Heritage Institute of Technology

M.Tech. in VLSI

(A PROGRAMME UNDER ECE DEPARTMENT)

Curriculum Structure

Release Date: July, 2018:Ver1.0

May, 2019: Ver. 1.1

April, 2021:Ver. 1.2

COURSE STRUCTURE IN

M.Tech. **VLSI**

1st. Year, Semester I

A. Theory								
Sl. No.	**Course Type**	**Code**	**Course Title**	**Contact Hours/Week**				**Credits**
				L	**T**	**P**	**Total**	
1	Professional core 1	**VLSI5101**	Digital VLSI IC Design	3	0	0	3	3
2	Professional core 2	**VLSI5102**	Embedded Systems Design	3	0	0	3	3
3	Professional Elective PE-1	**VLSI5131**	DSP For VLSI System	3	0	0	3	3
		VLSI5132	VLSI IC Fabrication					
4	Professional Elective PE-2	**VLSI5141**	CAD of Digital System	3	0	0	3	3
		VLSI5142	Modelling of VLSI Device					
5	Mgt. Group	**ECEN5103**	Research Methodology and IPR	2	0	0	2	2
6	Audit 1	**DIMA5116**	Disaster Management	2	0	0	2	0
		INCO5117	Constitution of India					
		PDLS5118	Personality Development					
		YOGA5119	Stress Management by Yoga					
		SANS5120	Sanskrit for Technical Knowledge					
Total of Theory				**16**	**0**	**0**	**16**	**14**

B. Practical								
1	Professional Core Lab1	**VLSI5151**	Digital VLSI IC Design Lab	0	0	4	4	2
2	Professional Core Lab2	**VLSI5152**	Embedded Systems Design Lab	0	0	4	4	2
Total of Practical				0	0	8	8	4
Total of Semester				**16**	**0**	**8**	**24**	**18**

1st. Year, Semester II

Sl. No.	Course Type	Code	Course Title	Contact Hours/Week				Credits
				L	T	P	Total	
1	Professional core 3	**VLSI5201**	Analog VLSI IC Design	3	0	0	3	3
2	Professional core 4	**VLSI5202**	VLSI Design, Testing and Verification	3	0	0	3	3
3	Professional Elective PE-3	**VLSI5231**	Memory Technologies	3	0	0	3	3
		VLSI5232	Low Power VLSI Design					
4	Professional Elective PE-4	**VLSI5241**	Advanced VLSI Processor	3	0	0	3	3
		VLSI5242	Advanced Nano Devices					
5		**VLSI5293**	Term Paper and Seminar	0	0	4	4	2
6	Aud 2	Any one subject from Elective3 or Elective4 buckets	Audit Course – 2	2	0	0	2	0
Total of Theory				**14**	**0**	**4**	**18**	**14**

B. Practical								
1	Professional Core Lab3	**VLSI5251**	Analog VLSI IC Design Lab	0	0	4	4	2
2	Professional Core Lab4	**VLSI5252**	VLSI Design, Testing and Verification Lab	0	0	4	4	2
Total of Practical				0	0	8	8	4
Total of Semester				**14**	**0**	**12**	**26**	**18**

2nd. Year, Semester I

A. Theory								
Sl. No.	**Course Type**	**Code**	**Course Title**	**Contact Hours/Week**				**Credits**
				L	**T**	**P**	**Total**	
1	Professional Elective PE-5	**VLSI6131**	Nano materials and Nano Technology	3	0	0	3	3
		VLSI6132	RF IC Design and MEMS					
2	Open Elective	**MATH6121**	Optimization Techniques	3	0	0	3	3
		CSEN6121	Business Analytics					
		ECEN 6125	Design and Technology for Photonic Integrated Circuit					
		AEIE6123	Intelligent Control					
Total of Theory				**6**	**0**	**0**	**6**	**6**

B. Sessional								
1	Dissertation	**VLSI6195**	Dissertation Phase I	0	0	20	20	10
Total of Semester				**6**	**0**	**20**	**26**	**16**

OPEN ELECTIVES TO BE OFFERED BY ECE DEPARTMENT (3rd. Semester):

