MADANAPALLE INSTITUTE OF TECHNOLOGY & SCIENCE
MADANAPALLE

(UGC-AUTONOMOUS)

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MASTER OF TECHNOLOGY

DIGITAL ELECTRONICS AND COMMUNICATION SYSTEMS (DECS)

COURSE STRUCTURE
&
DETAILED SYLLABI
For the students admitted to

Master of Technology in Digital Electronics and Communication Systems from the academic year 2018-19 Batches onwards

M. Tech Regular Two Year P. G. Degree Course

M.Tech DIGITAL ELECTRONICS AND COMMUNICATION SYSTEMS

CURRICULUM STRUCTURE

I Year I Semester

Sl. No.	Course Code	Name of the Course	Credits
1	18DECSP101	Wireless and Mobile Communication	3
2	18DECSP102	Digital CMOS VLSI Design	3
	Discipline Elective - I		
3	18DECSP401	Wireless Sensor Networks	3
	18DECSP402	Optical Networks	
	18DECSP403	Digital Signal and Image Processing	
	18DECSP404	Programming Languages for Embedded Software	
	Discipline Elective - II		
4	18DECSP405	Cognitive Radio	3
	18DECSP406	DSP Architecture	
	18DECSP407	Parallel Processing	
	18DECSP408	Design & Testability	
5	18DECSP201	Wireless and Mobile Communication Lab	2
6	18DECSP202	Digital CMOS VLSI Design Lab	2
7	18RMP101	Research Methodology & IPR	2
		Audit Course - I	
8	18AUP901	Disaster Management	0
	18AUP902	Sanskrit for Technical Knowledge	
	18AUP903	Constitution of India	
	18AUP904	Pedagogy Studies	
		Total Credits	18

I Year II Semester

Sl. No.	Course Code	Name of the Course	Credits
1	18DECSP103	Advanced Digital Signal Processing	3
2	18DECSP104	Microcontrollers and Programmable Digital Signal Processors	3
	Discipline Elective - III		
3	18DECSP409	Satellite Communication	3
	18DECSP410	Internet of Things	
	18DECSP411	Low power VLSI Design	
	18DECSP412	VLSI Signal Processing	
	Discipline Elective - IV		
4	18DECSP413	Markov Chain and Queuing System	3
	18DECSP414	MIMO System	
	18DECSP415	Network Security and Cryptography	
	18DECSP416	CAD of Digital System	
5	18DECSP203	Advanced Digital Signal Processing Lab	2
6	18DECSP204	Microcontrollers and Programmable Digital Signal Processors Lab	2
7	18DECSP701	Mini Project	2
		Audit Course - II	
8	18AUP905	English for Research Paper Writing	0
	18AUP906	Value Education	
	18AUP907	Stress Management by Yoga	
	18AUP908	Personality Development through Life Enlightment Skills	
		Total Credits	18

II Year I Semester

Sl. No.	Course Code	Name of the Course	Credits
	Discipline Elective - V		
1	18DECSP417	High Performance Networks	3
	18DECSP418	Pattern Recognition and Machine Learning	
	18DECSP419	Remote Sensing	
	18DECSP420	Nano Materials and Nano Technology	
	Open Elective		
2	18OEP301	Business Analytics	3
	18OEP302	Industrial Safety	
	18OEP303	Operations Research	
	18OEP304	Cost Management of Engineering Projects	
	18OEP305	Composite Materials	
	18OEP306	Waste to Energy	
3	18DECSP702	Dissertation Phase I	10
		Total Credits	16

II Year II Semester

Sl. No.	Course Code	Name of the Course	Credits
1	18DECSP703	Dissertation Phase II	16
		Total Credits	16

M. Tech I Year I Semester

18DECSP101 **WIRELESS AND MOBILE COMMUNICATION**

L	T	P	C
3	0	0	3

Course Prerequisite:

1. An undergraduate course in Communication Theory.
2. An undergraduate course in Mobile Communications
3. An undergraduate course in Signals and Systems.

Course Description:

The course goals are to introduce the principles of Wireless and Mobile Communication theory. This course is intended as an introductory course for Postgraduate Students in the areas of Communications and Signal Processing. Students in their final year undergraduate degree in ECE, who would like to specialize in this area, will also find this course revealing. The treatment would look at current and upcoming wireless communications technologies for broadband wireless access.

Course Objectives:

1. To expose the students to understand the fundamental of cellular mobile communication principles.
2. To study the recent trends adopted in modern wireless communication systems and standards.
3. Learn to model radio signal propagation issues and analyse their impact on wireless communication system performance.

UNIT I: CELLULAR COMMUNICATION FUNDAMENTALS

Cellular system design, Frequency reuse, Channel Assignment Strategies, handover concepts, Co channel and Adjacent channel interference, Trunking and Grade of Service, Improving coverage and capacity in cellular system- cell splitting, Cell sectorization, Repeaters, Micro cell zone concept.GSM architecture and interfaces, Concepts of Circuit and Packet switching. General Packet Radio Service (GPRS), 2.75 G Standards: EDGE. **(9)**

UNIT II: WIRELESS CHANNEL CHARACTERISTICS AND FADING

Large scale fading: Large Scale Path Loss, Free Space Propagation Model, Reflection, Ground Reflection (Two-Ray) Model, Diffraction, Scattering, Empirical Path Loss Models: Okumura Model and Hata Model, Rayleigh and Ricean Distributions, Small Scale Fading: Types of Small Scale Fading, Time Delay Spread; Flat, Frequency selective, Doppler Spread; Fast and Slow fading. **(9)**

UNIT III: EQUALIZATION AND DIVERSITY

Introduction, Fundamentals of Equalization, Algorithms for adaptive equalization, Equalizers in a communications receiver,Survey of Equalization Techniques: Linear Equalizers. Nonlinear Equalization equalizer. Diversity Techniques: Introduction, Spatial Diversity: Receiver diversity- Selection Combining, maximal ratio combining, Transmit Diversity: Alamouti scheme, polarization diversity, frequency diversity. **(9)**

UNIT IV: MULTIPLE ACCESS TECHNOLOGIES

FDMA, TDMA, Introduction to CDMA, PN Sequences, Multipath diversity, RAKE Receiver, CDMA 2000 layering structure and Channels. Introduction to OFDM, Multicarrier Generation using IFFT and Cyclic Prefix, Trans-receiver blocks, SNR performance, PAPR. **(9)**

UNIT V: 3G AND 4G WIRELESS STANDARDS

3G Standards: evolved EDGE, enhancements in 4G standard: LTE, WiMAX, UMTS, introduction to 5G. **(9)**

Course Outcomes:

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

1. Apply frequency-reuse concept in mobile communications, and to analyze its effects on interference, system capacity, handoff techniques.
2. Analyze the effects of large and small scale fading on the performance of a given wireless communication system.
3. Apply equalization and diversity technique for a given wireless system to combat fading.
4. Performs efficient spectral allocation using CDMA and OFDM techniques.
5. Understanding technologies like 3G, 4G and their standards.

Text Books:

1. Wireless Communications: Principles and Practice –Theodore Rappaport- Prentice Hall.
2. Wireless Communications: Andrea Goldsmith, Cambridge University Press.
3. Fundamentals of Wireless Communications – David Tse and Pramod Viswanath, Publisher - Cambridge University Press.

References:

1. William C.Y.Lee, "Mobile Cellular Telecommunications Analog and Digital Systems", 2nd edition, TMH, 1995.
2. Richard Van Nee &Ramjee Prasad., 'OFDM for Multimedia Communications' Artech House Publication, 2001.
3. V.K.Garg, "IS-95 CDMA & CDMA 2000", Pearson Education, 4th edition, 2009.
4. V.K.Garg, J.E.Wilkes, "Principle and Application of GSM", Pearson Education, 5th edition, 2008.

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

M. Tech I Year I Semester

18DECSP102 **DIGITAL CMOS VLSI DESIGN**

L	T	P	C
3	0	0	3

Course Prerequisite: Digital System Design

Course Description:
This course deals comprehensively with all aspects of transistor level design of all the digital building blocks common to all CMOS microprocessors, DPSs, network processors, digital backend of all wireless systems etc. The focus will on the transistor level design and will address all important issues related to size, speed and power consumption.

Course Objectives:
1. Understand and conceptualise the CMOS Design fundamentals.
2. Study and design the CMOS combinatorial logic blocks.
3. Study and design the CMOS sequential logic blocks.
4. To study the characteristics of arithmetic circuits and memories based on performance, power and area.
5. Learn the fundamentals of clock skew and clocking strategies.

UNIT – I: MOS TRANSISTOR PRINCIPLES AND MOS INVERTERS
Basic MOS structure and its operation, Threshold voltage of MOSFET- MOSFET Current-Voltage characteristics - Second order effects of MOSFET Inverter - Resistive load, Depletion load and CMOS inverters, Switching threshold and noise margin concepts and their evaluation, Calculation of delay times and switching power consumption of CMOS inverters. **(9)**

UNIT – II: DESIGNING COMBINATIONAL LOGIC
Static CMOS design, Ratioed logic, Differential Cascade Voltage switch logic, Pass transistor logic, CMOS transmission gate logic, Dynamic logic - Principles - Performance of Dynamic CMOS - noise consideration in Dynamic CMOS, Cascading dynamic gates.
(9)

UNIT – III: Designing Sequential Logic
Static sequential circuits, Bi-stability principle, Multiplexer based latches, CMOS static flip-flops, Master-slave edge-triggered flip-flops , Dynamic sequential circuits - pseudo static latch - dynamic 2-phase flip-flop, C^2MOS D-latch,NORA CMOS, True Single Phase Clocked Logic

(9)

UNIT – IV: Designing Arithmetic Building Blocks and Memories
Data path circuits, Architectures for Adders, Accumulators, Multipliers, Barrel Shifters, Speed and Area Tradeoffs, Semiconductor memories - Memory core - Memory peripheral circuitry

(9)

UNIT – V: Interconnect and Clocking Strategies

Capacitive parasitics, Resistiveparasitics, Inductive parasitics, clock skew and sequential circuit performance, Self timed circuit design, Clock generation and sychronization.

(9)

Course Outcomes:

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

1. Demonstrate the principles of MOS transistor and inverters.
2. Design combinational logic circuits.
3. Design sequential logic circuits.
4. Designing Arithmetic Building Blocks and Memories
5. To understand Interconnect and Clocking Strategies

Text / Reference Books

4. J P Rabaey, A P Chandrakasan, B Nikolic, "Digital Integrated circuits: A design perspective", Prentice Hall electronics and VLSI series, 2nd Edition.
5. Kang, S. and Leblebici, Y., "CMOS Digital Integrated Circuits, Analysis and Design", Tata MC Graw Hill, 3rdEdition, 2003.
6. N.Weste, K. Eshraghian, " Principles of CMOS VLSI Design", Addision Wesley, Second Edition, 1993.
7. Neil H. E. Weste, David Money Harris, "CMOS VLSI Design-A circuits and systems perspective, Pearson India, 3rd edition, 2006.
8. Pucknell, D.A. and Eshraghian, K., "Basic VLSI Design", PHI, 3rd Edition.

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective – I

18DECSP401 **WIRELESS SENSOR NETWORKS**

L	T	P	C
3	0	03	

Course Prerequisite: None

Course Description:
The course goals are to introduce the principles of Wireless sensor networks. The treatment would look at current and upcoming hardwares and programming tools for implementing wireless sensor networks.

Course Objectives:
1. To study about different types of sensor networks, advantages, applications and themechanism of transportation and processing involved in Wireless Sensor Networks.
2. To study about representation and different protocols and mechanisms involved in routing of Wireless Sensor Networks
3. To study about tools and simulators associated with Wireless Sensor Networks

UNIT – I: INTRODUCTION AND OVERVIEW OF SENSOR NETWORK
Introduction to wireless sensor networks and its applicatopns. Node Architecture - Hardware components, Energy consumption of sensor nodes, Operating systems and execution environments, Some examples of sensor nodes. **(9)**

UNIT – II: NETWORK ARCHITECTURE
Sensor network scenarios, Optimization goals and figures of merit, Design principles for WSNs, Service interfaces of WSNs, Gateway concepts. **(9)**

UNIT – III: PROGRAMMING TOOLS
C, nesC, Performance comparison of wireless sensor networks simulation and experimental platforms like open source (ns-2) and commercial (QualNet, Opnet). **(9)**

UNIT – IV: COMMUNICATION PROTOCOLS
Physical, MAC protocols, Link layer protocols, routing/ Network layer protocols, Localization and positioning protocols, Transport layer Protocols and quality of service based protocols.

(9)

UNIT – V: SPECIALIZED FEATURES
Energy preservation and efficiency; security challenges; faulttolerance,Issues related to Localization, connectivity and topology, Sensor deploymentmechanisms; coverage issues; sensor Web; sensor Grid, Open issues for future research, andEnabling technologies in wireless sensor network. **(9)**

Course Outcomes:
At the end of this course, students will be able to
1. Design wireless sensor network system for different applications under consideration.
2. Understand the hardware details of different types of sensors and select right type of sensorfor various applications.

