M. TECH – WIRELESS AND MOBILE COMMUNICATION SYSTEMS (FULL TIME)
Curriculum and Syllabus
(2018-19 and onwards)

FACULTY OF ENGINEERING AND TECHNOLOGY
SRM Institute of Science and Technology
SRM Nagar, Kattankulathur – 603 203

M. Tech – WIRELESS AND MOBILE COMMUNICATION SYSTEMS (FULL TIME)
Curriculum and Syllabus
Batch 2018-19 and onwards

S. No.	Category	No. of Credits			
		I Semester	II Semester	III Semester	IV Semester
1	Core Courses	12	12	-	-
2	Elective Courses	3	6	9	-
3	Supportive Courses	3	-	-	-
4	Interdisciplinary	-	3	-	-
5	Career Advancement Courses	1	1	1	-
6	Seminar	-	-	1	-
7	Project Work	-	-	6*	16**
Credits per semester		19	22	17	16
Total Credits					**74**

* Main Project-Phase I ** Main Project-Phase II

CORE COURSES

Course code	Course Title	L	T	P	C
WM2001	Coding Theory	3	1	0	4
WM2002	Digital Communication Techniques	3	0	2	4
WM2003	Optical Fiber Communication	3	1	0	4
WM2004	Antenna Theory and Design	3	1	0	4
	OR				
WM2005	Mobile Communication Systems and Standards	3	1	0	4
WM2006	High Speed Communication Networks	3	0	2	4
	OR				
WM2007	Wireless MIMO Communications	3	0	2	4
WM2008	Global Positioning Systems	3	1	0	4
	OR				
WM2009	Mobile Adhoc Networks	3	1	0	4
WM2010	Adaptive Signal Processing	3	1	0	4
	OR				
WM2011	Microwave Communication	3	1	0	4

PROGRAM ELECTIVES

Course code	Course Title	L	T	P	C
WM2101	Coding Techniques for Spread Spectrum Communications	3	0	0	3
WM2102	Cognitive Radio Technology	3	0	0	3
WM2103	Communication Network Security	3	0	0	3
WM2104	Digital Communication Receivers	3	0	0	3
WM2105	Electromagnetic Interference and Compatibility in System Design	3	0	0	3
WM2106	High Speed Switching Architecture	3	0	0	3
WM2107	Microwave Integrated Circuits	3	0	0	3
WM2108	Multi User Detection	3	0	0	3
WM2109	Non Linear Fiber Optics	3	0	0	3
WM2110	OFDM / OFDMA Communications	3	0	0	3
WM2111	Optical Network and Photonic Switching	3	0	0	3
WM2112	RF MEMS for wireless Communication	3	0	0	3
WM2113	RF System Design	3	0	0	3
WM2114	Satellite Communication	3	0	0	3
WM2115	Statistical Signal Processing	3	0	0	3
WM2116	Statistical Theory of Communications	3	0	0	3
WM2117	Ultra-Wideband Communication Systems	3	0	0	3
WM2118	WCDMA for UMTS	3	0	0	3
WM2119	Wireless Sensor Networks	3	0	0	3
WM2120	Stochastic Processes and Queuing theory	3	0	0	3
WM2121	Multicasting Techniques in MANETs	3	0	0	3
WM2122	Wavelet Transform and Application	3	0	0	3
WM2123	Antennas for Personal Area Communication	3	0	0	3
WM2124*	Reconfigurable Antennas	3	0	0	3
WM2125*	Fiber Wireless Access Network	3	0	0	3
WM2126*	Semiconductor Optical Amplifier based all Optical Circuits and Devices	3	0	0	3
WM2127*	Semiconductor Optoelectronic Devices	3	0	0	3
WM2128*	Wireless Optical Communication	3	0	0	3
WM2129*	Compressive Sensing	3	0	0	3
WM2130*	Photonic Integrated Circuits	3	0	0	3
WM2131*	Integrated Photonic Micro Ring Resonators	3	0	0	3
WM2132*	Near Field Optics and Plasmonics	3	0	0	3
WM2133*	Signal Processing Techniques for Speech Recognition	3	0	0	3
WM2134*	Visible Light Communication	3	0	0	3
WM2135*	Analysis and Design of Trans-Impedance Amplifier for Optical Receiver	3	0	0	3
WM2136*	Introduction to Digital Speech Processing	3	0	0	3
WM2137*	Statistical and Adaptive Signal Processing	3	0	0	3
WM2138*	Acoustic Echo Cancellation and Noise Control	3	0	0	3
WM2139*	Fiber Optics Integrated Circuits	3	0	0	3
WM2140*	Bragg Fibers Analysis and Applications	3	0	0	3

Course code	Course Title	L	T	P	C
WM2141*	Fiber Optics Component and Devices	3	0	0	3
WM2142*	Fiber Optic Sensors	3	0	0	3
WM2143*	Compressed Sensing Methods for Signal Processing	3	0	0	3
WM2144*	IoT Devices and Security	3	0	0	3
WM2145*	Mathematical Methods for Signal Processing	3	0	0	3
WM2146*	Underwater Acoustic Signal Processing	3	0	0	3
WM2147*	Principles of Underwater Communication	3	0	0	3
WM2148*	Photonic Crystal Analysis and Applications	3	0	0	3
WM2149*	Introduction to Internal Waves	3	0	0	3

SUPPORTIVE COURSES

Course code	Course Title	L	T	P	C
MA2009	Applied Mathematics	3	0	0	3
WM2201	Network Management	3	0	0	3
WM2202	Simulation of Communication System and Networks	3	0	0	3
WM2203	Linear Algebra	3	0	0	3
WM2204	Principle of Uncertainty	3	0	0	3
WM2205	Mathematical Methods for Communication Engineers	3	0	0	3

OTHER COURSES

Course code	Course Title	L	T	P	C
CAC2001	Career Advancement Course for Engineers –I	1	0	1	1
CAC2002	Career Advancement Course for Engineers –II	1	0	1	1
CAC2003	Career Advancement Course for Engineers –III	1	0	1	1
WM2047	Seminar	0	0	1	1
WM2049	Project Work – Phase - I	0	0	12	6
WM2050	Project Work – Phase – II	0	0	32	16

<table>
<tr><td rowspan="4">WM2001</td><td></td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>CODING THEORY</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td colspan="5">Total Contact Hours – 60</td></tr>
<tr><td colspan="5">Prerequisite : Nil</td></tr>
<tr><td colspan="6">PURPOSE</td></tr>
<tr><td colspan="6">In order to transfer data without error from source to destination, focus must be made on coding. This syllabus is highly intended to emphasize on various block coding techniques.</td></tr>
<tr><td colspan="6">INSTRUCTIONAL OBJECTIVES</td></tr>
<tr><td>1.</td><td colspan="5">To understand Galois field arithmetic and its implementation in coding theory.</td></tr>
<tr><td>2.</td><td colspan="5">To get a clear concept of block codes and cyclic codes.</td></tr>
</table>

UNIT I - GALOIS FIELDS **(12 hours)**

Groups, fields and Vector spaces – Elementary properties of Galois fields – Primitive polynomials and Galois fields of Order p^m - Zech's algorithms.

UNIT II - POLYNOMIALS OVER GALOIS FIELDS **(12 hours)**

Euclidean domains and Euclid's algorithm – Minimal polynomials and Conjugate elements – Factoring $X^n - 1$ - Ideals in the Ring $\frac{GF(q)[x]}{x^n - 1}$.

UNIT III - LINEAR BLOCK CODES **(12 hours)**

Block error control codes – Linear block codes – Standard array and syndrome-table decoding – Weight distribution of block codes – Hamming codes – Modified linear codes.

UNIT IV - CYCLIC CODES **(12 hours)**

General theory of linear cyclic codes – Shift register encoders and decoders for cyclic codes – Shortened cyclic codes and CRC error detection.

UNIT V - BCH AND REED SOLOMON CODES **(12 hours)**

Generator polynomial approach to BCH codes – Weight distribution for some binary BCH codes – Basic properties of Reed Solomon codes – Decoding algorithms for binary BCH codes, non-binary BCH codes, Reed Solomon codes (Berlekamp's algorithm) – Binary and non-binary erasure decoding.

REFERENCES

1. Stephen B. Wicker, *"Error control systems for Digital communication and storage"*, Prentice Hall, Upper Saddle River, NJ, 1995.
2. Shu Lin, Daniel Costello, *"Error control coding – Fundamentals and Applications"*, Second Edition, Prentice Hall, Upper Saddle River, NJ, 2004.
3. Simon Haykin, *"Digital Communication"*, John Wiley and Sons, 1988.
4. Bernard Sklar, *"Digital Communications, Fundamentals and Applications"*, Second Edition, Pearson Education, 2001.

WM2002	DIGITAL COMMUNICATION TECHNIQUES	L	T	P	C
		3	0	2	4
	Total Contact Hours - 75				
	Prerequisite: Nil				

PURPOSE	
To learn the basic principles that forms the background of the analysis and design of digital communication systems.	
INSTRUCTIONAL OBJECTIVES	
1.	To learn about Representation of signals and spectra
2.	Formatting, baseband and M-ary modulation/demodulation, and Symbol error rate
3.	Synchronization and Digital communications in fading channels.

UNIT I - SIGNALS AND SPECTRA (**15 hours)**

Digital communication signal processing – Classification of signals – Spectral density – Correlation and Covariance – Signal transmission through linear systems – Bandwidth of digital data – Nyquist minimum bandwidth – Shannon's Capacity theorem.

UNIT II - FORMATTING AND BASEBAND TRANSMISSION (15 hours)

Formatting textual data and analog information – Uniform and non-uniform quantization – Baseband transmission – Pulse coded modulation – Multilevel baseband transmission – Intersymbol interference – Partial response signaling. Matlab exercises

UNIT III – BANDPASS - MODULATION/DEMODULATION & SYMBOLERROR PERFORMANCE (15 hours)

Digital bandpass modulation/demodulation - M-ary signaling and modulation - Detection of signals in Gaussian noise – Coherent detection – Non-coherent detection – Error performance of binary systems – Symbol error performance for M-ary signaling. Matlab exercises

UNIT IV - SYNCHRONIZATION (15 hours)

Synchronization in the context of digital communications – Signal parameter estimation – Carrier phase estimation – Symbol timing estimation – Joint estimation of carrier phase and symbol timing – Frame synchronization – Network synchronization. Matlab exercises

UNIT V - DIGITAL COMMUNICATIONS THROUGH MULTIPATH FADING CHANNELS (15 hours)

Characterization of multipath fading channels – Effect of signal characteristics on the choice of a channel model – Frequency non-selective/selective slow fading channel – Diversity techniques for multipath fading channel – Multiple-antenna systems. Matlab exercises

REFERENCES

1. Bernard Sklar, "*Digital Communications – Fundamentals and Applications*", 2nd Edition, Pearson Education, 2001.
2. Proakis, J. G, M. Salehi, "*Digital Communications*", 5th Edition, McGraw Hill Inc., NY, 2008.
3. Haykins. S, "*Digital Communications*", John Wiley and Sons Inc., NJ, 1998.

		L	T	P	C
WM2003	**OPTICAL FIBER COMMUNICATION**	**3**	**1**	**0**	**4**
	Total Contact Hours – 60				
	Prerequisite: Nil				
PURPOSE					
This course is intended to bring to the students the information necessary to understand the design, operation and capabilities of fiber systems. Students will be introduced to the fundamental concepts of various optical components. Latest topics are included to keep in touch with the recent trends					
INSTRUCTIONAL OBJECTIVES					
1.	To introduce the terminology used in optical fibers				
2.	To describe the building blocks of an Optical Fiber system and to give clear understanding of various components such as Optical fibers, Optical sources, Photo-detectors and fiber amplifiers				
3.	To introduce loss and dispersion management				
4.	To introduce coherent and multichannel systems				

UNIT I – INTRODUCTION TO OPTICAL COMMUNICATION AND FIBER CHARACTERISTICS (9 hours)

Evolution of Light wave systems, System components, Optical fibers - Step Index and Graded index - Mode theory, Fiber modes – Dispersion in fibers, Limitations due to dispersion - - Fiber Losses - Non-linear effects

UNIT II - OPTICAL TRANSMITTERS AND RECEIVERS (9 hours)

Transmitter's basic concepts - LED's structures - Spectral Distribution - Semiconductor lasers - Threshold conditions – Single mode semiconductor laser –Laser Characteristics- Modulation - Transmitter design Receiver's basic Concepts - PIN and APD diodes structures- Photo detector Noise- Receiver sensitivity – BER and quantum limit - Receiver design

UNIT III - LOSS AND DISPERSION MANAGEMENT (9 hours)

Compensation of Fiber losses - Semiconductor optical amplifiers - Erbium-doped fiber amplifiers, Raman and Brillouin amplifiers Dispersion problems and its solution - Dispersion shifted and dispersion flattened fibers – Dispersion compensated fibers – PMD dispersion – Precompensation at the transmitter and compensation at the receiver Optical solitons - Soliton based communication system.

UNIT IV - ADVANCED LIGHTWAVE SYSTEMS (9 hours)

Homodyne and heterodyne detectors – Advanced modulation formats - Demodulation schemes - BER in synchronous receivers - Sensitivity degradation –Systems with the DBPSK format and DQPSK – System employing Orthogonal FDM

UNIT V - MULTICHANNEL SYSTEMS (9 hours)

WDM systems, multiple access networks - WDM Components - XPM based and FWM based wavelength converters – Fiber based optical regenerator - Hetero wavelength linear crosstalk and homo wavelength Linear Crosstalk – TDM - Code-division multiplexing

Tutorial = 15

REFERENCES

1. G.P.Agrawal, "*Fiber Optic Communication Systems*", 4th Edition, John Wiley and Sons, 2010.
2. John M. Senior, "*Optical Fiber Communications* –Principles and Practice", 2nd Edition, Pearson Education, 2009
3. G. Keiser, "*Optical Fiber Communication Systems*", 4th edition, Tata McGrawHill. Edition, 2010.
4. Djafar.K. Mynbaev Lowell and Scheiner, "*Fiber Optic Communication Technology*", Pearson Education Asia, 2009.
5. F.J.H. Franz and V.K. Jain, "*Optical Communication System*", Narosa Publishing House, New Delhi 2000

		L	T	P	C
WM2004	**ANTENNA THEORY AND DESIGN**	**3**	**1**	**0**	**4**
	Total Contact Hours – 60				
	Prerequisite: Nil				

PURPOSE	
Antenna Theory is central for all radio systems, and this course will enable the students to understand different radio antennas and their usage.	
INSTRUCTIONAL OBJECTIVES	
1.	To provide in-depth understanding of modern antenna concepts, and practical antenna design for various applications
2.	To explain the theory of different types of antennas used in communication systems
3.	An in-depth study will be made for the analysis and design of arrays
4.	Provide an overview of advanced analytical and numerical methods used to analyze and design antennas.
5.	Provide a solid background for research in the field of antenna analysis and design.

UNIT I - FUNDAMENTAL CONCEPTS AND RADIATION FROM WIRE ANTENNAS (9 hours)

Physical concept of radiation- Radiation pattern-near-and far-field regions,-antenna theorem-formulation of fundamental antenna properties -Friis transmission equation-radiation integrals and auxiliary potential functions-Infinitesimal dipole-finite-length dipole-linear elements near conductors- dipoles for mobile communication-small circular loop.

UNIT II - ANTENNA ARRAYS AND SYNTHESIS (9 hours)

Linear arrays-Analysis of uniformly spaced arrays with uniform and non-uniform excitation amplitudes –binomial array-phased array- synthesis of antenna arrays - Schelkunoff polynomial method- Woodward-Lawson method-Fourier transform method-Taylor method- Integral equations- moment method-impedances.

UNIT III - APERTURE AND REFLECTOR ANTENNAS (9 hours)

Huygens' principle- radiation from rectangular and circular apertures- design considerations -Babinet's principle -Radiation from sectoral and pyramidal horns-design concepts prime-focus parabolic reflector and cassegrain antennas.

UNIT IV - BROADBAND AND MICROSTRIP ANTENNAS (9 hours)

Log-periodic and Yagi antennas- frequency independent antennas- helical antennas -Basic characteristics of microstrip antennas -feeding methods- methods of analysis -design of rectangular and circular patch antennas-microstrip arrays.

UNIT V - ANTENNA MEASUREMENTS, SMART ANTENNAS AND CE (9 hours)

Antenna ranges-radiation pattern measurement-gain measurements-impedance-directivity-efficiency-polarization-Concept and benefits of smart antennas- Fixed weight beam forming basics- Adaptive beam forming-CEM for antennas-Method of movements-Finite difference time domain method.

Tutorial = 15

REFERENCES

1. C. A. Balanis, *"Antenna Theory Analysis and Design"*, 3rd Ed., John Wiley and Sons, 2008.
2. W. L. Stutzman, and G. A. Thiele, *"Antenna Theory and Design"*, 2nd Ed., John Wiley and Sons, 2010.
3. R. S. Elliot, *"Antenna Theory and Design"*, Revised edition, Wiley-IEEE Press, 2005.
4. R. E. Collin, *"Antennas and Radio Wave Propagation"*, McGraw-Hill., 1985.
5. F. B. Gross, *"Smart Antennas for Wireless Communications"*, McGraw-Hill, 2005.
6. John.D.Kraus and R.J.Marhetka*,"Antennas for all Applications"*3rd edition. Tata McGraw Hill, 2008.

			L	T	P	C
WM2005	**MOBILE COMMUNICATION SYSTEMS and STANDARDS**		**3**	**1**	**0**	**4**
	Total Contact Hours – 60					
	Prerequisite : Nil					
PURPOSE						
To train the students in the technological developments of mobile communication systems and standards.						
INSTRUCTIONAL OBJECTIVES: To impart						
1.	Developments in the current and next generation mobile technologies.					
2.	Details of advanced mobile communication standards and their evolution.					
3.	Knowledge on mobility support in network layers.					

UNIT I – EVOLUTION OF MODERN MOBILE COMMUNICATION (12 hours)

Personal communication systems –Wireless local area networks – Wireless broadband access systems - Wireless wide area networks – Cellular systems and design fundamentals.

UNIT II – 2G AND 3G CELLULAR SYSTEMS (12 hours)

GSM Architecture – Air interface – Protocols and Signalling - GPRS Architecture – Signalling – Mobility and location management - Interfaces and Protocols – Overview of IS95 – UMTS Architecture – Interfaces and Protocols - Mobility Management - Handover and security procedure.

UNIT III – ADVANCED MOBILE COMMUNICATION STANDARDS (12 hours)

IEEE 802.11 WLAN standard and its variants – PHY layer technologies – MAC mechanism – Security, Qos and handover Issues – IEEE 802.15 WPAN standard – Bluetooth Architecture and Protocol stack – IEEE 802.16 Wireless broadband access standard – PHY and MAC layer overviews – WiMAX network architecture – Initialization and handover procedures.

UNIT IV – BEYOND 3G (12 hours)

HSPA and LTE – Architecture – Radio interface and channels – Resource mapping – Session, mobility and security procedures – LTE Advanced – Heterogeneous Networks – Internetworking – IP based coupling Architecture - Multimode terminals and intersystem handover.

UNIT V – MOBILE NETWORK, TRANSPORT & APPLICATION LAYERS (12 hours)

Mobile IP – Packet delivery process – Routing optimization – Mobile ad-hoc networks and routing protocols – Mobile TCP – Wireless Application Protocols.

REFERENCE BOOKS:

1. Iti Saha Misra, "*Wireless Communication and Networks – 3G and Beyond*", Mc Graw Hill Education, Second Edition, 2013.
2. Jochen Schiller, "*Mobile Communications*", Pearson Education, Second Edition, 2012.
3. Andreas F.Molisch "*Wireless Communications*", Wiley, Second Edition, 2014.
4. E.Dahlman et. al. "*3G Evolution: HSPA and LTE for Mobile Broadband*", Elsevier, Second Edition, 2008.
5. G.Sasibhushana Rao, "*Mobile Cellular Communication*", Pearson, 2013.

WM2006		L	T	P	C
	HIGH SPEED COMMUNICATION NETWORKS	**3**	**0**	**2**	**4**
	Total Contact Hours – 75				
	Prerequisite: Nil				

PURPOSE	
The course is designed to make the student understand the basic principles of high speed communication networking. It provides a balance between the description of existing networks and the development of analytical tools. The descriptive material is used to illustrate the underlying concepts, and the analytical material is used to analyze the performance of various networks, and to sharpen one's conceptual and intuitive understanding of the field.	
INSTRUCTIONAL OBJECTIVES	
1.	Explanation of major concepts and principles in a simple non-mathematical way.
2.	Description of modeling issues and mathematical analysis.
3.	To acquire deeper understanding and the ability to do research in this field

UNIT I - LAYERED NETWORK ARCHITECTURES (15 hours)
Review of Open Systems Interconnection (OSI) and Transmission Control Protocol/Internet Protocol, and Internetworking

UNIT II - POINT-TO-POINT PROTOCOLS AND LINKS (15 hours)
Error detection – ARQ: Retransmission strategies – Framing – Point-to-point protocols at the network layer – The Transport layer – Broadband ISDN – Frame Relay – Asynchronous Transfer Mode. Lab exercise

UNIT III - DELAY MODELS IN DATA NETWORKS (15 hours)
M/M/1, M/M/m, M/M/m/m, M/M/∞, M/G/1 queuing models – Networks of Transmission lines - Time reversibility (Burke's theorem) – Network of Queues (Jackson's theorem). Lab exercise

UNIT IV - ROUTING IN DATA NETWORKS AND INTERNET ROUTIN (15 hours)
Wide area networking – Interconnected network Routing – Shortest path Routing – Multicast/Broadcast Routing information – Flow models – Optimal Routing & Topological design – Characterization of Optimal Routing – Interior & Exterior Routing protocols. Lab exercise

UNIT V - CONGESTION, TRAFFIC MANAGEMENT & FLOW CONTROL (15 hours)
Congestion control in data networks and Internets – Link-level flow and error control – TCP traffic control – Traffic and Congestion control in ATM networks – Means of Flow control – Main objectives of flow control – Window flow control – Rate control schemes. Lab exercise

REFERENCES

1. Dimitri Bertsekas and Robert Gallager , "*Data networks*" ,Second Edition, Prentice Hall, Inc., NJ, USA1992
2. William Stalling, "*High Speed Networks and Internets*", Second Edition, Pearson Education Inc., New Delhi, India, 2002
3. Leon Garcia and Widjaja ," *Communication networks: Fundamental concepts and key architectures*", McGraw Hill, Inc., NY, USA, 2006
4. Jean Walrand , " *Communication networks*", McGraw Hill, Inc., NY, USA, 1998.

WM2007			L	T	P	C
	WIRELESS MIMO COMMUNICATIONS		**3**	**0**	**2**	**4**
	Total Contact Hours – 75					
	Prerequisite: Nil					
PURPOSE						
Purpose of the course is to provide a comprehensive coverage of coding techniques for multiple-input, multiple-output (MIMO) communication systems.						
INSTRUCTIONAL OBJECTIVES						
1.	To learn about basic MIMO communication systems, Space-time block codes, Space-time trellis codes, MIMO systems for frequency-selective (FS) fading channels, Turbo codes and iterative decoding for MIMO systems.					

UNIT I - FADING CHANNELS AND DIVERSITY TECHNIQUES (15 hours)

Wireless channels – Error/Outage probability over fading channels – Diversity techniques – Channel coding as a means of time diversity – Multiple antennas in wireless communications.

UNIT II - CAPACITY & INFORMATION RATES OF MIMO CHANNELS (15 hours)

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. Matlab exercise

UNIT III - SPACE-TIME BLOCK AND TRELLIS CODES (15 hours)

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. Matlab exercise

UNIT IV - CONCATENATED CODES AND ITERATIVE DECODING (15 hours)

Development of concatenated codes – Concatenated codes for AWGN & MIMO channels – Turbo coded modulation for MIMO channels – Concatenated space-time block coding. Matlab exercise

UNIT V - SPACE-TIME CODING FOR FREQUENCY SELECTIVE FADING CHANNELS (15 hours)

MIMO frequency-selective channels – Capacity and Information rates of MIMO FS fading channels – Space-time coding and Channel detection for MIMO FS channels – MIMO OFDM systems. Matlab exercise

REFERENCES

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

<table>
<tr><td rowspan="4">WM2008</td><td></td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>GLOBAL POSITIONING SYSTEMS</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td colspan="5">Total Contact Hours – 60</td></tr>
<tr><td colspan="5">Prerequisite : Nil</td></tr>
<tr><td colspan="6">PURPOSE</td></tr>
<tr><td colspan="6">The purpose of this course is to develop a strong foundation in the field of Global Positioning Systems. The subject gives the students an in-depth knowledge about working of Global positioning receivers. Students are exposed to various errors occurring in GPS and latest variant DGPS receivers and GPS applications.</td></tr>
<tr><td colspan="6">INSTRUCTIONAL OBJECTIVES</td></tr>
<tr><td>1.</td><td colspan="5">At the end of this course students will gain knowledge in the topics such as introduction to global positioning</td></tr>
<tr><td>2.</td><td colspan="5">Types of signals used in the GPS systems and accuracy limits</td></tr>
<tr><td>3.</td><td colspan="5">Latest versions of GPS and its application</td></tr>
</table>

UNIT I - INTRODUCTION (**9 hours)**

GPS and GLONASS Overview – Satellite Navigation -Time and GPS – User position and velocity calculations – GPS – Satellite Constellation – Operation Segment – User receiving Equipment – Space Segment Phased development.