Open Elective	**ECEN6121**	Ad Hoc Networks and Uses	3	0	0	3	3
	ECEN6122	Embedded Systems					
	ECEN6123	Cognitive Radios					
	ECEN6124	Automation in VLSI Design					

2nd. Year, Semester II

Sl. No.	Course Type	Code	Course Title	Contact Hours/Week				Credits
				L	T	P	Total	
1	Dissertation	**VLSI6295**	Dissertation Phase-II	0	0	32	32	14
2	Grand Viva	**VLSI6297**	Comprehensive Viva Voce	-	-	-	-	2
Total of Semester				**0**	**0**	**32**	**32**	**16**

Total Credit Points = 68

Course Title: DIGITAL VLSI IC DESIGN					
Course Code : VLSI5101					
Contact Hours per week	L	T	P	Total	Credit Points
	3	0	0	3	3

CO (Course Outcome):

1. Students will learn CMOS Circuit used in Digital VLSI Domain
2. Students will learn Physical Layout Design of CMOS Standard Cell
3. Students will learn Digital VLSI Design Methodology
4. Students will learn HDL coding
5. Students will learn EDA High Level and Logic Level Synthesis Algorithms
6. Students will learn EDA Physical Place and Route Automation Algorithms

Module I: VLSI Circuits & Physical Layout: [12L]

Unit1: MOS Transistor Characteristics, MOS as Digital Switch, NMOS Logic Family, CMOS Logic Family, CMOS Inverter Characteristics (VTC), Inverter Delay & Noise, NAND and NOR gates, Complex Logic Circuits, Logical Effort, Pass Transistor Logic & Transmission Gate, CMOS Sequential Circuits, CMOS D-Latch and D-Flip-Flop, Pseudo NMOS Logic, Dynamic gate, Domino and NORA Logic

Unit2: CMOS Cross Section, Layout and Mask layers, Inverter Layout, Lambda Rule vs Micron Rule, Std Cell Layout Topology, Stick Diagram, Euler Path Algorithm, Layout Legging.

Module II: VLSI Design Methodology: [8L]

Unit1: Moore's Law, Scale of Integration (SSI, MSI, LSI, VLSI, ULSI, GSI), Technology growth and process Node,

Unit2: Full Custom Design, Std Cell based Semi Custom Design, Gate Array Design, PLD, FPGA: CLB, LUT, MUX, VLSI Design Cycle, Y-Chart.

Module III: EDA Tools: High level Synthesis and HDL: [8L]

Unit1: High level Synthesis EDA Flow, Control and Data Flow Graph, Scheduling, Allocation, Binding, RTL

Unit2: Why HDL ? Frontend Design Flow using HDL (Behavioral, RTL and Gate Level), VHDL/Verilog Modeling: Behavioral, Data-Flow, Structural and Mixed, FSM Example: Mealy Machine and Moore Machine.

Module IV: EDA Tools: Logical Synthesis and Physical Design Automation: [12L]

Unit1: Combinational Logic Optimization: BDD: Binary Decision Diagram, OBDD, ROBDD, Technology Mapping: Pattern DAG, Subject DAG, Sequential Logic Optimization

Unit2: Physical Layout Automation EDA Flow, Partitioning: KL Algorithm, Floor-planning cost function, Placement, Detailed Routing: Channel Routing, Horizontal Constraint Graph, Vertical Constraint Graph, Cyclic Constraint, Left-edge Algorithm, Global Routing: Steiner Tree, Maze Routing.

Text Book:

1. Principles of CMOS VLSI Design, A Systems Perspective, Author: Neil Weste, Kamran Eshraghian, Addison Wesley, 2nd Edition, 2000
2. Algorithms for VLSI Physical Design Automation, Author: N. Sherwani, KLUWER ACADEMIC PUBLISHERS (3rd edition)

Reference Book:

3. CMOS Digital Integrated Circuits, Analysis and Design, Author: Sung-Mo Kang, Yusuf Leblebici, Tata McGraw Hill (3rd Edition), 2006
4. CMOS VLSI Design, A Circuits and Systems Perspective (3rd Edition) Author: Neil Weste, David Harris, Ayan Banerjee. Pearson, 2011
5. Digital Integrated Circuit, Design Perspective, Author: .M. Rabaey, Prentice-Hall
6. VLSI Design and EDA TOOLS, Author: Angsuman Sarkar, Swapnadip De, Chandan Kumar Sarkar, SCITECH PUBLICATIONS (India) Pvt. Ltd., 2011
7. Algorithms for VLSI Design Automation, Author: Gerez, Wiley, 2011
8. A VHDL Primer, J. Bhasker, Prentice-Hall, 2013

Course Title: EMBEDDED SYSTEMS DESIGN					
Course Code : VLSI5102					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

CO (Course Outcome):

1. Students will learn Embedded System Design Methodology
2. Students will learn Embedded Processor Design
3. Students will learn 8051 Micro-controller
4. Students will learn basics of PIC & ARM Micro-controller
5. Students will learn Embedded Memory Architecture and Interface
6. Students will learn I/O Device configurations and Interfacing

Module I : Introduction to embedded systems: [8L]
Embedded systems overview with various type of examples in different domains such as in communication systems, robotics application and in control application, Design challenge – optimizing design metrics, embedded processor technology, Difference between embedded computer systems and general purpose computer Systems, Design methodology.

Module II: Embedded system processor design: [12L]
Custom single-purpose processors design: using finite state machine model and RTL model.
Standard single-purpose processors design: Timers, and watchdog timers, LCD controller.
Interfacing of Embedded Processors: Hardware protocol basics, interfacing with a general-purpose processor, RS232, I2C, CAN protocol.

Module III: [10L]
Introduction to 8051 microcontroller: 8051 architecture, pin configuration, I/O ports and Memory organization. Instruction set and basic assembly language programming. Interrupts, Timer/Counter and Serial Communication in 8051, Introduction to PIC & ARM micro-controllers.

Module IV: [10L]
Interfacing with Memory & I/O Devices:
Different types of embedded memory devices and interfacing: SRAM, DRAM, EEPROM, FLASH, CACHE memory. Different types of I/O devices and interfacing: Keypad, LCD, VGA. Square wave and pulse wave generation, LED, A/D converter and D/A Converter interfacing to 8051.

Text Book:
1. Embedded System Design: A Unified Hardware/Software Approach – 2nd Ed Frank Vahid and Tony Givargis

Reference Book:
2. Computers as Components: Principles of Embedded Computing System Design – 2nd Ed Wayne Wolf.

Course Title : DSP FOR VLSI SYSTEM					
Course Code : VLSI5131					
Contact Hours	L	T	P	Total	Credit Points
per week	3	0	0	3	3

CO (Course Outcome):

1. Students will learn DSP Algorithm
2. Students will learn Signal and Data flow graph
3. Students will learn Pipelining and Parallel Processing
4. Students will learn Retiming Techniques
5. Students will learn SISO systems
6. Students will learn MIMO Systems

Module I: **DSP Algorithms: [14L]**
Typical DSP Algorithms, Adaptive Filters, Discrete Cosine Transform, Vector Quantization, Viterbi Algorithm, Decimator & Expander, Wavelet Transform,
Filter Banks.

Module II: **Iteration Bound: [8L]**
Signal-flow graph, Data-flow graph, Dependence graph, Critical path, Loop & Iteration bounds, Computation of iteration bound .

Module III: **Pipelining and Retiming Techniques: [8L]**
Fine-grain pipelining of FIR filter, Low power aspects for pipelining and parallel processing, Cutset retiming, Clock period and Register minimizations.

Module IV: **Unfolding Algorithms: [10L]**
SISO and MIMO systems, properties of unfolding, sample period reduction, word and bit level parallel processing.

Text Book:

1. VLSI Digital Signal Processing Systems: Design and implementation
Keshab K Parhi, Wiley India, 2008

Reference Book:

2. DSP Processor Fundamentals: Architectures and Features, Phil Lapsley, Jeff Bier, Amit Shoham, Edward Lee, Wiley – IEEE Press, Jan, 1997
3. Computer Architecture – A Quantitative Approach, John L Hennessy, David A. Patterson,, Elsevier, 2012.