3. Understand radio standards and communication protocols to be used for wireless sensor network based systems and application.
4. Use operating systems and programming languages for wireless sensor nodes, performanceof wireless sensor networks systems and platforms.
5. Handle special issues related to sensors like energy conservation and security challenges.

Text / Reference Books

1. H. Karl and A. Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley & Sons, India, 2012.
2. F. Zhao and L. Guibas, "Wireless Sensor Networks: An Information Processing Approach", Morgan Kaufmann, 1st Indian reprint, 2013.

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective – I

18DECSP402 **OPTICAL NETWORKS**

L	T	P	C
3	0	0	3

Course Prerequisite: None

Course Description:
This course delivers cognitive approach to understand and analyse the concepts of Optical networks with emphasis on Inline technology of the field.

Course Objectives:
The students should be made to understand:
1. Optical system components like optical amplifiers, wavelength converters.
2. Up-to-date survey of development in Optical Network Architectures.
3. Network design perspectives.
4. Different Optical Network management techniques and functions

UNIT – I: INTRODUCTION TO OPTICAL NETWORKS AND COMPONENTS
Telecommunications Networks Architecture, Services, circuit switching and packet switching, Optical Networks: Multiplexing Techniques,Second generation Optical Networks, Optical Packet Switching, Transmission Basics: Wavelength, frequencies, and channel spacing, Wavelength standards, Optical power and loss, Network Evolution, Components: Couplers, Isolators and Circulators, Multiplexers and Filters, Optical Amplifiers, Transmitters, Detectors, Switches, Wavelength Converters. **(9)**

UNIT – II: TRANSMISSION SYSTEM ENGINEERING
System Model, Power Penalty, Transmitter, Receiver, Optical Amplifiers, Crosstalk, Dispersion, Fiber nonlinearities, Wavelength Stabilization, Overall Design Considerations. **(9)**

UNIT – III: CLIENT LAYERS OF THE OPTICAL LAYER
Physical layer, Elements of a SONET/SDH Infrastructure. ATM: Functions of ATM, Adaptation Layers, Quality of Service, Flow Control, Signaling and Routing. IP: Routing and Forwarding, QOS. MPLS, Storage Area Networks: ESCON, Fibre Channel, HIPPI , Concepts of Gigabit and 10-Gigabit Ethernet. Architecture of Optical Transport Networks (OTNs): Digital wrapper, in-band and out-of-band control signaling. **(9)**

UNIT – IV:
Optical line terminals, Optical Line Amplifiers, Optical Add/Drop Multiplexers:OADM Architectures, Reconfigurable OADMs, optical Cross Connects: All-optical OXC configurations.WDM Design: Cost Trade-Offs, LTD and RWA problems: Light path topology design, wavelength conversion, Routing and wavelength Assignment, Statistical Dimensioning Models: First passage model, Blocking model, Maximum load dimension models: Offline lightpath Requests, Online RWA in Rings. **(9)**

UNIT – V: NETWORK CONTROL & MANAGEMENT AND SURVIVABILITY
Network management functions, Optical layer services and Interfacing , layers with in Optical Layer, Multivendor Interoperability, Performance and fault management: Impact of

transparency, BER management, DCN and Signalling, Policing, Optical layer overhead, Configuration management: Equipment, Connection and Adaptation management. Network Survivability: Basics, Protection in SONET/SDH, Protection in I/P networks, Optical network Protection schemes: 1+1 OMS protection , OMS-SPRing, OCH-Mesh Protection. **(9)**

Course Outcomes;

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

1. Design and Analyze Network Components
2. Assess and Evaluate optical networks

Text / Reference Books

1. Rajiv Ramaswami and Kumar Sivarajan, "Optical Networks Practical Perspective", 3rd Edition, , Morgan - Kaufmann Publishers.
2. Optical Networks, Third Generation Transport Systems, Uyless Black, Pearson.

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective – I

18DECSP403 **DIGITAL SIGNAL AND IMAGE PROCESSING**

L	T	P	C
3	0	0	3

Course Prerequisite: None

Course Description:
This course is being designed to reflect the advantages of Digital Signal and Image Processing along with the concepts of real time Image processing.

Course Objectives:
1. Understanding of the use of computer algorithms to perform image processing on digital images.
2. Understanding of real time Image processing.

UNIT – I: REVIEW OF DISCRETE TIME SIGNALS AND SYSTEMS
Characterization in time and Z and Fourier – domain, Fast Fourier Transform algorithms – In-place computations, Butterfly computations, bit reversal's. **(9)**

UNIT – II: DIGITAL FILTER DESIGN
FIR - Windowing and Frequency Sampling, IIR – Impulse invariance, bilinear Transformation, Fixed point implementation of filters – challenges and techniques. **(9)**

UNIT –III: DIGITAL IMAGE PROCESSING
Digital Image Acquisition –Enhancement, Restoration. Digital Image Coding and Compression – JPEG and JPEG 2000. **(9)**

UNIT – IV: COLOR IMAGE PROCESSING
Color Image processing – Handling multiple planes, computational challenges. **(9)**

UNIT – V: VLSI IMAGE PROCESSING
VLSI architectures for implementation of Image Processing algorithms, Pipelining. **(9)**

Course Outcomes:
At the end of this course, students will be able to
1. Analyze discrete-time signals and systems in various domains
2. Design and implement filters using fixed point arithmetic targeted for embedded platforms
3. Compare algorithmic and computational complexities in processing and coding digital images.
4. Understanding of real time Image processing

Text / Reference Books

1. J.G. Proakis, Manolakis "Digital Signal Processing", Pearson, 4th Edition
2. Gonzalez and Woods, "Digital Image Processing", PHI, 3rd Edition

3. S. K. Mitra. “Digital Signal Processing – A Computer based Approach”, TMH, 3rd Edition, 2006
4. A. K. Jain, “Fundamentals of Digital Image Processing”, Prentice Hall
5. KeshabParhi, “VLSI Digital Signal Processing Systems – Design and Implementation”, Wiley India
6. Gerard Blanchet, Maurice Charbit,“ Digital signal and Image Processing using Matlab”, HERMES Science Europe Ltd

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective - I

18DECSP404 **PROGRAMMING LANGUAGES FOR EMBEDDED SOFTWARE**

L	T	P	C
3	0	0	3

Course Prerequisite: None

Course Description:
This course on Embedded systems will make the students to understand the fundamental requirements of embedded systems and the interaction between hardware and software in such systems. This course teaches the C programming language in the context of embedded systems.

Course Objectives:
1. The syntax and semantics of the C language for embedded programming
2. The principles of embedded software programming and real-time programming
3. How to debug a C program on a target device?
4. How to access memory-mapped peripherals using C•?
5. How to write interrupt handlers in C?
6. Best practices for embedded programme

UNIT I: EMBEDDED 'C' PROGRAMMING
Bitwise operations, Dynamic memory allocation, OS services , Linked stack and queue, Sparse matrices, Binary tree, Interrupt handling in C, Code optimization issues, Writing LCD drives, LED drivers, Drivers for serial port communication, Embedded Software Development Cycle and Methods (Waterfall, Agile) **(9)**

UNIT II: OBJECT ORIENTED PROGRAMMING
Introduction to procedural, modular, object-oriented and generic programming techniques, Limitations of procedural programming, objects, classes, data members, methods, data encapsulation, data abstraction and information hiding, inheritance, polymorphism. **(9)**

UNIT III: CPP PROGRAMMING
'cin', 'cout', formatting and I/O manipulators, new and delete operators, Defining a class, data members and methods, 'this' pointer, constructors, destructors, friend function, dynamic memory allocation. **(9)**

UNIT IV: OVERLOADING AND INHERITANCE
Need of operator overloading, overloading the assignment, overloading using friends, type conversions, single inheritance, base and derived classes, friend classes, types of inheritance, hybrid inheritance, multiple inheritance, virtual base class, polymorphism, virtual functions. **(9)**

UNIT V: TEMPLATES
Function template and class template, member function templates and template arguments
Exception Handling: syntax for exception handling code - try-catch- throw, Multiple Exceptions. Elimination of the background noise in Audio, Eliminating the Impulse noise-The Signal model, Click detection, Restoration. **(9)**

Course Outcomes:

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

1. Write an embedded C application of moderate complexity.
2. Develop and analyze algorithms in C++.
3. Differentiate interpreted languages from compiled languages.
4. Have a good knowledge of the list of standard exceptions and exception handling during program execution.

Text Books:

1. Michael J. Pont , "Embedded C", Pearson Education, 2nd Edition, 2008
2. Randal L. Schwartz, "Learning Perl", O'Reilly Publications, 6th Edition 2011

References:

1. Michael Berman, "Data structures via C++", Oxford University Press, 2002
2. Robert Sedgewick, "Algorithms in C++", Addison Wesley Publishing Company, 1999
3. Abraham Silberschatz, Peter B, Greg Gagne, "Operating System Concepts", John Willey & Sons,2005

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective – II

18DECSP405 **COGNITIVE RADIO**

L	T	P	C
3	0	03	

Course Prerequisite: Wireless and Mobile Communication

Course Description:
This course targets to discuss the cognitive radio and adaptive radio concepts from several aspects. It covers the need of improving the spectrum efficiency and effective methods to achieve it. It also gives an insight idea of machine learning in wireless communication systems

Course Objectives:
1. Understanding of adaptive wireless communication systems.
2. Understanding of Interference awareness, Signal analysis.
3. Understanding of emergence of Cognitive radio as a promisingtechnology to efficiently utilize the scarce radio resources by allowing the unlicensed users.
4. Understanding of cognitive features in the upcoming wireless standards.
5. Understanding of Spectrum, network, context, environment, location awareness for cognitive radio.

UNIT – I: INTRODUCTION TO COGNITIVE RADIOS
Digital dividend, cognitive radio (CR) architecture, functions of cognitive radio, dynamic spectrum access (DSA), components of cognitive radio, spectrum sensing, spectrum analysis and decision, potential applications of cognitive radio **(9)**

UNIT – II: SPECTRUM SENSING
Spectrum sensing, detection of spectrum holes (TVWS), collaborative sensing, geo-location database and spectrum sharing business models. **(9)**

UNIT – III: OPTIMIZATION TECHNIQUES OF DYNAMIC SPECTRUM ALLOCATION
Linear programming, convex programming, non-linear programming, integer programming, dynamic programming and stochastic programming. **(9)**

UNIT – IV: DYNAMIC SPECTRUM ACCESS AND MANAGEMENT
Spectrum broker, cognitive radio architectures, centralized dynamic spectrum access, distributed dynamic spectrum access. **(9)**

UNIT – V: SPECTRUM TRADING
Introduction to spectrum trading, classification to spectrum trading, radio resource pricing, brief discussion on economics theories in DSA, classification of auctions. **(9)**

Course Outcomes:

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

1. Understand the fundamental concepts of cognitive radio networks
2. Develop the cognitive radio, as well as techniques for spectrum holes detection that cognitive radio takes advantages in order to exploit it.
3. Understand technologies to allow an efficient use of TVWS for radio communications based on two spectrum sharing business models/policies.
4. Understand fundamental issues regarding dynamic spectrum access, the radio-resource management and trading, as well as a number of optimisation techniques for better spectrum exploitation.
5. Understanding of machine learning algorithms as an application to Cognitive Radio.
6. Understanding of theapplications of auction theory as an economic approach to enable the emerging cognitive radio systems very useful.

Text / Reference Books

1. Ekram Hossain, Dusit Niyato, Zhu Han, "Dynamic Spectrum Access and Management in Cognitive Radio Networks", Cambridge University Press, 2009.
2. Kwang-Cheng Chen, Ramjee Prasad, "Cognitive radio networks", John Wiley & Sons Ltd., 2009.
3. Bruce Fette, "Cognitive radio technology", Elsevier, 2nd edition, 2009.
4. Huseyin Arslan, "Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems", Springer, 2007
5. Francisco Rodrigo Porto Cavalcanti, Soren Andersson, "Optimizing Wireless Communication Systems" Springer, 2009
6. Linda Doyle, "Essentials of Cognitive Radio", Cambridge University Press, 2009

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective – II

18DECSP406 **DSP ARCHITECTURE**

L	T	P	C
3	0	03	

Course Prerequisite: Microprocessor, Digital Signal Processing

Course Description:
The course will provide an insight into the architectures of DSP processors for handling the bottlenecks in executing DSP algorithms. On the application side the students can developFPGA based DSP Systems and can understand the concept of multicore DSP as HPC infrastructure.