UNIT II - SIGNAL CHARACTERISTICS **(9 hours)**

GPS signal components – purpose, properties and power level – signal acquisition and tracking – Navigation information extraction – pseudorange estimation – frequency estimation – GPS satellite position calculation.

UNIT III - GPS RECEIVERS and DATA ERRORS **(9 hours)**

Receiver Architecture – receiver design options – Antenna design – SA errors – propagation errors – Methods of multipath mitigation – Ephemeris data errors – clock errors.

UNIT IV - DIFFERENTIAL GPS **(9 hours)**

Introduction – LADGPS – WADGPS, Wide Area Augmentation systems – GEO Uplink subsystem – GEO downlink systems – Geo Orbit determination – Geometric analysis – covariance analysis – GPS /INS Integration Architectures

UNIT V - GPS APPLICATIONS **(9 hours)**

GPS in surveying, Mapping and Geographical Information System – Precision approach Aircraft landing system – Military and Space application – Intelligent transportation system.

Tutorial = 15

REFERENCES

1. Mohinder S.Grewal, Lawrence R.Weill, Angus P.Andrews, "*Global positioning systems – Inertial Navigation and Integration*", John Wiley and sons, 2007.
2. E.D.Kaplan, Christopher J. Hegarty, "*Understanding GPS Principles and Applications*", Artech House Boston 2005.

		L	T	P	C
WM2009	**MOBILE ADHOC NETWORKS**	**3**	**1**	**0**	**4**
	Total Contact Hours – 45				
	Prerequisite : Nil				

PURPOSE	
To study the functionality of Mobile Adhoc Networking.	
INSTRUCTIONAL OBJECTIVES	
1.	To review the concept of packet radio networks
2.	To explore the routing protocols of MANET

UNIT I - ADHOC NETWORKING (9 hours)
Introduction – DOD perspective – Commercial applications – Characteristics and issues of adhoc networks – proactive and reactive routing protocols.

UNIT II - TABLE DRIVEN PROTOCOLS (9 hours)
Preview of routing protocols – DSDV Protocol – Properties and features of DSDV – Clustering – Transmission management – Backbone formation –routing efficiency

UNIT III - ON-DEMAND PROTOCOLS (9 hours)
AODV protocols – Unicast and Multicast – Optimizations and enhancements – DSR protocol – Overview – Properties – Additional features – support for heterogeneous networks

UNIT IV - HYBRID AND LINK REVERSAL ROUTING (9 hours)
Reconfigurable Wireless networks – ZPR – Intra and Interzone routing – General approach of Link reversal routing – GB algorithm – LMR – TORA – Protocol description – Properties – Recent extensions.

UNIT V - BEACONING AND BANDWIDTH EFFICIENT ROUTING (9 hours)
ABR routing protocol – Effect of Beaconing on battery life – ORA and LORA approaches for updating routes – Source Tree Adaptive Routing – Research issues of adhoc networking.

Tutorial = 15

REFERENCE

1. Charles E. Perkins, “*Adhoc Networking*”, Addision-Wesley, 2001.

		L	T	P	C
WM2010	**ADAPTIVE SIGNAL PROCESSING**	**3**	**1**	**0**	**4**
	Total Contact Hours – 60				
	Prerequisite : Nil				

PURPOSE

The purpose of this course is to make the students conversant with the design aspects of Advanced Digital Signal Processing.

INSTRUCTIONAL OBJECTIVES

At the end of the course, student should be able to know

1.	Discrete Random Signal Processing
2.	Spectrum Estimation
3.	Linear Estimation and Prediction
4.	Adaptive Filtering Concepts
5.	Multirate Signal Processing Concepts

UNIT I - INTRODUCTION TO DISCRETE RANDOM SIGNAL PROCESSING (9 hours)

Review of Linear Algebra, and Discrete Random Processes for random signal processing, Parseval'sTheorem, Wiener Khintchine Relation - Power Spectral Density, Sum Decomposition Theorem, SpectralFactorization Theorem - Discrete Random Signal processing by Linear Systems - Low Pass Filtering of White Noise. Spectrum estimation

UNIT II - SPECTRUM ESTIMATION (9 hours)

Non-Parametric Methods, Estimators and its Performance Analysis, Periodogram and it's based nonparametric methods - Signal Modeling and it's Based Approach's - Parameter Estimation Using Yule- Walker Method.

UNIT III - LINEAR ESTIMATION AND PREDICTION (9 hours)

Linear Estimation of Signals - Maximum Likelihood and Least Mean Squared Error Criterions – Wiener Filter - Discrete Wiener Hoff Equations, Kalman Filter, Linear Prediction, Whitening Filter, Inverse Filter, Levinson Recursion, Lattice Realization, and Levinson Recursion Algorithm for Solving Toeplitz System of Equations.

.UNIT IV - ADAPTIVE FILTERING (9 hours)

FIR Adaptive Filters, Steepest Descent Methods - Widrow Hoff, LMS Adaptive Algorithm – Adaptive filter applications in communication system, RLS Adaptive Filters and it's types - Simplified IIR LMS Adaptive Filter - Delay Line Structures.

UNIT V - MULTIRATE SIGNAL PROCESSING (9 hours)

Mathematical Description of Change of Sampling Rate - Integer sampling rate conversions, Single and Multistage Realization - Poly Phase Realization - Application to Sub Band Coding and Coding Gain - Wavelet Transform and Filter Bank Implementation of Wavelet expansion of signals. 2D Filter Banks.

Tutorial = 15

REFERENCES

1. Monson H.Hayes, *"Statistical Digital Signal Processing and Modeling"*, John Wiley and Sons, Inc., Singapore, 2002
2. Sopocles J. Orfanidis, *"Optimum Signal Processing"*, McGraw Hill, 2007..
3. John G.Proakis, Dimitris G.Manolakis, *"Digital Signal Processing"*, Pearson Ed., 2007.
4. B.Farhang-Boroujeny, *"Adaptive Filters:* Theory and Application", John Wiley and Sons Ltd, United Kingdom, 1998.
5. Simon Haykin , *"Adaptive Filter Theory"*, 4/E, Pearson Education, South Asia, 2009.
6. Vaidyanathan P.P, *"Multirate Systems and Filter Banks"*, Pearson Education, 2008.
7. Rafael C. Gonzalez, Richard E. Woods, *"Digital Image Processing",* Pearson Education Inc.,3/E, 2009.

<table>
<tr><td rowspan="4">WM2011</td><td></td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>MICROWAVE COMMUNICATION</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td colspan="5">Total Contact Hours – 60</td></tr>
<tr><td colspan="5">Prerequisite : Nil</td></tr>
<tr><td colspan="6">PURPOSE</td></tr>
<tr><td colspan="6">This course is intended to bring to the students the information necessary to understand the design of microwave system components. Students will be introduced to the state of the art RF systems using microwave principle to develop cutting edge technological products.</td></tr>
<tr><td colspan="6">INSTRUCTIONAL OBJECTIVES</td></tr>
<tr><td>1.</td><td colspan="5">To introduce the terminology used in microwave, analysis of RF and microwave transmission lines</td></tr>
<tr><td>2.</td><td colspan="5">To design the building blocks of an Microwave transmission system</td></tr>
<tr><td>3.</td><td colspan="5">To measure various parameters at microwave frequencies</td></tr>
<tr><td>4.</td><td colspan="5">To learn about microwave systems and its application in various fields</td></tr>
</table>

UNIT I - INTRODUCTION TO MICROWAVES (9 hours)

History of Microwaves, Microwave Frequency bands, Applications of Microwaves: Civil and Military, Medical, EMI/ EMC. Mathematical model of Microwave Transmission**,** Concept of Mode, Characteristics of TEM, TE and TM Modes,Losses in microwave transmission, Concept of Impedance in Microwave transmission.

UNIT II - ANALYSIS OF MICROWAVE TRANSMISSION LINES (9 hours)

Analysis of RF and Microwave Transmission Lines- Coaxial Line, Rectangular Waveguide, Circular waveguide, Stripline, Microstrip Line. Microwave Network Analysis **-**Equivalent Voltages and currents for non-TEM lines - Network parameters for microwave Circuits - Scattering Parameters.

UNIT III - MICROWAVE DESIGN PRINCIPLES (9 hours)

Impedance transformation, Impedance Matching, Microwave Filter Design, RF and Microwave Amplifier Design, Microwave Power amplifier Design, Low Noise Amplifier Design, microwave Mixer Design, Microwave Oscillator Design. Microwave Antenna**-** Microwave Antenna Parameters, Microwave antenna for ground based systems, Microwave antenna for airborne based systems, Microwave antenna for satellite borne systems, Microwave Planar Antenna.

UNIT IV - MICROWAVE MEASUREMENTS (9 hours)

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

UNIT V - MODERN TRENDS IN MICROWAVE SYSTEMS (9 hours)

Radar Systems, Cellular Phone, Satellite Communication, RFID, GPS. Modern Trends in Microwaves Engineering - Effect of Microwaves on human body, Medical and Civil applications of microwaves, Electromagnetic interference / Electromagnetic Compatibility (EMI / EMC), Monolithic Microwave IC fabrication, RFMEMS for microwave components, Microwave Imaging.

Tutorial = 15

REFERENCES

1. David M. Pozar, "*Microwave Engineering*", fourth Edition, Wiley India, 2011
2. R.E.Collin, "*Foundations for Microwave Engineering*", Second edition, John wiley and sons, 2007.
3. S. Ramo, J.R.Whinnery and T.V.Duzer, "*Fields and Waves in Communication Electronics*", Third Edition, Wiley India, 1994

		L	T	P	C
WM2101	**CODING TECHNIQUES FOR SPREAD SPECTRUM COMMUNICATIONS**	**3**	**0**	**0**	**3**
	Total Contact Hours - 45				
	Prerequisite : Nil				
PURPOSE					
This course is about the fundamental aspects that make error control coding work and their implementation in practical application.					
INSTRUCTIONAL OBJECTIVES					
At the end of the semester, the student should be able to					
1.	Get an Introduction on Spread spectrum communications				
2.	Design a system using a convolutional code				
3.	Design codes to correct burst errors				
4.	Understand the motivation for and theory of trellis coded modulation				
5.	Design a system using turbo codes				
6.	Design error control for channels with feedback				

UNIT I - SPREAD SPECTRUM OVERVIEW (9 hours)

Definition and Beneficial attributes of a spread spectrum system – Catalog of spreading techniques - Pseudonoise sequences – Direct-sequence spread-spectrum systems and applications.

UNIT II - CONVOLUTIONAL CODES & VITERBI DECODING ALGORITH (9 hours)
Linear convolutional encoders – Structural properties of convolutional codes – State diagrams – Transparent convolutional codes – Receiver phase offset and Differential decoding – Trellis diagrams – Viterbi algorithm – Performance analysis – Design and Implementation of Viterbi decoder – Punctured convolutional codes.

UNIT III - SEQUENTIAL DECODING ALGORITHMS and BURST ERROR CORRECTING CODE (9 hours)

Tree diagrams – The Fano algorithm – The Stack algorithm – Performance analysis for Sequential decoders – Burst error correcting codes – Decoding of single burst error correcting cyclic codes – Fire interleaved codes – Phased burst error correcting codes – Concatenated codes.

UNIT IV - TRELLIS CODED MODULATION(TCM) AND TURBO CODE (9 hours)
M-ary signaling – One and Two-dimensional TCM – Multiple TCM – Decoding and performance analysis – Implementational considerations – Turbo codes – Encoding – Performance Evaluation using bounding techniques – BCJR algorithm for decoding – Applications.

UNIT V - ERROR CONTROL FOR CHANNELS WITH FEEDBACK (9 hours)
Pure ARQ Protocols – Noisy feedback channels – Type I Hybrid ARQ Protocols – Type II Hybrid ARQ Protocols and Packet combining.

REFERENCES

1. Stephen B. Wicker, "*Error control systems for Digital communication and storage*", Prentice Hall, Upper Saddle River, NJ, 1995.
2. Shu Lin, Daniel Costello, "*Error control coding – Fundamentals and Applications*", Second Edition, Prentice Hall, Upper Saddle River, NJ, 2004.
3. Sklar, B., "*Digital Communications: Fundamentals and Applications*", Prentice Hall Inc., NJ, 2001.
4. E. Biglieri, et al. "*Introduction to Trellis coded modulation with Applications*", Macmillan Publishers, 1991.
5. R. Johannesson and K.S. Zigangirov, "*Fundamentals of Convolutional coding*", IEEE Series on Digital and Mobile Communication, Wiley-IEEE Press, 1999.

WM2102		**L**	**T**	**P**	**C**
	COGNITIVE RADIO TECHNOLOGY	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Pre-requisite: Nil				

PURPOSE	
To study the concept Cognitive Radio and its issues.	
INSTRUCTIONAL OBJECTIVES	
1.	To review the working of SDR.
2.	To explore the principle of Cognitive Radio
3.	To discuss the research challenges in Cognitive Radio Techniques

UNIT I - SOFTWARE DEFINED RADIO **(9 hours)**
Basic SDR – Software and Hardware Architecture of an SDR – Spectrum Management – Managing unlicensed spectrum – Noise Aggregation

UNIT II - SDR AS PLATFORM FOR COGNITIVE RADIO **(9 hours)**
Introduction – Hardware and Software architecture – SDR development process and Design – Application software – Component development – Waveform development – cognitive waveform development

UNIT III - COGNITIVE RADIO TECHNOLOGY **(9 hours)**
Introduction – Radio flexibility and capability – Aware – Adaptive – Comparison of Radio capabilities and Properties – Available Technologies – IEEE 802 Cognitive Radio related activities – Application.

UNIT IV - CR- TECHNICAL CHALLENGES **(9 hours)**
Design Challenges associated with CR – Hardware requirements – Hidden primary user problem – detecting spread spectrum primary users – sensing duration and frequency – security

UNIT V - SPECTRUM SENSING **(9 hours)**
Overview – Classification - Matched filter – waveform based sensing – cyclostationary based sensing – Energy detector based sensing – Radio Identifier – Cooperative sensing- other sensing methods

REFERENCES

1. Huseyin Arslan , *"Cognitive Radio, Software Defined Radio and Adaptive wireless system,* Springer, 1 edition ,September 24, 2007
2. Bruce A Fette, *"Cognitive Radio Technology",* Academic Press, 2009.
3. Mitola, J. and J. Maguire, G. Q., *"Cognitive radio: making software radios more personal,"* IEEE Personal Commun. Mag., vol. 6, no. 4, pp. 13–18, Aug. 1999.
4. Tevfik Y¨ucek and H¨useyin Arslan, *"A Survey of Spectrum Sensing Algorithms for Cognitive Radio Applications"* , IEEE Communications Surveys and Tutorials, Vol. 11, No.1, First Quarter 2009, Pp 116-130.

WM2103		L	T	P	C
	COMMUNICATION NETWORK SECURITY	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite: Nil				
PURPOSE					
To study various aspects of Network Security Attacks, Services and Mechanisms.					
INSTRUCTIONAL OBJECTIVES					
1.	To deal with various Encryption, Authentication and Digital Signature Algorithms				
2.	To deal with different general purpose and application of specific security protocols and techniques.				

UNIT I CONVENTIONAL ENCRYPTION (9 hours)

Introduction, Conventional Encryption Model, Data Encryption Standard, Block cipher, Encryption algorithms, Confidentiality, Key Distribution.

UNIT II PUBLIC KEY ENCRYPTION, HASH & MAC ALGORITHMS (9 hours)

Principles of public key cryptosystems, RSA Algorithm, Diffie-Hellman Key Exchange, Elliptic Curve Cryptography, Message Authentication and Hash Functions, Hash and MAC Algorithms, Digital Signatures and Digital Signature Standard.

UNIT III AUTHENTICATION SERVICES AND E-MAIL SECURITY (9 hours)

Kerberos, X.509 Directory Service, Pretty Good Privacy, Secure Multipurpose Internet Mail Extension.

UNIT IV IP SECURITY AND WEB SECURITY (9 hours)

IP Security Overview, IP Security Architecture, Authentication Header, Encapsulating Security Payload, Security Associations, Key Management, Web Security Requirements, Secure Sockets Layer, Transport Layer Security, Secure Electronic Transaction Layer, Dual Signature.

UNIT V SYSTEM SECURITY (9 hours)

Intruders, Intrusion Detection Techniques, Malicious Software, Viruses and Antivirus Techniques, Digital Immune Systems, Firewalls-Design goals, Limitations, Types and Configurations, Trusted Systems.

REFERENCE

1. William Stallings, *"Cryptography and network security"*, 5th Edition, Pearson Education, 2011.

WM2104		**L**	**T**	**P**	**C**
	DIGITAL COMMUNICATION RECEIVERS	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite: Nil				

PURPOSE	
To develop a strong foundation in the digital receivers; To explain the underlying principles in the Digital Communication receivers; To give exposer to AWGN and fading channels; To explain important functions like synchronization.	
INSTRUCTIONAL OBJECTIVES: At the end of this course students will know	
1.	Linear and nonlinear modulation techniques
2.	Various channels like AWGN and fading
3.	Synchronization Techniques
4.	Adaptive Equalization techniques.

UNIT I - REVIEW OF DIGITAL COMMUNICATION TECHNIQU (9 hours)
Baseband and bandpass communication, signal space representation, linear and nonlinear modulation techniques and spectral characteristics of digital modulation.

UNIT II - OPTIMUM RECEIVERS FOR AWGN CHANNEL (9 hours)
Correlation demodulator, matched filter, maximum likelihood sequence detector, Optimum demodulation and detection of CPM signals, M-ary orthogonal signals, envelope detectors for M-ary and correlated binary signals.

UNIT III - RECEIVERS FOR FADING CHANNELS (9 hours)
chacterisation of fading multiple channels, statistical models, slow fading, frequency selective fading, diversity technique, RAKE demodulator, Bit interleaved coded modulation, Trellis coded modulation.

UNIT IV - SYNCHRONIZATION TECHNIQUES (9 hours)
Carrier and symbol synchronization, carrier phase estimation-PLL, Decision directed loops, symbol timing estimation, maximum likelihood and non-decision directed timing estimation, joint estimation.

UNIT V - ADAPTIVE EQUALISATION (9 hours)
Zero-forcing algorithm, LMS algorithm, adaptive decision-feedback equalizer and Equalisation of Trellis-Coded signals, Kalman algorithm, blind equalizers and stochastic gradient algorithm.

REFERENCES

1. John.G.Proakis, M. Salehi, *"Fundamentals of Digital Communication Systems",* 5^{th} Pearson Education, 2005.
2. John R. Barry, E.A.Lee and D.G.Messerschmitt, *"Digital Communication",* 3rd Edition, Allied Publishers, New Delhi, 2004.
3. Heinrich Meyer, Mare Meneclacy, Stefan.A.Fechtel. *"Digital communication receivers",* Vol I Vol II, John Wiley, New York, 1997.
4. Marvin K. Simon, Mohammed-Slim Alouini, *"Digital Communication over fading channel",* John Wiley and Sons, New York, 2005.

WM2105		L	T	P	C
	ELECTROMAGNETIC INTERFERENCE and COMPATIBILITY IN SYSTEM DESIGN	**3**	**0**	**0**	**3**
	Total Contact Hours - 45				
	Prerequisite: Nil				

PURPOSE	
The purpose of this course is to expose the students to the basics and fundamentals of Electromagnetic Interference and Compatibility in System Design.	
INSTRUCTIONAL OBJECTIVES	
At the end of the course, student should be able to know:	
1.	EMI Coupling Principles
2.	EMI Specification, Standards and Limits
3.	EMI Measurements and Control Techniques
4.	EMC Design of PCBs

UNIT I - INTRODUCTION AND SOURCES OF EMI **(9 hours)**

EMI/EMC concepts and definitions, Sources of EMI, conducted and radiated EMI, Transient EMI, Time domain Vs Frequency domain EMI, Units of measurement parameters, Emission and immunity concepts, ESD.

UNIT II - TYPES OF ELECTROMAGNETIC COUPLING **(9 hours)**

Conducted, Radiated and Transient Coupling, Common Impedance Ground Coupling, Radiated Common Mode and Ground Loop Coupling, Radiated Differential Mode Coupling, Near78 Field Cable to Cable Coupling, Power Mains and Power Supply coupling.

UNIT III - EMI MEASUREMENTS **(9 hours)**

EMI Shielded Chamber, Open Area Test Site, TEM Cell, GTEM cell Sensors/ Injectors/ Couplers, LISN, voltage probe, Current probeTest beds for ESD and EFT.

UNIT IV - EMI MITIGATION TECHNIQUES **(9 hours)**

Shielding, Filtering, Grounding, Bonding, Isolation Transformer, Transient Suppressors, Cable Routing, Signal Control, Component Selection and Mounting.

UNIT V - EMC SYSTEM DESIGN **(9 hours)**

PCB Traces Cross Talk, Impedance Control, Power Distribution Decoupling, Zoning, Motherboard Designs and Propagation Delay Performance Models.

REFERENCES

1. V.P.Kodali, *"Engineering EMC Principles, Measurements and Technologies"*, IEEE Press, 1996
2. Henry W.Ott, "*Noise Reduction Techniques in Electronic Systems*", 2^{nd} Edition, John Wiley and Sons, NewYork. 1988
3. C.R.Paul, *"Introduction to Electromagnetic Compatibility"*, John Wiley and Sons, Inc, 2006
4. Bernhard Keiser, *"Principles of Electromagnetic Compatibility"*, Artech house, 3rd Ed, 1986

WM2106		**L**	**T**	**P**	**C**
	HIGH SPEED SWITCHING ARCHITECTURE	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite: Nil				
PURPOSE					
Speed is one of the demand put forth by the users of communication resources. So focus must be made on the switch architectures suitable for high speed application. This syllabus has been framed based on the above requirements.					
INSTRUCTIONAL OBJECTIVES					
1.	To understand the types of switch fabrics for high speed applications.				
2.	To get a clear idea about the traffic and Queuing systems				

UNIT I - BROADBAND NETWORKING **(9 hours)**

Hierarchy of switching networks - Switching in telecommunication networks, Evolution of networks - The path to Broadband networking - Network evolution through ISDN to B-ISDN - The protocol reference model -Transfer Mode and Control of the B-ISDN-ATM Standards, ATM adaptation layers.

UNIT II - SWITCHING CONCEPTS **(9 hours)**

Switch Forwarding Techniques, Switch Path Control, LAN Switching, Cut through Forwarding, Store and forward, Virtual LANs.

UNIT III - SWITCHING ARCHITECTURES **(9 hours)**

Issues and performance analysis - Banyan and knockout switches - Single and Multistage networks - Shuffle switch tandem banyan.

UNIT IV - QUEUING MODELS **(9 hours)**

SS7 Signaling - Traffic and queuing models - Input Queuing- Output Queuing -Shared Queuing- Performance analysis of Input, Output and Multiple shared Queuing

UNIT V - IP SWITCHING **(9hours)**

Addressing Model, IP switching types, Flow driven and topology driven solutions, IP over ATM, Address and next hop resolution Multicasting, IPV6 over ATM.

REFERENCES

1. Achille Pattavina, *“Switching Theory Architectures and performance in Broadband ATM networks”*, John wiley and sons Ltd,New York, 1998.
2. Christopher Y Metz, *“IP Switching Protocols and Architectures”,* McGraw Hill Professional Publishing, New York, 1999.
3. Ranier Handel. Manfred N Huber, Stefab Schrodder*,” ATM Networks - Concepts, Protocols, Application”s*, 3rd edition, Adisson Wesley, New York 1999.
4. Thiggarajan Viswanathan, *"Tele Communication Switching System and Networks"*, Prentice Hall of India, Pvt.Ltd., New Delhi, 2004.

WM2107		L	T	P	C
	MICROWAVE INTEGRATED CIRCUITS	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite : Nil				

PURPOSE
This course will give a broad introduction to MIC techniques, and will give students an opportunity to study the current literature and to design MICs. It will also cover a sufficient selection of the huge number of technology used in MICs such that the fabrication and operation of many microwave devices will be understandable.

INSTRUCTIONAL OBJECTIVES	
1.	Understanding of the different types of MICs and different transmission lines to be used in MICs.
2.	Knowledge of the concept of microstrip line and its interpretation in the analysis and design of microstrip line
3.	Design and Analysis of non-reciprocal components, active devices, High Power and Low Power Circuits.
4.	Micro fabrication of MIC devices will be covered in order to understand the major MIC fabrication techniques and how they interact with system design strategies.

UNIT I - ANALYSIS OF MIC **(9 hours)**
Introduction, Types of MICs and their technology, Propagating models, Analysis of MIC by conformal transformation, Numerical method, Hybrid mode analysis, Losses in microstrip, Introduction to slot line and coplanar waveguide.

UNIT II - COUPLERS AND LUMPED ELEMENTS IN MIC **(9 hours)**
Introduction to coupled microstrip, Even and odd mode analysis, Branch line couplers, Design and fabrication of lumped elements for MICs, Comparison with distributed circuits.