Course Title: VLSI IC FABRICATION					
Course Code : VLSI5132					
Contact Hours per week	L	T	P	Total	Credit Points
	3	0	0	3	3

CO (Course Outcome):

1. Students will learn Clean Room Concepts.
2. Students will learn individual fabrication steps.
3. Students will learn Pattern Transfer to Si from Mask using Lithography
4. Students will learn Semiconductor Doping Techniques
5. Students will learn planner MOSFET fabrication Process
6. Students will learn SOI fabrication Technology

Module I: Clean Room Technology and Oxidation [12L]

Unit1: Clean room concept- growth of single crystal from melt, surface contamination, cleaning and etching by solvent method and RCA clean.

Unit2: Growth mechanism and kinetics of oxidation, oxidation techniques and systems, oxide properties, oxide induced defects, characterization of oxide films use of thermal oxide and CVD oxide, growth and properties of dry and wet oxides, dopant redistribution, oxide quality. Etching Technology, Different kind of Interconnects, Concept of VIA.

Module II: Diffusion and ion implantation [10L]

Unit1: Diffusion: Fick's equation, atomic diffusion mechanisms, measurement techniques, diffusion in polysilicon and silicon dioxide diffusion systems.

Unit2: Ion Implantation: Range theory, equipments, annealing, shallow junction, high energy implantation.

Module III: Lithography, Deposition and Metallization [12L]:

Unit1: Lithography: Optical lithography, some advanced lithographic techniques

Unit2: Physical vapor deposition: APCVD, Plasma CVD, MOCVD

Unit3: Metallization: different types of metallization, uses and desired properties

Module IV: Process Integration [6L]:

MOSFET technology and MESFET Technology, IC manufacturing, future trends and challenges, SOI fabrication,

Text Book:

1. Semiconductor Devices Physics and Technology, Author: Sze, S.M.; Notes: Wiley, 1985
2. VLSI Technology 2ND Edition, Author: Sze, S.M.; MCGRAW HILL COMPANIES

Reference Book:

3. An Introduction to Semiconductor Microtechnology, Author: Morgan, D.V., and Board, K
4. The National Technology Roadmap for Semiconductors , Notes: Semiconductors Industry Association, SIA, 1994
5. Electrical and Electronic Engineering Series VLSI Technology, Author: Sze, S.M. Notes: Mcgraw-Hill International Editions

Course Title : CAD OF DIGITAL SYSTEM					
Course Code : VLSI5141					
Contact Hours per week	L	T	P	Total	Credit Points
	3	0	0	3	3

CO (Course Outcome):

1. Students will learn graph theory and data structures needed for CAD of VLSI
2. Students will learn basic algorithms needed for CAD of VLSI
3. Students will learn Physical Design Optimization on Partitioning and Floorplan
4. Students will learn Physical Sedign on Place and Route
5. Students will learn High Level and Logic Level Synthesis
6. Students will learn Verilog Modeling

Module I [10L]: VLSI design automation tools – Data structures and basic algorithms, graph theory and computational complexity, tractable and intractable problems.

Module II [10L]: General purpose methods for combinational optimization – partitioning, floor planning and pin assignment, placement, routing.

Module III [10L]: Simulation – logic synthesis, verification, high level Synthesis

Module IV [10L]: MCMS-VHDL-Verilog-implementation of simple circuits using VHDL

Text Book:

1. N.A. Sherwani, “Algorithms for VLSI Physical Design Automation”.

Reference Book:

2. S.H. Gerez, “Algorithms for VLSI Design Automation.

Course Title: MODELLING OF VLSI DEVICE					
Course Code : VLSI5142					
Contact Hours per week	L	T	P	Total	Credit Points
	3	0	0	3	3

CO (Course Outcome):

1. Students will learn BJT Modeling
2. Students will learn MOSFET Operation
3. Students will learn source of various MOSFET Capacitor Components
4. Students will learn SCE (Short Channel Effect) in MOS Devices
5. Students will learn MOS Scaling concepts on Future Technologies
6. Students will learn Industry Standard Compact Modeling

Module I: Semiconductor Physics, p-n junction and BJT [8L]

Semiconductors , Conduction, Contact Potentials, P-N Junction, Modifying the simple diode theory for describing bipolar transistor, Effect of emitter and base series resistances, Effect of base-collector voltage on collector current, Bipolar device models for Circuit and Time-dependent analyses.

