Relationship between Wireless Ad-Hoc Network & Wireless Sensor Network, WSN Architecture and Protocol Stack , WSN Applications, Factors Influencing WSN Design: Hardware Constrains-Fault Tolerance-Scalability-Production Costs-WSN Topology, Transmission, Media, Power Consumption	30 Hours	1
II	**Physical Layer and Medium Access Control** Physical Layer Standard: 802.15.4, Challenges for MAC, CSMA Mechanism, Contention Based MAC Protocols: S-MAC-B-MAC, Reservation Based Medium Access: TRAMA, Hybrid Medium Access: Zebra MAC **Communication with internet:** Design Principles for WSNs Gateway Concepts – Need for gateway – WSN to Internet Communication –Internet to WSN Communication –WSN Tunneling	30 Hours	1
III	**Network Layer and Transport Layer** Challenges For Routing, Data centric and Flat-Architecture Protocol: Flooding-Gossiping-Sensor Protocols for Information via Negotiation (SPIN)-Directed Diffusion, Hierarchical Protocols: LEACH-PEGASIS, Challenges for Transport	30 Hours	1

	Layer, Reliable Multi-Segment Transport (RMST) Protocol, Pump Slowly, Fetch Quickly (PSFQ) Protocol, Congestion Detection and Avoidance (CODA) Protocol		
IV	**Time Synchronization and Localization** Challenges for Time Synchronization, Network Time Protocol, Timing-Sync Protocol for Sensor Networks (TPSN), Reference-Broadcast Synchronization (RBS), Challenges in Localization, Ranging Techniques, Range-Based Localization Protocols	30 Hours	1

Text Books:

1. I.F. Akyildiz& M.C. Vuran, " Wireless Sensor Networks".
2. K. Soraby& D. Minoli, "Wireless Sensor Networks" Wiley.
3. Holger Karl and Andreas Wiilig, "Protocols and Architectures for Wireless SensorNetworks" John Wiley & Sons Limited 2008.
4. I.F .Akyildiz and Weillian, "A Survey on Sensor Networks", IEEE
5. Demin Wang and Dharma P. Agrawal, "Wireless Sensor Networks: Deployment Alternatives and Analytical Modeling," book published by Lambert Academic, 2010.
6. Jung Hyun Jun, Bin Xie, and Dharma P. Agrawal, "Wireless Mobile Sensor Networks," book chapter edited by Sudip Misra, Handbook of Wireless Ad Hoc and Sensor Networks (Springer).

MEC3251-MIMO Wireless Communication Lab

List of Experiments

1. Generate Rayleigh distributed random variable with the help of complex Gaussian random variable of zero mean and unity variance. From the generated random variable plot the received power in dB.
2. Generate Rician distributed random variable with the help of complex Gaussian random variable of unity mean and unity variance. From the generated random variable plot the received power in dB.
3. Outage performance of single antenna transmitter receiver system in Rayleigh fading channel
4. Average error probability (BPSK) of single antenna transmitter receiver system in Rayleigh fading channel.
5. System modeling of multi-antenna receiver with Maximum Ratio Combining.
6. System modeling of multi-antenna receiver with Selection Combining.

Generic Elective - I

GE35411Advanced Digital Signal Processing

Course Objective:

1. The primary objective of this course is to provide a thorough understanding and working knowledge of design, implementation and analysis DSP systems. Interpret, represent and process discrete/digital signals and systems.
2. Thorough understanding of frequency domain analysis of discrete time signals. Ability to design & analyze DSP systems like Adaptive Filter etc.
3. Practical implementation issues such as computational complexity, hardware resource limitations as well as cost of DSP systems or DSP Processors.
4. Understanding of spectral analysis of the signals

Learning Outcome:

1. After completion of the subject the student will be able to understand the design principles and the implementation of digital adaptive filters.
2. Students will be able to implement the FIR, IIR Decimation, interpolation algorithm.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Multirate DSP**- Introduction, Decimation by a Factor D, Interpolation by a Factor I, Sampling Rate Conversion by a Rational Factor IID, Filter Design and Implementation for Sampling Rate Conversion	30 Hours	1
II	**Implementation and Applications of Multi-rate Signal Processing** Multistage Implementation of Sampling Rate Conversion, Sampling Rate Conversion of Bandpass Signals, Sampling Rate Conversion by an Arbitrary Factor, Applications of Multi-rate Signal Processing	30 Hours	1
III	**Adaptive filters** Applications of Adaptive Filters, Adaptive Direct-Form FIR Filters-The LMS Algorithm, Adaptive Direct-Form FIR Filters-RLS Algorithms, Adaptive Lattice-Ladder Filters	30 Hours	1
IV	Power Spectrum Estimation-Estimation of Spectra from Finite-Duration Observations of Signals, Nonparametric Methods for Power Spectrum Estimation, Parametric Methods for Power	30 Hours	1