UNIT III - PASSIVE AND ACTIVE COMPONENTS IN MIC **(9hours)**
Ferrimagnetic substrates and inserts, Microstrip circulators, Phase shifters, Microwave transistors, Parametric diodes and amplifiers, PIN diodes, Transferred electron devices, Avalanche diodes, IMPATT, BARITT devices.

UNIT IV - MIC CIRCUITS AND ITS APPLICASTION **(9 hours)**
Introduction, Impedance transformers, Filters, High power circuits, Low power circuits, MICs in Radar and satellite

UNIT V - FABRICATION PROCESS IN MIC **(9 hours)**
Fabrication process of MMIC, Hybrid MICs, Dielectric substances, Thick film and thin film technology and materials, Testing methods, Encapsulation and mounting of devices.

REFERENCES

1. Leo G. Maloratsky, *"Passive RF and Microwave Integrated circuits",* Elsevier, 2004
2. Gupta K.C, Amarjit Singh*, "Microwave Integrated Circuits",* John Wiley, 1975.
3. Hoffman R.K *"Hand Book of Microwave Integrated Ciruits",* Artech House, Boston, 1987.

		L	T	P	C
WM2108	**MULTI USER DETECTION**	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite: Nil				
PURPOSE					
To know about the advanced area of multiple access and signal detection.					
INSTRUCTIONAL OBJECTIVES					
To impart					
1.	Code division multiple access channels				
2.	Optimum detection matched filter design				

UNIT I - MULTIACCESS COMMUNICATION (9 hours)

The multi-access channel - FDMA and TDMA - Random Multiaccess-CDMA - CDMA channel - Basic synchronous and asynchronous CDMA model - signature waveform- data streams-modulation-fading-antenna arrays- Discrete time synchronous and asynchronous models.

UNIT II - SINGLE USER MATCHED FILTER (9 hours)

Hypothesis testing - Optimal receiver for single user channel - Q function- matched filter in the CDMA function- Asymptotic multiuser efficiency and related measures- coherent single user matched filter in Reyleigh fading - differentially coherent demodulation- non coherent demodulation.

UNIT III - OPTIMUM MULTIUSER DETECTION (9 hours)

Optimum Detection and error probability for synchronous and asynchronous - channels - Reyleigh fading- optimum noncoherent multiuser detection - decorrelating detector in synchronous and asynchronous channel.

UNIT IV - NONDECORRELATING LINEAR MULTIUSER DETECTION (9 hours)

Optimum linear multiuser detection- Minimum mean square linear multiuser detection-performance of MMSE linear multiuser detection- Adaptive MMSE linear multiuser detection-canonical representation of linear multiuser detectors-blind MMSE multiuser detection.

UNIT V - DECISION – DRIVEN MULTIUSER DETECTORS (9 hours)

Successive cancellation - performance analysis of successive cancellation - multistage detection - CT tentative decisions - decision feedback multiuser detection.

REFERENCES

1. Sergio Verdo , "*Multiuser Detection*", Cambridge University Press, 1998.
2. IEEE Transaction of communication "*Special Issue on Multiuser detection*", November, 1997.

<table>
<tr><td rowspan="4">WM2109</td><td></td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>NON - LINEAR FIBER OPTICS</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="5">Total Contact Hours – 45</td></tr>
<tr><td colspan="5">Prerequisite: Nil</td></tr>
<tr><td colspan="6">PURPOSE</td></tr>
<tr><td colspan="6">Acquire an overall understanding of the origin, magnitude and importance of nonlinear optical effects. Become sufficiently well acquainted with the principles of nonlinear optics to be able to make intelligent use of numerical tools for designing and simulating fiber optic communication systems.</td></tr>
<tr><td colspan="6">INSTRUCTIONAL OBJECTIVES</td></tr>
<tr><td>1.</td><td colspan="5">To introduce the fundamentals of nonlinear optics and applications in integrated devices.</td></tr>
<tr><td>2.</td><td colspan="5">To present the theory of fiber for pulse compression</td></tr>
<tr><td>3.</td><td colspan="5">To introduce and teach the optical solitons used in modern optical systems</td></tr>
<tr><td>4.</td><td colspan="5">To broaden the perception of the role of optical engineering in communication sector.</td></tr>
</table>

UNIT I - FIBER CHARACTERISTICS AND NON–LINEARITIES (9 hours)

Optical losses - Chromatic dispersion - Modal birefringence – Non-linear refraction Stimulated Inelastic scattering – Importance of non–linear optical effects.

UNIT II - GROUP VELOCITY DISPERSION & SELF-PHASE MODULATION (9 hours)

Different propagation regimes – Higher order dispersion – Implications for Optical Communication Systems -SPM induced spectral broadcasting - Frequency chirp – Effect of GVD – Self steepening.

UNIT III - OPTICAL SOLITONS AND PULSE COMPRESSION (9 hours)

Modulation instability – Fundamental and higher order Solitons – Soliton lasers – Soliton based communication systems - Soliton interaction – Design aspects – Higher order non-linear effects - Optical pulse compression - Introduction - Grating pair – Fiber grating compressors - Soliton Effect compressors.

UNIT IV - CROSS-PHASE MODULATION (9 hours)

XPM - Induced nonlinear coupling – Nonlinear Birefringence effects – Optical Kerr effect - pulse shaping – Effect of birefringence on solitons – XPM induced modulation stability – Implications for Optical Communication Systems.

UNIT V - STIMULATED RAMAN AND BRILLOUIN SCATTERING (9 hours)

Raman Gain and Threshold – Fiber Raman lasers – Fiber Raman Amplifier – Soliton effects in stimulated Raman scattering – Brillouin Gain and Threshold – Fiber Brillouin lasers – Fiber Brillouin Amplifier – Four wave mixing.

REFERENCES

1. G.P. Agarwal, *"Non linear Fiber Optics"*, 5th edition, Academic Press, 2012.
2. G.P.Agrawal, *"Fiber Optic Communication Systems"*, 4th Edition, John Wiley and Sons, 2012.
3. G. Keiser, *"Optical Fiber Communication Systems"*, 4th edition, Tata McGrawHill. Edition, 2010
4. John M. Senior, *"Optical Fiber Communications –Principles and Practice",* Pearson Education, 2009
5. F.J.H. Franz and V.K. Jain, *"Optical Communication System"*, Narosa Publishing House, New Delhi, 2000.

		L	T	P	C
WM2110	**OFDM/OFDMA COMMUNICATIONS**	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite : Nil				

PURPOSE	
The purpose of this course is to provide a state-of-art research status and an indepth treatment of selected topics in OFDM and OFDMA which would provide enough background in wireless network characteristics not realizable with current wireless infrastructure.	
INSTRUCTIONAL OBJECTIVES: The objectives of this course are to	
1.	Take a comprehensive look at OFDMA/OFDM including channel modeling, spectrum efficiency, and resource management
2.	Know how OFDMA/OFDM can combine with MIMO to give high data rate transmissions,
3.	Know about adaptive modulation, channel estimation, and synchronization in OFDM/OFDMA systems,
4.	Know about co-operative OFDMA, and performance and optimization of relay assisted OFDMA networks, and
5.	Know about OFDMA applications and OFDMA based mobile WIMAX.

UNIT I - RADIO CHANNEL MODELING, RESOURCE ALLOCATION, AND SPECTRUM EFFICIENCY (9 hours)

Introduction – Statistical characterization – OFDM/OFDMA channel models – OFDMA scheduling and resource allocation – System model – transmit spectra – Egress reduction techniques.

UNIT II - RESOURCE MANAGEMENT & SYNCHRONIZATION: OFDM VS OFDMA (9 hours)

Resource allocation and Scheduling algorithms – Synchronization in OFDMA downlink and uplink – Synchronization for WIMAX

UNIT III - ADAPTIVE MODULATION & TRAINING SEQUENCE DESIGN (9 hours)

Adaptive modulation algorithms – Channel feedback – Optimal condition for training sequence – Realization of Optimal training – Differential Space time Block codes – Differential Space frequency block codes

UNIT IV - COOPERATIVE OFDMA, PERFORMANCE AND OPTIMIZATION OF RELAY ASSISTED OFDMA NETWORKS (9 hours)

Cooperative OFDMA uplink – Channel capacity – Frequency offset and channel estimation – Uplink/Downlink optimization – System performance.

UNIT V- OFDMA SYSTEMS, APPLICATIONS, & OFDMA-BASED MOBILE WIMAX (9 hours)

Mobile WIMAX – Evolved Universal Terrestrial Radio Access – OFDMA frame structure and sub channelization – Power saving mode – Handover.

REFERENCES

1. Tao Jiang, Lingyang Song, and Yan Zhang, *"Orthogonal Frequency Division Multiple Access (OFDMA) Fundamentals and Applications"*, Auberbach Publications, Taylor and Francis Group, 2010.
2. Yi (Geoffrey) Li, and Gordon L. Stuber, *" Orthogonal Frequency Division Multiplexing",* Springer Science+Business Media Inc., NY, USA, 2006.
3. Jeffrey G. Andrews, Arunabha Ghosh and Riaz Muhamed, *"Fundamentals of WIMAX: Understanding broadband wireless networking"*, 1st Edition, Prentice Hall Inc., NJ, 2007.
4. Lawrence Harte and Kalai Kalaichelvan, *"WIMAX explained: System fundamentals",* 1st Edition, Althos Publishing, 2007.

		L	T	P	C
WM2111	**OPTICAL NETWORK AND PHOTONIC SWITCHING**	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite : Nil				
PURPOSE					
The main purpose of this course is to introduce students the important areas of communication networks, mainly optical networks and photonic switching. This will enable the students to acquire a solid understanding of foundations of optical networks technologies, systems, networks issues as well as economic deployment considerations and also photonic switching.					
INSTRUCTIONAL OBJECTIVES: To learn about					
1.	Various components of optical networks				
2.	Multiplexing techniques and fiber characteristics				
3.	First generation and broadcast optical network				
4.	Network management and access networks				
5.	Various photonic switches				

UNIT-I - INTRODUCTION TO OPTICAL NETWORKS AND FIBERS (9 hours)

Introduction: Multiplexing Techniques - First and second generation optical networks – Transmission basics - Network evolution**.** Propagation of light energy in optical fibers**:** Loss and Bandwidth windows **–** Intermodal dispersion - Chromatic dispersion - non linear effects.

UNIT II - NETWORK COMPONENTS (9 hours)

Couplers, Isolators and Circulators, Multiplexers and Filters: Fiber gratings – Fabry Perot Filters – MZ interferometers – Arrayed waveguide grating – optical amplifiers: SOA, EDFA and Raman Amplifier – switches and wavelength converters – Add/Drop Multiplexer – optical cross connect.

UNIT III - OPTICAL NETWORKS (9 hours)

SONET/ SDH, Architecture of Optical transport networks (OTNs) – Network topologies and protection schemes in SONET/SDH – WDM – DWDM – relationship of WDM to SONET/SDH – LTD and RWA problems.

UNIT IV - NETWORK MANAGEMENT AND ACCESS NETWORKS (9 hours)

Network Management functions - Optical Layer services and Interfacing - Performance and fault management - optical safety; Access networks – Network Architecture Overview – HFC - FTTC.

UNIT V - PHOTONIC PACKET SWITCHING (9 hours)

OTDM – Synchronization – Header Processing – Buffering – Optical routers – Optical switching technologies – MEMS and thermo-optic switches.

REFERENCES

1. Rajiv Ramaswamy, Kumar N. Sivaranjan and Galen H. Sasaki, *"Optical Networks – A practical perspective"*, 3rd edition, Elsevier, 2010.
2. Uyless Black, *"Optical Networks – Third generation transport systems",* 1st edition, Pearson, 2002.
3. John M. Senior, *"Optical Fiber Communications –Principles and Practice",* Pearson Education, 2009
4. Biswanath Mukherjee, *"Optical Communication Networks",* McGraw-Hill, 1997.

		L	T	P	C
WM2112	**RF MEMS FOR WIRELESS COMMUNICATION**	**3**	**0**	**0**	**3**
	Total Contact Hours - 45				
	Prerequisite : Nil				
PURPOSE					
The purpose of this course is to make the students understand the fundamentals of RF MEMS circuit elements, MEMS based circuit design and its applications to wireless communications.					
INSTRUCTIONAL OBJECTIVES					
At the end of the course, student should be able to:					
1.	To introduce the physical aspects of RF circuit design				
2.	To familiarize with Micro fabrication and Actuation Mechanisms in MEMS				
3.	To know RF MEMS circuit elements such as switches, resonators				
4.	To understand the working of RF MEMS Phase Shifters, Filters, Oscillators				
5.	To explore on various Case Study of RF MEMS Devices				

UNIT I - WIRELESS SYSTEMS & ELEMENTS OF RF CIRCUIT DESIGN (9 hours)

Introduction, spheres of wireless activities, the home and office, the ground fixed/ mobile platform, the space platform, wireless standards, systems and architectures, wireless standards, conceptual wireless systems, wireless transceiver architectures, power and bandwidth-efficient wireless systems and challenges, MEMS based wireless appliances enable ubiquitous connectivity. Physical aspects of RF circuit design, skin effect, transmission lines on thin substrates, self-resonance frequency, quality factor packaging, practical aspects of RF circuit design, dc biasing, impedance mismatch effects in RF MEMS.

UNIT II - MICROFABRICATION & ACTUATION MECHANISMS IN MEMS (9 hours)

Introduction to Microfabrication Techniques- Materials properties, Bulk and surface micromachining, Wet and dry etching, Thin-film depositions (LPCVD, Sputtering, Evaporation), other techniques (LIGA, Electroplating)
Actuation Mechanisms in MEMS- Piezoelectric, Electrostatic, Thermal, Magnetic

UNIT III- RF MEMS SWITCHES, INDUCTOR AND CAPACITOR (9 hours)

RF MEMS relays and switches. Switch parameters. Actuation mechanisms. Bistable relays and micro actuators. Dynamics of switching operation. MEMS inductors and capacitors. Micromachined inductor. Effect of inductor layout. Modeling and design issues of planar inductor. Gap tuning and area tuning capacitors. Dielectric tunable capacitors.

UNIT IV - MICROMACHINED RF FILTERS, ANTENNAS AND MEMS PHASE SHIFTER (9 hours)

Micromachined RF filters. Modeling of mechanical filters. Electrostatic comb drive. Micromechanical filters using comb drives. Electrostatic coupled beam structures.
Micromachined antennas. Microstrip antennas – design parameters. Micromachining to improve performance. Reconfigurable antennas.
MEMS phase shifters. Types. Limitations. Switched delay lines. Micromachined transmission lines. Coplanar lines. Micromachined directional coupler and mixer

UNIT V -RF MEMS BASED CIRCUIT DESIGN AND CASE STUDIES (9 hours)

Phase shifters - fundamentals, X-Band RF MEMS Phase shifter for phased array applications, Ka-Band RF MEMS Phase shifter for radar systems applications, Film bulk acoustic wave filters - FBAR filter fundamentals, FBAR filter for PCS applications, RF MEMS filters - A Ka-Band millimeter-wave Micromachined tunable filter, A High-Q 8-MHz MEM Resonator filter, RF MEMS Oscillators - fundamentals, A 14-GHz MEM Oscillator, A Ka - Band Micromachined cavity oscillator, A 2.4 GHz MEMS based voltage controlled oscillator.

REFERENCES

1. Vijay K.Varadan, K.J. Vinoy, K.A. Jose., *"RF MEMS and their Applications",* John Wiley and sons, LTD, 2003
2. H.J.D.Santos, *"RF MEMS Circuit Design for Wireless Communications",* Artech House, 2002.
3. G.M.Rebeiz , *"RF MEMS Theory , Design and Technology",*Wiley , 2003.
4. S. Senturia, *"Microsystem Design*" , Kluwer, Springer, 2001.

WM2113		**L**	**T**	**P**	**C**
	RF SYSTEM DESIGN	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite: Nil				
PURPOSE					
To impart the modeling of RF system design in the field of communication system.					
INSTRUCTIONAL OBJECTIVES					
1.	RF Filter designing				
2.	Study of RF Active components				
3.	RF transistor amplifier design				
4.	Oscillators and mixers used in RF design				

UNIT I - RESONATORS (9 hours)

Basic resonator and filter configurations-special filter realization-filter implementation-coupled filter.

UNIT II - RF DIODE AND BJT (9 hours)

RF diodes-bipolar junction transistor - RF field effect transistor-high electron mobility transistors-diode models-transistor models-measurement of active devices-scattering parameter device characterization.

UNIT III - IMPEDANCE MATCHING (9 hours)

Impedance matching using discrete components-microstrip line matching networks-amplifier classes of operation and biasing networks.

UNIT IV - CHARACTERISTICS OF AMPLIFIERS (9 hours)

Characteristics of amplifier-amplifier power relations-stability consideration-constant gain-broadband, high power, and multistage amplifiers.

UNIT V - HIGH FREQUENCY OSCILLATORS (9 hours)

Basic oscillator model-high frequency oscillator configuration-basic characteristics of mixer.

REFERENCES

1. Reinhold Ludwig, Gene Bogdanov**,** *"RF circuit design, theory and applications"*, Pearson Asia Education, 2nd edition, 2009.
2. D.Pozar, *"Microwave Engineering"*, John Wiley and Sons, New York, 2008.
3. Bahil and P. Bhartia, *"Microwave Solid State Circuit Design"*, Wiley-Interscience, 2003.

WM2114		L	T	P	C
	SATELLITE COMMUNICATION	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite: Nil				

PURPOSE
Purpose of this course is to develop a strong foundation in the field of Satellite Communication. The subject gives the students an opportunity to know the communication principles involved in the satellite communications. Students are taught about the earth and space subsystems involved and their importance. Various types of satellite system used nowadays are explained.

INSTRUCTIONAL OBJECTIVES: At the end of this course students will learn	
1.	Various types of traffic management systems
2.	Power budget calculation
3.	Satellite applications

UNIT I - ORBITS and LANUNCHING METHODS (9 hours)

Kepler laws – Orbital elements – Orbital perturbations – Apogee perigee heights – Inclines orbits – Sun synchronous orbits – Geo stationary orbits – Limits of visibility – Sun transit outage – polar Mount antenna – Antenna Look angles – launching orbits – Low earth orbits – medium orbits – constellation.

UNIT II - SPACE LINK (9 hours)

EIRP – transmission losses – power budget equation – system Noise carrier to Noise ration – Uplink and downlink equations – Input and Output back Off - TWTA – Inter modulation Noise – C/No – G/T measurement.

UNIT III - SPACE and EARTH SEGMENT (9 hours)

Space segment – space subsystems payload – Bus – power supply – attitude control – station keeping – thermal control – TT and C Subsystem – Transponders – Antenna subsystem – Earth segment – cassegrain antenna – Noise temperature – Low Noise Amplifiers – Earth station subsystems – TVRO.

UNIT IV - MULTIPLEXING and MULITPLE ACCESS (9 hours)

Frequency Division multiplexing FDM/FM/FDMA – Single channel per carrier – MCPC – Combanded FDM/FM/FDMA – Time division multiplexing – T1 carrier – Time Division multiple Access – Frame Burst structure, Frame efficiency, frame Acquisition and synchronization – SS TDMA – SPADE – Spread spectrum – direct sequence – CDMA.

UNIT V - SATELLITE SERVICES (9 hours)

INTELSAT – INSAT Series – VSAT – Weather forecasting – Remote sensing – LANDSAT – Satellite Navigation – Mobile satellite Service – Direct to Home.

REFERENCES

1. Dennis Roddy, *"Satellite Communications"*, McGraw Hill, 2009.
2. Tri.T.Ha, *"Digital Satellite Communications"*, Tata McGraw-Hill Education-2009.
3. Dr.D.C. Agarwal, *"Satellite Communications"*, Khanna Publishers, 2001.
4. Trimothy Pratt, Charles W. Bostian, Jeremy E. Allnutt *"Satellite Communications"*, John Wiley and Sons, 2002.

WM2115		L	T	P	C
	STATISTICAL SIGNAL PROCESSING	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite : Nil				

PURPOSE	
To present a Graduate level overview of diverse statistical signal processing algorithmic approaches.	
INSTRUCTIONAL OBJECTIVES	
To learn about	
1.	Discrete-time Random processes and Signal modeling
2.	Linear estimation and prediction
3.	Levinson's recursion and Spectral factorization
4.	Spectral estimation
5.	Adaptive filtering.

UNIT I - DISCRETE-TIME RANDOM PROCESSES & SIGNAL MODELING (9 hours)

Discrete Random processes – Mean, variance, Co-variance – Parseval's theorem – Wiener Khintchine relation – Autocorrelation – Power spectral density – Filtering Random processes – Spectral factorization – Special types of Random processes – Signal modeling: Least squares method – Pade approximation – Prony's method – Iterative Prefiltering – Finite data records – Stochastic models.

UNIT II - LINEAR ESTIMATION AND PREDICTION (9 hours)

Maximum likelihood and Least mean squared error estimation – FIR and Split Lattice filters – Lattice methods for all-pole signal modeling – FIR and IIR Wiener filters – Discrete Wiener-Hoff equations – Recursive estimators – Kalman filters – Linear prediction – Prediction error – Whitening filter – Inverse filter

UNIT III - LEVINSON'S RECURSION & SPECTRAL FACTORIZATION (9 hours)

Levinson-Durbin recursion – Recursion algorithm to solve Toeplitz system of equations – Minimal/Maximal phase signals and filters – Partial energy and Minimal delay – Invariance of the Autocorrelation function – Minimal/Maximal delay property – Spectral factorization theorem.

UNIT IV - SPECTRUM ESTIMATION (9 hours)

Non-parametric models – Correlation/Covariance spectrum estimation and performance analysis – Periodogram estimators – Maximum entropy method – Bartlett/Welch spectrum estimation – Model-based approach (AR, MA, ARMA signal modeling) – Parameter estimation using Yule-Walker method.

UNIT V - ADAPTIVE FILTERING (9 hours)

FIR, RLS, Exponentially weighted RLS, Sliding window RLS, Widrow-Hoff LMS, Simplified IIR LMS adaptive filters – Adaptive channel equalization – Adaptive echo canceller – Adaptive noise cancellation.

REFERENCES

1. Monson H. Hayes, *"Statistical Digital Signal Processing and Modelling"*, John Wiley and Sons, NJ, USA, 2002.
2. Sophocles J. Orfanidis, *"Optimum Signal Processing"*, 2nd Edition, McGraw Hill Inc., NY, USA, 1988.
3. John G. Proakis and Dimitris G. Monalakis, *" Digital Signal Processing: Principles, Algorithms and Applications"* , 4th Edition, Pearson Prentice Hall, 2007.

		L	T	P	C
WM2116	**STATISTICAL THEORY OF COMMUNICATION**	**3**	**0**	**0**	**3**
	Total Contact Hours - 45				
	Prerequisites : Nil				
PURPOSE					
The course presents a unified approach to the problem of detection, estimation and modulation theory, which are common tools used in many applications of communication systems, signal processing and system theory. The idea is to develop a qualitative understanding of these three areas by examining problems of interest.					
INSTRUCTIONAL OBJECTIVES					
The goal is to develop decision, estimation and modulation theories to demonstrate how they can be used to solve a wealth of practical problems in many diverse physical situations.					

UNIT I - CLASSICAL DETECTION AND ESTIMATION THEORY (9 hours)

Introduction – Simple binary hypothesis tests – M Hypothesis – Estimation theory – Composite hypothesis – General Gaussian problem – Performance bounds and approximations.

UNIT II - REPRESENTATIONS OF RANDOM PROCESSES (9 hours)

Deterministic functions: Orthogonal representations – Random process characterization – Homogeneous Integral equations and Eigen functions – Periodic processes – Infinite time interval: Spectral decomposition – Vector Random processes.

UNIT III - DETECTION OF SIGNALS – ESTIMATION OF SIGNAL PARAMETERS (9 hours)

Detection and Estimation in White Gaussian and Non-White Gaussian noise – Signals with unwanted parameters: The Composite hypothesis problem – Multiple channels – Multiple parameter estimation.

UNIT IV - ESTIMATION OF CONTINUOUS WAVEFORMS (9 hours)

Derivation of Estimator equations – A Lower bound on the mean square estimation error – Multidimensional waveform estimation – Non random waveform estimation.

UNIT V - LINEAR ESTIMATION (9 hours)

Properties of Optimum processors – Realizable Linear filters: Stationary processes, Infinite past: Wiener filters – Kalman-Bucy filters – Linear Modulation: Communications context - Fundamental role of the Optimum linear filter.