Course Objectives:
1. To study about the programmable digital signal processing hardware.
2. To study about the architecture of TMS320CX processor and block diagram
3. To study syntax and write the assembly language programming for digital signal processors.
4. To study the architecture of FPGA based DSP for various applications
5. To study about High Performance Computing using P-DSP

UNIT – I: PROGRAMMABLE DSP HARDWARE
Processing Architectures (von Neumann, Harvard), DSP core algorithms (FIR, IIR, Convolution, Correlation, FFT), IEEE standard for Fixed and Floating Point Computations, Special Architectures Modules used in Digital Signal Processors (like MAC unit, Barrel shifters), On-Chip peripherals, DSP benchmarking. **(9)**

UNIT – II: STRUCTURAL AND ARCHITECTURAL CONSIDERATIONS
Parallelism in DSP processing, Texas Instruments TMS320 Digital Signal Processor Families, Fixed Point TI DSP Processors: TMS320C1X and TMS320C2X Family,TMS320C25 –Internal Architecture, Arithmetic and Logic Unit, Auxiliary Registers, Addressing Modes (Immediate, Direct and Indirect, Bit-reverse Addressing), Basics of TMS320C54x and C55x Families in respect of Architecture improvements and new applications fields, TMS320C5416 DSP Architecture, Memory Map, Interrupt System, Peripheral Devices, Illustrative Examples for assembly coding. **(9)**

UNIT – III: VLIW ARCHITECTURE
Current DSP Architectures, GPUs as an alternative to DSP Processors, TMS320C6X Family, Addressing Modes, Replacement of MAC unit by ILP, Detailed study of ISA, Assembly Language Programming, Code Composer Studio, Mixed C and Assembly Language programming, On-chip peripherals, Simple application developments as an embedded environment. **(9)**

UNIT – IV: FPGA BASED DSP SYSTEMS
Limitations of P-DSPs, Requirements of Signal processing for Cognitive Radio (SDR), FPGA based signal processing design-case study of a complete design of DSP processor. **(9)**

UNIT – V: HIGH PERFORMANCE COMPUTING USING P-DSP
Preliminaries of HPC, MPI, OpenMP, multicore DSP as HPC infrastructure. **(9)**

Course Outcomes:

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

1. Identify and formalize architectural level characterization of DSP hardware.
2. Design and test various digital signal processors.
3. Write assembly language programming for various digital signal processors.
4. Utilize FPGA based DSP hardware for Control, Audio and Video Signal processing applications
5. Understand the High Performance Computing using P-DSP

Text / Reference Books

1. "Digital Signal Processors", B Venkataramani and M Bhaskar TMH, 2002.
2. E.S.Gopi, "Algorithmic Collections for Digital Signal Processing Applications using MATLAB", 1st Edition, Springer Netherlands, 2007.
3. Digital Signal Processing: A practical approach, Ifeachor E. C., Jervis B. W Pearson-Education, PHI, 2002.
4. "Architectures for Digital Signal Processing", Peter Pirsch John Weily, 2007.

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective II

18DECSP407 **PARALLEL PROCESSING**

L	T	P	C
3	1	0	3

Course Prerequisite: Data structures, Operating Systems

Course Description:
With the growing number of cores on a chip, programming them efficiently requires modern Parallel processing Programming as a hands-on course. This is mainly because processing voluminous datasets is highly computation intensive. Parallel processing programming can process large datasets and handle other time-consuming operations of interest. This course discusses in detail the methodologies and trade-offs involved in designing a shared memory parallel computer.

Course Objectives:
1. To understand Parallel Processing and Pipelining.
2. To know Architectures of VLIW processors, Multithreaded Processors.
3. To know the design methods of Multiprocessors.

UNIT I: INTRODUCTION
Overview of Parallel Processing and Pipelining, Performance analysis, Scalability, Principles and implementation of Pipelining, Classification of pipelining processors, Advanced pipelining techniques, Software pipelining. **(9)**

UNIT II: VLIW PROCESSORS CASE STUDY
Superscalar Architecture- Pentium, Intel Itanium Processor, Ultra SPARC, MIPS on FPGA, Vector and Array Processor, FFT Multiprocessor Architecture **(9)**

UNIT III: MULTITHREADED ARCHITECTURE AND PERFORMANCE ISSUES
Multithreaded Architecture, Multithreaded processors, Latency hiding techniques, Principles of multithreading, Issues and solutions **(9)**

UNIT IV: PARALLEL PROGRAMMING TECHNIQUES
Message passing program development, Synchronous and asynchronous message passing, Shared Memory Programming, Data Parallel Programming, Parallel Software Issues. **(9)**

UNIT V: MULTIPROCESSOR SYSTEMS
Operating systems for multiprocessors systems, Shared memory multiprocessors and cache Coherence, Synchronization, Multiprocessors on a snoopy bus, Scalable multiprocessors and directory-based cache coherence. **(9)**

Course Outcomes:
Upon successful completion of the course, students will be able to
1. To understand Parallel Processing and Pipelining.
2. To know Architectures of VLIW processors, Multithreaded Processors.
3. To know the design methods of Multiprocessors.

Text Books:

1. D. E. Culler and J. P. Singh with A. Gupta, "Parallel Computer Architecture", Morgan-Kaufmann publishers.
2. J. L. Hennessy and D. A. Patterson, "Computer Architecture: A Quantitative Approach", Morgan-Kaufmann publishers.
3. Kai Hwang, Faye A. Briggs, "Computer Architecture and Parallel Processing", MGH International Edition.

References:

1. Kai Hwang, "Advanced Computer Architecture", TMH.
2. V. Rajaraman, L. Sivaram Murthy, "Parallel Computers", PHI.
3. William Stallings, "Computer Organization and Architecture, Designing for performance"
4. Prentice Hall, Sixth edition.
5. Kai Hwang, Zhiwei Xu, "Scalable Parallel Computing", MGH.
6. David Harris and Sarah Harris, "Digital Design and Computer Architecture", Morgan Kaufmann.

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective II

18DECSP408 **DESIGN AND TESTABILITY**

L	T	P	C
3	0	0	3

Course Prerequisite: ASIC Design

Course Description:
Testing is one of the most expensive process in the design flow of a typical chip. There exists various errors e.g. design errors, fabrication defects, fabrication errors and physical failures. This course covers: Introduction to Testing, Test methods and Design for Testability.

Course Objectives:
1. To know the different types of faults and to study fault detection
2. To understand the concepts of test generation - DFT and BIST.
3. To study in detail about fault diagnosis, memory testing and PLA testing

UNIT I: TESTING AND FAULT MODELING
Introduction to testing - Faults in Digital circuits - Modeling of faults - Logical fault models - Fault detection - Fault location -Fault equivalence - Fault dominance, Logic simulation - Types of Simulation - Compiled code simulation - Gate level event driven simulation - Delay models. Fault simulation - Serial fault simulation - Parallel fault simulation - Deductive fault simulation - Concurrent fault simulation - Differential fault simulation. **(9)**

UNIT II: TEST GENERATION
Test generation for combinational circuits - Truth table and fault matrix method - Path sensitization algorithm - Boolean difference method - D – algorithm - PODEM algorithm - FAN algorithm , Testable combinational logic circuit design, Test generation for sequential - circuits - Time frame expansion - Test generation based on circuit structure and state table. **(9)**

UNIT III: LOGIC BUILT-IN-SELF-TEST
Test pattern generators - Exhaustive testing - Pseudo random testing - Pseudo exhaustive testing, Output response compression techniques - ones count - transition count - parity check - syndrome check - signature analysis, BIST architectures - Built-in-Evaluation and Self Test (BEST) - Self Testing Using MISR and Parallel SRSG (STUMPS) - Built In Logic Block Observer (BILBO) - Modified BILBO, Test stimulus compression - Code based schemes.

(9)

UNIT IV: DESIGN FOR TESTABILITY AND MEMORY TESTING
Testability - Controllability and Observability, Adhoc Design for testability techniques, Generic Scan based designs - Full serial integrated scan - Isolated serial scan - Non- serial scan, Boundary scan architecture. Testing of RAM - RAM functional fault models - Test algorithms - Test generation for Embedded RAM - Built In Self Repair (BISR). **(9)**

UNIT V: FAULT DIAGNOSIS AND PLA TESTING
Diagnosis by UUT reduction, Combinational logic diagnosis - Cause-Effect analysis - Effect-Cause analysis, Self-checking design, PLA Testing - fault models - Test generation algorithms for PLA's. **(9)**

C**ourse Outcomes:**

After completion of the course the student will be able to

1. Demonstrate different types of fault models and fault simulation.
2. Acquire complete knowledge regarding test generation for combinational circuits and sequential circuits.
3. Demonstrate the concepts of BIST and their architectures.
4. Illustrate the concepts of DFT and memory testing.
5. Identify the fault location by diagnosis methods and design self checking circuits.

Text/ References Books:

1. Laung-Terng Wang, Cheng-Wen Wu, Xiaoqing Wen, "VLSI Test Principles and Architectures: Design for Testability", Morgan Kaufmann publishers, 2006.
2. M.L.Bushnell and V.D.Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers, 2002.

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

M. Tech. I Year I Semester

18DECSP201 **WIRELESS AND MOBILE COMMUNICATION LAB**

L	T	P	C
0	0	3	2

Course Prerequisite: Basic Electrical Engineering

Course Description:
This course is designed to help the students to understand the basics of wireless communication system, Wireless channel modeling, concepts of CDMA and OFDM technique and MIMO technique in order to make them handle any research objective.

Course Objectives:
1. To have practical knowledge of Mobile and Wireless Communication technology.
2. To have basic understanding of CDMA, OFDM technique and applying these technique to MIMO communication.

LIST OF EXPERIMENTS
1. To determine the free-space loss and the power received using MATLAB.
2. To determine path-loss for outdoor propagation using Okumura and Hata Model
3. Perform Monte Carlo simulation to plot BER of a binary antipodal signaling signalling communication system in AWGN, Rayleigh and Rician fadingchannel.
4. Perform ZF and MMSE equalization for MIMO communication system
5. Study of receive diversity technique using MRC scheme
6. Study of transmit diversity technique using Alamouti scheme
7. Generation of pseudo-noise (PN) sequence for CDMA technology
8. To perform modulation and demodulation of DS-CDMA technique
9. Generation and reception of OFDM signal
10. Analyze the BER performance of OFDM technique in multipath fading channel

Course Outcomes:
Upon successful completion of the course, students will be able to
1. Analyze the impact of large scale propagation on the performance of wireless communication system.
2. Study the effect of small scale fading on the performance of wireless communication system.
3. Understanding CDMA concept
4. Understanding the concepts of OFDM and its advantages over frequency selective channel
5. Understanding the need of MIMO and Diversity techniques.

Mode of Evaluation: Continuous Internal Evaluation, Practical Examination.

M. Tech I Year I Semester

18DECSP202 **DIGITAL CMOS VLSI DESIGN LAB**

L	T	P	C
0	0	3	2

Course Prerequisite: None

Course Description:
This lab is intended to teach the student the practicalities of chip design using industry-standard CAD tools.

Course Objectives:
To have extensive knowledge in Verilog RTL, Static Timing Constraints Analysis and Logic validation.

LIST OF EXPERIMENTS:

1. Use V_{DD} = 1.8V for 0.18um CMOS process, Plot I_D vs. V_{GS} at different drain voltages for NMOS, PMOS.
2. Use V_{DD}= 1.3V for 0.13um CMOS Process Plot I_D vs. V_{GS} at particular drain voltage (low) for NMOS, PMOS and determine Vt.
3. Use V_{DD} = 1V for 0.09um CMOS Process Plot log I_D vs. V_{GS} at particular gate voltage (high) for NMOS, PMOS and determine I_{OFF} and sub-threshold slope.
4. Use V_{DD} = 1V for 0.09um CMOS Process. Plot I_D vs. V_{DS} at different gate voltages for NMOS, PMOS and determine Channel length modulation factor.
5. Extract V_{th} of NMOS/PMOS transistors (short channel and long channel). Use V_{DS} = 30mV
   To extract V_{th} use the following procedure.
   I. Plot g_m vs V_{GS} and obtain peak g_m point
   II. Plot $y=I_D/(g_m)1/2$ as a function of V_{GS}.
6. FOR NMOS/PMOS transistors (short channel and long channel), Use V_{GS} = 50mV Plot I_D vs. V_{DS} at different drain voltages for NMOS, PMOS, plot DC load line and calculate g_m, g_{ds}, g_m/g_{ds}, and unity gain frequency.
   Tabulate your result according to technologies and comment on it.
7. Use V_{DD} = 1.8V for 0.18um CMOS process, Perform the following
   I. Plot VTC curve for CMOS inverter and thereon plot dV_{out}vs. dV_{in} and determine transition voltage. Calculate V_{IL}, V_{IH}, N_{MH}, N_{ML} for the inverter.
   II. Plot VTC for CMOS inverter with varying V_{DD}.
   III. Plot VTC for CMOS inverter with varying device ratio.
8. Perform transient analysis of CMOS inverter with no load and with load and determine tp_{HL}, tp_{LH}, 20% - to - 80% t_r and 80%-to-20% t_f. (use V_{PULSE} = 2V, C_{load} = 50fF).
9. Draw small signal voltage gain of the minimum-size inverter in 0.18um and 0.13um technology as a function of input DC voltage. Determine the small signal voltage gain at the switching point and compare the values for 0.18um and 0.13um process.
10. Consider a simple CS amplifier with active load, with NMOS transistor MN as driver and PMOS transistor MP as load, in 0.18um technology, $(W/L)_{MN}$= 5, $(W/L)_{MP}$ = 10 and L = 0.5um for both transistors.
    I. Establish a test bench, as explained in the lecture, to achieve $V_{DSQ}=V_{DD}/2$.
    II. Calculate input bias voltage if bias current=50uA.

Course Outcomes:
At the end of the laboratory work, students will be able to:
1. Design digital Circuit using CMOS.
2. Use EDA tools like Cadence, Mentor Graphics and other open source software tools.

