SCHEME OF COURSES FOR
ME (Wireless Communications)
For Batch 2016-18

First Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PWC104	Stochastic Processes and Information Theory	3	1	0	3.5
2.	PEC101	Discrete Time Signal Processing	3	1	2	4.5
3.	PEC104	Antenna Systems	3	0	2	4.0
4.	PEC105	Advanced Communication Systems	3	1	2	4.5
5.	PEC108/109	Embedded System Design (Four Self Effort Hours for Project – 2 Credits)	3	0	2+4	6.0
		Total	**15**	**3**	**12**	**22.5**

Second Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PWC203	Advanced Wireless Communication Systems	3	1	2	4.5
2.	PWC201	Space Time Wireless Communication	3	0	2	4.0
3.	PEC339	Image Processing and Computer Vision	3	0	2	4.0
4.	PEC215	Detection and Estimation Theory	3	0	0	3.0
5		Elective – I (2/0/2)	3	0	0	3.0
6.	PWC291	**Seminar**				**4.0**
		Total	**15**	**1**	**6**	**22.5**

Third Semester

S. No.	Course No.	Course Name	L	T	P	Cr
	PWC392	**Project**				**12.0**
2.	PEC 491	Dissertation (Starts)	-	-	-	-
3.		Elective – II	3	0	0	3.0
4.		Elective – III	3	0	0	3.0
		Total	**6**	**0**	**0**	**18.0**

Fourth Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PWC 491	Dissertation (Contd …)				**16.0**

Total Credits: 79

List of Electives

Elective–I

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PWC212	Wireless Security	3	0	0	3.0
2.	PWC	Advanced Wireless Networks	3	0	0	3.0
3.	PEC211	Passive Optical Networks	3	0	0	3.0
4.	PEC	Multimedia Compression Techniques	3	0	0	3.0
5.	PEC218	Digital Signal Processors	2	0	2	3.0
6.	PEC212	Audio and Speech Processing	3	0	0	3.0
7.	PEC216	Advanced Computer Networks and Protocols	3	0	0	3.0
8.	PEC	Fractional Transforms and Applications	3	0	0	3.0
9.	PVL203	VLSI Signal Processing	3	0	0	3.0
10.	PEC	Optoelectronics	3	0	0	3.0
11.	PVL	Nanoelectronics	3	0	0	3.0
12	PEC207	RF Devices and Applications	3	0	0	3.0
13.	PEC	HDL and System C Programming	2	0	2	3.0
14.	PVL	Photonic Integrated Devices & Circuits	3	0	0	3.0

Elective II

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PWC321	Next Generation Wireless Systems and Networks	3	0	0	3.0
2.	PWC	Advanced Error Control Coding Theory	3	0	0	3.0
3.	PWC	Wireless Broadband Networks	3	0	0	3.0
4.	PEC	Advanced Optical Technologies	3	0	0	3.0
5.	PEC217	Microstrip Antennas	2	0	2	3.0
6.	PEC337	Adaptive Signal Processing	3	0	0	3.0
7.	PVL332	Mixed Signal Circuit Design	3	0	0	3.0
8.	PVL334	High Speed VLSI Design	3	0	0	3.0
9.	PVL110	VLSI Architecture	3	0	0	3.0
10	PEC	Machine Learning	3	0	0	3.0
11	PEC	Robotics and Automation	3	0	0	3.0
12	PVL	Sensor Technology and MEMS	3	0	0	3.0

Electives–III

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PWC	Wireless Sensor Networks	3	0	0	3.0
2.	PWC336	Wireless Communication Protocol	3	0	0	3.0
3.	PWC	Spread Spectrum Communication	3	0	0	3.0
4.	PEC	IP over WDM	3	0	0	3.0
5.	PEC	Biomedical Signal Processing	3	0	0	3.0
6.	PEC	Cloud Computing	3	0	0	3.0
7.	PEC	Soft Computing Techniques	3	0	0	3.0
8.	PEC	RF Circuit Design	3	0	0	3.0
9.	PVL	System on Chip	3	0	0	3.0
10	PEC	Artificial Intelligence	3	0	0	3.0

PWC104 STOCHASTIC PROCESSES AND INFORMATION THEORY

L	T	P	Cr.
3	1	0	3.5

Prerequisite(s): None

Course Objectives: To gain and understand the complete knowledge of probability theory, random variables, stochastic processes, Information theory and source coding. To familiarize the students with the applications of probabilistic and stochastic methods in communication engineering and information theory problems.