REFERENCES

1. Harry L. Van Trees, "*Detection, Estimation and Modulation theory*"– Part I/ Edition 2, John Wiley and Sons, NY, USA, 2013.
2. P. Eugene Xavier, *"Statistical theory of Communication"*, New Age International Ltd. Publishers, New Delhi, 2007.
3. Prof. B.R. Levin, *" Statistical communication theory and its applications",* MIR Publishers, Moscow, 1982

<table>
<tr><td rowspan="4">WM2117</td><td></td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>ULTRA WIDEBAND COMMUNICATION SYSTEMS</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="5">Total Contact Hours - 45</td></tr>
<tr><td colspan="5">Prerequisite: Nil</td></tr>
<tr><td colspan="6">PURPOSE</td></tr>
<tr><td colspan="6">This course focuses on the basic signal processing techniques that concerns present and future dynamic UWB communication systems. This course encompasses all areas of design and implementation of UWB systems.</td></tr>
<tr><td colspan="6">INSTRUCTIONAL OBJECTIVES</td></tr>
<tr><td colspan="6">At the end of the semester, the student should be able to develop a comprehensive overview of UWB system design that spans propagation, transmit and receive antenna implementations, standards and advanced topics, modulation and multiple access, network issues, and applications.</td></tr>
</table>

UNIT I - UWB SIGNALS AND SYSTEMS WITH UWB WAVEFORMS (9 hours)

Introduction – Power spectral density – Pulse shape – Pulse trains – Spectral masks – Multipath – Penetration characteristics – Spatial and spectral capacities – Speed of data transmission – Gaussian waveforms – Designing waveforms for specific spectral masks – Practical constraints and effects of imperfections.

UNIT II - SIGNAL PROCESSING TECHNIQUES FOR UWB SYSTEMS AND UWB CHANNEL MODELING (9 hours)

Effects of a lossy medium on a UWB transmitted signal – Time domain analysis – Frequency domain techniques – A simplified UWB multipath channel model – Path loss model – Two-ray UWB propagation model – Frequency domain autoregressive model.

UNIT III - UWB COMMUNICATIONS AND ADVANCED UWB PULSE GENERATION (9 hours)

UWB modulation methods – Pulse trains – UWB transmitter/receiver – Multiple access techniques in UWB – Capacity of UWB systems – Comparison of UWB with other wideband communication systems – Interference and coexistence of UWB with other systems – Hermite pulses – Orthogonal prolate spheroidal wave functions – Wavelet packets in UWB PSM – Applications of UWB communication systems.

UNIT IV - UWB ANTENNAS AND ARRAYS, POSITION AND LOCATION WITH UWB SIGNALS (9 hours)

Antenna fundamentals – Antenna radiation for UWB signals – Conventional antennas and Impulse antennas for UWB systems – Beamforming for UWB signals – Radar UWB array systems – Wireless positioning and location – GPS techniques – Positioning techniques – Time resolution issues – UWB positioning and communications.

UNIT V - UWB COMMUNICATION STANDARDS AND ADVANCED TOPICS IN UWB COMMUNICATION SYSTEMS (9 hours)

UWB standardization in wireless personal area networks – DS-UWB proposal – MB-OFDM UWB proposal – IEEE proposals for UWB channel models – UWB ad-hoc and sensor networks – MIMO and Space-time coding for UWB systems – Self interference in high data-rate UWB communications – Coexistence of DS-UWB with WIMAX

REFERENCES

1. M. Ghavami, L. B. Michael and R. Kohno, *"Ultra Wideband signals and systems in Communication Engineering"*, 2nd Edition, John Wiley and Sons, NY, USA, 2007.
2. Jeffrey H. Reed, *"An Introduction to Ultra Wideband Communication systems",* Prentice Hall Inc., NJ, USA, 2012.

		L	T	P	C
WM2118	**WCDMA FOR UMTS**	**3**	**0**	**0**	**3**
	Total Contact Hours - 45				
	Prerequisite : Nil				
PURPOSE					
To impart the knowledge of 3G systems.					
INSTRUCTIONAL OBJECTIVES					
At the end of this course students will gain knowledge in the topics such as					
1.	Introduction to UMTS ,its services and applications.				
2.	Radio network planning, resource management and 3G systems.				

UNIT I - UMTS SERVICES AND APPLICATIONS (9 hours)

Introduction – Person-to-Person Circuit Switched Service-Person-to Person Packet Switched Services-Content-to-Person Services-Quality of Services Differentiation-Location Services in WCDMA – Summary of the Main parameters in WCDMA – Spreading and Despreading – Multipath Radio Channels – Power Control.

UNIT II - PHYSICAL LAYERS (9 hours)

Introduction – Transport Channels and their Mapping to the Physical Channels-Spreading and Modulation – User Data Transmission – Signaling-Physical Layer Procedures-Terminal Radio Access Capabilities.

UNIT III - RADIO NETWORK PLANNING (9 hours)

Introduction – Dimensioning-Capacity and Coverage Planning and Optimization – GSM Co-planning- Inter-operator Interference – WCDMA Frequency Variants.

UNIT IV - RADIO RESOURCE MANAGEMENT (9 hours)

Interference Based Radio Resource Management- Power Control –Handovers- Measurement of Air Interface Load- Admission Control – Load Control (Congestion Control).

UNIT V - QUALITY OF SERVICE IN 3G SYSTEMS (9 hours)

Introduction – Overview of the concepts-Classification of traffic-UTMS service attributes – Requesting Qos-Admission control-Providing requested Qos-Differentiated services.

REFERENCES

1. Harri Holma and Antti Toskala, "*WCDMA for UMTS, Radio access for third generation mobile communications*", Third Edition, John Wiley and Sons, UK, May 2004.
2. M.R. Karim and Mohsen sarraf, "*W-CDMA and CDMA 2000 for 3G Mobile Networks*", McGraw Hill, 2002.

WM2119		**L**	**T**	**P**	**C**
	WIRELESS SENSOR NETWORKS	**3**	**0**	**0**	**3**
	Total Contact hours - 45				
	Prerequisite : Nil				
PURPOSE					
To explore the functionalities Wireless Sensor Networks.					
INSTRUCTIONAL OBJECTIVES					
1.	To review the architecture of WSN.				
2.	To study the various protocols layers of WSN.				
3.	To study the establishment of WSN infrastructure				

UNIT I - INTRODUCTION **(9 hours)**

Architectural Elements, Basic Technology, Sensor Node, Hardware and Software, Sensor Taxonomy, Design challenges, Characteristics and requirements of WSNs, Applications.

UNIT II - MAC PROTOCOLS FOR WSN **(9 hours)**

Fundamentals of MAC Protocols, Performance Requirements, Common Protocols, MAC for WSN, Schedule based protocols, Random Access based Protocols, Sensor-MAC, IEEE802.15.4 LR-WPAN's Standard

UNIT III - ROUTING PROTOCOLS FOR WSN **(9 hours)**

Data Dissemination and Gathering, Challenges and Design Issues, Network Scale and Time-Varying Characteristics, Routing Strategies, Flooding and it's **vari**ants.

UNIT IV - TRANSPORT CONTROL PROTOCOLS FOR WSN **(9 hours)**

Design Issues, Congestion Detection and Avoidance, Event-to-Sink Reliable Transport, Reliable Multisegment Transport; Pump Slowly, Fetch Quickly, GARUDA, ATP, Congestion and Packet Loss Recovery.

UNIT V - WSN INFRASTRUCTURE ESTABLISHMENT **(9 hours)**

Topology Control, Clustering, Time Synchronization, localization and positioning, Sensor Tasking and Control.

REFERENCES

1. K. Sohraby, Minoli, and T.Znati , *" Wireless Sensor Networks: Technology, Protocols, and Applications",* John Wiley and Sons, March 2007.
2. H. Karl and A. Willig, *"Protocols and Architectures for Wireless Sensor Networks",* John Wiley and Sons, October 2007.
3. C.S. Raghavendra, K.M. Sivalingam, and T. Zanti ,*"Wireless Sensor Networks"* Editors, Springer Verlag, Sep. 2006.
4. E.H. Callaway, Jr. Auerbach , *"Wireless Sensor Networks: Architectures and Protocols",* Aug. 2003.

		L	T	P	C
WM2120	**STOCHASTIC PROCESSES AND QUEUING THEORY**	**3**	**0**	**0**	**3**
	Total Contact hours - 45				
	Prerequisite : Nil				
PURPOSE					
This course provides an introduction to stochastic processes in communications and signal processing. Topics include continuous and discrete random processes, spectral representation and estimation, entropy, Markov processes and queuing theory.					
INSTRUCTIONAL OBJECTIVES					
1.	The objective of this course is to develop the subject of probability and stochastic processes as a deductive discipline and to illustrate the theory with basic applications of general interest. Clarity and economy is discussed, avoiding sophisticated mathematics, or at the other end, a detailed discussion of practical applications is made.				

UNIT I - GENERAL CONCEPTS AND BASIC APPLICATIONS (9 hours)

Definitions – Systems with stochastic inputs – The power spectrum – Discrete-time processes - Random walks – Brownian motion and thermal noise – Poisson inputs and shot noise – Cyclostationary processes – Bandlimited processes and Sampling theory – Deterministic signals in noise – Bispectra and system identification.

UNIT II - SPECTRAL REPRESENTATION (9 hours)

Factorizations and innovations – Finite-order systems and state variables – Fourier series and Karhunen-Loeve expansions – Spectral representation of Random processes.

UNIT III: SPECTRAL ESTIMATION AND MEAN-SQUARE ESTIMATION (9 hours)

Ergodicity – Spectral estimation – Extrapolation and system identification – Filtering and prediction – Kalman filters.

UNIT IV - ENTROPY (9 hours)

Introduction – basic concepts – Random variables and Stochastic processes – The Maximum Entropy method – Coding – Channel capacity.

UNIT V - MARKOV PROCESSES AND QUEUING THEOR (9 hours)

The Level Crossing problem – Queuing theory – Network of Queues – Markov Processes

REFERENCES

1. Randolph Nelson," *Probability, Stochastic Processes and Queuing theory: The Mathematics of Computer performance modelling*" Springer-Verlag Inc., NY, 1995.
2. Athanosius Papoulis and S. Unnikrishna Pillai, "*Probability, Random Variables and Stochastic Processes"*, 4th Edition, McGraw Hill Inc., USA, 2002.
3. Athanosius Papoulis," *Probability, Random Variables and Stochastic Processes"*, 3rd Edition, McGraw Hill Inc., USA, 1991.

WM2121		L	T	P	C
	MULTICASTING TECHNIQUES IN MANETs	**3**	**0**	**0**	**3**
	Total Contact hours – 45				
	Prerequisite : Nil				
PURPOSE					
To provide a comprehensive guide on the new ideas in the area of Multicast Communication.					
INSTRUCTIONAL OBJECTIVES					
1.	To study the fundamentals of Communication Paradigms in MANETs				
2.	To learn the Modeling and simulation tools for MANETs				
3.	To study the multicast routing protocols and routing techniques in MANETs				

UNIT-I ROUTING IN MANETS (9 hours)

Introduction – Flooding - Classification of Routing Protocols - Study and Performance of Routing Protocols – Routing Modeling and Mathematical Analysis.

UNIT-II COMMUNICATION TECHNIQUES (9 hours)

Types of Communication – Multicast vs. Unicast – Scalability – Application of Group Communication – Characteristics of Group – Special Aspects of Group Communication – Support within the Communication System.

UNIT-III MULTICAST ROUTING PROTOCOL (9 hours)

Introduction – Multicast Protocols in Wired Networks – Multicast routing protocols in mobile ad hoc networks – MAODV, source based tree, core based tree, multicast mehs and location based multicast - multicast Routing Algorithms – protocol Comparisons – issues.

UNIT-IV IMPLEMENTATION AND SIMULATION (9 hours)

Introduction – Modeling and Simulation tools for MANETs – Network simulator, Glomosim, Qualnet and Opnet - Calculation of Metrics – Simulation parameters – Simulation Results – Conclusion.

UNIT-V SECURITY ASPECTS (9 hours)

Security threats in Mobile ad hoc networks – Classification of Potential Attacks – Attack Prevention Techniques – Intrusion Detection Techniques in ad hoc network.

REFERENCES

1. C.K.Toh, "Ad Hoc Mobile Wireless Networks", Pearson Education, 2002.
2. Ralph Wittmann, Martina Zitterbart."Multicast Communication: Protocols, Programming, and Applications" ,Morgan Kaufmann Publishers,2001.
3. C.Siva Ram Murthy and B.Smanoj, " Ad Hoc Wireless Networks – Architectures and Protocols", Pearson Education, 2004
4. George Aggelou, "Mobile Ad hoc Networks from wireless LANS to 4G Networks", Tata McGraw-Hill Edition 2009.
5. Mounir Frikha, "Ad hoc Networks Routing, Qos and optimization", Willey publication, 2011.

<table>
<tr><td rowspan="4">WM2122</td><td></td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>WAVELET TRANSFORMS AND APPLICATIONS</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="5">Total conduct Hours -45</td></tr>
<tr><td colspan="5">Prerequisites : Nil</td></tr>
<tr><td colspan="6">PURPOSE</td></tr>
<tr><td colspan="6">The purpose of this course is to acquire knowledge about various wavelet transforms and the design of wavelet transforms. Then apply wavelet transform for various signal and image processing applications</td></tr>
<tr><td colspan="6">INSTRUCTIONAL OBJECTIVES</td></tr>
<tr><td>1</td><td colspan="5">To study the basics of signal representation and Fourier theory</td></tr>
<tr><td>2</td><td colspan="5">To understand Multi Resolution Analysis and Wavelet concepts</td></tr>
<tr><td>3</td><td colspan="5">To study the wavelet transform in both continuous and discrete domain</td></tr>
<tr><td>4</td><td colspan="5">To understand the design of wavelets using Lifting scheme</td></tr>
<tr><td>5</td><td colspan="5">To understand the applications of Wavelet transform</td></tr>
</table>

UNIT I- FUNDAMENTALS (9hours)

Vector Spaces – Properties– Dot Product – Basis – Dimension, Orthogonality and Orthonormality – Relationship Between Vectors and Signals – Signal Spaces – Concept of Convergence – Hilbert Spaces for Energy Signals- Fourier Theory: Fourier series expansion, Fourier transform, Short time Fourier transform, Time-frequency analysis.

UNIT II- MULTI RESOLUTION ANALYSIS (9hours)

Definition of Multi Resolution Analysis (MRA) – Haar Basis – Construction of General Orthonormal MRA – Wavelet Basis for MRA – Continuous Time MRA Interpretation for the DTWT – Discrete Time MRA – Basis Functions for the DTWT – PRQMF Filter Banks.

UNIT III- CONTINUOUS WAVELET TRANSFORMS (9hours)

Wavelet Transform – Definition and Properties – Concept of Scale and its Relation with Frequency – Continuous Wavelet Transform (CWT) – Scaling Function and Wavelet Functions (Daubechies Coiflet, Mexican Hat, Sinc, Gaussian, Bi Orthogonal)– Tiling of Time – Scale Plane for CWT.

UNIT IV- DISCRETE WAVELET TRANSFORM (9hours)

Filter Bank and Sub Band Coding Principles – Wavelet Filters – Inverse DWT Computation by Filter Banks – Basic Properties of Filter Coefficients – Choice of Wavelet Function Coefficients – Derivations of Daubechies Wavelets – Mallat's Algorithm for DWT – Multi Band Wavelet Transforms Lifting Scheme- Wavelet Transform Using Polyphase Matrix Factorization – Geometrical Foundations of Lifting Scheme – Lifting Scheme in Z –Domain.

UNIT V- APPLICATIONS (9hours)

Wavelet methods for signal processing- Image Compression Techniques: EZW–SPHIT Coding – Image Denoising Techniques: Noise Estimation – Shrinkage Rules – Shrinkage Functions – Edge Detection and Object Isolation, Image Fusion, and Object Detection.

REFERENCES

1. R. Rao R M and A S Bopardikar, *"Wavelet Transforms Introduction to theory and Applications"*, Pearson Education, Asia, 2000.
2. L.Prasad and S.S.Iyengar, *"Wavelet Analysis with Applications to Image Processing",* CRC Press, 1997.
3. J. C. Goswami and A. K. Chan, *"Fundamentals of wavelets: Theory, Algorithms and Applications"* WileyInterscience Publication,John Wiley and Sons Inc., 1999.
4. M. Vetterli, J. Kovacevic, *"Wavelets and subband coding"* Prentice Hall Inc, 1995.
5. Stephen G. Mallat, *"A wavelet tour of signal processing"* 2 nd Edition Academic Press, 2000.
6. Soman K P and Ramachandran K I, *"Insight into Wavelets From Theory to practice"* Prentice Hall, 2004.

		L	T	P	C
WM2123	**ANTENNAS FOR PERSONAL AREA COMMUNICATION**	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite: Nil				
PURPOSE:					
Antenna Theory is central for all Radio Systems, and this course will enable the learners to understand different Radio Antennas and their usage.					
INSTRUCTIONAL OBJECTIVES:					
1	To List the various types of Printed Antennas				
2	To understand about Wearable Antennas				
3	To gain the knowledge about Active Integrated Antennas				
4	To apply the Reconfigurability function in Antenna Design				
5	To study about different array techniques				

UNIT-I PRINTED ANTENNAS (9 hours)

Concepts of Printed Antennas, Broadband Microstrip Patch Antennas, Circularly polarized planar antennas, Enhanced Gain Patch Antennas, Wideband Compact Patch Antennas, Microstrip Slot Antennas, Microstrip Planar Monopole Antenna, Patch Antennas for Multiband Applications.

UNIT-II WEARABLE ANTENNAS (9 hours)

Overview of Wearable Systems and its Characteristics, Antennas for Wearable Devices, Design Requirements, Modeling and Characterization of Wearable Antennas, WBAN Radio Channel Characterization and Effect of Wearable Antennas, Domains of Operation, Sources on the Human Body, Compact Wearable Antenna for Healthcare Sensors.

UNIT-III ACTIVE INTEGRATED ANTENNAS (9 hours)

Active Wearable Antenna Modules-Features, Electromagnetic Characterization of Fabrics and Flexible Foam Materials, Matrix-Pencil Two-Line Method, Small-Band Inverse Planar Antenna Resonator Method, Active Antenna Modules for Wearable Textile Systems, Substrate Integrated Waveguide Technology.

UNIT-IV RECONFIGURABLE ANTENNAS (9 hours)
Reconfigurable methodologies, Design Considerations for Reconfigurable systems, Reconfigurable Planar/printed antenna configurations, Active reconfigurable systems.

UNIT-V ARRAY ANTENNAS (9 hours)
Linear and planar array fundamentals, Mutual Coupling in Arrays, Multidimensional Arrays, Switched beam and Phased Arrays, Array Feeding Techniques, Array optimization techniques.

REFERENCES

1. Debatosh Guha, Yahia M.M. Antar, "*Microstrip and Printed Antennas*", 1st Edition, John Wiley and Sons, 2011.
2. Taming the Borg, "*Moving Wearables into the Mainstream*", Springer, 2008.
3. Eng Hock Lim , Kwok Wa Leung, "*Compact Multifunctional Antennas for Wireless Systems*", John Wiley and Sons, 2012.
4. Zhi Ning Chen, "*Antennas for Portable Devices*", John Wiley and Sons, 2007.
5. Apostolos Georgiadis, Hendrik Rogier, Luca Roselli, Paolo Arcioni, "*Microwave and Millimeter Wave Circuits and Systems*", First Edition, John Wiley and Sons, 2013.
6. Warren L Stutzman, Gary A.Thiele, " *Antenna Theory and Design*" 3rd edition, ", John Wiley and Sons, 2013.

<table>
<tr><td rowspan="4">WM2124</td><td></td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>RECONFIGURABLE ANTENNAS</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="5">Total Contact Hours - 45</td></tr>
<tr><td colspan="5">Prerequisites : Nil</td></tr>
<tr><td colspan="6">PURPOSE</td></tr>
<tr><td colspan="6">This course introduces the emerging area of reconfigurable antennas from basic concepts that provide insight into the fundamental design approaches to advanced techniques and examples that offer important new capabilities for next generation applications.</td></tr>
<tr><td colspan="6">INSTRUCTIONAL OBJECTIVES</td></tr>
<tr><td>1.</td><td colspan="5">To understand the basics of reconfigurable antennas and study the various reconfiguration Mechanism</td></tr>
<tr><td>2.</td><td colspan="5">To design, analyze and optimization of reconfigurable antenna using Graph Model</td></tr>
<tr><td>3.</td><td colspan="5">To gain knowledge on reflect array antennas</td></tr>
</table>

UNIT I-INTRODUCTION TO RECONFIGURABLE ANTENNA (9 hours)
Introduction-Definitions of critical parameters for antenna operation-Frequency response-Radiation characteristics-Linkage between frequency response and radiation characteristics-Implications for reconfigurable antennas

UNIT II-RECONFIGURATION TECHNIQUES AND CLASSIFICATION OF RECONFIGURABLE ANTENNAS (9 hours)
Reconfiguration mechanism-Types of reconfigurable antennas-Methods for achieving frequency reconfigurability-Methods for achieving polarization reconfigurability-Methods for achieving

pattern reconfigurability-Methods for achieving compound reconfigurability-Practical issues for implementing reconfigurable antennas-Reconfigurable antennas application and requirements

UNIT III-OPTIMIZATION TECHNIQUES FOR PLANAR ANTENNAS (9 hours)
Introduction-basic optimization concept-Real coded genetic algorithm-Neurospectral design of antenna-ANN Technique-Particle swarm optimization Techniques

UNIT-IV-RECONFIGURABLE ANTENNA DESIGN USING GRAPH MODEL (9 hours)
Introduction to Graphs-Rules and Guidelines for graph modeling antennas-Graph Algorithm-reconfigurable antenna design steps using graph-Redundancy reduction in antenna structure-Analyzing the complexity and reliability of reconfigurable antennas –Detection and correction of switch failures in reconfigurable antennas.

UNIT V-REFLECTARRAY ANTENNAS (9 hours)
Introduction-General review of reflect array antennas-Comparisons of reflect array and conventional reflector-wideband techniques for reflect arrays- cell elements and applications-development of novel loop based cell elements.

REFERENCES

1. Joseph Constantine, Youssef Tawk and Christos Christodoulou, “Design of Reconfigurable Antennas Using Graph Models,” Morgan andClaypool Publications, 2006.
2. Jennifer T. Bernhard, “Reconfigurable Antennas,” Morgan andClaypool Publications, 2007.
3. Debatosh Guha, Yahia, M.M. Antar, “Microstrip and Printed Antennas; new trends, techniques, applications,” John Wiley and Sons Ltd.2011

		L	T	P	C
WM2125	**FIBER WIRELESS ACCESS NETWORKS**	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite: Nil				
PURPOSE					
This course introduces the students to the emerging areas of access network technology and advantages with solid knowledge of fiber wire line access technologies like **PON** and **RoF,** and wireless accessing technologies like **WiFi**, **WiMAX** and **LTE** .					
INSTRUCTIONAL OBJECTIVES					
1.	To understand the basics of PON and RoF				
2.	To learn about WiFi, WiMAX, LTE Wireless Access Technologies.				
3.	To analyze the architecture of FiWi access network				

UNIT-I: FIBER ACCESS NETWORKS (9 hours)

GPON Architecture - Wavelength allocation - GPON encapsulation method - Bandwidth allocation -EPON Architecture - Multipoint control protocol - Dynamic bandwidth allocation (DBA) - 10G-EPON -Next-generation PON 1 - Next generation PON 2.

UNIT-II: INTRODUCTION TO RADIO OVER FIBER (9 hours)

Introduction - The Concept of a Radio over Fiber System - Categories of Radio over Fiber Systems - Performance of Radio over Fiber Systems - Applications of Radio over Fiber Technology.

UNIT-III: ROF SYSTEM DESIGN FOR DBWS (9 hours)

Wireless Trends - Provision of Broadband Access - System Capacity - Power Efficiency Fairness in Access -Architecture Options -The Global Centralized Architecture - Distributed Broadband Wireless Systems (DBWS) Architecture Elements - Physical Elements of the DBWS Radio over Fiber Link Design Issues - Number of Channels - Peak-to-Average-Power Ratio - Modulation Scheme - Uplink Power Control - - Example Link Design

UNIT-III: WIRELESS ACCESS NETWORKS (9 hours)

WiFi - Legacy WLAN - QoS in WLAN - HT WLAN - VHT WLAN - WiMAX - Fixed WiMAX - Mobile WiMAX - Next-Generation WiMAX - LTE - PHY layer - MAC layer - Power saving - Handover - LTE-Advanced.

UNIT-V: FIWI ACCESS NETWORKS (9hours)

RoF vs. RandF networks - Enabling technologies - State-of-the-art test beds - Challenges and open issues - Architectures - Cellular architectures - WiMAX based architectures - WiFi based architectures.

REFERENCES

1. Martin Maier, Navid Ghazisaidi, "FiWi Access Networks", Cambridge University Press, 2012.
2. Nathan J. Gomes, Paulo P. Monteiro, Atılio Gameiro, "Next Generation Wireless Communications using Radio Over Fiber", A John Wiley and Sons, Ltd., Publication, 2012.