Mode of Evaluation: Continuous Internal Evaluation, Practical Examination.

M. Tech I Year I Semester

18RMP101 RESEARCH METHODOLOGY AND IPR

L	T	P	C
2	0	0	2

Course Prerequisite: None

Course Description:
This course provides the fundamental aspects of data collection, analysis, and interpretation of research problem. it also provides the effective way of paper writing, intellectual property rights and process of patenting.

Course Objectives:
1. To obtain solution for research problem, data collection and analysis.
2. To know effective paper writing
3. To know the patenting process
4. To know the new developments in IPR

UNIT I: INTRODUCTION
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations, Effective literature studies approaches, analysis Plagiarism, Research ethics. **(6)**

UNIT II: EFFECTIVE PAPER WRITING
Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee. **(6)**

UNIT III:NATURE OF INTELLECTUAL PROPERTY:
Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT. **(6)**

UNIT IV: PATENT RIGHTS:
Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. **(6)**

UNIT V:NEW DEVELOPMENTS IN IPR
Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs. **(6)**

Course Outcomes:
Upon successful completion of the course, students will be able to
1. Analyze research related information
2. Follow research ethics
3. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.

4. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
5. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Text Books:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"

References:

1. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
3. Mayall , "Industrial Design", McGraw Hill, 1992.
4. Niebel , "Product Design", McGraw Hill, 1974.
5. Asimov , "Introduction to Design", Prentice Hall, 1962.

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

AUDIT COURSE - I

AUDIT COURSE - I

18AUP901 DISASTER MANAGEMENT

L	T	P	C
2	0	0	0

Course Objectives:

Upon the completion of subject student will be able to-

1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. critically understand the strengths and weaknesses of disaster management approaches,
5. planning and programming in different countries, particularly their home country or the countries they work in

UNIT I:

Disaster classification

Disaster: definition, factors and significance; difference between hazard and Disaster; natural disaster: earthquakes, volcanisms, cyclones, tsunamis, floods, droughts and famines, landslides and avalanches; man-made disasters: nuclear reactor meltdown, industrial accidents, oil slicks and spills, outbreaks of disease and epidemics, war and conflicts

UNIT II:

Repercussions of Disasters

Economic damage, loss of human and animal life, destruction of ecosystem.

Disaster Prone Areas in India:

Study of seismic zones; areas prone to floods and droughts, landslides and Avalanches; areas prone to cyclonic and coastal hazards with special reference to tsunami.

UNIT III:

Disaster Preparedness and Management

Preparedness: monitoring of phenomena triggering a disaster or hazard; Evaluation of risk: application of remote sensing, data from meteorological and Other agencies, media reports: governmental and community preparedness.

UNIT IV:

Risk Assessment

Disaster risk: concept and elements, disaster risk reduction, global and national disaster risk situation. Techniques of risk assessment, global co-operation in risk assessment and warning.

UNIT V

Disaster Mitigation

Meaning, concept and strategies of disaster mitigation, emerging trends in Mitigation. Structural mitigation and non-structural mitigation, programs of Disaster mitigation in India.

Course outcomes

After the completion of the subject following outcomes can be achieved-

1. Students will be able to understand disaster and its types in general.
2. They will understand the post disaster damage in terms of both like and commodity.
3. They will have clear picture of disaster prone zones,.
4. They will be able to understand the pre and post disaster preparedness needed to mitigate the disaster impact in large scale.
5. Student will also understand to quantify the risk in terms of monetary for both commodity and life.
6. Student will also learn the structural and non-structural measures for risk mitigation

Reference Books

1. Ghosh G.K., 2006, Disaster Management, APH Publishing Corporation

Text Books

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences and Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L., Disaster Administration And Management Text and Case Studies" ,Deep&Deep Publication Pvt. Ltd., New Delhi

AUDIT COURSE - I

18AUP902 SANSKRIT FOR TECHNICAL KNOWLEDGE

L	T	P	C
2	0	0	0

Course Objectives

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects
4. enhancing the memory power
5. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

UNIT-1

- Alphabets in Sanskrit,
- Past/Present/Future Tense,
- Simple Sentences

UNIT-II

- Order
- Introduction of roots
- Technical information about Sanskrit Literature

UNIT-III

- Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

Course Output

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

Suggested reading

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-VempatiKutumbshastri, Rashtriya SanskritSansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

AUDIT COURSE - I

18AUP903 CONSTITUTION OF INDIA

L	T	P	C
2	0	0	0

Course Objectives:

Students will be able to:

1. Understand the premises informing the twin thems of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.
4. To get knowledge about the Indian Federal System and Center – State Relations
5. To Understand the Election Commission functions and administration system

UNIT-I: INTRODUCTION

Historical Background – Drafting Committee (Composition & Working) – Philosophical foundations of the Indian Constitution – Preamble – Fundamental Rights – Directive Principles of State Policy – Fundamental Duties – Citizenship – Constitutional Remedies for citizens.

UNIT-II: STRUCTURE AND FUNCTION OF CENTRAL GOVERNMENT

Union Government – Structures of the Union Government and Functions – President – Vice President – Prime Minister – Cabinet – Parliament – Supreme Court of India – Judicial Review.

UNIT-III: STRUCTURE AND FUNCTION OF STATE GOVERNMENT

State Government – Structure and Functions – Governor – Chief Minister – Cabinet – State Legislature –Judicial System in States – High Courts and other Subordinate Courts.

UNIT-IV CONSTITUTION FUNCTIONS

Indian Federal System – Center – State Relations – President's Rule – Constitutional Amendments –Constitutional Functionaries - Assessment of working of the Parliamentary System in India.

UNIT-V: ELECTION COMMISSION

Central Election Commission - Role and functioning – Chief Election Commissioner and Election Commissioners – State Election Commission – Institute and Bodies for the welfare of SC/ST/OBC and Women

Course Outcomes:

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

1. Know about Human rights protection by Indian Constitution.
2. Understand the functions of the Indian government
3. Understand and abide the rules of the Indian constitution.
4. Role of Constitution in Socio-economic development and welfare activities of the Country.

TEXTBOOKS:

1. Durga Das Basu, "Introduction to the Constitution of India ", Prentice Hall of India, New Delhi.
2. R.C.Agarwal, (1997) "Indian Political System", S.Chand and Company, New Delhi.

REFERENCES:

1. The Constitution of India, 1950 (Bare Act), Government Publication
2. Dr. S.N. Busi, Dr. B.R. Ambedkar framing of Indian Constitution, 1st Edition, 2015
3. M.P. Jain, Indian Constitution Law, 7thEdn., Lexis Nexis, 204
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015

AUDIT COURSE - I

18AUP904 PEDAGOGY STUDIES

L	T	P	C
2	0	0	0

Course Objectives:

Students will be able to:

1. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
2. Identify critical evidence gaps to guide the development.

UNIT-I

Introduction and Methodology:

- Aims and rationale, Policy background, Conceptual framework and terminology
- Theories of learning, Curriculum, Teacher education.
- Conceptual framework, Research questions**.**
- Overview of methodology and Searching.

UNIT-II

- Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.
- Curriculum, Teacher education.

UNIT-III

- Evidence on the effectiveness of pedagogical practices
- Methodology for the in depth stage: quality assessment of included studies.
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?
- Theory of change.
- Strength and nature of the body of evidence for effective pedagogical practices.
- Pedagogic theory and pedagogical approaches.
- Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT-IV

- Professional development: alignment with classroom practices and follow-up support
- Peer support
- Support from the head teacher and the community.
- Curriculum and assessment
- Barriers to learning: limited resources and large class sizes

UNIT-V

- **Research gaps and future directions**
- Research design
- Contexts

- Pedagogy
- Teacher education
- Curriculum and assessment
- Dissemination and research impact.

Course Outcomes
Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy

Suggested reading

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2):245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, ‘learning to read’ campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

M. Tech I Year II Semester

18DECSP103 ADVANCED DIGITAL SIGNAL PROCESSING

L	T	P	C
3	0	0	3

Course Prerequisite: Signals and Systems, Digital Signal Processing

Course Description:
The course gives complete knowledge regarding various algorithms associated with Digital signal processing and multi rate signal processing. It also covers various power spectral estimation methods. It makes the reader to understand the effects of finite word length in fixed-point DSP systems by using ADC and FFT algorithms.

Course Objectives:
1. To study about the digital signal processing algorithms and multi- rate signal processing.
2. To study about the power spectral estimation by using Barlett, Welch &Blackmann&Tukey methods.
3. To study about the effects of finite word length in fixed-point DSP systems.

UNIT – I: MULTI-RATE DIGITAL SIGNAL PROCESSING
Introduction, Decimation by a factor 'D' and Interpolation by a factor 'I', Sampling rate conversion by factor 'I/D', Multistage implementation of sampling rate conversion, Applications of multi-rate DSP: Implementation digital filter banks, Sub-band coding of Speech signal, Quadrature Mirror Filter. **(9)**

UNIT – II: LINEAR PREDICTION
Innovation representation of a stationary random process, Forward and backward linear prediction filters, Solution of normal equations, AR Lattice and ARMA Lattice-Ladder filters, Wiener filters for filtering and prediction.

UNIT – III OPTIMUM LINEAR FILTERS
Adaptive Filters: Applications, Gradient Adaptive Lattice, Least Mean Square (LMS) algorithm, Recursive Least Square algorithm. **(9)**

UNIT – IV: POWER SPECTRUM ESTIMATION
Estimation of Spectra from Finite-Duration Observations of Signals. Nonparametric Methods for Power Spectrum Estimation, Parametric Methods for Power Spectrum Estimation, Minimum-Variance Spectral Estimation, Eigen analysis Algorithms for Spectrum Estimation. **(9)**

UNIT – V: WAVELET TRANSFORM AND APPLICATION OF DSP
Introduction to wavelets, Continuous Wavelet and Short Time Fourier Transform, Mathematical Preliminaries and properties, Discrete Wavelet Transform, Haar Scaling Functions, Haar wavelet function, Daubechies wavelets, Image compression and wavelet. **(9)**

Course Outcomes:
At the end of this course, students will be able to
1. To understand theory of Multi-rate DSP, solve numerical problems and write algorithms.
2. To understand theory of different filters and algorithms

3. To understand theory of prediction and solution of normal equations
4. To understand the theory of Wavelet transform

Text / Reference Books

1. J.G.Proakis and D.G.Manolakis, "Digital signal processing: Principles, Algorithm and Applications", 4th Edition, Prentice Hall, 2007.
2. M. H. Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley & Sons Inc., 2002.
3. K.P Soman, K.I. Ramachandran,"Insight into Wavelets- from Theory to Practice", PHI Third Edition-2010
4. N. J. Fliege, "Multirate Digital Signal Processing: Multirate Systems -Filter Banks – Wavelets", 1st Edition, John Wiley and Sons Ltd, 1999.
5. Bruce W. Suter, "Multirate and Wavelet Signal Processing",1st Edition, Academic Press, 1997.
6. S.Haykin, "Adaptive Filter Theory", 4th Edition, Prentice Hall, 2001.
7. D.G.Manolakis, V.K. Ingle and S.M.Kogon, "Statistical and Adaptive Signal Processing", McGraw Hill, 2000.

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

M. Tech I Year II Semester

18DECSP104 MICROCONTROLLERS AND PROGRAMMABLE DIGITAL SIGNAL PROCESSORS

L	T	P	C
3	0	0	3

Course Prerequisite: None

Course Description:
This course is being designed to make the students aware of the features, architectures and applications of microcontrollers and programmable digital signal processors.

Course Objectives:
1. To understand the basic architecture, types and memory structures of microcontrollers.
2. To understand the simulator and programming with microcontrollers.

UNIT I: ARM CORTEX-M3 PROCESSOR
Applications, Programming model – Registers, Operation modes, Exceptions and Interrupts, Reset Sequence Instruction Set, Unified Assembler Language, Memory Maps, Memory Access Attributes, Permissions, Bit-Band Operations, Unaligned and Exclusive Transfers. Pipeline, Bus Interfaces. **(9)**

UNIT II: LPC 17XX MICROCONTROLLER
Internal memory, GPIOs, Timers, ADC, UART and other serial interfaces, PWM, RTC, WDT. **(9)**

UNIT III: PROGRAMMABLE DSP (P-DSP) PROCESSORS
Harvard architecture, Multi port memory, architectural structure of P-DSP- MAC unit, Barrel shifters, Introduction to TI DSP processor family. **(9)**

UNIT IV: VLIW ARCHITECTURE AND TMS320C6000 SERIES
Architecture study, data paths, cross paths, Introduction to Instruction level architecture of C6000 family, Assembly Instructions memory addressing, for arithmetic, logical operations. **(9)**

UNIT V: CODE COMPOSER STUDIO
CCS for application development for digital signal processing, On chip peripherals , Processor benchmarking. **(9)**

Course Outcomes:
At the end of this course, students will be able to
1. Compare and select ARM processor core based SoC with several features/peripherals based on requirements of embedded applications.
2. Identify and characterize architecture of Programmable DSP Processors.
3. Understand the implementation of basic DSP algorithms.
4. Develop small applications by utilizing the ARM processor core and DSP processor based platform.