	Spectrum Estimation, Filter Bank Methods, Eigen analysis Algorithms for Spectrum Estimation		

Text/ Reference Books:

1. Proakis "Advanced Digital Signal Processing Macmillan publishing company", 1992.
2. S.Haykins "Adaptive filter Theory", Printice Hall, 1986.
3. Avtar Singh & S.Srinivasan, "Digital Signal Processing Implementation", Thomson Press.

GE35412 Modeling and Simulation of Wireless Communication Systems

Course Objective:

1. The main objective of this subject is to provide basic concepts of probability theory and fundamental learning of wireless communication system simulation modelling.
2. It will make our students aware of the role of simulation in our practical life.

Learning Outcome:

1. After completion of the subject, the students will be able to understand various probability concepts and can model different channels via simulation.
2. Students will also learn about simulating various modulation schemes and communication system like CDMA.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Modeling and Simulation Approach** Review of stochastic process and their properties. Methods of performance evaluation-simulation approach- Advantages and limitations. System model steps and its types involved in simulation study. Basic concepts of modeling – modeling of systems, devices, random process and hypothetical systems. Error sources in simulation. Validation, simulation environment and software issues. Role of simulation in communication system and random process. Steps involved in simulation study.	30 Hours	1
II	**Generation and Parameter Estimation** Monte Carlo simulation, properties, random number Generation, Generating independent and correlated random sequences. Testing of random number generators. **Parameter estimation:** Estimating mean, variance, confidence interval, Estimating the Average Level of a Waveform, Estimating the Average power of a waveform, Power Spectral Density of a process, Delay and Phase.	30 Hours	1
III	**Modeling Of Communication Systems** Information sources, source coding, base band modulation, channel coding, RF and optical modulation, filtering, multiplexing, detection/demodulation- carrier and timing recovery for BPSK and QPSK. Modeling	30 Hours	1

	considerations for PLL. **Communication Channel Models** Fading and multipath channels- statistical characterization of multipath channels and time-varying channels with Doppler effects, models for multipath fading channels. Finite state channel models – channels with and without memory. Methodology for simulating communication systems operating over fading channels.		
IV	**Performance Estimation and Evaluation** **Estimation of Performance Measures** - Estimation of SNR, Performance Measures for Digital Systems, Importance sampling method, Efficient Simulation using Importance Sampling, Quasi-analytical Estimation. **Case Studies:** (1) Performance of 16-QAM equalized Line of Sight Digital Radio Link, (2) performance evaluation of CDMA Cellular Radio System.	30 Hours	1

Text/ Reference Books:

1. M.C. Jeruchim, Philip Balaban and K. Samshanmugam, "Simulation of communication systems," Plemum press, New York, 2007.
2. M.Law and W. David Kelton ," Simulation Modelling and analysis" ,Tata McGraw Hill, NewYork, 2008.
3. K. Hayes, "Modelling and Analysis of computer communication networks," Plenum press, NewYork,1984.
4. Banks, J.S. Carson, Nelson and D.M. Nicol, "Discrete –Event system simulation," 4th Edition, Prentice Hall of India, 2005 .
5. Z. Peebles , "Probability, Random Variable and Random Signal Principles," 4TH edition, Tata McGraw Hill, 2002.

GE35413 Mobile Satellite Communication

Course Objective:

1. The main objective of this subject is to provide the basic knowledge of two different types of infrastructure networks i.e. satellite Communication and mobile Communication System.
2. To aware our students about the information flow among them in order to interchange the information.