Detail contents:

Probability and Induction: Axioms of Probability, Set Theory, Probability Space, Conditional Probability, Repeated Trials, Combined Experiments, Bernoulli Trials, Bernoulli's Theorem, and Games of Chance, Concept of a Random Variables, Distribution and Density, Function Specific Random Variables, Conditional Distributions, Binomial Random Variables, Functions of One Random Variable, its Distribution, Mean and Variance, Moments, Characteristic Functions; Bivariate Distributions, Two Functions of Two Random Variables, Joint Moments, Joint Characteristic Functions, Conditional Distributions, Conditional Expected Values, Normality, Stochastic Convergence and Center Limit Theorem

Estimation & Hypothesis Testing: Time and Ensemble Averages, Covariance and Correction Functions. Simple binary hypothesis tests, Decision Criteria, Neyman pearson tests, Bayes Criteria, Multiple Hypothesis testing, Composite hypothesis testing, Asymptotic Error rate of LRT for simple hypothesis testing

Stochastic Processes: Systems with Stochastic Inputs, Power Spectrum, Random Walks and Poisson Points, Cyclostationary Processes, Bandlimited Processes and Sampling Theory, Deterministic Signals in Noise Bispectra and System Identification, Poisson Sum Formula, Schwarz Inequality Problems, Spectral Representation of Random Processes, Factorization and Innovations, Finite-Order Systems and State Variables, Karhunen–Lo`eve Expansions, Ergodicity, Extrapolating Spectra and Youla's Parametrization, Minimum-Phase Functions, All-Pass Functions, Mean Square Estimation, Entropy, Maximum Entropy Method, Markov Chains, Higher Transition Probabilities and Chapman–Kolmogorov Equation, Stationary Distributions and Limiting Probabilities, Transient States and Absorption Probabilities, Branching Processes, Mixed Type Population of Constant Size, Structure of Periodic Chains

Queueing Systems: Characteristics of Queueing Process, birth-death process, arrival and service, steady state solution; M/G/1 and G/M/1, occupancy distribution, renewal theory, waiting time and busy period, Series Queues, Jackson Networks, Cyclic Queues. Little's theorem, modeling & analysis of M/M-/-queues, Burke's Theorem, Reversibility, Queues with vacations, Work conservation principle, Priority queues, Queues served in cyclic order, Fluid-flow and diffusion approximations

Statistical Modeling of Noise: Probability density of a jointly-Gaussian random vector, Fourier transforms for joint densities, Wide-sense stationary (WSS) processes, Poisson process noise, sources of noise in communication systems, shot noise, resistor noise, calculation of noise in linear systems, noise bandwidth, noise temperature, noise in two-port networks, noise-figure, cascaded stages, signal in presence of AWGN, narrow band noise and colored noise

Information Theory: Unit of information, rate of information, joint entropy and conditional entropy, mutual information, Shannon-Hartley Theorem, bandwidth SNR trade off, channel capacity calculations of different channels, Source Coding- Coding efficiency, Shannon-Fano coding, Huffman coding, Lempel-Ziv adaptive coding

Text Books:

1. *Athanasios Papoulis, Probability Random Variables and Stochastic Processes, McGraw-Hill (1984)*
2. John N. Daigle, Queueing theory with applications to packet telecommunication Springer (2005)
3.Bernard Sklar, "Digital Communication", Prentice Hall.(Edition).

Reference Books:

1. *P.Z. Peebles, Probability, random variables, and random signal principles, McGraw-Hill (1980)*
2. Dimitri P. Bertsekas, Robert G. Gallager, Data networks, Prentice-Hall (1987)
3. A. Larson and B. O. Schubert, Stochastic Processes, vol. I and II, Holden-Day (1979)
4. W. Gardener, Stochastic Processes, McGraw Hill (1986)
5. IEEE Transactions on Information Theory
6. David J. C. Mackay, " Information Theory, Inference and Learning algorithms", Cambridge University Press, 2003

Course Learning Outcomes:

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

- Identify and formulate fundamental probability distribution and density functions, as well as, functions of random variables.
- Describe the concepts of expectation and conditional expectation, and describe their properties.
- Recognize and analyze continuous and discrete time random processes.
- Describe the concepts of stationarity and wide–sense–stationarity and appreciate their physical significance.
- Apply the theory of stochastic processes to analyze linear systems, and to have knowledge about cross– and auto–correlation of stochastic processes.
- Comprehend power spectral analysis of stationary stochastic processes and ergodicity.
- Recognize the basic concepts of information theory, Entropy and mutual information, models of communication channels, the ultimate limits of data transmission, the process of data compression.

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

PWC 201 SPACE TIME WIRELESS COMMUNICATION

L	T	P	Cr
3	0	2	4.0

Prerequisite(s): None

Course Objective: To understand the performance of MIMO system, MIMO-OFDM system, space time block codes (STBC), Alamouti schemes of channel estimation, space time Tresllis codes, and other various space time coding schemes and their performances analysis.

Introduction: MIMO wireless communication, MIMO channel and signal model, A fundamental trade-off, MIMO transceiver design, MIMO in wireless networks, MIMO in wireless standards. Equalizer Noise Enhancement, Equalizer Types, Folded Spectrum and ISI-Free Transmission, Linear Equalizers, Zero Forcing (ZF) Equalizers , Minimum Mean Square Error (MMSE) Equalizer, Maximum Likelihood Sequence Estimation ., Decision-Feedback Equalization

Performance Limits Of Multiple-Input Multiple-Output Wire Less Communication Systems: MIMO System Model, Capacity in AWGN , Channel Side Information at Receiver ,Channel Side Information at Transmitter and Receiver, Capacity of Frequency-Selective Fading MIMO System Capacity Derivation, Capacity of MIMO Systems with Random Channel Coefficients Channels, Capacity of MIMO Systems with Static , Capacity of MIMO Systems with Fading Channels