Text / Reference Books

1. Joseph Yiu, “The definitive guide to ARM Cortex-M3”, Elsevier, 2nd Edition
2. Venkatramani B. and Bhaskar M. “Digital Signal Processors: Architecture, Programmingand Applications” , TMH , 2nd Edition.
3. Sloss Andrew N, Symes Dominic, Wright Chris, “ARM System Developer's Guide: Designing and Optimizing”, Morgan Kaufman Publication.
4. Steve furber, “ARM System-on-Chip Architecture”, Pearson Education.
5. Frank Vahid and Tony Givargis, “Embedded System Design”, Wiley.
6. Technical references and user manuals on www.arm.com, NXP Semiconductor www.nxp.com and Texas Instruments www.ti.com

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective – III

18DECSP409 **SATELLITE COMMUNICATION**

L	T	P	C
3	0	0	

Course Prerequisite: Wireless communication

Course Description:
Satellite communication is a form of wireless communication that covers large area and long distance using satellites as repeaters. In this course the students will get the basic technical knowledge of orbital dynamics, subsystems used in space segment and ground segment, power and bandwidth requirement, effect of the transmission medium, other impairments and techniques to mitigate them, regulatory aspect and standards, and some value added examples.

Course Objectives:
1. To know the Orbit, Space segment, Ground segment and propagation effect
2. To understand multiple access schemes and Capacity enhancement.
3. To be familiar with the concept of Nonlinearity and Synchronization.

UNIT – I: INTRODUCTION OF SATELLITE COMMUNICATION AND ORBITAL ANALYSIS
Brief discussion of wireless communication, History of Satellite systems, A basic architecture of satellite Communication, advantages and disadvantages, applications, and frequency bands used for satellite communication.
Orbital Analysis: Orbital equations, Kepler's laws of planetary motion, Apogee and Perigee for an elliptical orbit, evaluation of velocity, orbital period, angular velocity of a satellite, Look angle determination. **(9)**

UNIT – II: SATELLITE SUB-SYSTEMS AND SPACE SEGMENT
Architecture and Roles of various sub-systems of a satellite system such as Telemetry, tracking, command and monitoring (TTC & M), Communication sub-system, power sub-systems, antenna sub-system. Satellite uplink and downlink analysis and design, link budget, C/N and E/N calculation. **(9)**

UNIT – III: TYPICAL PHENOMENA IN SATELLITE COMMUNICATION
Solar Eclipse on satellite, its effects, remedies for Eclipse, Sun Transit Outage phenomena, its effects and remedies, Doppler frequency shift phenomena and expression for Doppler shift. **(9)**

UNIT – IV: MODULATION AND MULTIPLE ACCESS SCHEMES
Modulation and Multiplexing, Voice, data, video, analog digital transmission system, Digital video broadcast, Multiple access: FDMA,TDMA,CDMA Spread Spectrum communication, encryption. **(9)**

UNIT – V: ANTENNA SEGMENT
Antenna used in satellite communication. Transmitting and Receiving antenna for satellite communication, VSAT ,INSAT, propagation, Inter modulation and interference, Link power budget equation , System noise ,Antenna noise Amplifier noise and temperature. Attenuation,

Rain attenuation and cloud attenuation. Direct to home TV systems, GPS, GPS Navigation. satellite telephony using LEO. **(9)**

Course Outcomes:

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

1. Visualize the architecture of satellite systems as a means of high speed, high range communication system.
2. State various aspects related to satellite systems such as orbital equations, sub-systems in a satellite, link budget.
3. Understand the phenomena that affect the performance of Satellite Communication System.
4. Solve numerical problems related to orbital motion and design of link budget for the given parameters and conditions.
5. Analyse themodulation and multiple access schemes of recently launched satellites.

Text / Reference Books

1. Timothy Pratt and Others, "Satellite Communications", Wiley India, 2nd edition,2010.
2. S. K. Raman, "Fundamentals of Satellite Communication", Pearson Education India, 2011
3. Dennis Roddy, "Satellite Communication", McGraw Hill, 4th Edition, 2008
4. Satellite Communications Systems: systems, techniques and technology, 5th edition, by G. Maral, M. Bousquet, Z. Sun, Publisher: John Willy and sons.
5. Louis J.Ippolito,Jr, " Satellite Communications Systems Engineering" Wiley series on Wireless communication and Mobile Computing.

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective – III

18DECSP410 **INTERNET OF THINGS**

L	T	P	C
3	0	0	3

Course Prerequisite: Communication Systems, Wireless sensors

Course Description:
Internet of Things (IoT) is presently a hot technology worldwide. IoT cuts across different application domain ranging from civilian to defence sectors. Following this course the reader will know the step by step flow of IoT system design. At the end of the course, the student is expected to make the right choice of hardware, software and protocols for the proposed application.

Course Objectives:
At the end of this course, students will be able to
1. Understand the concept of IoT and M2M
2. Study IOT architecture and applications in various fields
3. Study the security and privacy issues in IoT

UNIT – I: INTRODUCTION TO IOT
Definitions and characteristics-Things in IoT, IoT protocols-IoT functional blocks, IoT communication models, IoT communication APIs- IoT enabling technology. **(9)**

UNIT – II: IOT AND M2M
A Basic Perspective– Introduction, Some Definitions, Differences-Software defined networking-Network function virtualization. **(9)**

UNIT – III: IOT ARCHITECTURE AND PROTOCOLS
An IoT architecture outline, standard considerations, ETSI architecture, IETF architecture, IoT reference model.
Protocols – Web service protocols, MQ telemetry transport for sensor networks (MQTT-S), ZigBee compact application protocol (CAP), Service discovery, Simple network management protocol (SNMP), Real-time transport and sessions, Industry-specific protocol. **(9)**

UNIT – IV: DOMAIN SPECIFIC IOTS
Home automation, cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health

(9)

UNIT – V: PRIVACY, SECURITY AND GOVERNANCE
Overview of Governance, Privacy and Security Issues, Contribution from FP7 Projects, Security, Privacy and Trust in IoT-Data-Platforms for Smart Cities. **(9)**

Course Outcomes:
At the end of this course, students will be able to
1. Understand what IoT technologies are used for today, and what is required in certain scenarios
2. Understand Machine-to-Machine Communications.

3. Understand the basic model of IoT architecture and necessary protocols standards used in IoT.
4. Understand the domain specific IoTs and security related issues.

Text / Reference Books

1. Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on-Approach)", 1st Edition, VPT, 2014.
2. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, DavidBoyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1st Edition, Academic Press, 2014.
3. A. McEwen, H. Cassimally, "Designing the Internet of Things", Wiley, 2013.
4. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1stEdition, Apress Publications, 2013.
5. Samuel Greenguard, "Internet of things", MIT Press, 2015.

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective – III

18DECSP411 **LOW POWER VLSI DESIGN**

L	T	P	C
3	0	03	

Course Prerequisite: CMOS VLSI Design

Course Description:
This course introduces various strategies and methodologies for designing low power circuit and systems. It describes the issues faced by designers at architectural, logic, circuit and device levels and presents some of the techniques that have been proposed to overcome these difficulties.

Course Objectives:
1. To identify the sources of power dissipation and understand challenges involved in low power CMOS VLSI design.
2. To study power estimation at various levels of abstraction
3. To identify suitable techniques to reduce power dissipation
4. To know low power synthesis and optimization techniques
5. To design low power memory and microprocessor

UNIT – I: TECHNOLOGY & CIRCUIT DESIGN LEVELS
Sources of power dissipation in digital ICs –Dynamic power dissipation – short circuit power dissipation, Design principles of low power design, Low Power figure of Merits - Physics of power dissipation in CMOS FET devices – Leakage components of MOSFET devices – Scaling. **(9)**

UNIT – II: POWER ESTIMATION
Signal probability calculation, Probabilistic techniques for signal activity estimation, Estimation of glitching power, Power estimation at circuit level, Simulation power analysis – SPICE circuit simulation – gate level logic simulation – architecture level analysis, System level power analysis, Algorithmic level power estimation and analysis. **(9)**

UNIIT -III: LOW POWER CIRCUIT TECHNIQUES
Circuit level techniques – Transistor and gate sizing – Network structuring and reorganization – special latches and flip-flops, Low voltage circuit design techniques - Variable-threshold (VTCMOS) approach, Multi-threshold-voltage CMOS (MTCMOS) approach, Dual-Vt assignment approach (DTCMOS) – multiple threshold CMOS based on path criticality, Adiabatic computation, pass transistor logic synthesis. **(9)**

UNIT – IV: SYNTHESIS FOR LOW POWER
Behavioral level transforms – Algorithm level transforms for low power – Architecture driven voltage scaling – power optimization using operation reduction and operation substitution – Precomputation based optimization for low power, Logic level optimization for low power, Low power arithmetic operators – Addition – Multiplication – other operations, number systems and constraints. **(9)**

UNIT – V: LOW POWER MEMORY DESIGN AND LOW POWER MICROPROCESSOR DESIGN SYSTEM

Low Power Static RAM Architectures – Organization of Static RAM, operation of 4T SRAM Cell – 6T SRAM Cell – Banked organization of SRAM – Reducing Voltage swings on bit lines – Reducing power in write driver circuits – Reducing power in sense amplifier circuits, Software design for low power – sources of software power dissipation – software power optimizations – code sign for low power. Circuit design style - Software power estimation - co design, for low power. **(9)**

Course Outcomes:

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

1. Identify the sources of power dissipation in digital IC systems & understand the impact of power on system performance and reliability.
2. Understand Power Estimation techniques.
3. Demonstrate circuit level techniques for reducing power.
4. Illustrate behavioural level and logic level approaches for low power design
5. Understand Low Power memory and Microprocessor design

Text Books

1. Kaushik Roy, Sharat Prasad, "Low power CMOS VLSI circuit design", John Wiley sons Inc.,2000.
2. Christian Piguet, "Low power CMOS circuits Technology, Logic Design and CAD tools", CRC PressTaylor and Francis Group.,2006.
3. Gary Yeap, "Practical low power digital VLSI design", Kluwer, 1998.

Reference Books

1. J.B.Kulo and J.H Lou, "Low voltage CMOS VLSI Circuits", Wiley, 1999.
2. A.P.Chandrasekaran and R.W.Broadersen, "Low power digital CMOS design", Kluwer, 1995

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination

Discipline Elective – III

18DECSP412 **VLSI SIGNAL PROCESSING**

L	T	P	C
3	0	0	

Course Prerequisite: Digital Signal Processing

Course Description:
DSP systems run the same program repetitively on an infinite time series. This course focuses on designing efficient architectures, algorithms and circuits for improving performance or reducing power or reducing area.

Course Objectives:
1. To learn transformations to alter DSP architectures to suit VLSI implementations
2. To know techniques for algorithmic and numerical strength reduction
3. To study about the various arithmetic architectures for DSP and features of DSP

UNIT – I: PIPELINING AND PARALLEL PROCESSING OF DIGITAL FILTERS
Introduction to DSP systems – Typical DSP algorithms, Data flow graph representation – critical path, Loop bound, iteration bound, Algorithms for computing iteration bound, Pipelining and Parallel processing of FIR filters, Pipelining and Parallel processing for low power. **(9)**

UNIT – II: RETIMING, UNFOLDING AND FOLDING TRANSFORMATIONS
Retiming – definitions and properties- Retiming techniques, Unfolding – Algorithm for Unfolding - properties of unfolding - Applications of Unfolding, Folding – Folding transformation – Register minimizing techniques - Register Minimization in folded architectures. **(9)**

UNIT – III: ALGORITHMIC AND NUMERICAL STRENGTH REDUCTION
Fast convolution - Cook-Toom algorithm - Modified Cook-Toom algorithm - Winograd algorithm - Modified Winograd algorithm - Design of fast convolution by inspection, Numerical strength reduction - sub-expression elimination -Multiple constant multiplication - sub-expression sharing in digital filters. **(9)**

UNIT – IV: BIT-LEVEL ARITHMETIC AND REDUNDANT ARITHMETIC
Bit-level arithmetic architectures – parallel multipliers - bit serial multipliers - Canonic Signed Digit Arithmetic - Distributed Arithmetic, Redundant arithmetic - Redundant number representations - Carry-free radix-2 addition and subtraction - Hybrid radix-4 addition - radix-2 hybrid redundant multiplication architectures. **(9)**

UNIT – V: SYNCHRONOUS & ASYNCHRONOUS PIPELINES AND PROGRAMMABLE DIGITAL SIGNAL PROCESSORS
Synchronous pipelining and clocking styles, Wave pipelining, Asynchronous pipelining, Low Power Design, Programmable Digital Signal Processors - Evolution - Features of DSP processors - DSP processors for Mobile and Wireless communications - Processors for multimedia signal processing. **(9)**

Course Outcomes:

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

1. Acquire knowledge about DSP algorithms and Design filter structures for improving speed / power.
2. Gain knowledge about retiming, folding and unfolding techniques.
3. Demonstrate methods for algorithm strength reduction and numerical strength reduction.
4. Understand the basics of Bit-level and Redundant arithmetic architectures.
5. Illustrate the features of various Pipelines and Digital signal processors

Text / Reference Books

1. Keshab K. Parhi, " VLSI Digital Signal Processing Systems, Design and implementation ", Wiley, Interscience, 2007.
2. U. Meyer – Baese, " Digital Signal Processing with Field Programmable Gate Arrays", Springer, Second Edition, 2004.
3. Roger Woods, John McAllister, Gaye Lightbody and Ying Yi, "FPGA Based Implementation of Signal Processing Systems", John Wiley & Sons, 2008.
4. S.Y. Kung, H.J. White House, T. Kailath, "VLSI and Modern Signal Processing", Prentice Hall, 1985.