Module II: MOS Capacitors and MOSFETs [12L]

Band diagrams for accumulation, depletion and inversion, threshold voltage, weak, moderate and strong inversions, Pao-Sah drain-current model, Source of MOS Capacitance, Transient Response, Capacitance-Voltage curves.

Module III: Scaled MOS Transistors [12L]

Concept of scaling (field, voltage and generalized scaling), ITRS specifications, two-dimensional field patterns and Poisson's equation, charge sharing and barrier lowering, carrier mobility degradation, channel length modulation, velocity saturation, hot carrier effects (gate leakage, impact ionization)

Module IV: Compact Models [8L]

Definitions and types of compact models: physical, empirical and look-up table based models, threshold voltage-based, surface potential-based and charge-based compact models, Commercial compact models.

Text Book:

1. Fundamentals of Modern VLSI Devices by Yuan Taur & Tak H. Ning (Cambridge)

Reference Book:

2. The MOS Transistor (second edition) Yannis Ts ividi s (Oxford)
3. Compact MOSFET Models for VLSI Design by A.B. Bhattacharyya, John Wiley & Sons Pte. Ltd., IEEE Press, 2009.

Course Title: Digital VLSI IC Design Lab					
Course Code : VLSI 5151					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**4**	**4**	**2**

CO (Course Outcome):

1. Students will learn Cadence Virtuoso
2. Students will learn Schematic Entry of CMOS gates
3. Students will learn Pre layout simulation using Spectra
4. Students will learn Layout Entry of CMOS gates using Nano Technology with key focus on Standard Cells
5. Students will learn Layout Verification Techniques like DRC, LVS, Post Layout Extraction using Assura
6. Students will learn Post layout simulation using Spectra

List of Experiments:

Sub Micron and Deep Sub Micron Technology based Experiments:

1) Introduction to **Cadence Virtuoso & Assura Tools**
    a. Transient, DC, Parametric analysis of CMOS Inverter
    b. Implementation of Various Logic gates using Advanced CMOS technology
    c. Layout design and Verification Using Cadence: Std Cell Layout
    d. Parasitic Extraction, Back-annotation and Post Layout Timing Analysis Using Cadence
2) Introduction to **TCAD Synopsys** Device and Process Simulator: Nano Technology

Course Title: Embedded Systems Design Lab					
Course Code : VLSI 5152					
Contact Hours per week	L	T	P	Total	Credit Points
	0	0	4	4	2

CO (Course Outcome):

1. Students will learn Xilinx Vivado Simulator
2. Students will learn VHDL coding and Simulation/Verification
3. Students will learn Finite State Machine coding using HDL
4. Students will learn Test Bench HDL coding for RTL Verification
5. Students will learn FPGA synthesis, Place & Route and Hardware Programming
6. Students will learn ARM Cortex based Software/Hardware

List of Experiments:

1. Introduction to **XILINX-Vivado Simulator, VHDL Coding and Test Bench** Simulation
    a. Logic Design and Verification of a 15 bit Ripple-Carry Adder
    b. Logic Design and Verification of a universal shift register
    c. Logic Design and Verification of a Finite State Moore Machine
    d. Logic Design and Verification of a Finite State Mealy Machine
    e. Design of hand shake protocol to establish Communication between Master and Slave
2. **FPGA Programming Flow** using XILINX Kits: Implementing and verifying many of above experiments in FPGA hardware Kits.
3. **Embedded System Kits**: ARM Cortex M3 Evaluation Board and ARM Cortex based Microcontroller Development Software.
4. **DSP** C6713 Evaluation Kits

Course Title : Research Methodology & IPR					
Course Code : ECEN5103					
Contact Hours per week	L	T	P	Total	Credit Points
	2	0	0	2	2

Research Methodology and IPR

Course Outcome:

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

1. Understand research problem formulation
2. Analyze research related information
3. Follow research ethics
4. Understand the ultimate importance of ideas, concept and creativity
5. Importance of IPR for individuals and nations
6. Appreciate that IPR protection provides incentive to inventors for further research work

Syllabus Contents:

Module I (6L)

Meaning of research problem, Sources of research problem, Criteria and 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 problems, data collection, analysis, interpretation, necessary instrumentations.