Learning Outcome:

1. After completion of the subject, the student will be able to understand about the call flow and protocol integration among cellular and satellite communication.
2. They will also understand the role of gateway nodes in the inter communication of two different types of infrastructure network.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction** Evolution, Spectrum Allocation, Regulatory considerations, Types of channels and its characteristics, Channel models for narrow and wideband channels. Basic mobile satellite system parameters & design, Design objectives-Network availability, Reliability, Service coverage, Network capacity.	30 Hours	1
II	**Mobile Satellite Network** GSM signaling and S-PCN signaling protocol architecture, Mobility management-cell location, location management, handover management. Resource Management-Resource allocation strategies, Network operation and procedures.	30 Hours	1
III	**Integrated Terrestrial Satellite Mobile Networks** Integration with PSTN-Protocol Architecture and access functions. Integration with GSM-Impact of integration on handover, location management and call set up procedures. CODECS for Mobile Satellite Communication.	30 Hours	1
IV	**Applications** Mobile satellite system for UMTS, GSM/EDGE, MOBILE IP, WLAN, Global Broadband services, ATM, GEO and Non GEO Mobile satellite systems.	30 Hours	1

Text/ Reference Books:

1. Ray E. Sheriff and Y. Fun Hu, “Mobile Satellite communication Networks,” John Wiley & Sons, 2008.
2. Michael, J.Miller, BrankaVucetic and Les berry , “Satellite Communication: mobile and fixed services,” Kluwer Academic Publishers, 2007.
3. M.Richharia “Mobile Satellite Communications, Principles and Trends,” Pearson Education, 2007.
4. Stojce DimovIllcev , “Global mobile satellite communication for maritime land and aeronautical Applications”. http://w15.easy-share.com/11522731.html .
5. Peter Alfred Swan and Carrie L.Devieux, “Global mobile satellite Systems: A systems overview”, 2003.

GE35414 Global Positioning System

Course Objective:

1. The purpose of this course is to develop a strong foundation in the field of Global Positioning Systems.
2. The subject gives the students an in-depth knowledge about working of Global positioning receivers.
3. Students are exposed to various errors occurring in GPS and latest variant DGPS receivers and GPS applications.

Learning Outcome:

1. At the end of this course students will gain knowledge about the topics such as global positioning, Different types of signals used in the GPS systems and its accuracy limits.
2. They will also learn about various GPS Segments and latest versions of GPS and its application.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**GPS: Basic Concepts and Evolution** GPS History , GPS Overview, GPS Modernization Program Markets and Applications, Concept of ranging using TOA Measurements, Reference Coordinate systems, Position determination using PRN Codes, Time and GPS	30 Hours	1
II	**GPS Segments and GPS Satellite Characteristics** GPS Segments-Space Segment, Control Segment, User Segment, Modulations for Satellite Navigation, Legacy GPS Signals, Navigation Message Format, Modernized GPS Signals	30 Hours	1
III	**Satellite Signal Acquisition and other Parameters** GPS Receiver Code and Carrier Tracking, Carrier Tracking Loops, Code tracking loops, Loop Filters, Measurements Errors and Tracking Thresholds, Formation of Pseudo-range, delta pseudo-range and integrated Doppler, Signal Acquisition, Sequence of Initial receiver operations, Data demodulation, Use of digital processing, Radio frequency interference, Multipath, Ionospheric Scintillation	30 Hours	1
IV	**Standalone GPS and Differential GPS** Measurement Errors, PVT Estimation concepts, GPS Availability, GPS Constellation, GPS Integrity, Introduction to differential GPS, Code	30 Hours	1

	based Techniques, Carrier Based Techniques, Message formats, GPS Inertial Integration, Sensor Integration in Land Vehicle system, Introduction to GNSS		

Text/ Reference Books:

1. Elliot D. Kaplan and Christopher J. Hegarty, " Understanding GPS: Principles and Applications", Artech House INC. Second Edition.
2. MohinderS.Grewal, Lawrence R.Weill, Angus P.Andrews, "Global positioning systems - Inertial Navigation and Integration", John wily & sons, 2001

Generic Elective - II

GE35421 Smart Antennas

Course Objective:

1. To provide comprehensive knowledge of different design and performance parameters of antenna.
2. To provide the overall idea about various existing antennas and different advance antennas presently in practice.
3. To provide principle of operation, analysis and application of different antennas such as micro-strip antenna, smart antenna, etc.
4. To study about various diversity-combining methods to combat fading in mobile communications, and effects of errors on array system performance and error-reduction schemes.
5. The use of smart antennas in mobile communications to increase the capacity of communication channels has reignited research and development in this very exciting field.