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective-IV

18DECSP413 **MARKOV CHAIN AND QUEUING SYSTEM**

L	T	P	C
3	0	0	3

Course Prerequisite: Programming language and Mathematics at Undergraduate label

Course Description:
The aim of this course is to provide students with basic knowledge of stochastic models with a special focus on queuing models that may apply to telecommunications topics, such as traffic modelling, performance evaluation, resource provisioning and traffic management. It begins with a review of some probability theory and then defines processes used to analyse queuing systems, the birth-death process.

Course Objectives:
1. To understand fundamental concepts of Queuing Theory
2. To understand Infinite source Queuing systems and finite source Queuing systems

UNIT I: INTRODUCTION
Review of basic probability, properties of nonnegative random variables, laws of large numbers and the Central Limit Theorem. **(9)**

UNIT II: RENEWAL PROCESSES
Basic definitions, recurrence times, rewards and renewal reward theorem, point processes, Poisson process, Walds equation, Blackwell's theorem. **(9)**

UNIT III: DISCRETE TIME MARKOV CHAINS
Definitions and properties, matrix representation, Perron-Frobenius theory. **(9)**

UNIT IV: CONTINUOUS TIME MARKOV CHAINS
Basic definitions, Q-matrix, birth-death processes, quasi birth death processes, Embedded Markov processes, semi Markov processes, reversible Markov chains, Random walks. **(9)**

UNIT V: FUNDAMENTAL QUEUING RESULTS
Advanced queuing models: priority, vacation and retrials in queues. **(9)**

Course Outcomes:
At the end of this course, students will be able to
1. Understand basic concepts of probability theory for realizing Queuing system.
2. Understand Markov Chains and regenerative processes used in modelling a wide variety of systems and phenomena.
3. Model a system as queuing system with some aspect of the queue governed by a random process.
4. Understand telecommunication systems modelling using Markov chains with special emphasis on developing queuing models.

Text / Reference Books

1. Cliffs, "Stochastic Modelling and the Theory Queues", Prentice Hall, 1989.
2. P.Bremaud, "Markov Chains", Springer-Verlag, 1999.
3. E.Seneta, "Non Negative Matrices and Markov Chains", Springer Series in Statistics, Springer, 1981.
4. R.Gallager, "Discrete Stochastic Processes", Kluwer Academic Press, 1996.
5. L.Kleinrock, "Queuing Systems", vols I and II, John Wiley and Sons 1976.
6. T.G. Robertazzi, Computer Networks and Systems - Queueing Theory and Peformance Evaluation, Springer 2000.
    1. L. Kleinrock, Queueing Systems Volume 1: Theory, Wiley 1975

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective-IV

18DECSP414 **MIMO SYSTEMS**

L	T	P	C
3	0	0	3

Course Prerequisite: Digital Communications, Basics of Linear Algebra, Statistical Methods

Course Description:
With the bandwidth requirements that today's video, audio, and data systems demand, MIMO is often an ideal solution for communication especially urban environments where clear line-of-sight is harder to achieve and the abundance RF / microwave systems that can pose interference issues. This course covers the fundamentals of Multiple input multiple output (MIMO) antenna based wireless communication systems. MIMO is now an essential part of modern wireless communication systems, such as 3G, 4G, WLAN / Wifi, LTE, WiMax, etc. MIMO is expected to be one of the enabler of 5G communication systems. This course covers important concepts of MIMO communication such as capacity computation, error probability analysis, transmitter and receiver design, multi-user communication, etc.

Course Objectives:
1. To understand how MIMO exploits the space dimension to improve wireless system's capacity, range and reliability
2. To understand MIMO in 4G and expected 5G.

UNIT I: INTRODUCTION TO MULTI-ANTENNA SYSTEMS AND DIVERSITY
Motivation; Preliminaries- Multiantenna Systems, Array Gain, Diversity Gain, Data Pipes, Spatial Multiplexing; MIMO System Model; MIMO System Capacity; Channel Unknown to the Transmitter; Channel Known to the Transmitter - Water-Pouring Principle, Capacity When Channel Is Known to the Transmitter; Deterministic- Channels, SIMO Channel Capacity, MISO Channel Capacity; Random Channels- Ergodic Capacity, Outage Capacity; Influence of Fading Correlation on MIMO Capacity; Influence of LOS on MIMO Capacity; Influence of XPD on MIMO Capacity; Keyhole Effect: Degenerate Channels; Capacity of Frequency Selective MIMO Channels. **(9)**

UNIT II: MUTUAL INFORMATION AND CAPACITY OF REAL-WORLD RANDOM MIMO CHANNELS
Capacity of fading channels with perfect transmit channel knowledge; Ergodic capacity of I.I.D. Rayleigh fast fading channels with partial transmit channel knowledge; Mutual information and capacity of correlated Rayleigh channels with partial transmit channel knowledge; Mutual information and capacity of Ricean channels with partial transmit channel knowledge; Mutual information in some particular channels; Outage capacity and diversity-multiplexing trade off in I.I.D. Rayleigh slow fading channels; Outage capacity and diversity-multiplexing trade-off in semi-correlated Raylaigh and Ricean slow fading channels. **(9)**

UNIT III: PRE-CODING AND MMO CHANNEL MODEL
Transmit channel side information; Information-theoretic foundation for exploiting CSIT; A transmitter structure; Precoding design criteria; Linear precoder designs; Precoder

performance results and discussion; Applications in practical systems; Smart antenna systems- Beamforming. **(9)**

UNIT IV: INTRODUCTION TO SPACE-TIME CODING & RECEIVER DESIGN

Space-Time Coding;Space-Time Block Codes; Space-Time Trellis Codes; Spatial Multiplexing; Space-Time Coding with CSI Knowledge at the Transmitter; Other Space-Time Coding Schemes; Reception of uncoded signals; Factor graphs and iterative processing; MIMO receivers for uncoded signals; MIMO receivers for coded signals; Iterative receivers; Rake receivers. **(9)**

UNIT V: CHANNEL ESTIMATION

Channel estimation techniques; Estimation and tracking; Training based channel estimation; Blind channel estimation; Channel estimation architectures; Iterative channel estimation; MMSE channel estimation; Correlative channel sounding; Channel estimationvin single carrier systems; Channel estimation for CDMA; Channel estimation for OFDM. **(9)**

Course Outcomes:

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

1. Understand channel modelling and propagation, MIMO Capacity, space-time coding, MIMO precoding,Equalising MIMO systems and MIMO receivers.
2. Understand Beamforming principles of MIMO.
3. Understand MIMO for multi-carrier systems (e.g. MIMO-OFDM), multi-user communications, multi-user MIMO.
4. Understand cooperative and coordinated multi-cell MIMO, introduction to MIMO in 4G (LTE, LTE-Advanced, WiMAX).
5. Perform Mathematical modelling and analysis of MIMO systems

Text / Reference Books

1. Claude Oestges, Bruno Clerckx, "MIMO Wireless Communications: From Real-world Propagation to Space-time Code Design", Academic Press, 1st edition, 2010.
2. Biligeri et. al., “MIMO wireless communications”, Cambridge University Press, 2010.
3. MohinderJanakiraman, “Space - Time Codes and MIMO Systems”, Artech House Publishers, 2004.
4. George Tsoulos, “MIMO Systems Technology for Wireless Communications”, CRC Press, 2006.
5. Wireless Communications by A. Goldsmith, Cambridge
6. Introduction to Space Time Wireless Communications by A. Paulraj, Nabar and Gore

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective-IV

18DECSP415 **NETWORK SECURITY AND CRYPTOGRAPHY**

L	T	P	C
3	0	0	3

Course Prerequisite: Discrete Structures, Algorithms

Course Description:
The aim of this course is to introduce the student to the areas of cryptography and cryptanalysis. This course develops a basic understanding of the algorithms used to protect users online and to understand some of the design choices behind these algorithms. It develops the mathematical tools required to understand the topic of cryptography. The course deals with modern trends in asymmetric key cryptography, namely using Elliptic Curves. The course concludes with the design rationale of network protocols for key exchange and attacks on such protocols.

Course Objectives:
1. To identify and utilize different forms of cryptography techniques
2. To incorporate authentication and security in the network applications
3. To distinguish among different types of threats to the system and handle the same.

UNIT I: SECURITY
Need, security services, Attacks, OSI Security Architecture, one time passwords, Model for Network security, Classical Encryption Techniques like substitution ciphers, Transposition ciphers, Cryptanalysis of Classical Encryption Techniques. **(9)**

UNIT II: NUMBER THEORY
Introduction, Fermat's and Euler's Theorem, The Chinese Remainder Theorem, Euclidean Algorithm, Extended Euclidean Algorithm, and Modular Arithmetic. **(9)**

UNIT III: PRIVATE-KEY (SYMMETRIC) AND PUBLIC-KEY (ASYMMETRIC) CRYPTOGRAPHY
Block Ciphers, Stream Ciphers, RC4 Stream cipher, Data Encryption Standard (DES), Advanced Encryption Standard (AES), Triple DES, RC5, IDEA, Linear and Differential Cryptanalysis, RSA, Key Distribution and Management, Diffie-Hellman Key Exchange, Elliptic Curve Cryptography, Message Authentication Code, hash functions, message digest algorithms: MD4 MD5, Secure Hash algorithm, RIPEMD-160, HMAC. **(9)**

UNIT IV: AUTHENTICATION
IP and Web Security Digital Signatures, Digital Signature Standards, Authentication Protocols, Kerberos, IP security Architecture, Encapsulating Security Payload, Key Management, Web Security Considerations, Secure Socket Layer and Transport Layer Security, Secure Electronic Transaction. **(9)**

UNIT V: NETWORK AND SYSTEM SECURITY
Intruders, Intrusion Detection, Password Management, Worms, viruses, Trojans, Virus Countermeasures, Firewalls, Firewall Design Principles, Trusted Systems. **(9)**

Course Outcomes:

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

1. To understand different types of security issues.
2. To know the mathematical tools required to understand the topic of cryptography.
3. To understand different types of Cyphers and their cryptanalysis.
4. To understand the concepts of Network and System securityand incorporate authentication and security in the network applications.

Text / Reference Books

1. William Stallings, "Cryptography and Network Security, Principles and Practices", Pearson Education, 3rd Edition.
2. Charlie Kaufman, Radia Perlman and Mike Speciner, "Network Security, Private Communication in a Public World", Prentice Hall, 2nd Edition.
3. Christopher M. King, ErtemOsmanoglu, Curtis Dalton, "Security Architecture, Design Deployment and Operations", RSA Pres.
4. Stephen Northcutt, LenyZeltser, Scott Winters, Karen Kent, and Ronald W. Ritchey,"Inside Network Perimeter Security", Pearson Education, 2nd Edition.
5. Richard Bejtlich, "The Practice of Network Security Monitoring: Understanding Incident Detection and Response", William Pollock Publisher, 2013.
6. Cryptography and Network Security – by Atul Kahate – TMH.
7. Data Communications and Networking- by BehourzAForouzan.
8. Cyber Security Operations Handbook – by J.W. Rittiaghouse and William M.Hancok – Elseviers

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective-IV

18DECSP416 **CAD OF DIGITAL SYSTEM**

L	T	P	C
3	0	0	3

Course Prerequisite: Digital logic design and Data structures

Course Description:
This course provides an introduction to the fundamentals of Computer-Aided Design tools for the modelling, design, analysis, test, and verification of digital Very Large-Scale Integration (VLSI) systems.

Course Objectives:
1. To demonstrate comprehensive understanding of the various phases of CAD for digital electronic systems, from digital logic simulation to physical design, including test and verification.
2. To demonstrate knowledge of computational and optimization algorithms and tools applicable to solving CAD related problems.
3. To inculcate the knowledge of Verilog HDL and its simulation and synthesis aspects.

UNIT I: VLSI DESIGN FLOW, TOOLS AND BASIC ALGORITHMS
VLSI Physical Design Automation - Design and Fabrication of VLSI Devices, VLSI Design Methodologies – VLSI Design Automation Tools - Algorithmic Graph Theory and Computational Complexity – General Purpose methods for Combinational Optimization. **(9)**

UNIT II: LAYOUT, PLACEMENT AND PARTITIONING
Layout Compaction – Algorithms for constraint graph compaction Placement – Constructive Placement – Iterative Improvement, Partitioning –Kernighan Lin Algorithm – simulated annealing. **(9)**

UNIT III: FLOOR PLANNING AND ROUTING
Floor planning and Pin assignment - Routing – Classifications of Global Routing Algorithms – Detailed Routing –Single Layer Routing algorithms and Two Layer Routing Algorithms – Clock Routing Algorithms – Power and Ground Routing. **(9)**

UNIT IV: SIMULATION AND SYNTHESIS
Gate level modeling and Simulation – Switch level modeling and simulation - Logic Synthesis – Binary Decision Diagrams – Two Level Logic Synthesis – High Level Synthesis – Hardware models , Internal representation – Allocation, Assignment and Scheduling – Simple Scheduling algorithms. **(9)**

UNIT V: VERILOG
Hierarchical modeling concepts – lexical conventions – data types –Gate level modeling – Data flow modeling – Behavioralmodeling – Tasks and functions – Modeling examples – Finite state machine – Universal Shift register – Counter – ALU. **(9)**

Course Outcomes:

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

1. Explain the fundamentals of VLSI Design and CAD tools for modeling, design, test and verification of VLSI systems.
2. Understand Placement and Partitioning phases of physical design
3. Demonstrate floor planning and routing algorithms for VLSI circuits.
4. Demonstrate the concepts of simulation and synthesis.
5. Design and Develop digital circuits using Verilog HDL.