Multiple Antennas and Space-Time Communications: Narrowband MIMO Model, Parallel Decomposition of the MIMO Channel MIMO Diversity Gain: Beamforming, Diversity/Multiplexing Tradeoffs, Space-Time Modulation and Coding. ML Detection and Pair wise Error Probability

Space-Time Block Codes: Alamouti Space-Time Code with Multiple Receive Antennas, Space-Time Block Codes (STBC), STBC for Real Signal Constellations, STBC for Complex Signal Constellations, Decoding of STBC, Performance of STBC, Effect of Imperfect Channel Estimation and Antenna Correlation on Performance

Layered Space-Time Codes: LST Transmitters, LST Receivers, QR Decomposition, Interference Minimum Mean Square Error (MMSE) Suppression Combined with Interference Cancellation, Iterative LST Receivers, An Iterative Receiver with PIC, An Iterative MMSE Receiver, Comparison of the Iterative MMSE and the Iterative PIC-DSC Receiver, VBLAST architecture, DBLAST Architecture.

Space-Time Trellis Codes: Encoder Structure for STTC, Generator Description, Optimal STTC Based on the Rank, Determinant and Trace Criterion, Performance Comparison for Codes Based on Different Design Criteria, The Effect of Imperfect Channel Estimation on Code Performance, Design of Space-Time Trellis Codes on Fast Fading Channels, Construction of Recursive STTC,

Course Learning Outcomes:

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

- Recognize the basic concepts of space time coding techniques and their used in MIMO and MIMO-OFDM system.
- Evaluate the performance of various space time coding schemes in different fading channel scenario.
- Analyze the engineering problems related to space time coding using in MIMO-OFDM system in different fading channels.

Recommended Books

1. *Larsson, Erik G. and Petre Stoica, Space-Time Block Coding for Wireless Communications, Cambridge University Press (2008).*
2. *David, Tse and Viswanath, Pramod, Fundamentals of Wireless Communication, Cambridge University Press (2006).*
3. *Fitzek, Frank H.P., Katz and Marcos D., Cooperation in Wireless Networks: Principles and Applications, Springer (2007) 2nd ed.*
4. *Arogyaswami., Paulraj, Gore, Dhananjay and Nabar, Rohit., Introduction to Space-Time Wireless Communications, Cambridge University Press (2008).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PWC201 ADVANCED WIRELESS COMMUNICATION SYSTEMS

L	T	P	Cr
3	1	2	4.5

Prerequisite(s): None

Course Objective: To understand the fundamentals of wireless communication, wireless channel modeling (large scale and small scale). Calculate the capacity of wireless channels along with performance of digital modulation techniques over wireless fading channels.

Overview of Wireless Communications:

Introduction, history of wireless, Types of Wireless communication system, fundamentals of cellular system, concept of frequency reuse.

Large scale fading model: Radio Wave Propagation, Free-Space Path Loss, Ray Tracing, Two-Ray Model, Ten-Ray Model (Dielectric Canyon), General Ray Tracing, Empirical Path Loss Models, Okumura Model, Hata Model, COST231, Outage probability.

Small scale fading model: Time-Varying Channel Impulse Response, Autocorrelation, Cross Correlation, and Power Spectral Density Level Crossing Rate and Average Fade Duration, Finite State Markov Channels, Wide band Fading Models, Power Delay Profile, Coherence Bandwidth, Doppler and Channel Coherence Time, Transforms for Autocorrelation and Scattering Functions, Discrete-Time Model, Space- Time Channel Models

Capacity of Wireless Channels: Capacity in AWGN, Capacity of Flat-Fading Channels, Channel and System Model, Channel Distribution Information (CDI) Known, Channel Side Information at Receiver, Channel Side Information at Transmitter and Receiver, Capacity with Receiver Diversity, Capacity Comparisons, Capacity of Frequency- Selective Fading Channels.

Diversity: Diversity techniques for binary signals, multiphase signals, M-ary orthogonal signals on multipath channel , Receiver Diversity, System Model, Combining techniques , Moment Generating Functions in Diversity Analysis for MRC, EGC, SC of Non-coherent and Differentially Coherent Modulation

Multicarrier Modulation: Data Transmission using Multiple Carriers, Overlapping Sub channels, Mitigation of Sub carrier Fading, Discrete Implementation of Multi-carrier, Cyclic Prefix, OFDM, Matrix Representation of OFDM, PAPR, Frequency and Timing Offset., Multi-user Channels, Multiple Access,

Recent Trends in wireless communication: Software defined radio: Introduction, architecture, SDR block diagram. ADC and DAC, signal processing hardware components, SDR examples. **Cognitive Radio:** Cognitive transceiver Architecture, Principle of Interweaving, Spectrum sensing, Spectrum management and Spectrum Sharing. **Cooperative communication:** Principle and fundamentals of Relaying, Types of Relaying: Decode and forward, amplify and forward. Relay selection.

Course Learning Outcomes:

At the end of this course, the students should be able to:

- Recognize the fundamentals and advancement in wireless communication systems.
- Analyze the modeling (large scale and small scale) of wireless Channel.
- Evaluate the performance of digital modulation techniques in wireless environment.