Learning Outcome:

1. At the completion of this course the students will be able to know about various antenna array processing schemes, adaptive algorithms to adjust the required weighting on antennas.
2. Students will be able to do the performance comparisons.
3. Students will learn about various diversity-combining methods to combat fading in mobile communications, and effects of errors on array system performance and error-reduction schemes.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction to Array Antennas**: Basic Array characteristics, Linear Arrays- Patterns, Beamwidth, Sidelobes, grating lobes, bandwidth, planar Arrays- Array coordinates, beam-width, grating lobes	30 Hours	1
II	**Adaptive Array Fundamentals** :- Antenna Null Rotation, Electronic Null Steering , Constrained Power minimization, Weak Signal Adaptation, Side lobe canceller, the Davies Beam former, Multiple Null Formation	30 Hours	1
III	**Vector and Matrix techniques for Adaptive Arrays** : Narrow Band Signals , Vector Inner Products, Angles Between Vectors, Orthogonality achieved by projections, output powers, covariance Matrices, Quadratic Forms	30 Hours	1
IV	**Optimal Antennas & Adaptive Solutions of optimal Antennas:**: Meaning of optimality, Eigen	30 Hours	1

	value, Solution for maximum SNIR, Least Mean Square (LMS) Error Criterion, Maximization Of Probability of Detection, Direct maximization of SNR, Optimization of power pattern, Meaning of Adaptivity, Gradient Methods, Real Time Least Mean square Error Algorithm.		

Text/ Reference Books:

1. J.E. Hudson, “Adaptive Array Principles”, Peter Peregrinus Ltd.
2. R.T Compton and JR, “Adaptive Antennas, Concepts and Performance”, Prentice Hall, New Jersey
3. Eli Brookner “Practical Phased Array Antenna Systems”, Editor Artech House, Boston, London
4. R.C. Hansen, “Phased Array Antennas”, Wiley Series in Microwave and optical Engg, John Wiley & Sons Inc, Wiley- Interscience Publication
5. R. A. Monzingo and TW Miller, “Introduction to Adaptive Arrays”, Wiley.

GE35422-Advance Optical Communication

Course Objective:

1. To introduce the students to various optical fiber modes, configurations and various signal degradation factors associated with optical fiber and to study about various optical sources and optical detectors and their use in the optical communication system.
2. To learn the basic elements of optical fiber transmission link, fiber modes configurations and structures.
3. To understand the different kind of losses, signal distortion in optical wave guides and other signal degradation factors.
4. To learn the various optical source materials, LED structures, quantum efficiency, Laser diodes.
5. To understand the concepts of optical power launching and coupling techniques.

Learning Outcome:

1. At the end of the course students will be able to gain knowledge about the fundamentals of optical communication.
2. Students will learn the Principles of optoelectronic devices and how to differentiate between Amplifiers and Optical Amplifiers.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**A Review Of Optical Fibers** The Evolution of Fiber Optic System, Fiber optic cable, Basic Network Information Rates, Classification of optical fiber , Elements of an Optical Fiber Transmission link, Structure of Optical Fibers, Basic Optical laws and definitions, Modes and configurations-Step and Graded index fiber and their comparison	30 Hours	1
II	**Optical Losses And Sources** Optical Losses, Leaky modes, Dispersion - Material dispersion-Waveguide dispersion, Optical Sources, LASER operation, Fabry-Parot resonator, DFB LASER, Comparison of LED and LASER	30 Hours	1
III	**Optical Amplification** Semiconductor Optical amplifier, Semiconductor Laser Amplifier, Optical Pumping , Fiber nonlinear effect, WDM, System requirements of WDM	30 Hours	1

	techniques, Application of optical amplifier		
IV	**Optical Detectors And Couplers** Photo Detectors and Characteristics, Resonant cavity enhancement (RCE) Photo Detector, Photo diodes, PIN photo detector, Avalanche photo detector, Avalanche multiplication noise, Effect of temperature on Avalanche gain, Power Launching and Coupling, Lensing scheme, Splicing techniques-Connectors-Splices	30 Hours	1

Text/ Reference Books:

1. Gerd Keiser, Optical fiber communications, McGraw Hill, 3rdedition.
2. John. M. Senior, Optical fiber communications: principles and practice, Prentice Hall of India.
3. R. P. Khare, Fiber optic and optoelectronics, Oxford University press.