		L	T	P	C
WM2126	**SEMICONDUCTOR OPTICAL AMPLIFIER BASED ALL OPTICAL CIRCUITS AND DEVICES**	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite: Nil				
PURPOSE					
To familiarize the student with SOA based All optical circuits					
INSTRUCTIONAL OBJECTIVES					
1.	To learn the operating principles of SOA				
2.	To understand the SOA Nonlinearities				
3.	To design and analyze SOA based All optical circuits				

UNIT-I: Semiconductor Optical Amplifiers (9hours)
Introduction - Operation Principles - SOA Gain - Refractive Index- Line width Enhancement Factor – Amplifier Rate Equations for Pulse Propagation - Pulse Amplification - Multichannel Amplification - Amplifier Application in Optical Transmission Systems - Amplifier Noise - Gain Dynamics

UNIT-II: SOAs Nonlinearities and Applications (9hours)
Four-Wave Mixing - Cross Gain Modulation - Cross Phase Modulation- Wavelength Conversion –Optical Demultiplexing - OTDM System Applications

UNIT-III: Optical Logic Operations (9hours)
SOA-MZI Gate - SOA-MZI Transfer Function - Michelson Interferometer - Optical Logic XOR - Optical Logic OR - Optical Logic AND - Optical Logic NOT- Optical Logic NOR - Optical Logic XNOR - Optical Logic NAND

UNIT IV: Optical Logic Circuits (9hours)
All optical Flip Flop – Adder - Parity Checker - All-Optical Pseudorandom Binary Sequence (PRBS) Generator - All-Optical Clock Recovery -

UNIT-V: All Optical signal processing and switching circuits (9hours)
All optical regeneration – Data format conversion – All-Optical Header/Payload separation -. All-Optical correlator - All-Optical packet routing - All-Optical Header Processor

REFERENCES

1. Ali Rostami, Hamed Baghban, Reza Maram, “Nanostructure Semiconductor Optical Amplifiers”, Springer, 2010.
2. Hiroshi Ishikawa, “Ultrafast All-Optical Signal Processing Devices”, A John Wiley and Sons, Ltd., Publication, 2008.
3. Niloy K Dutta and Qiang Wang, “Semiconductor Optical Amplifiers”, World Scientific Publishing Co. Pte. Ltd., 2006.

WM2127	Semiconductor Optoelectronic Devices	L	T	P	C
		3	0	0	3
	Total Contact Hours – 45				
	Prerequisite: Nil				

PURPOSE

This course introduces the students to the semiconductor optoelectronic devices which find applications in display devices, Optical sources and detectors. Also, it deals with modulation and switching devices which can be used for optical signal processing.

INSTRUCTIONAL OBJECTIVES

1.	Acquire fundamental understanding of the basic physics behind optoelectronic devices.
2.	Develop basic understanding of display devices, light emitting diodes and Lasers
3.	Acquire in depth understanding of Optical detector devices
4.	Acquire detailed knowledge optoelectronic modulation and switching devices.
5.	Develop basic understanding of optoelectronic integrated circuits.

UNIT-I: OPTICAL PROCESSES IN SEMICONDUCTORS (9 hours)

Review of Semiconductor Device Physics - Semiconductor optoelectronic materials, Bandgap modification, Heterostructures and Quantum Wells - Interaction of photons with electrons and holes in a semiconductor – Band-to-Band Absorption and Emission - Rates of Absorption and Emission - Refractive Index

UNIT-II: DISPLAY DEVICES AND LASERS (9 hours)

Liquid crystal cells - Challenges in scaling to a display screen – Passive Matrix LCD – TFT – Field emission displays, Plasma Display, Numeric Displays

Injection Electroluminescence LED Characteristics- Semiconductor Laser Amplifiers – Gain, Pumping, Heterostructures – Semiconductor Injection Lasers - Amplification, Feedback, and Oscillation, Power, Spectral Distribution, Spatial Distribution, Mode Selection, Characteristics of Typical Lasers, Quantum-Well Lasers, Mode Locking

UNIT-III: OPTICAL DETECTION DEVICES (9 hours)

Photo Conductors, Junction Photo diodes- PIN and Heterojunction diodes - Avalanche Photodiodes, Special detection schemes – Phototransistor, Modulated Barrier Photodiode, Schottky Barrier photodiode, MSM photodiode, Wavelength selective detection, Microcavity photodiodes- Photovoltaics and Solar cells

UNIT-IV: MODULATION AND SWITCHING DEVICES (9 hours)

Figures of merit for modulators – Electro-Optic Modulators – Interferometric Modulators – Stark effect modulators Directional Coupler - Switches - Opto-Mechanical, Electro-Optic, Acousto-Optic, and Magneto-Optic Switches - All Optical Switches - Bistable Optical Devices - Bistable Systems - Principle of Optical Bistability - Bistable Optical Devices - Hybrid Bistable Optical Devices

UNIT-V: OPTICAL INTEGRATED CIRCUITS (9 hours)

Need for Integration – Material and Processing for OEICs – Integrated Transmitters and Receivers – Guided wave Devices - Coplanar and Vertical couplers - Grating assisted couplers.

Ring cavity couplers for add-drop - Photodiode-Amplifier Integration - Optical Interconnections- - Holographic Interconnections - Optical Interconnections in Microelectronics

REFERENCES

1. Pallab Bhattacharya "Semiconductor Opto Electronic Devices", 2nd Edition, Prentice Hall of India Pvt., Ltd., New Delhi, 2006.
2. Jasprit Singh, "Optoelectronics – As Introduction to materials and devices", McGraw-Hill International Edition, 1996
3. J. Wilson and J.Hawkes, "Opto Electronics – An Introduction",3rd Edition Prentice Hall, 1998.
4. Bahaa E. A. Saleh, Malvin Carl Teich, "Fundamentals of Photonics" John Wiley and Sons,1991

		L	T	P	C
WM2128	**WIRELESS OPTICAL COMMUNICATION**	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite : Nil				
Purpose					
To familiarize the student with the design of communication systems for wireless optical channels. To expose the physical aspects of wireless optical channels including propagation characteristics to serve as an introduction to communication specialists.					
INSTRUCTIONAL OBJECTIVES					
1.	To understand the extension of the wealth of modern design practices from electrical channels to optical intensity domain				
2.	To analyze vector representation of optical signals, design and capacity of signaling sets and use of multiple transmitter and receivers to improve spectral efficiency				

UNIT I – FUNDAMENTALS OF WIRELESS COMMUNICATION (9hours)

Introduction – Brief history of wireless optical communication–Wireless Optical Channels: Atmospheric channel, underwater and interstellar medium – Wireless optical intensity channels – Optoelectronic components-noise – Channel topologies.

UNIT II – INTRODUCTION TO OPTICAL SIGNALLING (9hours)

Communication system model: Channel model – Vector channel and signal space –Isolated pulse detection – Probability of error, Bandwidth: definition – Inter-symbol interference, Modulation example: Binary level modulation and multi-level modulation – The communication system design problem.

UNIT III – SIGNALLING DESIGN (9hours)

Optical intensity signal space model: Signal space model – Admissible region– Peak optical power bounding region – Peak optical power per symbol – Peak-symmetric signalling schemes, Example and geometric properties – Atmospheric turbulence channel modeling.

UNIT IV – OPTICAL CHANNEL CAPACITY (9hours)

Channel capacity: Background, problem definition, bandwidth constraints, upper bound on channel capacity,lower bound on channel capacity, example and discussion – Channel capacity of hybrid free space optical wireless channels.

UNIT V – MUTIELEMENT TECHNIQUES (9hours)

MIMO wireless optical channel – Experimental prototype, MIMO optical channel model– Pixel-Matched Systems – Pixelated wireless optical channel coded MIMO FSO communication – Buffering – Optical routers – Optical switching technologies – Lattice codes.

REFERENCES

1. Steve Hranilovic, "Wireless Optical Communication Systems ", I Edition, Springer, 2005.
2. Ivan Djordjevic, William Ryan and Bane Vasic, “Coding for Optical Channels”, I Edition,
   Springer, 2010.
3. Olivier Bouchet, HervéSizun, Christian Boisrobert and Frédérique de Fornel and Pierre-Noël Favennec , “Free-Space Optics: Propagation and Communication”, I Edition, Wiley-ISTE, 2006.

		L	T	P	C
WM2129	**COMPRESSIVE SENSING**	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Pre-requisite: Nil				
PURPOSE					
To provide mathematical knowledge to address the real world signal acquisition and compression using compressive sensing.					
INSTRUCTIONAL OBJECTIVES					
1.	To acquire knowledge on the basics and applications of sparse signals				
2.	Basic algorithms and tools from linear algebra and probability theory.				
3.	Coherence and isometry property of under sampling technique.				

UNIT I –BASIC ALGORITHMS (9 hours)

Introduction to Compressive Sensing, Applications, Motivations Extensions, **Sparse Solutions to underdetermined Systems**- Sparsity and compressibility, minimal number of measurements, NP-Hardness of l0 minimization. **Basic Algorithms** -Optimization Methods, Greedy Methods, Thresholding Based methods.

UNIT II –TOOLS FROM LINEAR ALGEBRA (9 hours)

Basic pursuit- Null Space property, stability, robustness, recovery, Low-rank matrix recovery.

UNIT III –TOOLS FROM PROBABILITYTHEORY (9 hours)

Essentials, moments and trials, Cramer’s theorem, Hoeffding’s inequality, sub Gaussian random variables, Bernstein Inequalities.

UNIT IV –COHERENCE AND ISOMETRY PROPERTY (9 hours)

Definition and basic properties, Matrices with Small Coherence, Analysis of OrthogonalMatching Pursuit, Analysis of Basis Pursuit, Analysis of thresholding algorithm, Analysis of Greedy algorthim.

UNIT V –SPARSE RECOVERY WITH RANDOM MATRICES (9 hours)

Restricted Isometry property for subguassian matrices and guassian matrices, Nonuniform Recovery, Null Space Property for Gaussian Matrices.

REFERENCES

1. Simon Foucart, HolgerRaghut, "*A Mathematical Introduction to Compressive sensing*", Birkhauser, Springer, 2013.
2. Michael Elad, "*Sparse and Redundant Representations from theory to applications in signal and image processing*", Springer, 2010.
3. D. Donoho, "*Compressed sensing*," *IEEE Trans. Inform. Theory,* vol. 52, no. 4,pp. 1289-1306, Apr. 2006.
4. E. Candès, J. Romberg, and T. Tao, "*Robust uncertainty principles: Exact signalreconstruction from highly incomplete frequency information*," *IEEE Trans.Inform. Theory,* vol. 52, no. 2, pp. 489–509, Feb. 2006.
5. R. Baraniuk. "*Compressive sensing*". IEEE Signal Process. Magazine, 24(4):118–121, 2007.

		L	T	P	C
WM2130	**PHOTONIC INTEGRATED CIRCUITS**	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite : Optical Communications, Electromagnetic Theory				
PURPOSE					
To familiarize the student with the basics of Photonic Integrated Circuits					
INSTRUCTIONAL OBJECTIVES					
1.	To analyze optical waveguides and devices and coupling between them				
2.	To study various applications of PICs				

UNIT I: THEORY OF OPTICAL WAVEGUIDES AND COUPLING MODE THEORY (9 hours)

Introduction to Optical waveguides – Planar Waveguides – Channel Waveguides – Modes in Planar waveguides and channel waveguides – Losses in Optical Waveguides - Fundamentals of Optical Coupling – Fiber to Waveguide Couplers – Coupling mode theory – Diffraction grating in waveguides – Numerical techniques for analyzing PICs - Beam Propagation Method.

UNIT II: INTEGRATED LASER DIODES & INTEGRATED DETECTORS (9hours)

Laser Diode – New Semiconductor materials for new wavelengths – Advanced Heterojunction Laser Structures – Distributed Feedback Lasers – Fabrication Techniques – Nanoscale DFB Lasers - Future Prospects for Microwave Modulation of Laser diodes - Monolithically Integrated Direct Modulators — Waveguide Photodiodes – Techniques for modifying Spectral Response – Factors Limiting Performance of Integrated Detectors - Fiber Lasers

UNIT III: OPTOELECTRONIC INTEGRATED CIRCUITS & AMPLIFIERS (9hours)

Electro-optic devices – Acoustic-Optic devices - Thermo-Optic devices – Magneto-optic devices – Integration Techniques – OEIC Transmitters and Receivers – Integrated Semiconductor Optical Amplifiers – Comparison of Ion-Doped Fiber Amplifiers with SOAs.

UNIT IV: ACTIVE PHOTONIC INTEGRATED CIRCUITS – A SIMULATION STUDY (9hours)

Introduction – Fundamental Requirements of a simulator – Simulation environment – Simulation Examples – Phase discriminator – Clock sources – Optical AND gate – Advanced Photonic Integrated Circuits – Waveguide Photodetectors – Transceivers/Wavelength Converters, Triplexers – PICs for Coherent Optical Communications - Coherent Optical Communications Primer – Coherent Receiver Implementations.

UNIT V: APPLICATIONS OF PHOTONIC INTEGRATED CIRCUITS (9hours)

Nano Photonics – Benefits of Nano structures – Photonic crystals – Nano Photonic Devices – Resonators – Sensors – Micro-Opto-Electro-Mechanical Systems – Basic equations of Mechanics – Thin Membrane Devices – Torsional Devices - Bio Photonic applications – Optical Biosensors - VLSI Photonics – Optical Printed circuit board - Directional Coupler Type Switches – Ultrashort Pulse Sources and Switches.

REFERENCES

1. Robert G. Hunsperger, “Integrated Optics – Theory and Technology”, Sixth Edition, Springer Verlag, 2009.
2. GinesLifante, “Integrated Photonics – Fundamentals”, Wiley Publications, 2003.
3. Joachim Piprek, “Optoelectronic Devices – Advanced Simulation and Analysis”, Springer verlag, 2005.
4. L. A. Coldren, S. W. Corzine, M. L. Masanovic, “Diode Lasers and Photonic Integrated Circuits”, Second Edition, Wiley Publications, 2012.
5. Ronald W. Waynant, Marwood N. Ediger, “Electro-Optics Handbook”, Second Edition, Mc Graw Hill Publications.
6. Paras N. Prasad, “Introduction to Bio Photonics”, Wiley Publications, 2003.
7. http://photonicssociety.org/newsletters/oct04/optical.html

<table>
<tr><td rowspan="4">WM2131</td><td></td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Integrated Photonic Micro Ring Resonators</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="5">Total Contact Hours – 45</td></tr>
<tr><td colspan="5">Pre-requisite : Nil</td></tr>
<tr><td colspan="6">PURPOSE</td></tr>
<tr><td colspan="6">This course is intended to bring to the students the basic theory and fundamentals of photonic microring resonators. Topics included in this course will enlighten the student with the research activity in the field of ring resonators.</td></tr>
<tr><td colspan="6">INSTRUCTIONAL OBJECTIVES</td></tr>
<tr><td>1.</td><td colspan="5">To describe the fundamental theory and principles of Microring resonators</td></tr>
<tr><td>2.</td><td colspan="5">To introduce tuning activity ring resonator systems</td></tr>
<tr><td>3.</td><td colspan="5">To introduce various techniques of fabricating ring resonators</td></tr>
</table>

UNIT I: MICRO RING RESONATORS – THEORY AND PRINCIPLES (9 hours)

Introduction to microring resonators – Putting the micro in micro ring – Building Blocks of ring resonator devices – Couplers – Bends - Spot size converters for light in and outcoupling - General characteristics of micro ring resonators – Sources of loss in micro ring resonators – Nonlinear susceptibility - Resonator enhanced $\chi^{(3)}$nonlinear effects - Enhanced nonlinear phase shift - Enhanced four wave mixing efficiency in micro ring resonators

UNIT II: TUNING IN MICRO RING RESONATORS (9 hours)

Control factors for tunable micro ring resonators – Micro ring resonators with active tuning - Electrically tuned micro ring resonators - Electro-optic switches - All-Optically tuned micro ring resonators - Optical bistability - Thermally tuned micro ring resonators - Thermal–Optical bandwidth tuning - MEMS-tuned micro ring resonators - Tunable coupling conditions - Reconfigurable add-drop filters - MEMS-tuned resonator loss – Trimming.

UNIT III: MICRO RING RESONATORS – TYPES AND APPLICATIONS (9 hours)

All pass ring resonators – Add drop ring resonators - Series coupled ring resonators – Parallel coupled ring resonators - Spectral filters -General IIR Optical transfer functions - Sum–Difference all-pass micro ring filters -Optical delay lines - Label-free biosensors – Modulators

UNIT IV: MICRO RING RESONATORS FOR COMMUNICATION AND SIGNAL PROCESSING APPLICATIONS (9 hours)

Functions of ring resonators in Optical communication and signal processing - Channel adding/dropping in TDM systems - Generation and demodulation for advanced data formats - Frequency comb generation for arbitrary waveform generation - Dispersion compensators – Optical AND, OR, XNOR logic gates using MRR.

UNIT V: FABRICATION TECHNIQUES FOR MICRO RING RESONATORS (9 hours)

Resonator material systems - III–V Semiconductors for active and passive microrings – Growing a waveguide stack –Dry etching – Micro ring resonators based on wafer-based processing techniques - Deep Ultraviolet (DUV) Lithography - Electron Beam Lithography (EBL) - Nanoimprinting Lithography (NIL) - Characterization methods – Conventional characterization - Optical low coherence reflectometry.

REFERENCES

1. IoannisChremmos, Otto Schwelb,Nikolaos Uzunoglu, *Photonic Microresonator Research and Applications*, Springer series in Optical Sciences 156, 2010.
2. D. G. Rabus, *Integrated Ring Resonators - The Compendium*, Springer series in Optical Sciences 127, 2007.
3. John Heebner, Rohit Grover, Tarek Ibrahim, *Optical Microresonators - Theory, Fabrication and Applications*, Springer series in Optical Sciences 138, 2008.
4. WimBogaerts et al., *Silicon microring resonators*,Laser and Photonics Reviews, Vol. 6, No. 1, pp. 47-73, Wiley publications, 2012.

		L	T	P	C
WM2132	NEAR-FIELD OPTICS AND PLASMONICS	3	0	0	3
	Total Contact Hours – 45				
	Pre-requisite : Nil				

PURPOSE

To provide an introduction to the fundamentals of nano-optics and to get exposure on design and analysis of computational methods

INSTRUCTIONAL OBJECTIVES

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

1.	understand the fundamentals of nano-optics
2.	gain knowledge in FiniteTime Domain Method tools for the design and analysis of opto-electronic devices
3.	gets an overview of nanoantenna's application and designing the plasmonic materials
4.	understand the concepts of biosensors in the field of optics

UNIT–I: FUNDAMENTAL CONCEPTS OF EM WAVES (9 hours)

Wave optics and wave mechanics - scattering, propagation, focusing Angular spectrum representation of EM waves- resolution limits in classical optics - Near-fields and far-fields – diffraction limit

UNIT–II: COMPUTATIONAL METHODS IN NANO-OPTICS (9 hours)

Typical boundary-value problems for Maxwell equations in nanostructures: effective constitutive relations and effective boundary conditions. Introduction to FDTD – 1D FDTD: formulation, implementation, post processing, examples – 2D FDTD: PML, formulation, implementation – Periodic FDTD – 3D FDTD and advanced optics.

UNIT–III: NANOANTENNAS (9 hours)

Overview of nanoantennas: radiation pattern, radiation impedance, partial photonic DOS, Nanoantenna realizations: plasmonic-nanowire antennas, carbon nanotube antennas, bowtie antennas.

UNIT–IV: APPLICATIONS OF NANOANTENNAS (9 hours)

Near-field optical microscopy: Surface Enhanced Raman Scattering (SERS), Enhanced Fluorescence, Surface Enhanced Infrared Spectroscopy (SEIRS) - Spontaneous Emission Enhancement, Solar cells – Plasmonic materials.

UNIT–V: OPTICAL BIOSENSOR (9 hours)

Overview of biosensors – optical sensing/detection techniques and instrumentation - photonic structures in sensing: Optical label-free detection, Optical fluorescence detection – Surface Enhanced Raman Spectroscopy - Microfluidics and optofluidics – Overview of nanotechnology in bio/chemical sensing – optical manipulation and sorting

REFERENCES

1. Robert W. Boyd, "Nonlinear Optics", Academic Press, 3rd Edition, 2013.
2. Stefan Alexander Maier, "Plasmonics: Fundamentals and Applications, Springer Science and Business Media, 2007.
3. Sarhan M. Musa, "Computational Nanotechnology Using Finite Difference Time Domain", CRC Press, 2013.
4. Marc Lamy de la Chapelle Annemarie Pucci, "Nanoantenna: Plasmon-Enhanced Spectroscopies for Biotechnological Applications", CRC Press, 2013.
5. Nermeen Ahmed Eltresy, Saber Helmy Zainud-Deen, Hend Abd El-Azem Malhat, "Nanoantennas Design and Applications", Lambert Academic Publishing (LAP), 2016.

		L	T	P	C
WM2133	**SIGNAL PROCESSING TECHNIQUES FOR SPEECH RECOGNITION**	**3**	**0**	**0**	**3**
	Total contact hours: 45				
	Prerequisite: Nil				
PURPOSE: To present overview of speech production mechanism and the algorithms					
INSTRUCTIONAL OBJECTIVES: To learn about					
1.	Speech Production Mechanism				
2.	Speech Signal Processing concepts				
3.	Speech recognition,Feature selection				
4.	Distance measures for comparing speech patterns				
5.	GCI/GOI Algorithms				

UNIT-I: THE SPEECH PRODUCTION MECHANISM (9 hours)

Physiological and Mathematical Model-Relating the physiological and mathematical model-Categorization of Speech Sounds based on the source-system and the articulatory model.Basic Speech Signal Processing Concepts-Discrete time speech signals, relevant properties of the fast Fourier transform.

UNIT-II: SPEECH MODELING (9 hours)

Z-transform for speech recognition, convolution, linear and nonlinear filter banks-Spectral estimation of speech using the Discrete Fourier transforms-Pole-zero modeling of speech and linear prediction (LP) analysis of speech-Homomorphic speech signal de convolution, real and complex cepstrum, application of cepstral analysis to speech signals.

UNIT-III: FEATURE EXTRACTION FOR SPEECH RECOGNITION (9 hours)

Static and dynamic features for speech recognition, robustness issues, discrimination in the feature space, feature selection-Mel frequency cepstral co-efficients (MFCC), Linear prediction cepstral coefficients (LPCC), Perceptual LPCC. Distance measures for comparing speech patterns-Log spectral distance, cepstral distances, weighted cepstral distances, distances for linear and warped scales

UNIT-IV: DYNAMIC TIME WARPING FOR ISOLATED WORD RECOGNITION (9 hours)

Statistical models for speech recognition-Vector quantization models and applications in speaker recognition-Gaussian mixture modeling for speaker and speech recognition-Discrete and Continuous Hidden Markov modeling for isolated word and continuous speech recognition.

UNIT-V: GLOTTAL CLOSURE/OPENING INSTANTS ALGORITHMS (9 hours)

Hilbert Envelope based detection(HE) method-Dynamic Programming Phase Slope Algorithm (DYPSA)-Zero frequency resonator – based method(ZFR)-Speech Event Detection using Residual Excitation And a Mean-based Signal(SEDREAMS) and the Yet Another GCI Algorithm (YAGA).

References

1. JW Picone, "Signal Modeling Techniques in Speech Recognition", Proceeding of IEEE, June 1993.
2. JW Picone, "Signal Modeling Techniques in Speech Recognition", Proceeding of the IEEE Vol 81, No 9,September 1993.
3. SB Davis and P Mermelstein, "Comparison of Parametric Representations for Monosyllabic Word Recognition in Continuously Spoken Sentences", IEEE Transaction on Acoutics,Speech and Signal Processing, Vol ASSP 28, No.4, August 1980.
4. H Hermansky and N Morgan, "RASTA Processing of Speech", IEEE Transactions on Processing of Speech and Audio Processing, Vol 2, No.4, October 1994.
5. DA Reynolds and RC Rose, "Robust Text-Independent Speaker Identification Using Gaussian Mixture Speaker Models", IEEE Transaction on Speech and Audio Processing, Vol 3, No 1, January 1995.
6. LR Rabiner and BH Juang, "An Introduction to Hidden Markov Models", IEEE ASSP Magazine January 1986.
7. LR Rabiner, "A Tutorial on Hidden Markov Models and Selected Applications in Speech Recognition", Proceeding of IEEE, Vol 77, No 2, Feburary 1989.
8. Thomas Drugman, "Detection of Glottal Closure Instants from Speech Signals: a Quantitative Review, IEEE Transactions on Audio, Speech, and Language Processing", IEEE Transactions on Audio, Speech and Language Processing, Vol 20, No.3, March 2012.
9. Thomas F. Quatieri, "Discrete-Time Speech Signal Processing: Principles and Practice", Pearson Education, 2008.
10. L. Rabiner and B. Juang, "Fundamentals of Speech Recognition", Prentice-Hall Signal Processing Series, 1993.

WM2134		L	T	P	C
	Visible Light Communication	**3**	**0**	**0**	**3**
	Total Contact Hours : 45				
	Prerequisite : Nil				
PURPOSE					
To provide a comprehensive idea on Visible Light Communication & modulation techniques					
INSTRUCTIONAL OBJECTIVES :					
1.	To study the communication devices and systems in VLC				
2.	To study the Physical and MAC layer in VLC				
3.	To understand the modulation techniques used in VLC				
4.	To study the enhancing techniques for VLC system performance				

Unit I – Lighting and communications: Devices and Systems (9 Hours)
Introduction- Lighting systems- Radiometry -Photometry and Colorimetric essentials. LED: Circuit models - White LEDs - LED's Colormetric models - ON/OFF drivers - Analog Drivers. Photodetectors- PIN and Avalanche photodiodes - Electrical circuit equivalent model.