Recommended Books

1. *Goldsmith Andrea, Wireless Communications, Cambridge University Press (2005).*
2. *Tse, David and Viswanath, Pramod, Fundamentals of Wireless Communication, Cambridge University Press (2006).*
3. *Rappaport, T.S., Wireless Communications, Pearson Education 2nd ed (2007).*
4. *Paulraj, Arogyaswami, Gore, Dhananjay and Nabar, Rohit, Introduction to Space-Time Wireless Communications, Cambridge University Press (2008).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PWC212 WIRELESS SECURITY

L	T	P	Cr
3	**0**	**0**	**3.0**

Prerequisite(s): None

Course Objectives: To gain and understand the complete knowledge of threats within wireless environments. To recognize typical vulnerabilities and safeguards for wireless communication to include; Cellular and Personal Communications Services (PCS) network security, secure wireless encrypted e-mail solution, Wireless handheld device security, PAN and LAN security.

Wireless Network Overview: RF Overview, Wireless Signal Propagation (Reflection, Refraction Diffraction, Scattering Absorption), Signal-to-Noise Ratio, Modulation, Amplitude Modulation, Frequency Modulation, Phase Modulation, Complementary Code Keying (CCK), Quadrature Amplitude Modulation (QAM).

Risks and Threats of Wireless Goals of Information Security, Analysis, Spoofing, Denial-of-Service, Malicious Code, Social Engineering, Rogue Access Points, Cell Phone Security, Wireless Hacking and Hackers, Cordless Phone Driving, War Dialing, Tracking War Drivers, RFID.

Wireless Physical Layer Technologies ISM Spectrum**,** Frequency Hopping Spread Spectrum (FHSS), Direct Sequence Spread Spectrum (DSSS), Orthogonal Frequency Division Multiplexing (OFDM).

Wireless Local and Personal Area Networks Ad Hoc Mode, Infrastructure Mode, Bridging, Repeater, Mesh Wireless Networks, Local Area Networking Standards, IEEE 802.11, Real-World Wireless Data Rates, Personal Area Network (PAN) 802.15, Bluetooth 802.15.1, Infrared (IR), Ultra wide Band 802.15.3, ZIGBEE 802.15.4

Wide Area Wireless Technologies: Cell Phone Technologies, Analog, TDMA, CDMA, CDMA2000, GSM, GPS, 802.16 Air Interface Standards, 802.20 Standards.

The Wireless Deployment Process: Gather Requirements, Estimation. Make the Business Case, Site Survey

Course Learning Outcomes:

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

- Recognize the basic concepts of wireless security and methods to achieve it.
- Analyze the process of data hiding and its utility in wireless communication.
- Differentiate Encryption and decryption of data using optimal tools/techniques.
- Evaluate the various model and their parameters on which performance of network depends in communication.

Recommended Books

1. *Randall K.Nichols,Panos C. Lekkas Wireless Security Models, Threat And Solution, Tata Mc-Greaw HILL Edition,2006*
2. *Aaron E.Earle , Wireless Security Handbook, Aurebeach Publication,2006*
3. *Tara M, Swaminatha, Charles R. Elden, "Wireless Security and Privacy : Best Practice And Design Technique", Pearson Edition,2003*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PWC ADVANCED WIRELESS NETWORKS

L	T	P	Cr
3	0	0	3.0

Prerequisite(S): None

Course Objectives: Build an understanding of the fundamental concepts of wireless networking. Familiarize the student with the basic taxonomy and terminology of the various channel modeling and layers of the network. Introduce the student to resource management and security issues in wireless networks. Allow the student to gain expertise in some specific areas of networking such as Ad Hoc networks, sensors networks, and active networks.

Fundamentals: 4G Networks and Composite Radio Environment, Protocol Boosters, Hybrid 4G Wireless Network Protocols, Green Wireless Networks, Physical Layer and Multiple Access, Multicarrier CDMA, Ultrawide Band Signal, MIMO Channels and Space Time Coding

Channel Modeling for 4G: Macrocellular Environments, Urban Spatial Radio Channels in Macro/MicroCell Environment, MIMO Channels in Micro- and PicoCell Environment, Outdoor Mobile Channel, Microcell Channel, Wireless MIMO LAN Environments

Adaptive and Reconfigurable Link Layer: Link Layer Capacity of Adaptive Air Interfaces, Adaptive Transmission in *Ad Hoc* Networks, Adaptive Hybrid ARQ Schemes for Wireless Links, Stochastic Learning Link Layer Protocol, Adaptive Medium Access Control

Adaptive Network and TCP Layer: Graphs and Routing Protocols, Graph Theory, Routing with Topology Aggregation, Network and Aggregation Models, Effective Capacity, TCP Operation and Performance, TCP for Mobile Cellular Networks, Random Early Detection Gateways for Congestion Avoidance TCP for Mobile *Ad Hoc* Networks.

Mobility and Resource Management: Prioritized Handoff, Cell Residing Time Distribution, Mobility Prediction in Pico- and Micro-Cellular Networks, Channel Assignment Schemes, Resource Management in 4G.