GE35423 Multimedia Communication Systems

Course Objective:

1. The main objective of this subject is to provide the basicknowledge of Multimedia Communication Systems.
2. Students will understand various audio and video compression techniques as well as how they can provide the security to the data transmitting over the internet.

Learning Outcome:

1. At the end of the course students will have a good understanding of multimedia enabling technologies, services and applications.
2. They will gain the sound knowledge of basic Networking concepts and protocols.
3. They will understand about the functioning of Multimedia application in networking environment.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Introduction to Multimedia Communication, multimedia networks, its application, Multimedia Information and its representation, digitization principals, representation of text , images, audio & video.	30 Hours	1
II	**Text & Image Compression:** Text Compression: Principles, Static Huffman coding, Dynamic Huffman coding, Arithmetic coding, Lempel-ziv coding, Lempel-ziv-welsh coding Image Compression: Principles, Graphics Interchange format, Tagged image file format, digitized document, Digitized Pictures, Introduction to JPEG.	30 Hours	1
III	**Audio &Vidéo Compression:** Audio Compression: Principles, DPCM, Adaptive differential PCM, Adaptive predictive coding, Linear predictive coding, Code-excited LPC Perceptual coding, MPEG audio coders, Dolby audio coders Video Compression : basic principle, video compression standards H.261, H.263, Introduction to MPEG	30 Hours	1

IV	**Internet Application** Introduction, E-mail, TCP, UDP , security, Encryption Basics-Stream Ciphers, Block Ciphers, Properties of Crypto Algorithms, Types Of Cryptography, Various modes of Operation, Various algorithms -DES,3-DES	30 Hours	1

Text/ Reference Books:

1. Fred Halsall, “Multimedia Communications”, Prentice Hall.
2. Richard E.smith, “Internet Cryptography”, Pearson Education.
3. K. R. Rao, Zoran S. Bojkovic , Dragorad A. Milovanovic, “Multimedia Communication Systems: Techniques Standards, and Networks”, Prentice Hall.

GE35424 CDMA and OFDM for Wireless Communication

Course Objective:

1. The main objective of this subject is to provide the basicknowledge of multiple access environment and the techniques used like CDMA and OFDMA.
2. It gives the introduction to advanced signal detection and estimation principles with applications in wireless communication systems.

Learning Outcome:

1. At the end of the course students will have a good understanding of CDMA and OFDM concepts.
2. Students will understand about the channel estimation, equalization, synchronization methods used in spread spectrum systems.
3. Students will also get the idea of single carrier and multi carrier Spread spectrum techniques.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Principles of Code Division Multiple Access** Spread spectrum technique – Direct sequence and frequency hopping spread spectrum communication system – PN codes and Walsh codes – Rake receiver – Capacity – Effects of loading, sectorization and voice activity – Power control – Hand off – Link structure – Forward link – Pilot, synchronization, paging and traffic channels – Reverse Link – access and traffic channel.	30 Hours	1
II	**Call Processing and Traffic** Call processing states – Initialization, idle, access and traffic states – Forward link and Reverse link analysis - Calculation of Ec/I0 and Eb/N0 – Traffic intensity – Grade of Service – Erlang-B and C models.	30 Hours	1
III	**OFDM Basics** OFDM principles – system model – Generation of sub carrier using IFFT, guard time and cyclic extensions – windowing - Choice of OFDM parameters - OFDM signal processing. **Coding, Modulation and Channel Estimation** FEC coding – Interleaving – QAM – Coded modulation – Synchronization – Synchronization using cyclic extension and special training symbols – Coherent detection – One and two dimensional	30 Hours	1

	channel estimation – Special training symbols – Decision directed channel estimation – Differential detection in the time and frequency domain.		
IV	**OFDMA and MC-CDMA** Frequency hopping in OFDMA - OFDMA system description – Channel coding, modulation, time and frequency synchronization, Combination of OFDM and CDMA - MC-CDMA, MT-CDMA and MC-DS CDMA systems, Difference between OFDMA and MC-CDMA .	30 Hours	1

Text/ Reference Books:

1. Samuel C Yang, "CDMA RF System Engineering," Artech House, 2008.
2. Richard Van Nee and Ramjee Prasad, "OFDM for Wireless Multimedia Communication," Artech House, 2007.
3. Lajas Hanzo, "OFDM and MC-CDMA for Broadband Multiuser Communications," 2003
4. Khaled Fazal and Stephen Kaiser, "Multicarrier and Spread Spectrum Systems," 2008