Unit II –VLC standard: PHY and MAC layer (9 Hours)
Overview of IEEE standard 802.15.7 - Network architecture - MAC Layer: MAC frame structure - Random Access mechanisms - starting and maintaining a VPAN - Transmission and Reception and Acknowledgment of MAC frames - PHY layer: Modulation - FEC coding - Interleaving - Line coding - Scrambling - System models for PHY layer.

Unit III – Modulation Schemes (9 Hours)
Baseband Modulation- PAM - PPM - PIM - DAPM - VPPM - PWM - Comparison of Baseband modulation schemes - Carrierless amplitude phase modulation (CAP) - Principles of CAP - modulation and coding schemes for dimmable VLC- Introduction to Optical OFDM- Properties of Bipolar OFDM - Unipolar OFDM formats

Unit IV – Advanced modulation Schemes (9 Hours)
DC-biased optical OFDM (DCO-OFDM) - asymmetrically clipped optical OFDM (ACO-OFDM) - pulse amplitude discrete multitone (PAM - DMT) - Unipolar OFDM - Performance comparison - DC bias and scaling optimizations - LED non linearity mitigation - PAPR reduction - Hybrid optical OFDM - Enhanced U- OFDM - Layered ACO-OFDM - Reverse Polarity optical OFDM - asymmetrically hybrid optical OFDM - Introduction to color shift keying.

Unit V – Techniques for enhancing VLC systems performance (9 Hours)
PAPR reduction techniques for optical OFDM Communication systems- Pilot assisted OFDM technique - Pilot signal estimation -PAPR reduction by clipping- PAPR reduction comparison - Effect of PAPR reduction on error performance.MIMO - VLC non imaging MIMO channel model and detection methods - MIMO system Setup.

REFERENCES

1. Zabih Ghassemlooy, Luis Nero Alves, Stanislav Zvanovec, and Mohammad-Ali Khalighi,"Visible Light Communications Theory and Applications", CRC Press, 2017.
2. Zhaocheng Wang, Qi Wang, Wei Huang, and ZhengyuanXu,"Visible Light Communications: Modulation and Signal Processing", Wiley-IEEE Press, 2017.

WM2135	ANALYSIS AND DESIGN OF TRANS-IMPEDANCE AMPLIFIER FOR OPTICAL RECEIVER	L	T	P	C
		3	0	0	3
	Total Contact Hours : 45				
	Prerequisite : Nil				

PURPOSE	
The explosive growth in optical communications, expects the design of Trans-impedance amplifier with wide dynamic range and Low noise. This course aims to introduce the design of TIA suitable For optical receiver.	
INSTRUCTIONAL OBJECTIVES	
1.	To acquire knowledge on Front – end Optical Receiver design
2.	To Analysis of various noises associated with photodetector & transimpedance amplifier
3.	To Gain the knowledge of Various Trans-impedance amplifier design

Unit –I: Optical Receiver Fundamentals (9 hours)

Photo detector diodes-Classification of optical receiver – Trans-impedance amplifier – AGC Post amplifiers – Data and clock recovery circuits – Optical receiver performance characteristics - Receiver model – Noise and Bit error Rate – Signal to Noise Ratio – Sensitivity – Noise bandwidth and personick integrals – Optical SNR – Intersymbol Interference and – Bandwidth - Frequency response.

Unit –II: Basic Trans-impedance Amplifier Specification and Design (9 hours)

Input overload current – Maximum input current for linear operation – Bandwidth – Phase linearity and group Delay variation – Timing Jitter – Input referred noise current – Crosstalk – Low and high impedance front ends – Shunt feedback TIA – Noise analysis – Noise optimization – Noise matching.

Unit –III: Advanced Trans-impedance amplifier Design (9 hours)

TIA with post amplifier – Differential inputs and outputs – TIA with DC input current control – TIA with Adaptive trans-impedance – Common base and common gate TIAs – Regulated cascode TIA – TIA with Inductive broad banding – Distributed amplifier TIA.

Unit- IV: Advanced TIA Design and Circuit Examples (9 hours)

TIA with non resistive feedback – Current mode TIA – TIA with bootstrapped photo detector – Burst mode TIA – Analog receiver TIA, Timing Jitter : Data Jitter – Clock Jitter – Phase noise and Bit error rate. **Circuit Examples:** BJT, HBT, and BICMOS Circuits – CMOS Circuits – MESFET and HFET Circuits.

Unit –V: **Photodiode Amplifier Noise Analysis (9 hours)**

Various noises inside the amplifier - Photodiode current noise calculations - Op-amp voltage noise calculations – Thermal noise calculations - Total noise for trans-impedance amplifier - Spice analysis - Measuring the noise for the Trans-impedance Amplifier.

REFERENCES

1. Eduard Sackinger, “Analysis and Design of Trans-impedance Amplifiers for Optical Receivers”, John Wiley & Sons, 2018.
2. Harold Kolimbiris, “Fiber Optics Communication”, Pearson Prentice Hall, 2008.
3. Art Kay, “Operational Amplifier Noise- Techniques and Tips for Analyzing and Reducing Noise”, 1st Edition, Elsevier, 2012.

WM2136	**INTRODUCTION TO DIGITAL SPEECH PROCESSING**	**L**	**T**	**P**	**C**
	Total contact hours - 45	3	0	0	3
	Prerequisite: Basic knowledge of Signals and Digital Signal Processing				

Purpose	
To study human speech production system and concepts of speech signal analysis	
Instructional Objectives	
1.	To study the human speech production system
2.	To understand the time domain methods in speech processing
3.	To emphasize speech signal analysis
4.	To review the concept of speech signal analysis
5.	To understand the auditory system and hearing

Unit I - Introduction to speech processing **(9 hours)**

Digitization and recording of speech signal, Review of Digital Signal Processing Concepts, Human speech production, Acoustic Phonetics and Articulatory Phonetics, Different categories of speech sounds, Location of sounds in the acoustic waveform and spectrograms, Uniform tube modeling of speech production, Speech Perception.

Unit II - Time Domain Methods in Speech Processing **(9 hours)**

Analysis and synthesis of pole-zero speech models Short-Time Fourier Transform, Analysis of Fourier Transform view and filtering view, Synthesis: Filter bank summation (FBS) method and OLA method.

Unit III-Speech Signal Analysis **(9 hours)**

Featureextraction, Extraction of fundamental frequency, Speech distortion measures: Mathematical and Perceptual, Log spectral distance, Cepstral distances, Weighted cepstral distances and filtering, Likelihood distortions, Spectral distortion using a warped frequency scale, LPC, PLP and MFCC coefficients, Time alignment and normalization, Dynamic time warping, Multiple time – alignment paths.

Unit IV - Speech Signal Modeling **(9 hours)**

Hidden Markov Models: Markov Processes, HMMs – Evaluation, Optimal State Sequence – Viterbi algorithm, Training and testing using HMMs, Implementation issues.

Unit V-Auditory System and Hearing **(9 hours)**

Anatomy, Physiology and function of the auditory systems, Physiological measures, Auditory processing models, Speech intelligibility, Signal processing in hearing aids

REFERENCES

1. L. R. Rabiner and R. W. Schafer, “Theory and Applications of Digital Speech Processing”, Upper Saddle River:Pearson c2011.

2. Daniel Jurafsky and James H Martin, “Speech and Language Processing – An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition”, Pearson Education, 2008.
3. Steven W. Smith, “The Scientist and Engineer’s Guide to Digital Signal Processing”, California Technical Publishing, 2002.
4. Thomas F Quatieri, “Discrete-Time Speech Signal Processing – Principles and Practice”, Prentice Hall,1st edition 2008.
5. Ben gold and Nelson Morgan, “Speech and audio signal processing”, processing and perception of speech and music, Wiley- India Edition, 2006 Edition

WM2137	**STATISTICAL AND ADAPTIVE SIGNAL PROCESSING**	**L**	**T**	**P**	**C**
	Total contact hours: - 45	**3**	**0**	**0**	**3**
	Prerequisite: Basic knowledge of Statistics, Random process and Digital Signal Processing				

Purpose	
To study about the fundamentals of statistical digital signal processing and concepts of estimation theory and spectral analysis.	
Instructional Objectives	
1.	To study the fundamentals of statistical signal processing
2.	To review the concept of parameter estimation theory
3.	To understand the concepts of LMMSE filters
4.	To emphasize the use of adaptive filters for signal processing
5.	To learn the spectral analysis concepts.

Unit I - Introduction to random process (9 hours)

Distribution and density functions, moments, Independent, Uncorrelated and orthogonal random variables, Vector-space representation of random variables, Schwarz Inequality, Orthogonality principle in estimation, Central Limit theorem, Random processes, Wide-Sense Stationary processes, Autocorrelation and autocovariance functions, Spectral representation of random signals, Wiener Khinchin theorem, Properties of power spectral density, Gaussian Process and White noise process, Linear System with random input, Spectral factorization theorem and its importance, Innovation process and whitening filter,,Random signal modelling: MA(q), AR(p) , ARMA(p,q) models.

Unit II - Parameter Estimation Theory (9 hours)

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

Unit III - Estimation of signal in presence of white Gaussian Noise (9 hours)

Linear Minimum Mean-Square Error (LMMSE) Filtering, Wiener Hoff Equation, FIR Wiener filter, Causal IIR Wiener filter, Noncausal IIR Wiener filter, Linear prediction of signals, Forward and backward predictions, Levinson Durbin algorithm, Lattice filter realization of prediction error filters.

Unit IV - Adaptive Filtering (9 hours)

Principle and application, Steepest descent algorithm, Convergence characteristics, LMS algorithm, Convergence, Excess Mean Square Error, Leaky LMS algorithm, Application of adaptive filters, RLS algorithm, Matrix inversion Lemma, Intialization, Tracking of nonstationarity.

Unit V- Spectral analysis (9 hours)

Estimated autocorrelation function, Periodogram, Averaging the periodogram (Bartlett Method), Welch modification, Blackman and Tukey method of smoothing periodogram, Parametric method, AR(p) spectral estimation and detection of Harmonic signals.

Applications of adaptive signal processing: System identification, channel equalization, noise and echo cancellation.

References

1. Statistical Digital Signal Processing and Modeling, Monson Hayes, J Wiley and sons.1996
2. S. Haykin,"Adaptive Filters Theory," Prentice-Hall,5th edition 2013.
3. Jacob Benesty,Yiteng Huang, 'Adaptive Signal Processing',Springer,2003.
4. Dimitris G. Manolakis, Vinay K. Ingle, Stephan M Krgon: Statistical and Adaptive Signal Processing, McGraw Hill,2000.
5. B. Farhang-Boroujeny, Adaptive filters:Theory and Applications, John-Wiley, 2nd edition 2013.
6. S. M. Kay: Modern Spectral Estimation, Prentice Hall, 2009.

<table>
<tr><td rowspan="3">WM2138</td><td colspan="2">ACOUSTIC ECHO CANCELLATION AND NOISE CONTROL</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td colspan="2">Total contact hours: - 45</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="6">Prerequisite: Basic knowledge of Engineering physics and DSP</td></tr>
<tr><td colspan="7">Purpose</td></tr>
<tr><td colspan="7">To learn about adaptive filtering algorithms and practical implementation.</td></tr>
<tr><td colspan="7">Instructional Objectives</td></tr>
<tr><td>1.</td><td colspan="6">To review the concepts of adaptive filtering</td></tr>
<tr><td>2.</td><td colspan="6">To understand the concepts of sub band adaptive filtering</td></tr>
<tr><td>3.</td><td colspan="6">To emphasize the concepts of acoustic echo and noise control</td></tr>
<tr><td>4.</td><td colspan="6">To review the concept nonlinear acoustic echo canceller</td></tr>
<tr><td>5.</td><td colspan="6">To learn the basics of double talk detection</td></tr>
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Unit I-Introduction to adaptive filtering algorithms (9 hours)

Human perception of echoes, Echo problem, Adaptive filters for echo cancellation, Review of LMS and its variants, Review of RLS and its variants, Affine projection algorithm, Misadjustment, behavior in non-stationary environment, Complex Affine Projection Algorithm

Unit II -Sub band adaptive filtering for echo cancellation. (9 hours)

Multirate system, Decimation and interpolation, Filter bank, Sub band adaptive filter, Delay less sub band adaptive filters, Frequency domain adaptive filtering.

Unit III-Data selective adaptive filtering (9 hours)

Set membership LMS, Set membership NLMS,Set membership binormalised LMS, Computational complexity, Partial update adaptive filters, Application of data selective filters for system identification, echo cancellation.

Unit IV-Nonlinear acoustic echo cancellation (9 hours)

Introduction to non linear system, Polynomial method of non linear system, Volterra and Weiner non linear model, Volterra representation, Discrete non linear Weiner model, Non linear Hammerstein model, Frequency domain non linear acoustic echo cancellation methods.

Unit V-Double Talk Detection (9 hours)

Introduction to Double Talk, Giegel algorithm, Cross correlation based DTD,Variable impulse response algorithm, Time domain based DTD, and Frequency domain based DTD.

References

1. Steven L.Gay, Jacob Benesty, "Acoustic Signal Processing for Telecommunication", Springer, 2001 edition (March, 2000)
2. **Diniz**, Paulo S. R., "Adaptive filtering algorithms and practical implementation", Springer US, 2013.
3. IEEE transaction on Audio, Speech and language processing, "A FDAF prediction error method framework for Double talk robust acoustic echo cancellation", Dec 2014.
4. IEEE transaction on Audio, Speech and language processing, "Delay based double talk detector", Aug. 2012
5. IEEE transaction on Audio, Speech and language processing, "Functional Link Adaptive Filters for nonlinear AEC", July 2013.

WM2139	FIBER OPTICS INTEGRATED CIRCUITS	L	T	P	C
	Total contact hours: - 45	3	0	0	3
	Prerequisite: Basic Optics, Optical Communication				

Purpose	
To understand and analyze various fiber optic integrated circuits and it's applications.	
Instructional Objectives: At the end of this course, learner will be able to	
1.	Study the different types of waveguides and coupling mode theory
2.	Know the various materials and fabrication technology used.
3.	Understand the operating principles and fabrication techniques of Integrated Laser diodes and Integrated detectors
4.	Analyze the different types of opto-electronic integrated circuits and the amplifiers
5.	Know the various applications areas for PICs

UNIT 1 ANALYSIS OF OPTICAL WAVEGUIDES AND COUPLED MODE THEORY (9 Hours)

Introduction to Optical waveguides – Planar Waveguides – Channel Waveguides – Modes in Planar waveguides and channel waveguides – Graded index waveguides– Losses in Optical Waveguides – Dispersion in waveguides– Fundamentals of Optical Coupling– Coupled mode theory– Beam Propagation Method– Numerical techniques for analyzing PICs

UNIT II MATERIALS AND FABRICATION TECHNOLOGY (9 Hours)

Substrate materials for optical integrated circuits– Deposited thin films– Substitutional dopant atoms– Carrier-concentration reduction waveguide– epitaxial growth– Electro optic waveguide– Oxidation– Methods for fabricating channel waveguides– Polymers: Types– Processing– Application of polymer waveguide interconnection– Polymer and optical waveguide devices.

UNIT III INTEGRATED LASER DIODES AND DETECTORS (9 Hours)

Laser Diode – New Semiconductor materials for new wavelengths – Advanced Heterojunction Laser Structures – Distributed Feedback Lasers – Fabrication Techniques – Nanoscale DFB Lasers - Monolithically Integrated Direct Modulators –– Waveguide Photodiodes –Factors Limiting Performance of Integrated Detectors

UNIT IV OPTOELECTRONIC INTEGRATED CIRCUITS & AMPLIFIERS (9 Hours)

Electro-optic devices – Acoustic-Optic devices - Thermo-Optic devices – Magneto-optic devices – Integration Techniques – OEIC Transmitters and Receivers – Integrated Semiconductor Optical Amplifiers – Comparison of Ion-Doped Fiber Amplifiers with SOAs

UNIT V APPLICATIONS OF FIBER OPTIC INTEGRATED CIRCUITS (9 Hours)

Nano Photonics – Photonic crystals – Nano Photonic Devices – Resonators – Sensors – Micro-Opto-Electro-Mechanical Systems – Basic equations of Mechanics – Thin Membrane Devices – Torsional Devices - Bio Photonic applications – Devices and System for telecommunication.

LEARNING RESOURCES

1. Robert G. Hunsperger, “Integrated Optics – Theory and Technology”, Sixth Edition, Springer, Verlag, 2009
2. C. R. Pollock and M. Lip Son, “Integrated Photonics, Kluwer Pub., 2003.
3. GinesLifante, “Integrated Photonics – Fundamentals”, Wiley Publications, 2003
4. Joachim Piprek, “Optoelectronic Devices – Advanced Simulation and Analysis”, Springer, Verlag, 2005.
5. L. A. Coldren, S. W. Corzine, M. L. Masanovic, “Diode Lasers and Photonic Integrated Circuits”, Second Edition, Wiley Publications, 2012
6. Ronald W. Waynant, Marwood N. Ediger, “Electro-Optics Handbook”, Second Edition, McGraw Hill Publications.2000

WM2140	**BRAGG FIBERS: ANALYSIS AND APPLICATIONS**	**L**	**T**	**P**	**C**
	Total contact hours: - 45	3	0	0	3
	Prerequisite: NIL				
Purpose					
To understand and analyze the structure and working of Bragg Fibers.					
Instructional Objectives: At the end of this course, learner will be able to					
1.	Understand the structure of Bragg fibers				
2.	Analyze the properties and modes in Bragg fibers				
3.	Calculate bending and differential losses				
4.	Determine and analyze optical and dispersion losses				
5.	Various applications of Bragg fibers				

UNIT I INTRODUCTION (9 hours)

Theory of Bragg fibers: Introduction – Matrix method in concentric stratified fiber – Bragg Fibers – Mode Characteristics and Leak consideration.

Bragg reflection waveguide: Introduction – Surface leaks in Layered Dielectric: Transverse Wave number representation – Modified Transverse Representation – Solution using spectral function – Dielectric Slabguides: Transverse Resonance – Scattering Experiment –Orthogonality Relations – Solution of the scattering problem – Bragg Reflection waveguide

UNIT II ANALYSIS AND MODES IN BRAGG FIBERS (9 hours)

Analysis methods: Transfer matrix method- Asymptotic method- Galerkin method- Asymptotic analysis of silicon based Bragg fibers

Modes: Modes in Bragg fiber- Hybrid modes- Modes of Bragg fiber with cladding made of delta functions.

UNIT III LOSSES IN BRAGG FIBERS (9 hours)

Bending loss: Bending losses in straight waveguide approximation and Edge guided mode approximation – Bending loss in Dielectric tube leaky waveguide- Differential loss

UNIT IV OPTICAL LOSS AND DISPERION LOSS (9 hours)

Optical power flow- Optical power flow under quarter wave stack condition- fractional optical power- Fiber losses- Contour loss curves- Confinement factors: Expression and properties- Optimum index for confinement factor.

Dispersion: Group velocity dispersion- Compensation

UNIT V APPLICATIONS (9 hours)

VCSEL- Accelerometer- Bio sensing applications- Broadband transmissions

LEARNING RESOURCES

1. PochiYeh and AmnonYariv, "Theory of Bragg fiber",Journal of Optical society of America., vol. 68, pp. 1196-1201, 1978
2. Steven R. A. Dods, "Bragg reflection waveguide", Journal of Optical society of America, 1989
3. ShangpingGuo, SachariaAlbin, " Comparative analysis of Bragg Fibers",Journal of Optical Society of America, 2004
4. Yong Xu, and AmnonYariv, "Asymptotic analysis of silicon based Bragg fibers", Journal of Optical Society of America, 2003
5. Jun-ichi Sakai, "Hybrid modes in a Bragg fiber: general propertiesand formulas under the quarter-wavestack condition", Journal of Optical Society of America, 2005.
6. Chunguang Jing, W.M. Liu, W. Gai, J.G. Power,Thomas Wong, "Mode analysis of a multilayered dielectric-loadedaccelerating structure", Nuclear Instruments and Methods in Physics Research, Elsevier, 2004
7. Mitsunobu Miyagi, "Bending losses in hollow and dielectric tube leaky waveguides", Journal of Applied Optics, 1981.
8. C. Martijn de Sterke and I. M. Bassett, "Differential losses in Bragg fibers", Journal of Applied Physics, 1994.
9. Jun-ichi Sakai, "Optical loss estimation in a Bragg fiber", Optical Society of America, 2007.
10. Jun-ichi Sakai," Optical power confinement factor in a Bragg fiber", Journal of Optical Society of America, 2007.
11. Jun-Ichi Sakai and KazukiKuramitsu," Group-velocity dispersion in a Bragg fiber", Journal of Optical Society of America, 2008.
12. George Ouyang, Yong Xu, and AmnonYariv," Theoretical study on dispersioncompensation in air-core Bragg fibers", Journal of Optical Society of America, 2002.
13. *M.G. Greally,MJ. Steer, J.E.F. Fro, J. Woodheaa, J.S. Roberts andMJ Adams, "*Top Spatial Filter Bragg Waveguide VCSEL", IEEE 1998.
14. Amit Mizrahi and Levi Schächter, "Optical Bragg accelerators", The American Physical Society, 2004.
15. K. Milenko, D.J.J. Hu, P.P. Shumand T.R. Wolinski, "Hollow-Core Bragg Fiber for Bio-Sensing Applications", Optical and Acoustical Methods in Science and Technology, 2010
16. Dora Juan Juan Hu, Gandhi Alagappan, Yong-Kee Yeo, Perry Ping Shum and Ping Wu, "Broadband transmission in hollow-core Bragg fibers with geometrically distributed multilayered cladding", Journal of Optical society of America, 2010.

WM2141	FIBER OPTICS COMPONENT AND DEVICES	L	T	P	C
	Total Contact Hrs. - 45	3	0	0	3
	Prerequisite: Fiber optics				
Purpose					
To understand the fundamental of fiber optic devices and component					
OBJECTIVES					
1. To study about fundamentals of optical fiber and their application.					
2. To understand the industrial application and relevant principle of optical fibers.					
3. To study the laser fundamentals and their interaction with optical fibers.					
4. To study about various directional coupler and their uses in instrumentations.					
5. To understand the theory, manufacturing and types off fiber grating.					

UNIT I OPTICAL FIBRES AND THEIR PROPERTIES (9 hours)

Principles of light propagation through a fiber - Different types of fibres and their properties, fiber characteristics – Absorption losses – Scattering losses – Dispersion – Connectors and splicer's – Fiber termination – Optical sources –LED- Double heterojunctions- coupling with optical fibres and efficiency– Optical detectors – photoconductivity – photovoltaic effect- performance parameter and noise equivalent power.

UNIT II INDUSTRIAL APPLICATION OF OPTICAL FIBRES (9 hours)

Fiber optic sensors – chemical resistant optical fibre- embedded sensors for structural health monitoring. Infrastructural and speciality optical fibres- for energy and nuclear applications. Fiber optic instrumentation system – Different types of modulators – Interferometric method of measurement of length – Moire fringes – Measurement of pressure, temperature, current, voltage, liquid level and strain.

UNIT III LASER FUNDAMENTALS (9 hours)

Fundamental characteristics of lasers – Einstein's coefficients; Population inversion; Amplification of stimulated emission; Laser instrumentation fundamentals: Cavity, resonator and pumping processes; Gain medium- three level and four level lasers – properties of laser – laser modes – resonator configuration – q-switching and mode locking – cavity damping – types of lasers – gas lasers, solid lasers, liquid lasers, semiconductor lasers

UNIT IV DIRECTIONAL COUPLERS (9 hours)

Analysis, fabrication and characterization: Fused and polished fiber couplers application in power dividers, wavelength division multiplexing, Interleavers and loop mirrors: Fiber half-block devices and application in polarizers, and wavelength filters.

UNIT V FIBER GRATING (9 hours)

Manufacturing- interference- sequential writing- photomasking- point by point- theory. Types of grating- type I, type IA, type II, regenerated, apodized, chirped, Short and long period gratings. Analysis, fabrication and characterization: Applications of fiber gratings in add-drop multiplexing, gain flattening, dispersion compensation and wavelength locking and sensing.

TOTAL: 45 PERIODS

REFERENCES

1. J.M. Senior, ‘Optical Fiber Communication – Principles and Practice’, Prentice Hall of India, 1985.
2. J. Wilson and J.F.B. Hawkes, ‘Introduction to Opto Electronics’, Prentice Hall of India, 2001.
3. Introduction to Fiber Optics, Ajoy Ghatak and K Thyagarajan, Cambridge University Press, 1998. Reprinted by Foundation Books, New Delhi.
4. Guided Wave Optics, Selected Topics, Ed. Anurag Sharma, Viva Books Private Limited, 2005
5. Polarization of light with application in optical fiber; Ajoy Ghtak and Arun Kumar,Tata McGraw Hill, New Delhi 2012.
6. Fundamentals of Optical Waveguides, K Okamoto, Academic Press, 2006.
7. G. Keiser, ‘Optical Fibre Communication’, McGraw Hill, 1995.
8. M. Arumugam, ‘Optical Fibre Communication and Sensors’, Anuradha Agencies, 2002.
9. John F. Read, ‘Industrial Applications of Lasers’, Academic Press, 1978.