Security: Authentication, Security Architecture, Security Management in GSM Networks, Security Management in UMTS, Security Architecture for UMTS/WLAN Interworking, Security in *Ad Hoc* Networks, Security in Sensor Networks.

Network Deployment and Management: Cellular Systems with Overlapping Coverage, Multitier Wireless Cellular Networks, Local Multipoint Distribution Service., Self-organization in 4G Networks, Simple Network Management Protocol, Distributed Network Management.

***Ad Hoc* and Sensor Networks:** Routing Protocols, Hybrid Routing Protocol, Scalable Routing Strategies, Multipath Routing, Clustering Protocols. Cashing Schemes for Routing, Distributed QoS Routing, Sensor Networks Parameters, Sensor Networks Architecture. Mobile Sensor Networks Deployment, Directed Diffusion

Active Networks: Programmable Networks Reference Models, Programmable 4G Mobile Network Architecture, Cognitive Packet Networks, Game Theory Models in Cognitive Radio Networks, Biologically Inspired Networks. Energy-efficient Wireless Networks: Energy Cost Function, Minimum Energy Routing, Maximizing Network Lifetime, Energy-efficient MAC in Sensor Networks.

Network Information Theory: Effective Capacity of Advanced Cellular Networks, Capacity of *Ad Hoc* Networks. Information Theory and Network Architectures, Cooperative Transmission in Wireless Multihop *Ad Hoc* Networks, Network Coding,

Course Learning Outcomes:
Having successfully completed this course, the students will be able to:
- Recognize various channel model used for 4G wireless systems
- Demonstrate the advanced knowledge of networking and wireless networking in particular.
- Analyze the protocols and programming used in wireless communications

Recommended Books

1. *Lewis, Barry D., Davis, Peter T., Wireless Networks for Dummies, John Wiley and sons (2004).*
2. *Chen, Hsiao-Hwa and Guizani, Mohsen, Next Generation Wireless Systems and Networks, John Wiley and Sons (2006).*
3. *Glisic, Savo G., Advanced Wireless Networks, John Wiley and Sons (2006).*
4. *Rappaport, T.S., Wireless Communications*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PWC321 NEXT GENERATION WIRELESS SYSTEMS AND NETWORKS

L	T	P	Cr
3	0	0	3.0

Prerequisite(s): None

Course Objectives: To understand and gain complete knowledge of wireless systems and networks of next generation like IEEE 802.15, IEEE 802.16, Bluetooth technology, and 4G. To understand the basic concepts of cognitive and software defined radio, Mobile IP, IPv6 versus IPv4, Wireless Application Protocol (WAP), IP on Mobile Ad Hoc Networks.

Review: Background Knowledge, 3GMobile Cellular Standards, Wireless Networking, B3G and Emerging Wireless Technologies.

Fundamentals of Wireless Communications: Theory of Radio Communication Channels, Spread Spectrum Techniques, Multiple Access Technologies, Multiple User Signal Processing, OSI Reference Model, Switching Techniques, IP-Based Networking.

3G Mobile Cellular Technologies: CDMA2000, WCDMA, TD-SCDMA.

Wireless Data Networks: IEEE 802.11 Standards for Wireless Networks, IEEE 802.11a Supplement to 802.11 Standards, IEEE 802.11 Security, IEEE 802.15 WPAN Standards, IEEE 802.16 WMAN Standards, ETSI HIPERLAN and ETSI HIPERLAN/2 Standards, MMAC by Japan, Bluetooth Technologies.

All-IP Wireless Networking: Some Notes on 1G/2G/3G/4G Terminology, Mobile IP, IPv6 versus IPv4, Mobile IPv6, Wireless Application Protocol (WAP), IP on Mobile Ad Hoc Networks. All-IP Routing Protocols.

MIMO Systems: SIMO, MISO, and MIMO Systems, Spatial Diversity in MIMO Systems, Spacial Multiplexing in MIMO Systems, STBC-CDMA Systems, Generic STBC-CDMA System Model, Unitary Codes Based STBC-CDMA System, Complementary Coded STBC-CDMA System.

Cognitive Radio Technology: Why Cognitive Radio, History of Cognitive Radio, SDR to Cognitive Radio, Cognitive Radio for WPANs, Cognitive Radio for WLANs, Cognitive Radio for WMANs, Cognitive Radio for WWANs, Cognitive Radio for WRANs: IEEE 802.22, Challenges to Implement Cognitive Radio, Cognitive Radio Products and Applications.

Laboratory Work: Matlab related simulation experiments.

Course Learning Outcomes:

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

- Recognize the fundamentals and operation of next generation wireless communication systems like 3G, OFDM, MIMO systems, cognitive radio and 3GPP (4G),
- Evaluate the performance of broadband wireless networks and all IP based wireless networking.
- Analyze the performance of next generation wireless communication systems.