Generic Elective – III

GE35431 Statistical Signal Processing

Course Objective:

1. Generalize the properties of statistical models in the analysis of signals using stochastic processes.
2. Differentiate the prominence of various spectral estimation techniques for Achieving higher resolution in the estimation of power spectral density.
3. Outline various parametric estimation methods to accomplish the signal modeling even at higher order statistics.
4. Design and development of optimum filters using classical and adaptive algorithms.
5. Extrapolate the importance of least squares techniques and decomposition methods in analyzing the signal estimations.
6. The main purpose of this course is to provide the basic theory and methods necessary for the design of optimal signal processing algorithms.
7. It explores the role of probability modelling in the development of robust and consistent (matched) signal transformations.
8. The course reviews a range of frequency transforms and spectrum estimation techniques.

Learning Outcome:

1. At the end of the course students will have a good understanding of statistical signal processing of discrete signals and systems.
2. Students will learn about the tools and methods for using stochastic processes for signal modeling, filtering and estimation.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Signal modeling**- least square method, pade approximation, prony's method - linear prediction, Applications. FIR least squares Inverse filters, finite data records, stochastic models.	30 Hours	1
II	**Levinson-Durbin Recursion**- The lattice filter, Levinson Recursion, split Levinson Recursion.	30 Hours	1
III	**Wiener filtering**- FIR & IIR Wiener filter , discrete Kalman filter.	30 Hours	1
IV	**Spectrum estimation** - Non parametric methods, minimum variance spectrum estimation, maximum entropy method, parametric method.	30 Hours	1

Text/ Reference Books:

1. Monson Hayes, “Statistical Digital signal processing and modelling” John Wiley, & sons 1996.
2. D.G. Manolakis, V.K.Ingle, S.M.Kogon, “Statistical & Adaptive Signal Processing” McGrawHill, 2000.
3. Simon Haykin, “ Adaptive Filter Theory” PHI, 1996.
4. S.M. Kay “Modern Spectral Estimation” PHI, 1987.

GE35432 Spread Spectrum Communication

Course Objective:

1. The main purpose of this course is to make our students aware of basic concepts of spread spectrum (SS) communications and its major applications (e.g. anti-jamming, positioning, CDMA) and techniques for analyzing the systems.
2. The course will review these concepts and emphasize the various trade-offs in the design of such systems.

Learning Outcome:

1. At the end of the course students will have a good understanding of the principles and theory of spread spectrum communications with emphasis on Direct Sequence Spread Spectrum System and Frequency Hopping Spread Spectrum System.
2. Student will have in-depth knowledge about CDMA techniques and their applications in wireless communications like jamming and anti-jamming.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Origins of SS communications – Advantages of Spectrum spreading – Types of techniques used for spread spectrum – Processing gain and other fundamental parameters – Jamming methods – Linear Feedback shift register sequence generation – msequence and their statistical properties. Introduction to Non-linear sequences – Gold codes; Kasami sequences & chaotic sequences	30 Hours	1
II	**Direct Sequence Spread Spectrum System:** Coherent direct sequence systems – Model of a DS/BPSK system, Chernoff bound – Performance of encoded DS/BPSK – Constant power and pulse jammer. Coded DS/BPSK Performance for known and unknown channel states	30 Hours	1
III	**Frequency Hopping SS System:** Non-coherent FH system model – Uncoded FH/BFSK performance under constant power broadband jammer – Partial band noise jammer – Multi-tone jammer. Coded FH/BFSK performance for partial and multi-tone jammer. Performance of FH/MDPSK in the presence of partial band multi-tone jamming	30 Hours	1
IV	**Synchronization of SS Receivers & Applications:** Acquisition and tracking in DS SS	30 Hours	1

	receivers & FH SS receivers – Sequential estimation – Matched filter techniques of acquisition and tracking – Delay locked loop – Tau-Dither loop. Applications: Space systems – Satellite communication. Anti-jam military communication – Low probability of intercept communication – Mobile communications.		

Text/ Reference Books:

1. R.C. Dixon, “Spread spectrum systems”, John Wiley, 1984.
2. M.K. Simon, J.K. Omura, R.A. Schiltz and B.K. Levitt, “Spread spectrum communication”, Vol-I, II & IV, Computer Science Press, USA, 1985.
3. G.R.Coopeand, CD.Mc.Gillem, “Modern communications and spread spectrum”, McGraw Hill, 1986.