Module II (6L)

Effective literature studies approaches and analysis
Plagiarism, Research ethics

Module III (6L)

Effective technical writing, how to write report, Paper
Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Module IV (6L)

Nature of Intellectual Property: Patents, Design, Trade and Copyright, Process of Patenting and Development: technological research, innovation, patenting, and development. International Scenario: International cooperation on Intellectual property. Procedure for grants of patents, Patenting under PCT.
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical indication.
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.

References:

- Stuart Melville and Wayne Goddard, "Research and methodology: An introduction for science & engineering students'"
- Wayne Goddard and Stuart Melville, "Research and methodology: An introduction"
- Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007
- Mayall, "Industrial Design", McGraw Hill, 1992
- Niebel, "Product Design", McGraw Hill, 1974
- Asimov, "Introduction to Design", Prentice Hall, 1962
- Robert P. Merges, Peter S. Menell, Mark A Lemley, "Intellectual Property in New Technological Age", 2016
- T. Ramappa, "Intellectual Property Rights Under WTO", S Chand, 2008

Course Title : Audit Course 1					
Course Code : DIMA5116					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	2	**0**	**0**	**2**	**0**

DISASTER MANAGEMENT

Course Outcome: -Students 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, planning and programming in different countries, particularly their home country or the countries they work in.

Syllabus

	Units	CONTENTS	Hours
Module -I	1	**Introduction on Disaster** Disaster: Definition Types of Disaster • Natural Disaster: such as Flood, Cyclone, Earthquakes, Landslides etc. • Man-made Disaster: such as Fire, Industrial Pollution, Nuclear Disaster, Biological Disasters, Accidents (Air, Sea, Rail & Road), Structural failures (Building and Bridge), War & Terrorism etc. • Differences, Nature and Magnitude • Factors Contributing to Disaster Impact and Severity • Repercussions of various types of Disasters o Economic Damage o Loss of Human and Animal Life o Destruction of Ecosystem o Outbreaks of Disease and Epidemics o War and Conflict Natural Disaster-prone areas in INDIA • Areas prone to o Earthquake o Floods and Droughts, o Landslides and Avalanches; o Cyclonic And Coastal Hazards such as Tsunami; Trends of major Disasters and their Impact on India • Lessons Learnt from Recent Disasters	3
	2	**Introduction to Disaster Management** What is Disaster Management Different Phases of Disasters Disaster Management Cycles Disaster Management Components	3

		• Hazard Analysis • Vulnerability Analysis • Prevention and Mitigation • Preparedness • Prediction and Warning • Response • Recovery Disaster Management Act, 2005 National Disaster Management Structure Organizations involved in Disaster Management	
Module -II	1	**Overview on Hazard Analysis and Vulnerability Analysis** **Disaster Preparedness** • Disaster Risk Assessment, People's Participation in Risk Assessment • Disaster Risk Reduction • Preparedness Plans • Community preparedness: Emergency Exercises/ Trainings/Mock Drills	3
	2	**Disaster Prediction and Warning** • Activities o Tracking of disaster o Warning mechanisms o Organizational response o Public education o Communication o Evacuation planning • Current tools and models used for Prediction and Early Warnings of Disaster o Application of Remote Sensing o Data From Meteorological and other agencies o Smartphone/ Web based Apps for Disaster Preparedness and Early Warning used in different parts of Globe	3
Module -III	1	**Disaster Response** • Crisis Management: The Four Emotional Stages of Disaster o Heroic Phase o Honeymoon Phase o Disillusionment Phase o Reconstruction Phase • Need for Coordinated Disaster Response o Search, Rescue, Evacuation, Medical Response and Logistic Management o Psychological Response and Management (Trauma, Stress, Rumor and Panic) • Role of Government, International and NGO Bodies	3
	2	**Post-disaster Situation Awareness** • Need for Situation Awareness in Post Disaster scenario	3