Recommended Books

1. *Chen, Hsiao-Hwa and Mohsen Guizani, Next Generation Wireless Systems and Networks John Wiley and sons (2006).*

2. *Wong, David T., Kong, Peng-Yong, Ying-Chang Liang and Chua, Kee C., Wireless Broadband networks, John Wiley and sons (2009).*
3. *Kaveh, Pahlavan and Levesque, Allen H., Wireless Information Networks, 2nd Edition, John Wiley and Sons (2005).*
4. *Glisic, Savo G., Advanced Wireless Networks: 4G Technologies, John Wiley and Sons (2006).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PWC ADVANCED ERROR CONTROL CODING THEORY

L	T	P	Cr
3	0	0	3.0

Prerequisite(s): None

Course Objectives: To provide a comprehensive introduction to error correction coding, including both classical block and trellis based codes and recent developments in iteratively decoded codes such as turbo codes and LDPC codes. To understand the coding using Factor Graph methods and message passing. To understand the methods of designing efficient channel encoder and decoder using various coding schemes like Block codes, Turbo coding, convolution coding, cyclic coding and LDPC coding.

Introduction: Codes and ensembles, MAP and ML decoding, APP processing, Channel Coding Theorem, Linear Codes and complexity, Hamming codes, Gallager's parity check codes, Decoding complexity of linear codes, Convolutional codes and its complexity, Iterative coding and decoding, Extending, Puncturing and shortening of codes

Factor Graphs: Distributive law, Graphical representation of factorization, Recursive determination of marginals, Marginalization via message passing, Decoding via message passing, Limitations of cycle-free codes, Message passing on codes with cycles.

Binary Erasure Channel: Channel model, Transmission via linear codes, Tanner graphs, Low density parity check (LDPC) codes, Message passing decoder, Computation graph and tree ensemble, Convergence to tree channel, Density evolution, Monotonicity, Gallager's lower bound on density, Sparse distribution, Maxwell decoder

Turbo Codes: Structure and encoding, decoding of turbo codes, Density evolution, Stability condition, Exit charts, MAP performance, High performance turbo codes, Sliding window turbo codes, Turbo coded modulation, Set parttioning, Multi level codes.

Course Learning Outcomes:
At the end of this course, the students should be able to:

- Recognize the basic concepts of different types of coding techniques like block codes, trellis based codes, iteratively decoded codes such as turbo codes and LDPC codes.
- Design the channel encoder and decoder using different coding schemes.
- Evaluate the performance of different channel encoders.

Recommended Books

1. *Tom Richardson, Rudiger Urbanke, "Modern Coding Theory", Cambridge University Press, 2008.*
2. *S. Lin and D. J. Costello, Jr., Error Control Coding, Prentice Hall, Englewood Cliffs, NJ, USA, 2nd ed., 2004.*
3. *C. Schlegel and L. C. Perez, Trellis and Turbo Coding,Wiley-IEEE Press, 2004*
4. *John G. Proakis, "Digital Communication", Mcgraw Hill, 2008.*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PWC WIRELESS BROADBAND NETWORKS

L	T	P	Cr
3	0	0	3.0

Prerequisite(s): None

Course Objectives: To understand and gain the complete knowledge of wireless broadband networks which include the concepts of OFDM, OFDMA, MAC and routing protocols for broadband networks, modem design, concepts of equalizer and Convergence of Networks of various of networks.

Review Basics of Probability, Random Variables, Random Processes, and Queueing Systems: Probability, Random Variables, Poisson Random Process, Birth-Death Processes, Basic Queueing Systems.

Enabling Technologies For Wireless Broadband Networks: Orthogonal Frequency-Division Multiplexing and Other Block-Based Transmissions: Block-based Transmissions, Orthogonal Frequency-Division Multiplexing Systems, Single-Carrier Cyclic Prefix Systems, OFDMA, IFDMA, SC-FDMA, CP-based CDMA Systems, Receiver Design.

Routing Protocols For Multihop Wireless Broadband Networks: Multihop Wireless Broadband Networks: Mesh Networks, Importance of Routing Protocols,Routing Metrics, Classification of Routing Protocols, MANET Routing Protocols; Radio Resource Management for Wireless Broadband Networks:, Packet Scheduling, Admission Control. Quality of Service for Multimedia Services: Traffic Models, Quality of Service in Wireless Systems, Outage Probability for Video Services in a Multirate DS-CDMA System.

Modem Design: Basic Modulation Techniques, Theoretical Limits and Practical Impairments, Traditional Modems for Wide-Area Wireless Networks, Other Aspects of Modem Implementation. Broadband Modem Technologies: Effects of Frequency-Selective Multipath Fading, Discrete Multipath Fading Channel Model, Adaptive Discrete Matched Filter, Adaptive Equalization, Sectored Antennas, Multi-carrier, OFDM, and Frequency Diversity, MIMO in Frequency-Selective Fading.

Systems for Wireless Broadband Networks: Long-Term-Evolution Cellular Networks.: Network Architecture, Physical Layer, Avoidance MAC, Polling MAC, Reservation MAC, Energy-Efficient MAC, Multi-Channel MAC, Directional-Antenna MAC, MultiHop Saturated Throughput of IEEE 802.11 MAC, Mobility Resource Management: Types of Handoffs, Handoff Strategies, Channel Assignment Schemes, Location Management, Mobile IP, Cellular IP, HAWAII.. Radio Resource Management, Security, Quality of Service, Applications

Wireless Broadband Networking with WiMAX: WiMAX Overview, Competing Technologies, Overview of the Physical Layer, PMP Mode, Mesh Mode, Multihop Relay Mode.