GE35433 Cooperative Communication

Course Objective:

1. The main objective of this course is to provide the fundamental tools to understand, analyze, and design the cooperative communications systems.
2. To make our students understand about wireless channel modeling, relaying and different combining techniques.

Learning Outcome:

1. At the end of the course students will have a good understanding of the principles and theory of cooperative communication.
2. Students will gain the knowledge of various Transparent and Regenerative Relaying Techniques as well as combining schemes.
3. Students will be able to model a wireless relay environment.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** General Characteristics and Trends: Propagation Principles, Propagation Modeling, Channel Modeling	30 Hours	1
II	**Wireless Relay Channel:** Regenerative Relaying Channel: Propagation Modeling, Envelope and Power Fading Statistics, Temporal Fading Characteristics, Spatial–Temporal Fading Characteristics, Spectral–Spatial–Temporal Fading Characteristics, Transparent Relaying Channel: Propagation Modeling, Envelope and Power Fading Statistics, Temporal Fading Characteristics, Spatial–Temporal Fading Characteristics, Spectral–Spatial–Temporal Fading Characteristics, Distributed MIMO Channel.	30 Hours	1
III	**Transparent Relaying Techniques:** Transparent Relaying Protocols: Single-Branch Dual-Hop AF, Single-Branch Multi-hop AF, Multi-branch Dual-Hop AF, Multi-branch Multi-hop AF, Transparent Space–Time Processing: Distributed Space–Time Block Codes, Distributed Space–Time Trellis Codes, Distributed Spatial Multiplexing, Distributed Beam forming, Distributed System Optimization: Distributed Adaptive Power Allocation, Distributed Relay Selection.	30 Hours	1
IV	**Regenerative Relaying Techniques:** Regenerative Relay Protocols: Decode and Forward, Compress and Forward, Soft Information Relaying, Adaptive Relaying, Selective Decode and	30 Hours	1

	Forward, Distributed Space–Time Coding: Distributed Space–Time Coding, Distributed Space–Time Trellis Coding, Distributed Turbo Coding, Distributed Network Coding: Distributed Network–Channel Coding, Network Coding Division Multiplexing.		

Text/ Reference Books:

1. Mischa Dohler & Yonghui Li "Cooperative Communication" John Wiley & Sons, 2010.
2. FRANK H.P. FITZEK & MARCOS D. KATZ "Cooperation in Wireless Networks: Principles and Applications" Springer, 2006.

GE35434 Cognitive Radio Communication

Course Objective:

1. The main objective of this course is to provide the fundamental theory behind cognitive radio and cognitive radio networking.
2. To understand various spectrum sensing methodologies as well as spectrum sensing and spectrum access methods.

Learning Outcome:

1. At the end of the course students will have a good understanding of the principles and theory of cognitive radio environment and its application.
2. Students will learn various techniques for spectrum sensing and access schemes.
3. Students will get the insight of cognitive adaption engine and its operating parameters.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Defining Cognitive Radio: History, Applications, Cognitive Radio Terminology Standardization	30 Hours	1
II	**Spectrum sensing, identification, access and sharing:** Primary Signal Detection, From Detecting Primary Signals to Detecting Spectrum Opportunities, Fundamental Trade-offs: Performance versus Constraint, Fundamental Trade-offs: Sensing Accuracy versus Sensing Overhead. Unlicensed Spectrum Sharing, Licensed Spectrum Sharing, Secondary Spectrum Access, Non-Real-Time SSA, Real-Time SSA.	30 Hours	1
III	**Reconfiguration, adaptation, and optimization:** Adaptation Engine, Operating Parameters, Parameter Relationships, Cognitive Adaptation Engines.	30 Hours	1
IV	**Cognitive Radio Network Architectures:** Cognitive Radio Network Architectures, Topology-Aware CRN Architectures, Publish-Subscribe CRN Architecture.	30 Hours	1

Text/ Reference Books:

1. A. M. Wyglinski, M. Nekovee, Y. T. Hou "Cognitive Radio Communications and Networks Principles and Practice", Academic Press, 2010.

2. Yang Xiao, Fei Hu, “Cognitive Radio Network”, CRC Press Taylor & Francis Group, 2009.
3. Samuel Cheng, “Foundation of Cognitive Radio Systems” Intech, 2012.