WM2142	**FIBER OPTIC SENSORS**	**L**	**T**	**P**	**C**
	Total Contact Hrs. - 45	3	0	0	3
	Prerequisite: Basic knowledge about fiber optic sensor				
Purpose					
To understand the design model of fiber optic sensor					
OBJECTIVES					
6. To familiarize about fiber optic sensor technology					
7. To study various types of grating sensors.					
8. To acquire knowledge about magnetic sensors					
9. To know about Chemical and Biosensors.					
10. To gain knowledge about the utility of fiber sensors in varied fields.					

UNIT I: SENSOR TECHNOLOGY (9 hours)

Meridional and skew rays- bent fibres – Mechanism of attenuation- mode pattern – polarization maintaining fibres. The Emergence of Fiber Optic Sensor Technology-Optical Fibers-Light Sources-Optical Detectors- Optical Modulators- Intensity-Based and Interferometric Sensors-Fabry perot, MachZender, Michelson and Sagnac interferometer.

UNIT II: GRATING SENSORS (9 hours)

Bragg grating concept- Bragg grating sensors – distributed sensing- wavelength detection schemes- harsh environment. Multimode Grating and Polarisation Sensors- Sensors Based on Relative Movement of Opposed Gratings-Grating Period Modulation-Sensors Based on the Photoelastic Effect-Retardation Plates- Fiber Grating Sensors

UNIT III: DISTRIBUTED AND MAGNETIC SENSORS (9 hours)

Fiber Optic Distributed and Magnetic Sensor-Distributed Sensing- Basic Principles of Sensor Multiplexing- Interferometric Sensor Multiplexing- Faraday effect sensors-Magneto strictive-

Magnetic rotation-based sensors- phase modulation – Lorentz force sensors-Evanescent Field Absorption Sensors. Introduction

UNIT IV: CHEMICAL AND BIOSENSOR **(9 hours)**
Fiber Optic Chemical and Biosensor: Reagent Mediated Sensor-Humidity sensor – pH sensor – Hydrogen sensor – CO_2 sensor – Ammonia sensor – Chloride sensor – Glucose sensor – Oxygen sensor – Surface Plasmonic Resonance based sensor. Placement of bio sensors- DNA sensors- Microbial sensors- ozone sensors and metastatic cancer bio sensors.

UNIT V: APPLICATIONS **(9 hours)**
Industrial Applications of Fiber Optic Sensors: Temperature – Pressure – fluid level – flow – position – vibration – rotation measurements – Current -voltage measurement – Chemical analysis. Introduction to smart structures – Applications –skins.

TOTAL: 45 Periods

REFERENCES

1. Eric Udd, William B. Spillman, Jr., "Fiber Optic Sensors: An Introduction for Engineers and Scientists", John Wiley and Sons 2011
2. Bhagavānadāsa Gupta, Banshi Das Gupta, "Fiber Optic Sensors: Principles and Applications", New India Publishing 2006
3. David A. Krohn, "Fiber optic sensors: fundamentals and applications", ISA Publishing 2000
4. Francis T.S. Yu, Shizhuo Yin, Paul B. Ruffin, "Fiber Optic Sensors", CRC Press Publisher 2010
5. B.Culshaw and J.Daykin, "Optic fiber Sensors Systems and Applications", Artech House 1989
6. KTV Grattan & BT Meggit, "Optical fiber sensor technology & Applications", Kluwer Academic 2000.

WM2143	**COMPRESSED SENSING METHODS FOR SIGNAL PROCESSING**	**L**	**T**	**P**	**C**
	Total Contact Hrs - 45	3	0	0	3
	Prerequisite : Basic knowledge of compression algorithms				
Purpose					
To understand the concept of Compressed sensing and to acquire knowledge about its application in signal processing.					
OBJECTIVES					
1. To acquire knowledge on the basics and applications of compressed sensing					
2. To understand basic algorithms for signal reconstruction					
3. To study the techniques and advantages of block compressed sensing					
4. To introduce the concepts of adaptive compressed sensing and adaptive matrix design					
5. To Study the compressed sensing models for video					

UNIT I INTRODUCTION (9 hours)

Shannon nyquist theorem, Compressed sensing basics – Sparsity, Compressibility, Stability, Restricted Isometry Property, Coherence, Single pixel camera , Random matrices, Geometry of sparse signals, Design of CS matrices, Structure in CS matrices – Subsampled incoherent bases, Structurally subsampled matrices, Subsampled circulant matrices, Seperable matrices, Applications of CS – Error correction, Imaging, Radar

UNIT II BASIC ALGORITHMS (9 hours)

CS recovery problems, Algorithm properties, Greedy algorithms – Orthogonal matching pursuit, Stagewise orthogonal matching pursuit, Compressive sampling matching pursuit, Thresholding based algorithms – Basic thresholding, Iterative hard thresholding, Hard thresholding pursuit, subspace pursuit

UNIT III BLOCK COMPRESSED SENSING (9 hours)

Drawbacks of conventional compressed sensing, Need for Block compressed sensing, block based image representation – Advantages, Geometric interpretations, BCS techniques – Reweighted sampling, Coefficient random permutation, Adaptive sampling, Granular computing based clustering, weighted overlapped block compressed sensing

UNIT IV ADAPTIVE COMPRESSED SENSING (9 hours)

Adaptive CS – Advantages, geometric interpretations, Adaptive CS algorithms - CASS algorithm STD-BCS-SPL Algorithm - Framework , Adaptive sampling rate allocation procedure, Perceptual compressed sensing – Human perception characteristics, sampling scheme, Adaptive reweighted BCS – sampling scheme, properties, measurement allocation, allocation factors, Adaptive CS based on human vision system, Adaptive matrix design - Near orthogonal CS, Maximum energy CS

UNIT V COMPRESSED SENSING MODELS FOR VIDEO (9 hours)

Temporal compressive sensing for video – Temporal resolution of video cameras , Motion blur model and camera exposure modulation, CS-Video model, Active video CS measurement techniques, Passive video CS technique, CS video reconstruction, Gaussian mixture model for CS video, Adaptive CS video strategies, Video frames recovered from snapshot using CS

TEXTBOOKS

1. Simon Foucart, Holger Raghut, “A Mathematical Introduction to Compressive sensing”, Birkhauser, Springer, 2013.
2. Holger Boche, Robert Calderbank, Gitta Kutyniok, Jan, “Compressed sensing and its applications”, Birkhauser, Springer, 2013.
3. Mangia, Mauro, Fabio Pareschi, Riccardo Rovatti, and Gianluca Setti. "Adaptive matrix design for boosting compressed sensing." IEEE Transactions on Circuits and Systems I: Regular Papers 65, no. 3 (2018): 1016-1027.
4. Malloy, Matthew L., and Robert D. Nowak. "Near-optimal adaptive compressed sensing." IEEE Transactions on Information Theory 60, no. 7 (2014): 4001-4012.
5. Gao, Zhirong, Chengyi Xiong, Lixin Ding, and Cheng Zhou. "Image representation using block compressive sensing for compression applications." Journal of Visual Communication and Image Representation 24, no. 7 (2013): 885-894

6. You, Hanxu, Lianqiang Li, and Jie Zhu. "A Weighted Overlapped Block-Based Compressive Sensing in SAR Imaging." IEICE TRANSACTIONS on Information and Systems 100, no. 3 (2017): 590-593
7. Wang, Fang, Aixin Zhang, Jianhua Li, and Shenghong Li. "Perceptual Compressive Sensing Scheme Based on Human Vision System." In Computer and Information Science (ICIS), 2012 IEEE/ACIS 11th International Conference on, pp. 351-355. IEEE, 2012.
8. Duarte, Marco F., and Yonina C. Eldar. "Structured compressed sensing: From theory to applications." IEEE Transactions on Signal Processing 59, no. 9 (2011): 4053-4085.
9. Zhu, Shuyuan, Bing Zeng, and Moncef Gabbouj. "Adaptive reweighted compressed sensing for image compression." In Circuits and Systems (ISCAS), 2014 IEEE International Symposium on, pp. 1-4. IEEE, 2014.

WM2144	**IOT: Devices and Security**	**L**	**T**	**P**	**C**
	Total Contact Hrs - 45	3	0	0	3
	Prerequisite : Basic knowledge of computing				
Purpose					
To understand the architecture and basic concepts of IoT					
OBJECTIVES					
11. To understand the architecture of Internet of Things and connected world					
12. To understand IoT framework and design principles of M2M Communication					
13. To introduce the concepts of programming using python					
14. To explore the use of various physical devices and interfaces					
15. To identify vulnerabilities and attacks involving in IoT					

UNIT I: INTRODUCTION TO INTERNET OF THINGS (IoT) (9 hours)

Definition and characteristics of IoT, physical design of IoT, logical design of IoT, IoT enabling technologies, IoT levels and deployment, domain specific IoTs.

UNIT II: IoT AND M2M (9 hours)

Introduction, M2M, difference between IoT and M2M, software defined networking (SDN) and network function virtualization (NFV) for IoT, basics of IoT system management with NETCONF-YANG.

UNIT III: IoT ARCHITECTURE AND PYTHON (9 hours)

IoT Architecture: State of the art introduction, state of the art; Architecture reference model: Introduction, reference model and architecture, IoT reference model.

Logical design using Python: Installing Python, Python data types and data structures, control flow, functions, modules, packages, file handling.

UNIT IV: IoT PHYSICAL DEVICES AND ENDPOINTS (9 hours)

Introduction to Raspberry Pi interfaces (Serial, SPI, I2C), programming Raspberry PI with Python, other IoT devices

UNIT V: IoT PRIVACY AND SECURITY **(9 hours)**

Iot refernce model, security threats, security Requirements, IoT security – protocols, gateway and security, routing attacks, bootstraping and authentication, authorization mechanisms, security framework for IoT – Light weight cryptography, Asymmetric LWC algorithm, privacy in IoT networks – secure data aggregation, Enigma, zero knowledge protocols, privacy in beacons

TEXTBOOKS

1. Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach" , Universities Press, 2015
2. Rajkumar Buyya, Amir vahid dastjerdi, "Internet of things principles and paradigms" , Elsevier, 2016
3. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things", Cisco Press, 2017
4. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1 st Edition, Apress Publications, 2013
5. Olivier Hersent, David Boswarthick, Omar Elloumi, "The Internet of Things – Key applications and Protocols", Wiley, 2012.
6. Jan Holler, Vlasios Tsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014. .

WM2145	MATHEMATICAL METHODS FOR SIGNAL PROCESSING	L	T	P	C
	Total Contact Hours: 45	3	0	0	3
	Prerequisites: Probability and Linear Algebra				
Purpose					
To understand mathematical techniques used for signal estimation.					
Objectives					
1. To acquire knowledge on fundamentals of mathematical models.					
2. To get familiar with the signal detection and estimation techniques.					
3. To gain knowledge on Kalman filter as estimator.					

UNIT I – FUNDEMENTALS OF SIGNAL PROCESSING **(9 hours)**

Models for linear systems and signals- Linear discrete-time models, Stochastic MA and AR models, Continuous-time notation, Issues and applications, Identification of the modes, Control of the modes.

Gaussian random variables and random processes - Conditional Gaussian densities, Markov and Hidden Markov Models.

UNIT II – DETECTION AND ESTIMATION (9 hours)

Detection and estimation theory, Game theory and decision theory, Randomization, Special cases, Conditional expectation, Transformations of random variable, Sufficient statistics- Examples, Complete sufficient statistics, Exponential families.

UNIT III - DETECTION THEORY (9 hours)

Introduction to hypothesis testing, Neyman-Pearson theory- Simple binary hypothesis testing, The Neyman-Pearson lemma, Application of the Neyman-Pearson lemma, The likelihood ratio and the receiver operating characteristic (ROC), Bayes decision theory, The Bayes principle, The risk function, Some M-ary problems, Maximum-likelihood detection.

UNIT IV – ESTIMATION THEORY (9 hours)

The maximum-likelihood principle, ML estimates and sufficiency, Estimation quality- The score function, The Cramiir-Rao lower bound, Asymptotic properties of maximum-likelihood estimators, Minimum-variance unbiased estimators, The linear statistical model, Applications of ML estimation, Bayes estimation theory, Bayes estimation with the Gaussian distribution.

UNIT V - KALMAN FILTER (9 hours)

State-space signal model, Kalman filter I: The Bayes approach, Kalman filter II: Innovations, Discrete-time Kalman filter, Comparison with the RLS adaptive filter algorithm, Numerical considerations: Square-root filters, Application in continuous-time systems, Extensions of Kalman filtering to nonlinear systems, Smoothing.

REFERENCES

1. Moon, Todd K., and Wynn C. Stirling. "*Mathematical methods and algorithms for signal processing*". Vol. 1. Upper Saddle River, NJ: Prentice hall, 2000.
2. Scharf, Louis L., and Cédric Demeure. "*Statistical signal processing: detection, estimation, and time series analysis*". Vol. 63. Reading, MA: Addison-Wesley, 1991.
3. Ristic, Branko, Sanjeev Arulampalam, and Neil Gordon. "*Beyond the Kalman filter: Particle filters for tracking applications*". Artech house, 2003.
4. Stark, Henry, and John W. Woods. "*Probability and Random Processes with Applications to Signal Processing*". 2nd Edition, Pearson Higher Ed, 2014.

WM2146		L	T	P	C
	Underwater Acoustic Signal Processing	**3**	**0**	**0**	**3**
	Total contact hours: 45				
	Prerequisite: Nil				

PURPOSE: To understand the basics of Ambient noise, Underwater Signals and Random functions	
INSTRUCTIONAL OBJECTIVES: To learn about	
1.	To acquire knowledge on basics of Ambient noise
2.	To acquire knowledge on basics of Underwater Signals
3.	To know the basic concepts of Filters and its Random functions

Unit – I: Fundamentals of Underwater Acoustics **(9 hours)**

The Ocean acoustic environment, measuring sound level, Sources and receivers, relevant units, sound velocity in sea water, typical vertical profiles of sound velocity, Sound propagation in the Ocean- characteristic sound propagation paths-deep water and shallow water, Range dependent environment. Sound attenuation in sea water, Bottom Loss, Surface bottom loss and volume scattering, Snell's law for range dependent Ocean.

Unit-II: Ambient noise in the sea **(9 hours)**

Sources of ambient noise-introduction, different frequency bands of ambient noise, process of surface noise generation, shallow water, variability of ambient noise, spatial coherence of ambient noise, directional characteristics of ambient noise, intermittent sources of noise-biological & non biological (rain, earthquakes, explosions and volcanoes).

Unit-III: Signals, filters and Random functions **(9 hours)**

Fourier representations, filters and noise, digital filter design techniques, temporal resolution and bandwidth of signals, signal to noise power ratio, Estimates of auto-covariance, power spectrum, cross covariance and cross spectrum.

Unit-IV: Characteristics of sonar systems **(9 hours)**

Sonar systems, active and passive sonar equations, transducers and their directivities, Sensor array characteristics-array gain, receiving directivity index, beam patterns, shading and super directivity, adaptive beamforming.

Unit-V: DSP processors **(9 hours)**

Architecture of ADSP 218x, architecture of TMS 3200541X. **Case study:**

1. Signal processing of ocean ambient noise data.
2. Beamforming of vertical linear array data.

References

1. Principles of Underwater Sound by Robert J Urick
2. Ambient noise in the sea by Robert J.Urick
3. Acoustical Oceanography : Principles and Applications by Clay & Medwin
4. Fundamental of ocean acoustics by L.M.Brekhovskikh and Yu.P.Lysanov
5. Sonar signal processing by Richard 0.Nielsen
6. DAP processor manuals.

<table>
<tr><td rowspan="3">WM2147</td><td>PRINCIPLES OF UNDERWATER COMMUNICATION SYSTEMS</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Total contact hours - 45</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Prerequisite: Digital Communication Systems</td><td colspan="4"></td></tr>
<tr><td colspan="6">PURPOSE</td></tr>
<tr><td colspan="6">Understand the basics of Underwater Acoustics, Sonar systems, Oceanographic Instrumentation.</td></tr>
<tr><td colspan="6">OBJECTIVES</td></tr>
<tr><td colspan="6">4. To acquire knowledge on basics of Underwater Acoustics.</td></tr>
<tr><td colspan="6">5. To acquire knowledge on Characteristics of Sonar systems.</td></tr>
<tr><td colspan="6">6. To know the basic concepts of oceanographic instrumentation, underwater sensors and noises.</td></tr>
</table>

Unit – I: Fundamentals of Underwater Acoustics (9 hours)

The Ocean acoustic environment, measuring sound level, Sources and receivers, relevant units, sound velocity in sea water, typical vertical profiles of sound velocity, Sound propagation in the Ocean- characteristic sound propagation paths-deep water and shallow water, Range dependent environment. Sound attenuation in sea water, Bottom Loss, Surface bottom loss and volume scattering, Snell's law for range dependent Ocean.

Unit-II: Characteristics of sonar systems (9 hours)

Sonar systems, active and passive sonar equations, transducers and their directivities, Sensor array characteristics-array gain, receiving directivity index, beam patterns, shading and super directivity, adaptive beamforming

Unit-Ill Various Underwater Sensors (9 hours)

Sonars – Active & passive sonars, hydrophones, DAS, ROV, AUV, Sidescan sonar, Echo sounder, MBEC, Sub bottom profiler, magnetometer, dredger, sensors application in shallow water and deep water.

Unit-IV Underwater Noises (9 hours)

Basic Concept of noises in underwater- Types of noises — natural , man made, ambient noise types -seismic, wind, biological, lobsters , dolphin, shipping, turbulence noise, rain etc., Study on location based noises, Comparison between various noises in underwater. Case study on noises.

Unit-V Oceanographic Instrumentation (9 hours)

Descriptions of research vessels, cruise, position fixing in the sea; sampling devices — Grab samplers, bottom samplers, dredges, sediment traps, boomerang samplers, water samplers, Winches, temperature measurement instruments, tools for studying ocean floor topography.

References

1. Principles of Underwater Sound by Robert J Urick.
2. Acoustical Oceanography: Principles and Applications by Clay & Medwin.
3. Fundamental of ocean acoustics by L.M.Brekhovskikh and Yu.P.Lysanov.
4. J.J. Bhatt. Oceanography — Exploring the Planet Ocean. D. Van. Nostrand Company, New York, 1994.
5. Gross, M.G. Principles of Oceanography, 7th Edition, Prentice-Hall, 1995.
6. Ask, T., Handbook of Marine Surveying, Sheridan House, 2007

WM2148	PHOTONIC CRYSTALS: ANALYSIS AND APPLICATIONS	L	T	P	C
	Total contact hours: - 45	3	0	0	3
	Prerequisite: NIL				

Purpose	
To understand and analyze the structure and working of Photonic crystals.	
Instructional Objectives: At the end of this course, learner will be able to	
1.	Understand the structure of Photonic crystals
2.	Analyze the numerical methods for Photonic crystals
3.	Analyze different physical phenomena of Photonic crystals
4.	Understand the fabrication techniques for Photonic crystals
5.	Various applications of Photonic crystals

UNIT I: INTRODUCTION (9 hours)

Photonic crystals: Introduction –Optical properties-Scattering regime – Regime operation of Photonic crystals Photonic crystals waveguide: Introduction – Surface leaks in Layered Dielectric: Transverse Wave number representation — Photonic crystals as low loss mirrors: Photonic band gap effects – Photonic crystals for out of bandgap operation – Solution of the scattering problem – Crystal Reflection waveguide

UNIT II: NUMERICAL METHODS FOR PHOTONIC CYSTALS (9 hours)

Analysis methods: Transfer matrix method- Plane wave expansion method- Finite difference time domain-Finite element method-Analysis of cavity quality factor–Density of states (DOS)

UNIT III: DIFFERENT PHYSICAL PHENOMENA OF PHOTONIC CYSTALS (9 hours)

Anderson localization - Necklace states-co-localization of photon and phonon- Decay in oscillation of the average light transmission as a function of the sample length-Control of average light transmission as a function of disorder

UNIT IV: FABRICATION TECHNOLOGYOF ONE DIMENSIONAL PHOTONIC CRYSTALS (9 hours)

Sol-gel method- Spin coating method- Plasma Enhanced Chemical Vapor Deposition method- Molecular Beam Epitaxy method- Metal Organic Chemical Vapor Deposition method- Physical Vapor Deposition method- Thermal deposition method

UNIT V: APPLICATIONS OF ONE DIMESIONAL PHOTONIC CYSTALS (9 hours)

1D photonic crystal in photovoltaic- Microwave- Optical communication- Sensing-Imaging

LEARNING RESOURCES

1. John, Sajeev. "Strong localization of photons in certain disordered dielectric superlattices." Physical review letters 58, no. 23 (1987): 2486.
2. Arregui, Guillermo, Norberto Daniel Lanzillotti-Kimura, C. M. Sotomayor-Torres, and Pedro David García. "Anderson Photon-Phonon Colocalization in Certain Random Superlattices." Physical review letters 122, no. 4 (2019): 043903.

3. Topolancik, Juraj, B. Ilic, and Frank Vollmer. "Experimental observation of strong photon localization in disordered photonic crystal waveguides." Physical review letters 99, no. 25 (2007): 253901.

4. Huisman, S. R., GeorgiosCtistis, SørenStobbe, A. P. Mosk, Jennifer Lynn Herek, AartLagendijk, Peter Lodahl, Willem L. Vos, and PepijnWillemszoon Harry Pinkse. "Measurement of a band-edge tail in the density of states of a photonic-crystal waveguide." Physical Review B 86, no. 15 (2012): 155154.

5. Ilinykh, V. A., and L. B. Matyushkin. "Fabrication of one-dimensional photonic crystals by sol-gel method." In *2016 IEEE NW Russia Young Researchers in Electrical and Electronic Engineering Conference (EIConRusNW)*, pp. 47-50. IEEE, 2016.

6. Colodrero, Silvia, Manuel Ocana, and Hernán Míguez. "Nanoparticle-based one-dimensional photonic crystals." *Langmuir* 24, no. 9 (2008): 4430-4434.

7. Subramanian, A. Z., Pieter Neutens, Ashim Dhakal, Roelof Jansen, Tom Claes, Xavier Rottenberg, Frédéric Peyskens et al. "Low-loss singlemode PECVD silicon nitride photonic wire waveguides for 532–900 nm wavelength window fabricated within a CMOS pilot line." *IEEE Photonics Journal* 5, no. 6 (2013): 2202809-2202809.

8. Asakawa, Kiyoshi, Yoshimasa Sugimoto, Yoshinori Watanabe, Nobuhiko Ozaki, Akio Mizutani, Yoshiaki Takata, Yoshinori Kitagawa et al. "Photonic crystal and quantum dot technologies for all-optical switch and logic device." *New Journal of Physics* 8, no. 9 (2006): 208.

9. Povey, I. M., M. Bardosova, F. Chalvet, M. E. Pemble, and H. M. Yates. "Atomic layer deposition for the fabrication of 3D photonic crystals structures: Growth of Al2O3 and VO2 photonic crystal systems." *Surface and Coatings Technology*201, no. 22-23 (2007): 9345-9348.

10. Liu, GuangPing, YiMin Xuan, YuGe Han, and Qiang Li. "Investigation of one-dimensional Si/SiO 2 hotonic crystals for thermophotovoltaic filter." *Science in China Series E: Technological Sciences* 51, no. 11 (2008): 2031-2039.

11. Faraon, Andrei, Dirk Englund, Douglas Bulla, Barry Luther-Davies, Benjamin J. Eggleton, Nick Stoltz, Pierre Petroff, and Jelena Vučković. "Local tuning of photonic crystal cavities using chalcogenide glasses." *Applied Physics Letters* 92, no. 4 (2008): 043123.

12. Braun, Paul V., Stephanie A. Rinne, and Florencio García-Santamaría. "Introducing defects in 3D photonic crystals: state of the art." *Advanced Materials* 18, no. 20 (2006).

WM 2149	INTRODUCTION TO INTERNAL WAVES	L	T	P	C
	Total Contact Hrs. – 45	3	0	0	3
	Prerequisite: Basic knowledge of ocean properties and signal processing				
PURPOSE					
To understand the physical characteristics of oceanic internal waves with special emphasis on Indian Ocean.					
INSTRUCTIONAL OBJECTIVES					
1.	To understand the basics of Physical oceanography and properties of sea water.				
2.	To study the internal wave dynamics.				
3.	To understand various methods of measurements				
4.	To explore various applications of Internal waves				
5.	To explore various detection techniques of Internal waves.				

Unit I - Introduction to Physical Oceanography (9 Hours)

History, Current & Future Oceanographic research – Properties of sea water – Temperature, Salinity, Density, pH, Sound Speed, light – Spatial & Temporal Distributions – Waves, Tides, Currents

Unit II - Internal Waves (9 Hours)

Basic Properties- Amplitude, Wavelength, Speed – Frequency limits, high and low frequency internal wave, Brant Vaisala Frequency, Inertial Frequency – Dispersion Relation – Two layer approximation –Factors affecting – Propagation of Internal waves

Unit III - Measurement of Internal Waves (9 Hours)

Methods of Measurement – Mooring, Profiling, Satellite imagery – basic theories, merits, demerits.