Wireless Local Area Networks: Network Architectures, Physical Layer of IEEE 802.11n, Medium Access Control, Mobility Resource Management; Quality of Service, Applications.

Wireless Personal Area Networks: Network Architecture, Physical Layer, Medium Access Control, Mobility Resource Management, Routing, Quality of Service, Applications.

Convergence of Networks: GPP/WLAN Interworking, IEEE 802.11u Interworking with External Networks, LAN/WLAN/WiMax/3G Interworking Based on IEEE 802.21 Media-Independent Handoff, Future Cellular/WiMax/WLAN/WPAN Interworking, Analytical Model for Cellular/WLAN Interworking.

Course Learning Outcomes:
At the end of this course, the students should be able to:
- Recognize the concepts and operation of wireless broadband networks.
- Analyze and evaluate the performance of physical layer (OFDM and OFDMA), data link layer (MAC protocols) and routing protocols for wireless broadband networks.
- Differentiate types of networks and the concepts of convergence of networks.

Recommended Books

1. *Wong, David T., Kong, Peng-Yong, Liang, Ying-Chang and Chua, Kee C., Wireless Broadband Networks, John Wiley and sons (2009).*
2. *Pahlavan, Kaveh and Levesque, Allen H., Wireless Information Networks, 2nd Edition, John Wiley and Sons (2005).*
3. *Goldsmith, Andrea, Wireless Communications, Cambridge University Press (2007).*
4. *Geier, Jim, Wireless Networks first-step, Cisco Press (2004).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PWC WIRELESS SENSOR NETWORKS

L	T	P	Cr
3	0	0	3.0

Prerequisite(s): None

Course Objectives: To understand and gain the complete knowledge of wireless sensor networks. To understand the fundamentals of various architectures, different layers protocols and their applications, topology Control, routing protocols details, transport layer and quality of service. To understand the concepts of data-centric and content-based networking.

Introduction: The vision of Ambient Intelligence., Application examples, Types of applications, Challenges for WSNs, Why are sensor networks different?, Enabling technologies.

Single Node Architecture: Hardware components, Energy consumption of sensor nodes, Operating systems and execution environments, Some examples of sensor nodes, Conclusion.

Network Architecture: Sensor network scenarios, Optimization goals and figures of merit, Design principles for WSNs, Service interfaces of WSNs, Gateway concepts, Conclusion.

Physical Layer: Introduction, Wireless channel and communication fundamentals, Physical layer and transceiver design considerations in WSNs.

MAC Protocols: Fundamentals of (wireless) MAC protocols, Low duty cycle protocols and wakeup concepts, Contention-based protocols, Schedule-based protocols, The IEEE 802.15.4 MAC protocol, How about IEEE 802.11 and Bluetooth.

Link Layer Protocols: Fundamentals: Tasks and requirements, Error control, Framing, Link management, Summary.

Topology Control: Motivation and basic ideas, Flat network topologies, Hierarchical networks by dominating sets, Hierarchical networks by clustering, Combining hierarchical topologies and power control, Adaptive node activity.

Routing Protocols: Geometric routing, Routing with virtual coordinates, Gossiping and agent-based unicast forwarding, Energy-efficient unicast, Broadcast and multicast, Geographic routing, Mobile nodes.

Data-Centric and Content-based Networking: Introduction, Data-centric routing, Data aggregation, Data-centric storage.

Transport Layer and Quality of Service: The transport layer and QoS in wireless sensor networks, Coverage and deployment, Reliable data transport, Block delivery, Congestion control and rate control.

Advanced Application Support: Advanced in-network processing, Security, Application-specific support.

Course Learning Outcomes:
At the end of the course, the students should be able to:
- Recognize the fundamentals of various Architectures, different layers protocols and their applications, topology Control and routing protocols details.

- Analyze the data-centric and content-based networking.
- Evaluate the performance of transport layer and quality of service.

Recommended Books

1. *Karl, Holger and Andreas, Willig, Protocols and Architectures for Wireless Sensor Networks, John Wiley and sons (2005).*
2. *Xiaoyan, Cheng Maggie and Li, Deying, Advances in Wireless Ad Hoc and Sensor Networks Series, Springer (2008).*
3. *Sohraby, Kazem, Minoli, Daniel and Taieb Znati, Wireless Sensor Networks: Technology, Protocols, and Applications, John Wiley and Sons (2007).*
4. *Swami, Ananthram, Qing, Zhao, Hong, Yao-Win, and Lang Tong (editors), Wireless Sensor Networks: Signal Processing and Communications, Wiley (2007).*
5. *Rappaport, T.S., Wireless Communications, Prentice hall of India 2nd ed(2003).*
6. *Jun, Zheng and Jamalipour, Abbas, Wireless Sensor Networks: A Networking Perspective, Wiley-IEEE Press (2009).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PWC336 WIRELESS COMMUNICATION PROTOCOLS

L	T	P	Cr
3	0	0	3.0

Prerequisite(s): None

Course Objectives: To understand wireless networking, Mobile IP and wireless access protocols, Introduction to mobile network layers and WAP protocols. Study of wireless ATM and Hyper LAN.