Text / Reference Books:

1. S.H. Gerez, "Algorithms for VLSI Design Automation", John Wiley & Sons, 2002.
2. N.A. Sherwani, "Algorithms for VLSI Physical Design Automation", Kluwer Academic Publishers, 2002.
3. Sadiq M. Sait, Habib Youssef, “VLSI Physical Design automation: Theory and Practice”, World Scientific 1999.
4. Samir Palnitkar, “Verilog HDL: A Guide to Digital Design and Synthesis” , Second Edition, Prentice Hall, 2003.
5. J. Bhaskar,, “Verilog HDLSynthesis : A Practical Primer”, Star Galaxy Publications

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

M. Tech I Year II Semester

18DECSP203 **ADVANCED DIGITAL SIGNAL PROCESSING LAB**

L	T	P	C
0	0	3	2

Course Prerequisite: Signals and Systems, Digital Signal Processing.

LIST OF EXPERIMENTS:

1. Stability Using Hurwitz Routh Criteria.
2. FFT and its Applications
3. Chebychev Type I, II Filter
4. State Space Matrix from Differential Equation
5. Decimation And Interpolation Using Rationale Factors
6. FIR filtering by interfacing Matlab with Code Composer Studio
7. To plot Impulse response of first order and second order systems and calculate the damping factor.
8. Convolution And M Fold Decimation & PSD Estimator
9. Inverse Z Transform
10. Group Delay Calculation

Mode of Evaluation: Continuous Internal Evaluation, Practical Examination.

M. Tech I Year II Semester

18DECSP204 MICROCONTROLLERS AND PROGRAMMABLE DIGITAL SIGNAL PROCESSORS LAB

L	T	P	C
0	0	3	2

Course Prerequisite: None

Course Description:
The course is designed to perform experiments on Cortex-M3 development boards using GNU tool chain. Another part of the course focuses on experiments to be carried out on DSP C6713 evaluation kits using code composer studio (CCS).

Course Objectives:
1. Programming using arithmetic, logical and bit manipulation instructions of microcontrollers.
2. To understand the flow control instructions of Digital signal processors and the real time computation with the Digital signal processors.

LIST OF EXPERIMENTS:
1. Blink an LED with software delay, delay generated using the SysTick timer.
2. System clock real time alteration using the PLL modules.
3. Control intensity of an LED using PWM implemented in software and hardware.
4. Control an LED using switch by polling method, by interrupt method and flash the LED once every five switch presses.
5. Temperature indication on an RGB LED.
6. UART Echo Test.
7. To develop an assembly code and C code to compute Euclidian distancebetween any two points.
8. To develop assembly and C code for implementation of convolution operation.
9. To develop assembly code and study the impact of parallel, serial and mixed execution.
10. To design and implement filters in C to enhance the features of given input sequence/signal.

Course Outcomes:
At the end of the laboratory work, students will be able to:
1. Install, configure and utilize tool sets for developing applications based on ARM processor core SoC and DSP processor.
2. Develop prototype codes using commonly available on and off chip peripherals on the Cortex M3 and DSP development boards.

Mode of Evaluation: Continuous Internal Evaluation, Practical Examination.

AUDIT COURSE - II

AUDIT COURSE -II

18AUP905 ENGLISH FOR RESEARCH PAPER WRITING

L	T	P	C
2	0	0	0

Course objectives:

Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title

Ensure the good quality of paper at very first-time submission

UNIT-I

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT-II

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

UNIT-III

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

UNIT-IV

key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,

UNIT-V

skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT-VI

useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

Suggested Studies:

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

Adrian Wallwork, English for Writing

AUDIT COURSE-II

18AUP906 VALUE EDUCATION

L	T	P	C
2	0	0	0

Course Objectives

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

UNIT-I

- Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.
- Moral and non- moral valuation. Standards and principles.
- Value judgements

UNIT-II

- Importance of cultivation of values.
- Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.
- Honesty, Humanity. Power of faith, National Unity.
- Patriotism.Love for nature,Discipline

UNIT-III

- Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.
- Punctuality, Love and Kindness.
- Avoid fault Thinking.
- Free from anger, Dignity of labour.
- Universal brotherhood and religious tolerance.
- True friendship.
- Happiness Vs suffering, love for truth.
- Aware of self-destructive habits.
- Association and Cooperation.
- Doing best for saving nature

UNIT-IV

- Character and Competence –Holy books vs Blind faith.
- Self-management and Good health.
- Science of reincarnation.
- Equality, Nonviolence,Humility, Role of Women.

- All religions and same message.
- Mind your Mind, Self-control.
- Honesty, Studying effectively

Course outcomes
Students will be able to

1. Knowledge of self-development
2. Learn the importance of Human values
3. Developing the overall personality

Suggested reading

1. Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

AUDIT COURSE - II

18AUP907 STRESS MANAGEMENT BY YOGA

L	T	P	C
2	0	0	0

Course Objectives

1. To achieve overall health of body and mind
2. To overcome stress

UNIT-I

Definitions of Eight parts of yog. (Ashtanga)

UNIT-II

Yam and Niyam.
Do`s and Don't's in life.
i) Ahinsa, satya, astheya, bramhacharya and aparigraha
ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

UNIT-III

Asan and Pranayam
i) Various yog poses and their benefits for mind & body
ii)Regularization of breathing techniques and its effects-Types of pranayam

Course Outcomes:

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

Suggested reading

1. 'Yogic Asanas for Group Tarining-Part-I" :Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata

AUDIT COURSE - II

18AUP908 PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

L	T	P	C
2	0	0	0

Course Objectives

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

UNIT-I

Neetisatakam-Holistic development of personality

- Verses- 19,20,21,22 (wisdom)
- Verses- 29,31,32 (pride & heroism)
- Verses- 26,28,63,65 (virtue)
- Verses- 52,53,59 (dont's)
- Verses- 71,73,75,78 (do's)

UNIT-II

- Approach to day to day work and duties.
- Shrimad BhagwadGeeta : Chapter 2-Verses 41, 47,48,
- Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,
- Chapter 18-Verses 45, 46, 48.

UNIT-III

- Statements of basic knowledge.
- Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68
- Chapter 12 -Verses 13, 14, 15, 16,17, 18
- Personality of Role model. Shrimad BhagwadGeeta:
- Chapter2-Verses 17, Chapter 3-Verses 36,37,42,
- Chapter 4-Verses 18, 38,39
- Chapter18 – Verses 37,38,63

Course Outcomes

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

Suggested reading

1. “Srimad Bhagavad Gita” by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata
2. Bhartrihari’s Three Satakam (Niti-sringar-vairagya) by P.Gopinath,
3. Rashtriya Sanskrit Sansthanam, New Delhi.

Discipline Elective – V

18DECSP417 **HIGH PERFORMANCE NETWORKS**

L	T	P	C
3	0	03	

Course Prerequisite: Background in Networking, Telecommunications and Performance evaluation along with adequate programming skills in C or C++.

Course Description:
The world is undergoing a revolution in information and communication technology.Traditional wired networks are being replaced or complemented by networks based on wireless, optical, satellite, and other media.These new networking media and the new ways of communication over these networks have given rise to a host of new performance issues and concepts. This course has been designed to cover all these issues and concepts.

Course Objectives:
1. To know about protocols for real time interactive applications.
2. To know Peer- Peer models and protocols.
3. To be aware of Network Performance Evaluation.
4. To understand principles of Cryptography and its applications.

UNIT I: MULTIMEDIA NETWORKING
Multimedia Networking Applications. Streaming stored Audio and Video, Best effort service, protocols for real time interactive applications, Beyond best effort, scheduling and policing mechanism, integrated services, and RSVP-differentiated services. **(9)**

UNIT II: VoIP
Overview of the PSTN and Comparisons to Voice over IP, Voice over IP Benefits and Applications: Key Benefits of VoIP Packet Telephony Call Centers, Enterprise Case Study: Acme Corporation, IP Signaling Protocols :H.323, Session Initiation Protocol, Gateway Control Protocols Simple Gateway Control Protocol Media Gateway Control Protocol. **(9)**

UNIT III: P2P SYSTEMS
VPN-Remote-Access VPN, site-to-site VPN, Tunneling to PPP, Security in VPN. MPLSoperation, Routing, Tunneling and use of FEC, Traffic Engineering, MPLS based VPN, overlay networks-P2P connections. **(9)**

UNIT IV: TRAFFIC MODELING
Little's theorem, Markovian FIFO queuing systems, Non Markovian and self similarmodels , Network of ques. **(9)**

UNIT V: NETWORK SECURITY AND MANAGEMENT
Principles of cryptography, Authentication, integrity, key distribution and certification, Access control and fire walls, attacks and counter measures, security in many layers. **(9)**

Course Outcomes:

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

1. Apply knowledge of mathematics, probability, and statistics to model and analyze some networking protocols.
2. Design, implement, and analyze computer networks.
3. Identify, formulate, and solve network engineering problems.
4. Show knowledge of contemporary issues in high performance computer networks.
5. Use techniques, skills, and modern networking tools necessary for engineering practice.

Text / Reference Books

1. James F. Kurose , Computer Networking: A Top-Down Approach Featuring the Internet, 3/e,Pearson Education India, 2005.
2. Jonathan Davidson, James F. Peters, Manoj Bhatia, Voice Over IP Fundamentals, Cisco press,2006.
3. Nader F. Mir, Computer and Communications Networks, Pearson education, 2009.
4. Kershenbaum A., "Telecommunications Network Design Algorithms", Tata McGraw Hill,1993.
5. Larry Peterson & Bruce David, "Computer Networks: A System Approach", MorganKaufmann, 2003.
6. Douskalis B., "IP Telephony: The Integration of Robust VoIP Services", Pearson Ed. Asia,2000.
7. Warland J., Varaiya P., "High-Performance Communication Networks", MorganKaufmann, 1996.
8. Stallings W., "High-Speed Networks: TCP/IP and ATM Design Principles", Prentice Hall,1998
9. Leon Garcia, Widjaja, "Communication networks", TMH 7threprint 2002.
10. William Stalling, "Network security, essentials", Pearson education Asia publication, 4thEdition, 2011.

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective – V

18DECSP418 PATTERN RECOGNITION AND MACHINE LEARNING

L	T	P	C
3	0	0	3

Course Prerequisite: Basic knowledge of Signal Processing, Probability Theory and Graph Theory.

Course Description:
This course gives the importance and usefulness of the design, analysis, and development of methods for the classification or description of patterns, objects, signals, and processes. Many commercial applications of pattern recognition exist today, including voice recognition, fingerprint classification, and retinal scanners. Recent developments in statistical modeling using Bayesian techniques, neural networks, decision trees, fuzzy logic, and syntactic structures have accelerated the growth of pattern recognition applications. Analytical aspects have been adequately stressed so that on completion of the course the students can apply the concepts learnt in real life problems.

Course Objectives:
1. To know "What is pattern recognition?"
2. To introduce the fundamental methods of pattern recognition, both statistical and neural, with examples from several application areas.
3. To learn Bayesian learning and Bayes algorithm.
4. To understand Minimum distance classifier, K-NN Classifier, Linear discriminant functions and Non-linear decision boundaries.
5. To understand the current state of the art in machine learning and be able to begin to conduct original research in machine learning.

UNIT I: INTRODUCTION TO PATTERN RECOGNITION
Pattern recognition systems: sensing, segmentation and grouping, Feature extraction, Classification, Post processing. The design Cycle: Data collection, Feature Choice, Model Choice, Training, Evaluation, Computational Complexity. Learning and Adaption: Supervised learning, Unsupervised learning, Reinforcement learning. **(9)**

UNIT II: NEURAL NETWORK
Classification of neural networks, Comparison between artificial and biological neural network, artificial neuron model, activation functions and types of activation functions, single layer feed- forward network, multilayer feed-forward network, learning strategy, neural network learning rules, application of neural networks, advantages of neural networks. **(9)**

UNIT III: LINEAR DISCRIMINANT FUNCTIONS
Decision surfaces, two-category, multi-category, minimum squared error procedures, the Ho-Kashyap procedures, linear programming algorithms, Support vector machine. **(9)**

UNIT IV: STOCHASTIC METHODS
Stochastic search, Boltzmann learning, Evolutionary methods, Genetic Algorithm. **(9)**

UNIT V:Algorithm independent machine learning – lack of inherent superiority of any classifier, bias and variance, re-sampling for classifier design, combining classifiers
Unsupervised learning and clustering – k-means clustering, fuzzy k-means clustering, hierarchical clustering. **(9)**

Course Outcomes:
At the end of this course, students will be able to
1. Understand the usefulness of pattern recognition.
2. Study the parametric and linear models for classification.
3. Design neural network and SVM for classification.
4. Understand linear discriminant functions.
5. Develop machine independent and unsupervised learning techniques

Text / Reference Books

1. C. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
2. Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification", 2nd Edition John Wiley & Sons, 2001.
3. Trevor Hastie, Robert Tibshirani, Jerome H. Friedman, "The Elements of Statistical Learning", 2nd Edition, Springer, 2009.
4. K. Vinoth Kumar, "Neural Network & Fuzzy logic control", 1st edition Lakshmi Publications, 2008
5. Yegnanarayana, B. *Artificial neural networks*. PHI Learning Pvt. Ltd., 2009.
6. Earl Gose, Richard Johsonbaugh and Steve Jost, "Pattern Recognition and Image Analysis", Prentice Hall, 1999.