Unit IV - Applications of Internal Waves (9 Hours)

Ocean dynamics –Ocean modeling– Underwater acoustic propagation – Submarine Detection – Climate change – Deployment of Arrays.

Unit V - Internal Wave Detection (9 Hours)

Detection of Coastlines in SAR images –Wavelet Analysis in SAR Ocean Image Profiles–Feature Extraction of Oceanic Internal waves– Wave Packet Characterization using EMD, –Wave detection using MODIS– Determination of wave properties – Wave detection using PCANet.

References

1. Paul R. Pinet : Invitation to Oceanography, 6th edition, Jones & Bartlett learning, 2013.
2. G. L. Pickard and W. J. Emery. *Descriptive physical oceanography*. Perg- amon Press, Oxford, 5th edition, 1990
3. Andreas Niedermeier, Edzard Romaneeßen, and Susanne Lehner, Detection of Coastlines in SAR Images usingWavelet Methods, IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 38, NO. 5, SEPTEMBER 2000.
4. Joseph A. R´odenas and Ren´e Garello, *Senior Member*, *IEEE*, Wavelet Analysis in SAR Ocean Image Profiles for Internal Wave Detection and Wavelength Estimation, IEEE

TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 35, NO. 4, JULY 1997.

5. Chih-Chung Kao, Ming-Jer Huang, Ying-Jang Yang, Feature Extraction of Oceanic Internal Waves Based on Remote Sensing Imagery, MAPPS/ASPRS 2006 Fall Conference, Nov 6 – 10, 2006 * San Antonio, Texas.
6. Xilin Gan, Weigen Huang, Jingsong Yang and Bin Fu, Internal Wave Packet Characterization from SAR Images using Empirical Mode Decomposition (EMD), Congress on Image and Signal Processing, 2008.
7. Christopher Jackson, Internal wave detection using the Moderate Resolution Imaging Spectroradiometer (MODIS), JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 112, C11012, doi:10.1029/2007JC004220, 2007.
8. Rafael J.Ramos , Bjorn Lund, HansC.Graber, Determination of internal wave properties from X-Band radar observations, Ocean Engineering vol 36 ,pp. 1039–1047,2009.
9. Shengke Wang*, Qinghong Dong, Lianghua Duan, Yujuan Sun, Muwei Jian, Jianzhong Li and Junyu Dong , A Fast Internal Wave Detection Method Based on PCANet for Ocean Monitoring Journal of Intelligent System. 2017.

<table>
<tr><td rowspan="4">MA2009</td><td></td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>APPLIED MATHEMATICS</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="5">Total Contact hours – 45</td></tr>
<tr><td colspan="5">Prerequisite : Nil</td></tr>
<tr><td colspan="6">PURPOSE</td></tr>
<tr><td colspan="6">To develop analytical capability and to impart knowledge in Mathematical and Statistical methods and their applications in Engineering and Technology and to apply these concepts in engineering problems they would come across.</td></tr>
<tr><td colspan="6">INSTRUCTIONAL OBJECTIVES</td></tr>
<tr><td>1.</td><td colspan="5">At the end of the course, Students should be able to understand Mathematical and Statistical concepts, Discrete Fourier transform, Z transform, queueing theory concepts and apply the concepts in solving the engineering problems.</td></tr>
</table>

UNIT I – BOUNDARY VALLUE PROBLEMS (9 hours)

Solution of initial and boundary value problems - Characteristics - D'Alembert's Solution - Significance of Characteristic curves - Laplace transform solutions for displacement in a long string - a long string under its weight - a bar with prescribed force on one end - free vibration of a string.

UNIT II – SPECIAL FUNCTIONS (9 hours)

Series solutions - Bessel's equation - Bessel Functions - Legendre's equation - Legendre Polynomials - Rodrigue's formula - Recurrence relations - Generating Functions and orthogonal property for Bessel functions of the first kind.

UNIT III – DISCRETE TRANSFORMS (9 hours)

Discrete Fourier Transforms and its properties - Fourier series and its properties - Fourier representation of finite duration sequences - Z-transform - Properties of the region of convergence - Inverse Z-transform - Z-transform properties.

UNIT IV – RANDOM VARIABLES (9 hours)

Review of Probability distributions - Random variables -Moment generating functions and their properties - Functions of Random variables.

UNIT V – QUEUEING THEORY (9 hours)

Single and Multiple server Markovian Queuing models - Customer impatience - Queuing applications.

REFERENCES

1. Veerarajan T, "*Mathematics IV*", Tata McGraw Hill, 2000. (Unit II Chapter 3 Section 3.4 Unit I Chapter 5)
2. Grewal B.S., "*Higher Engineering Mathematics*", Khanna Publishers. 34th Edition (Unit II - Chapter 17 Section 17.3, Unit III Chapter 15)
3. Sankara Rao K., "*Introduction to Partial Differential Equations*", PHI, 1995 (Unit II - Chapter 1, Section 1.3, Chapter 6 Section 6.13)
4. Veerajan T, "*Probability, Statistics and Random Processes*", 2004 (Unit IV - Chapter 1,2,3,4 Unit V - Chapter 5)
5. Taha H.A., "*Operations Research - An introduction*", 7th edition, PH, 1997
6. Churchil R.V., "*Operational Mathematics*". Mc Graw Hill, 1972
7. Richard A. Johnson, Miller and Freund : "*Probability and Statistics for Engineers*", 5th edition, PHI, 1994
8. Narayanan S., Manicavachagom Pillai T.K. and Ramanaiah G., "*Advanced Mathematics for Engineering Students*", Vol. II S. Viswanathan and Co.

		L	T	P	C
CO2201	**NETWORK MANAGEMENT**	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite: Nil				
PURPOSE					
This course is designed to familiarize the student with the design, analysis operation and management of modern data communications networks. The course will provide the student with a working knowledge of the types of communications network management systems and their strengths and weaknesses in solving various information network management problems.					
INSTRUCTIONAL OBJECTIVES					
1.	To understand the fundamental concepts of network management				
2.	To provide an exposure to network security aspects				

UNIT I - OVERVIEW OF NETWORK MANAGEMENT (9 hours)

Network Management: Goals, Organization and Functions, Network and system Management, OSI network management model- Organizational model-Information model, Communication model. Abstract Syntax Notation - Encoding Structure, Macros Functional Model CMIP/ CMIS.

UNIT II - SNMP NETWORK MANAGEMENT **(9 hours)**
SNMP - organizational model - system overview, information model, communication model - Functional model. SNMPv2 system architecture, SNMPv3 architecture, SNMP management: RMON.

UNIT III - BROADBAND ATM NETWORKS **(9 hours)**
ATM Technology - VP, VC, ATM Packet, Integrated service, ATMLAN emulation, Virtual LAN, ATM Network Management - ATM Network reference model, ATM Management Information base, ATM Management, M1, M2, M3, M4 interface

UNIT IV -NETWORK MANAGEMENT TOOLS AND SYSTEMS **(9 hours)**
Network Management Tools, Network Statistics measurement systems, System management.

UNIT V - NETWORK MANAGEMENT APPLICATIONS **(9 hours)**
Configuration management, Fault management, Performance management, Event Correlation Techniques security management, Accounting management, Report Management, Policy Based Management, Services Level Management.

REFERENCES

1. Mani Subramanian, *"Network Management Principles and Practice"*, 2nd Edition Pearson Education India, 2010.
2. Salah aiidarons, Thomas Plevayk, *"Telecommunications Network Technologies and Implementations"*, Eastern Economy Edition IEEE press, New Delhi, 1998
3. Lakshmi G Raman, *"Fundamentals of Telecommunication Network Management"*, Eastern Economy Edition IEEE Press, New Delhi, 1999.

		L	T	P	C
CO2202	**SIMULATION OF COMMUNICATION SYSTEMS and NETWORKS**	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite : Nil				
PURPOSE					
To impart the modeling of communication networks and their simulation.					
INSTRUCTIONAL OBJECTIVES					
To learn about					
1.	Monte Carlo simulations involving random variables and random processes				
2.	Modeling of Communication systems: Transceiver systems				
3.	Communication channels and models,				
4.	Estimation of Parameters and Performance measures in simulation.				

UNIT I - FUNDAMENTALS OF RANDOM VARIABLES AND RANDOM PROCESSES FOR SIMULATION (9 hours)

Random variables – Univariate models – Multivariate models – Transformations of Random variables – Bounds and approximations – Random processes and its models – Transformation of Random processes – Sampling of stationary random processes.

UNIT II - MONTE CARLO SIMULATION AND GENERATION OF RANDOM NUMBERS (9 hours)

Principle of Monte Carlo simulation – Random number generation – Generating independent random sequences – Generating correlated random sequences – Testing of random number generators

UNIT III - MODELING OF COMMUNICATION SYSTEMS: TRANSMITTER AND RECEIVER SUBSYSTEMS (9 hours)

Information sources – Formatting/Source coding – Digital waveforms: Baseband modulation – Line coding: Baseband modulation – Channel coding – Radio frequency and Optical modulation – Demodulation and detection – Filtering – Multiplexing/Multiple access – Radio frequency and Optical carrier sources – Synchronization – Calibration of Simulations.

UNIT IV - COMMUNICATION CHANNELS AND MODELS (9 hours)

Fading and multipath channels – The Almost free-space channel – Conducting and Guided wave media – Finite-state channel models – Methodology for simulating communication systems operating over fading channels.

UNITV - ESTIMATION OF PARAMETERS AND PERFORMANCE MEASURES IN SIMULATION (9 hours)

Preliminaries – Estimating the average level of a waveform – Estimating the average power of a waveform – Estimating the probability density or cumulative distribution function of the amplitude of a waveform – Estimating the power spectral density of a process – Estimating the delay and phase – Estimation of SNR – Estimating performance measures for Digital systems.

REFERENCES

1. Jeruchim, M. C., Balaban, P. and Sam Shanmugam, K., *"Simulation of Communication Systems – Modeling, Methodology and Techniques"*, Plenum Press, New York, Second Edition, 2001.
2. Sklar, B., *"Digital Communications – Fundamentals and Applications",*2nd Edition, Pearson Education India, 2009.
3. Proakis, J. G., *"Digital Communications"*, 5th Edition, McGraw-Hill Higher Education, 2008.

CO2203		L	T	P	C
	LINEAR ALGEBRA	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite : Nil				
PURPOSE					
The purpose of this course is to apply the learned concepts in real world phenomena such as communication networks, traffic flow, and electrical networks, and to use MATLAB to perform matrix computations and to explore and analyze linear algebra concepts.					
INSTRUCTIONAL OBJECTIVES					
1.	Understand several important concepts in linear algebra, including systems of linear equations and their solutions, matrices and their properties, determinants and their properties, vector spaces, linear independence of vectors, subspaces, basis and dimensions of vector spaces, inner product space, linear transformations, eigenvalues and eigenvectors.				
2.	Improve our ability to prove mathematical theorems.				
3.	Improve our ability to think logically, analytically, and abstractly.				
4.	Improve our ability to communicate mathematics, both orally and in writing.				

UNIT I - MATRICES AND SYSTEMS OF EQUATIONS, DETERMINANT (9 hours)
Systems of linear equations – Row echelon form – Matrix algebra – Elementary matrices – Partitioned matrices – The Determinant of a Matrix – Properties of Determinants – Cramer's rule.

UNIT II - VECTOR SPACES AND LINEAR TRANSFORMATIONS (9 hours)
Definition and examples – Subspaces – Linear independence – Basis and dimensions – Change of basis – Row space and Column space – Linear transformations: Definition – Matrix representations

UNIT III - ORTHOGONALITY AND EIGENVALUES (9 hours)
The Scalar product in R – Orthogonal subspace – Least squares problem – Inner product space – Orthonormal sets – The Gram-Schmidt Orthogonalization procedure – Orthogonal polynomials – Eigenvalues and Eigenvectors – Systems of Linear differential equations – Diagonalization – Hermitian matrices – The Singular Value Decomposition – Quadratic forms – Positive defnite matrices – Non-negative matrices.

UNIT IV - NUMERICAL LINEAR ALGEBRA (9 hours)
Floating point numbers – Gaussian elimination – Pivoting strategies – Matrix norms and Condition numbers – Orthogonal transformations – The Eigenvalue problem – Least squares problem.

UNIT V - ITERATIVE METHODS AND CANONICAL FORMS (9 hours)
Power method – Inverse power method – Inverse power method with shifts – Iterative method for finding eigenvalues – Jordan canonical form

REFERENCES

1. Gilbert Strang (2009)," *Introduction to Linear algebra"*, Fourth edition, Wesley Cambridge Press, MA, USA.
2. Keith Mathews (1998*), "Elementary Linear algebra",* University of Queensland, Australia.

3. Jim Hefferon (2001*)," Linear algebra",* Saint Michael's college, Vermont, USA.
4. Steven J. Leon (2009): "*Linear algebra and its applications,*" Eighth edition, Prentice Hall Inc., NY, USA.

CO2204		**L**	**T**	**P**	**C**
	PRINCIPLES OF UNCERTAINITY	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite:Nil				
PURPOSE					
To give the fundamental methods of using uncertainty, randomness in the computer programming.					
INSTRUCTIONAL OBJECTIVES					
1.	To make the student learn uncertainty, randomness, fuzziness and their applications for various problems.				
2.	To develop skills for implementation of these concepts as algorithms and computer programs and learn the mathematical basis for testing and verification.				

UNIT I – INTRODUCTION (9 hours)

Probability- conditional probability and Bayes theorem – Discrete random variables – continuous random variables.

UNIT II – DECISION METHODS (9 hours)

Transformations – making decisions – conjugate analysis – hierarchical structuring of a model – Markov chain Monte Carlo method – Multiparty problem.

UNIT III – MATHEMATICAL LOGIC (9 hours)

Induction – Number theory – graph theory – communication networks – relations and functions.

UNIT IV – COMPUTATIONAL MATHEMATICS (9 hours)

Sums, approximations and asymptotics, - recurrences – counting – generating functions – wired happenings – random walks.

UNIT V – FUZZY LOGIC (9 hours)

Logic and fuzzy systems, Fuzzy arithmetic and the extension principle, monotone measures: belief, plausibility, probability and possibility.

REFERENCE BOOKS

1. Joseph B. Kadane, "Principles of Uncertainty", Chapman and Hall/CRC Texts in Statistical science, 2011.
2. Eric Lehman and Tom Leighton, "Mathematics for Computer Science", MIT Press, 2010.
3. Kishore S.Trivedi, "Probability and Statistics With Reliability, Queuing And Computer Science Applications", 2nd Ed, PHI, 2008.
4. Timothy Ross, "Fuzzy logic and engineering implementation", John Wiley and Sons, 2010.
5. Deyi Li, Yi Du, "Artificial Intelligence with Uncertainty", CRC Press, 2007.

<table>
<tr><td rowspan="4">CO2205</td><td></td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Mathematical Methods for Communication Engineers</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="5">Total Contact Hours – 60</td></tr>
<tr><td colspan="5">Prerequisite : Nil</td></tr>
<tr><td colspan="6">Purpose</td></tr>
<tr><td colspan="6">To develop the ability to use the concepts of matrix algebra for solving problems related to communication networks. To formulate and construct a mathematical model for vector field problems in specific areas of communication engineering. To expose the students to numerical methods and solving differential equations by various techniques.</td></tr>
<tr><td colspan="6">INSTRUCTIONAL OBJECTIVES</td></tr>
<tr><td>1.</td><td colspan="5">At the end of the course, the students will have an in depth understanding of the usefulness of mathematical and statistical methods in communication engineering. The course will cover vector and matrix algebra, differential equations (for understanding Maxwell's electrodynamics, wave equations etc.) and statistical theory (to perceive sources of noise in communication systems, information theory etc.)</td></tr>
</table>

UNIT-I: Matrix Algebra (9 hours)
Solution of simultaneous equations by: matrices and Cramer's rule, derivatives of matrix, Eigen values and Eigen vectors, Introduction to special matrices with complex elements-Hermitian, Unitary and Idempotent Matrices.

UNIT- II: Review of Ordinary Differential Equations and Laplace Transforms (9 hours)
Solution of 1^{st} order differential equations by separation of variables, homogenous first order differential equation, linear first order differential equations and second order differential equation, Simple problems onnon-linear differential equation**,** Laplace Transformation: basic properties and simple problems – L [eatf(t)] – L [tnf(t)]-L[eatt f(t)] –L[f(t)/t] .

UNIT – III: Numerical Methods and Solutions (9 hours)
Scatter diagram, Curve fitting, method of least squares, Numerical Integration: A general quadrature formula for equally spaced arguments, trapezoidal rule, Simpsons one third rule.

UNIT – IV: Vector Analysis (9 hours)
Triple Products: Properties of scalar triple products, vector triple products of three vectors, differentiation of vectors, differentiation of sums and product of vectors, Partial differentiation of vectors: integration of vector functions, Scalar and vector fields: Gradient of a scalar field, directional derivatives, divergence and curl of vector function.

UNIT – V: Probability Distributions and Statistics (9 hours)
Introduction to Binomial and Normal distributions, Basics of Markov Chains, Linear correlation, product moment formula for determining linear correlation coefficient, significance of correlation coefficient, Introduction to linear regression, least square linear regression lines.

REFERENCES

1. John Bird, "Higher Engineering Mathematics", 6^{th} Edition, Elsevier, 2010
2. K.A.Stroud and Dexter J.Booth, "Advanced Engineering Mathematics", 5th edition, Palgrave Macmillan, 2011.

3. Alan Jeffrey, “Advanced Mathematics for Engineering”, I Edition, Harcourt Academic Press, 2002.
4. C.B.Gupta, A. K..Malik, V. Kumar, “Advanced Mathematics”, New Age International (P) Limited, Publishers, 2009.
5. Raymond N. Greenwell, Nathan P. Ritchey, Margaret L. Lial, “Calculus for the Life Sciences”, 2nd Edition, Pearson Education, 2014.

		L	T	P	C
CAC2001	**Career Advancement Course for Engineers -I**	**1**	**0**	**1**	**1**
	Total Contact Hours - 30				
	Prerequisite: Nil				
PURPOSE					
To enhance holistic development of students and improve their employability skills					
INSTRUCTIONAL OBJECTIVES					
1.	To improve aptitude, problem solving skills and reasoning ability of the student.				
2.	To collectively solve problems in teams and group.				
3.	Understand the importance of verbal and written communication in the workplace				
4.	Understand the significance of oral presentations, and when they may be used				
5.	Practice verbal communication by making a technical presentation to the class				
6.	Develop time management Skills				

UNIT I–BASIC NUMERACY: Types and Properties of Numbers, LCM, GCD, Fractions and decimals, Surds

UNIT II-ARITHMETIC – I: Percentages, Profit and Loss, Equations

UNIT III-REASONING – I: Logical Reasoning

UNIT IV-SOFT SKILLS – I: Presentation skills, E-mail Etiquette

UNIT V-SOFT SKILLS – II: Goal Setting and Prioritizing

ASSESSMENT

Soft Skills (Internal)

Assessment of presentation and writing skills.

Quantitative Aptitude (External)

- Objective Questions- 60 marks
- Descriptive case lets- 40 marks*
- Duration: 3 hours

***Engineering problems will be given as descriptive case lets.

REFERENCES

1. Quantitative Aptitude by Dinesh Khattar – Pearsons Publicaitons
2. Quantitative Aptitude and Reasoning by RV Praveen – EEE Publications
3. Quantitative Aptitude by Abijith Guha – TATA Mc GRAW Hill Publications
4. Soft Skills for Everyone by Jeff Butterfield – Cengage Learning India Private Limited
5. Six Thinking Hats is a book by Edward de Bono - Little Brown and Company
6. IBPS PO - CWE Success Master by Arihant - Arihant Publications(I) Pvt.Ltd - Meerut

		L	T	P	C
CAC2002	**Career Advancement Course for Engineers -II**	**1**	**0**	**1**	**1**
	Total Contact Hours - 30				
	Prerequisite: CAC2001				

PURPOSE	
To enhance holistic development of students and improve their employability skills	
INSTRUCTIONAL OBJECTIVES	
1.	To improve aptitude, problem solving skills and reasoning ability of the student
2.	To collectively solve problems in teams and group
3.	Understand the importance of verbal communication in the workplace
4.	Understand the significance of oral presentations, and when they may be used
5.	Understand the fundamentals of listening and how one can present in a group discussion
6.	Prepare or update resume according to the tips presented in class

UNIT I-ARITHMETIC – II: Ratios and Proportions, Mixtures and Solutions

UNIT II - MODERN MATHEMATICS: Sets and Functions, Data Interpretation, Data Sufficiency

UNIT III – REASONING – II: Analytical Reasoning

UNIT IV – COMMUNICATION – I: Group discussion, Personal interview

UNIT V - COMMUNICATION – II: Verbal Reasoning test papers

ASSESSMENT

1. **Communication (Internal)**
   - Individuals are put through formal GD and personal interviews.
   - Comprehensive assessment of individuals' performance in GD and PI will be carried out.

2. **Quantitative Aptitude (External)**

   Objective Questions- 60 marks (30 Verbal +30 Quants)
   Descriptive case lets- 40 marks*
   Duration: 3 hours
   *Engineering problems will be given as descriptive case lets.

REFERENCES

1. Quantitative Aptitude by Dinesh Khattar – Pearsons Publicaitons
2. Quantitative Aptitude and Reasoning by RV Praveen – EEE Publications
3. Quantitative Aptitude by Abijith Guha – TATA Mc GRAW Hill Publications
4. General English for Competitive Examination by A.P. Bharadwaj – Pearson Educaiton
5. English for Competitive Examination by Showick Thorpe - Pearson Educaiton
6. IBPS PO - CWE Success Master by Arihant - Arihant Publications(I) Pvt.Ltd - Meerut
7. Verbal Ability for CAT by Sujith Kumar - Pearson India
8. Verbal Ability and Reading Comprehension by Arun Sharma - Tata McGraw - Hill Education

		L	T	P	C
CAC2003	**Career Advancement Course For Engineers - III**	**1**	**0**	**1**	**1**
	Total Contact Hours - 30				
	Prerequisite: Nil				

PURPOSE	
To develop professional skills abreast with contemporary teaching learning methodologies	
INSTRUCTIONAL OBJECTIVES At the end of the course the student will be able to	
1	acquire knowledge on planning, preparing and designing a learning program
2	prepare effective learning resources for active practice sessions
3	facilitate active learning with new methodologies and approaches
4	create balanced assessment tools
5	hone teaching skills for further enrichment

UNIT-I: DESIGN **(2 hrs)**
Planning andPreparing a learning program, Planning and Preparing a learning session

UNIT-II: PRACTICE **(2 hrs)**
Facilitating active learning , Engaging learners

UNIT-III: ASSESSMENT **(2 hrs)**
Assessing learner’s progress**,** Assessing learner’s achievement

UNIT-IV: HANDS ON TRAINING **(10 hrs)**
Group activities – designing learning session, Designing teaching learning resources, Designing assessment tools, Mock teaching session

UNIT-V: TEACHING IN ACTION **(14 hrs)**
Live teaching sessions, Assessments

<u>ASSESSMENT (Internal)</u>
Weightage:
Design - 40%
Practice – 40%
Quiz – 10%
Assessment – 10%

REFERENCES

1. Cambridge International Diploma for Teachers and Trainers Text book by Ian Barker - Foundation books
2. Whitehead, Creating a Living Educational Theory from Questions of the kind: How do I improve my Practice? Cambridge J. of Education

CO2047	SEMINAR	L	T	P	C
	Total Contact Hours - 15	**0**	**0**	**1**	**1**

Every student will be required to present a seminar talk on a topic approved by the Department. The Committee constituted by the Head of the Department will evaluate the presentation and will award the marks based on

- Comprehensible arguments and organization.
- Accessible delivery
- Accessible visuals in support of arguments.
- Question and Answers.

CO2049	PROJECT WORK – PHASE - I	L	T	P	C
	Total Contact Hours - 12	**0**	**0**	**12**	**6**

Student has to identify the faculty supervisor (Guide), topic, objectives, deliverables and work plan. The topic should be of advanced standing requiring use of knowledge from program core and be preferably hardware oriented. Students are evaluated on monthly basis, by conducting reviews by the department throughout the project period. Student has to submit a report describing his/her project work. End semester examination/ Viva-voce will be conducted by the Department.

CO2050	PROJECT WORK – PHASE – II	L	T	P	C
	Total Contact hours - 32	**0**	**0**	**32**	**16**

Student has to continue the project work he/she was doing in phase –I. The Student will be evaluated with monthly reviews and an end semester examination / viva-voce. The students are encouraged to submit his/her project work in Conference/Journal and due weightage will be given in their evaluation

AMENDMENTS

S. No.	Details of Amendment	Effective from	Approval with date
1.	CO2121 24th Academic Council Meeting (ACM), Agenda No. 3.3.3	19-Oct-2013	
2.	CO2122 to CO2127, CO2204 26th ACM, Agenda No. 3.3.6	25-Jul-2014	
3.	CO2128, CO2205 28th ACM, Agenda No. 3.3.4	23-Mar-2015	
4.	COR2005 29th ACM, Agenda No. 3.3.19	29-Aug-2015	
5.	CO2129 to CO2131 31st ACM, Agenda No. 3.3.10	24-Mar-2016	