Introduction To Wireless Networking: Introduction, Difference between wireless and fixed telephone networks, Development of wireless networks, Traffic routing in wireless networks.

Mobile IP And Wireless Access Protocol: Mobile IP Operation of mobile IP, Co-located address, Registration, Tunneling, WAP Architecture, overview, WML scripts, WAP service, WAP session protocol, wireless transaction, Wireless datagram protocol.

Bluetooth: Overview, Radio specification, Base band specification, Links manager specification, Logical link control and adaptation protocol. Introduction to WLL Technology.

Mobile Network Layer: Mobile IP: Overview, Terminologies related to Mobile IP, IP packet delivery, Agent advertisement and solicitation, Registration, Tunneling and Encapsulation, Optimizations, Reverse Tunneling, IPv6, Dynamic Host Configuration protocol: History, Applications of DHCP, DHCP Protocol: Significance and importance of DHCP, Routing , Routing types: Least cost, Adaptive, Non Adaptive routing namely DSDV and DSR protocols, Transport Layer: Traditional TCP, Congestion control, Slow start, Fast retransmit/fast recovery, Classical TCP improvements: Indirect TCP, Snooping TCP, Mobile TCP.

Wireless Application Protocol: WAP(1.0) Introduction, Main Objectives, Integration of WAP components, Stack arrangement with WAP, WAP network, Protocol stack of WAP, WAP client architecture, WAP network architecture, WAP (2.0): Advantages, Main architectural components of WAP 2.0, WAP Programming model, Uses of WAP 2.0 additional services.

Wireless ATM & Hiper LAN: Introduction, Wireless ATM, HIPERLAN, Adhoc Networking and WPAN.

Course Learning Outcomes:

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

- Recognize the basic concepts wireless networking and methods to achieve it.
- Identify various wireless devices and their utility in wireless communication.
- Analyze various protocols used in wireless communication
- Apply the protocols for data optimized performance and to achieve QoS.

Recommended Books

1. *Wireless Communication of Networks* - *William Stallings PHI*
2. *BlueTooth* - *Demystified Nathan J.Muller Tata McGraw – Hill Publication, New Delhi.*
3. *Wireless Communication and Networking – William Stallings, PHI, 2003.*
   Mobile Communications - *Jochen Schiller Pearson Education, New Delhi.*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)

1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PWC SPREAD SPECTRUM COMMUNICATION

L	T	P	Cr
3	0	0	3.0

Prerequisite(S): None

Course Objectives: To understand the basic concept of spread spectrum communication, spreading codes. To understand and gain complete knowledge of radio channel modeling, OFDM, hybrid multiple access technique like OFDMA, MC-CDMA, BLAST architecture.

Introduction: Radio channel characteristics, Channel Modeling, Channel Statics, ISI and ICI, Discrete Multipath Channel Models, Diversity, Multi Carrier Transmission OFDM, Advantages and drawbacks of OFDM, Applications and standards of OFDM, Spread Spectrum Techniques, Multicarrier Spread Spectrum, MC-CDMA, MC-DS-CDMA

Hybrid Multiple Access Schemes: Multi carrier FDMA, OFDMA, OFDMA with code division multiplexing, distributed DFT, localized DFT, multi carrier TDMA, Pseudo random PPM Ultra Wide Band systems, Comparison of Hybrid multiple access schemes, Multi carrier modulation and demodulation, synchronization, channel estimation, channel coding and decoding, signal constellation, mapping demapping and equalization, Adaptive techniques in multi carrier transmission, RF issues

Applications: 3GPP LTE systems, Requirements on LTE, Radio Access Network Architecture, Radio protocol Architecture, Downlink and Uplink Transmission Scheme, WiMax, System Architecture, WiMax Profiles, Hyper Man and 802.16x, Future mobile communication concepts, VSF-OFCDM access schemes, Wireless LAN, interaction channel for DVB-T:DVB-RCT

Additional Techniques for Capacity and Flexibility Enhancement: MIMO, BLAST architecture, Space-time coding, diversity techniques for multi carrier transmission, spatial pre -coding for multi carrier transmission, software defined radio.

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

- Recognize the basic concepts of Spread Spectrum Communication, spreading codes, the basic concepts of OFDM and various Hybrid Multiple Access Schemes
- Describe the basic ideas of the applications related to the spread spectrum communication
- Analyze the performance of techniques for capacity and flexibility enhancement related to the spread spectrum communication.
- Evaluate the performance of MIMO and BLAST Architecture

Recommended Books

1. *K. Fazel and S. Kaiser, Multi-Carrier and Spread Spectrum Systems, John Wiley & Sons, 2nd ed. 2008.*
2. *David, Tse and Viswanath, Pramod, Fundamentals of Wireless Communication, Cambridge University Press (2006).*
3. *Fitzek , Frank H .P., Katz and Marcos D., Cooperation in Wireless Networks: Principles and Applications, Springer (2007) 2nd ed.*
4. *Arogyaswami., Paulraj , Gore, Dhananjay and Nabar , Rohit., Introduction to Space-Time Wireless Communications, Cambridge University Press (2008).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20