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective – V

18DECSP419 **REMOTE SENSING**

L	T	P	C
3	0	03	

Course Prerequisite: Electromagnetic spectrums and basics of Microwave, Basics of analog, digital and optical sensors, Statistical data analysis, Basics of image processing.

Course Description:
This course covers the basic concepts of remote sensing, energy interactions with atmosphere and earth surface features,thermal and hyper spectral sensing.

Course Objectives:
1. To understand Physics of Remote Sensing.
2. To understand remote sensing satellites and their features.

UNIT I: PHYSICS OF REMOTE SENSING
Electro Magnetic Spectrum, Physics of Remote Sensing, Energy interaction in atmosphere, Atmospheric Scattering, Atmospheric absorption and transmissions Atmospheric window, Energy interaction with surface features, Spectral reflectance of vegetation, soil and water atmospheric, Influence on spectral response patterns, Multi concept in Remote sensing. **(9)**

UNIT II: DATA ACQUISITION
Sensing and classification of sensors, Aerial camera, Multispectral scanners, spatial, temporal and spectral characteristics of sensor's data, Types of Platforms–Aircrafts-Manned and Unmanned, Space crafts–sun synchronous and geo synchronous satellites, Stereoscopy, Characteristics of different platforms: LANDSAT, SPOT, IRS, INSAT, IKONOS, QUICKBIRD, Data selection criteria. **(9)**

UNIT III: SCATTERING SYSTEM
range and azimuth, Real aperture and Synthetic aperture RADAR. Distortion in RADAR images, Characteristics of Microwave images, Topographic effect, Advance Remote Sensing platforms: airborne and space borne sensors, Principles and applications of ERS, JERS, RADARSAT, RISAT , Scatterometer, Altimeter, LiDAR remote sensing. **(9)**

UNIT IV: THERMAL AND HYPER SPECTRAL REMOTE SENSING
Sensors characteristic, Principle of spectroscopy, Imaging spectroscopy ,Field conditions, Compound spectral curve, Spectral library, Radiometric aspects, Radiative models, Derivative spectrometry, Remote sensing below ground surface, Thermal remote sensing, data processing and applications. **(9)**

UNIT V: DATA ANALYSIS
Resolution–Spatial, Spectral, Temporal, and Radiometric and signal to noise ratio, Data products and their characteristics, Visual and digital interpretation, Perception of color, Basic principles of data processing. Radiometric, Cosmetic and Atmospheric correction. Vision based Image enhancement, Stereoscopic correction, Image classification, Aerial Laser Terrain Mapping. **(9)**

Course Outcomes:

At the end of this course, students shall be able to

1. Understand basic concepts, principles and applications of remote sensing, particularly the geometric and radiometric principles;
2. Provide examples of applications of principles to a variety of topics in remote sensing, particularly related to data collection, radiation, resolution, and sampling.
3. Understand Radar interferometry and Shuttle Radar Topographic Mission.
4. Understand thermal sensors, principles, thermal data processing, and applications.
5. Understand Principles of LiDAR.

Text / Reference Books

1. Lillesand T.M., and Kiefer,R.W. Remote Sensing and Image interpretation, John Wiley & Sons-2000, 6thEdition.
2. Kerle, Norman, Lucas LF Janssen, and Gerrit C. Huurneman. "Principles of remote sensing." *ITC, Educational textbook series* 2 (2004): 250.
3. John R. Jensen, Introductory Digital Image Processing: A Remote Sensing Perspective, 2nd Edition, 1995.
4. John A. Richards, Springer –Verlag, Remote Sensing Digital Image Analysis, 1999.
5. Paul Curran P.J. Principles of Remote Sensing, ELBS; 1995.
6. 'Introduction to Remote Sensing - Principles and Concepts' by Paul J Gibson, Routledge - Taylor & Francis, 2000.
7. 'Introduction to Remote Sensing', J.B. Cambell, Taylor & Francis, UK, 2002.
8. 'Remote Sensing - Principles and Interpretation', F.F. Sabins Jr, W.H. Freeman & Co., New York, 1986.
9. Charles Elachi and Jakob J. van Zyl , Introduction To The Physics and Techniques of Remote Sensing , Wiley Series in Remote Sensing and Image Processing, 2006.

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Discipline Elective – V

18DECSP420 **NANOMATERIALS AND NANOTECHNOLOGY**

L	T	P	C
3	0	0	3

Course Prerequisite: Basic knowledge of atomic structure and materials property.

Course Description:
Nanomaterial's research takes a materials science-based approach to nanotechnology. Nanotechnology is manipulation of matter on an atomic, molecular, and supra-molecular scale. This course covers fundamentals of nano-materials, their classifications, Carbon nanotubes, nano scales and various applications.

Course Objectives:
1. To learn the basic science behind the fabrication of nonmaterial's.
2. To study the new solutions for current problems and competing technologies for future applications.
3. To study the inter disciplinary projects applicable to wide areas.
4. To study the operation for fabrication and characterization devices to achieve precisely designed systems.

UNIT I: NANO-MATERIALS IN ONE AND HIGHER DIMENSIONS
Basic concept of Nano science and technology, Quantum wire, Quantum wel, Quantum dot, properties and technological advantages of Nano materials, carbon nanotubes and application, material processing by Sol, Gel method, Chemical vapour deposition and physical vapour deposition, principles of SEM,TEM and AFM. **(9)**

UNIT II: APPLICATIONS OF ONE AND HIGHER DIMENSION NANO-MATERIALS
Application of Fullerene, CNT, Graphene and other carbon nanomaterials, Mechanical, Thermal application, Electronic applications and biological applications. **(9)**

UNIT III: NANO-LITHOGRAPHY, MICRO ELECTRO-MECHANICAL SYSTEM (MEMS) AND NANO-PHONICS
Necessity for a clean room, different types of clean rooms, Lithography, Printing, Chemical process, Etching techniques, the modern process, optical micro, nanolithography, Applications of nanolithography. Introduction to Micro sensors and MEMS, Evolution of Micro sensors & MEMS, MEMS types, MEMS sensors, Applications and Advantages of MEMS technology. Photons and electrons, similarities and differences, free space propagation, confinement of photons and electrons, nanoscale optical interaction, axial and lateral nanoscopic localization, nanoscale confinement of electronics interactions. **(9)**

UNIT IV: CARBON NANOTUBES – SYNTHESIS AND APPLICATIONS
History, types of CNTs, synthesis methods, CVD method, Laser ablation and electric arc processes growth mechanisms, purification methods, applications Lithium ion battery, fuel cell sensor applications, applications to nanoelectronics, nanocomposites. **(9)**

UNIT V: INTERDISCIPLINARY ARENA OF NANOTECHNOLOGY

Energy challenge in the 21st Century and nanotechnology, conventional and unconventional fissile fuels, nanotechnology in fuel production, renewable energy sources, photovoltaic's, hydrogen production, fuel cells, thermoelectricity, implementation of renewable energy technologies. **(9)**

Course Outcomes:

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

1. Understand the basic science behind the design and fabrication of nano scale systems.
2. To understand and formulate new engineering solutions for current problems and competing technologies for future applications.
3. Make inter disciplinary projects applicable to wide areas by clearing and fixing the boundaries in system development.
4. To gather detailed knowledge of the operation of fabrication and characterisation devices to achieve precisely designed systems.

Text / Reference Books

1. Nano scale Materials in Chemistry edited by Kenneth J. Klabunde and Ryan M. Richards, 2ndedn, John Wiley and Sons, 2009.
2. Nano crystalline Materials by A I Gusev and AARempel, Cambridge International Science Publishing, 1st Indian edition by Viva Books Pvt. Ltd. 2008.
3. Springer Handbook of Nanotechnology by Bharat Bhushan, Springer, 3rdedn, 2010.
4. Carbon Nanotubes: Synthesis, Characterization and Applications by Kamal K. Kar, Research Publishing Services; 1stedn, 2011, ISBN-13: 978-9810863975..

Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

OPEN ELECTIVE - I

M. Tech II Year I Semester

Open Elective -I

18OEP301 BUSINESS ANALYTICS

	L	T	P	C
Course Prerequisite: None	**2**	**0**	**2**	**3**

Course Description:
Course delves into commonly encountered business situations requiring optimization of business resources and provides basic solutions methods using traditional and advanced methods.

Course objective:
1. Refresh basic statistics
2. Explain the importance of statistics in business analytics
3. Introduce predictive modeling for business decisions
4. Explain the tools for predictive modeling
5. Explain the use of simulation to make business decision
6. Explain the use of data mining techniques for making business decision

UNIT I: INTRODUCTION TO BUSINESS ANALYTICS

Introduction to Business Analytics (BA). Evolution and Scope of Business Analytics. Data for Business Analytics.Analyzing uncertainty and model assumptions – What if analysis, Data tables, Scenario manager and Goal Seek. Regression modelling.

UNIT II: STATISTICS FOR BUSINESS ANALYTICS

Brief overview of descriptive statistics, graphical representation of data, and overview of hypothesis testing, Introduction to R statistical software

UNIT III: PREDICTIVE ANALYTICS METHODS

Forecasting techniques – Statistical forecasting techniques. Decomposition model – Estimation of trend, seasonality and cyclical components. Smoothing models for forecasting – moving average, exponential smoothing methods, time series analysis.

UNIT IV: SIMULATION, RISK ANALYSIS AND DATA MINING

Simulation and Risk Analysis – Monte Carlo simulation Examples of simulation models, Introduction to Data Mining – Scope of Data Mining. Data exploration and reduction. Classification – Measuring classification performance. Classification techniques – K nearest neighbor, Discriminant Analysis, factor analysis, and Logistic regression.

UNIT V: DECISION ANALYSIS

Decision making with uncertain information. Decision strategies for a minimize objective. Decision strategies for a maximize objective. Decision Tress. Building a decision tree. Decision trees and risk. Sensitivity analysis, Baye‘s Rule.

Case Study: Compulsory and Relevant Cases have to be discussed in each unit.
Assignment: Two relevant assignments have to be given to the students

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

1. Understand the need and significance of business analytics for decision making
2. Use statistical tools to extract information from raw data
3. Use regression technique to build predictive models
4. Apply simulation technique to predict business scenarios
5. Use data mining techniques to make business decsisions

Text Books:
Essentials of Business Analytics, Jeffrey Camm, James Cochran, Michael Fry, Jeffrey Ohlmann, David Anderson

References:

1. Albright C. S., Winston Wayne L. and Zappe C. J (2009). *Decision Making Using Microsoft Excel (India Edition).* Cengage Learning.
2. Evans J. R (2013). Business Analytics *Methods, Models and Decisions.* Pearson, Upper Saddle River, New Jersey.

M. Tech II Year I Semester

Open Elective - I

18OEP302 INDUSTRIAL SAFETY

L	T	P	C
3	0	0	3

UNIT-I:

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT-II:

Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department,Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT-III:

Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT-IV:

Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT-V:

Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Reference:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

M. Tech II Year I Semester

Open Elective - I

18OEP303 OPERATIONS RESEARCH

L	T	P	C
3	0	0	3

UNIT-I
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

UNIT-II
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

UNIT-III
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

UNIT-IV
Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

UNIT-V
Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

Course Outcomes:

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

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

References:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

M. Tech II Year I Semester

Open Elective - I

18OEP304 COST MANAGEMENT OF ENGINEERING PROJECTS

L	T	P	C
3	0	0	3

Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and
Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation
problems, Assignment problems, Simulation, Learning Curve Theory.

References:

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

M. Tech II Year I Semester

Open Elective - I

18OEP305 COMPOSITE MATERIALS

L	T	P	C
3	0	0	3

UNIT–I:
INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT – II:
REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT – III:
Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique,
Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix
Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT–IV:
Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

UNIT – V:
Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TEXT BOOKS:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

References:

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

M. Tech II Year I Semester

Open Elective - I

18OEP306 WASTE TO ENERGY

L	T	P	C
3	0	0	3

UNIT-I:
Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue,Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNIT-II:
Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods – Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT-III:
Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT-IV:
Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixedbed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNIT-V:
Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology andstatus - Bio energy system - Design and constructional features - Biomass resources and their
classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion – Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

References:

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.