		• Challenges in communication of situational data from affected areas • Need for community-driven disaster management for reliable situation awareness • Crowd-sourcing of situational data: Issues and challenges **Post-disaster Damage and Need Assessment** • Current Trends and Practices – RAPID Damage and Need Assessment • SPHERE standards in Disaster Response • ICT based techniques for Post-disaster damage and need assessment	
Module -IV	1	**Rehabilitation, Reconstructions and Recovery** • Reconstruction and Rehabilitation as a Means of Development. • Post Disaster effects and Remedial Measures • Creation of Long-term Job Opportunities and • Livelihood Options • Disaster Resistant House Construction • Sanitation and Hygiene • Education and Awareness • Dealing with Victims' Psychology • Long-term Counter Disaster Planning	3
	2	**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	3

SUGGESTED READINGS:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies", New Royal book Company.
2. Sahni, Pardeep et.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.

Course Name : Sanskrit for Technical Knowledge					
Course Code: SANS5120					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	2	**0**	**0**	**2**	**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
6. Huge knowledge from ancient literature

Course Outcomes:

After the completion of this course, students should 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

Module I (6L)

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

Module II (6L)

- Simple Sentences
- Order

Module III (6L)

- Introduction of roots
- Technical information about Sanskrit Literature

Module IV (6L)

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

References

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

Course Name : Personality Development through Life Enlightenment Skills					
Course Code: PDLS5118					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	2	**0**	**0**	**2**	**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

Course Outcomes:

After the completion of this course, students should 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.

Module I (6L)

Neetisatakam-Holistic development of personality

- Verses- 19,20,21,22 (wisdom)
- Verses- 29,31,32 (pride & heroism)
- Verses- 26,28,63,65 (virtue)

Module II (6L)

Approach to day to day work and duties.

- Verses- 52,53,59 (dont's)
- Verses- 71,73,75,78 (do's)
- Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,

Module III (6L)

Statements of basic knowledge.

- Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,
- Chapter 18-Verses 45, 46, 48.
- Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68
- Chapter 12 -Verses 13, 14, 15, 16,17, 18

Module IV (6L)

Personality of Role model.

- Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,
- Chapter 4-Verses 18, 38,39
- Chapter18 – Verses 37,38,63

References

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication 2. Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

Course Name : Constitution of India					
Course Code: INCO5117					
Contact Hours Per Week	L	T	P	Total	Credit Points
	2	0	0	2	0

Course Objectives

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion 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

Course Outcomes:

After the completion of this course, students should be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

Module I (8L)

- History of Making of the Indian Constitution: History, Drafting Committee, (Composition & Working)
- Philosophy of the Indian Constitution: Preamble, Salient Features

Module II (4L)

- Contours of Constitutional Rights & Duties: Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

Module III (4L)

- Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions

Module IV (8L)

- Local Administration: District's Administration head: Role and Importance; Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation; Pachayati raj: Introduction, PRI: ZilaPachayat; Elected officials and their roles; CEO ZilaPachayat: Position and role; Block level: Organizational Hierarchy (Different departments); Village level: Role of Elected and Appointed officials, Importance of grass root democracy
- Election Commission: Election Commission: Role and Functioning; Chief Election Commissioner and Election Commissioners; State Election Commission: Role and Functioning; Institute and Bodies for the welfare of SC/ST/OBC and women.

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, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course Name : Stress Management by Yoga					
Course Code: YOGA5119					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	2	**0**	**0**	**2**	**0**

Course Objectives

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

Course Outcomes:

After the completion of this course, students should be able to:
1.Develop healthy mind in a healthy body thus improving social health also
2.Improve efficiency

Module I (6L)

- Definitions of Eight parts of yog. (Ashtanga)

Module II (6L)

Yam and Niyam.
Do`s and Don't's in life.

- Ahinsa, satya, astheya, bramhacharya and aparigraha
- Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

Module III (6L)

Asan and Pranayam

- Various yog poses and their benefits for mind & body

Module IV (6L)

- Regularization of breathing techniques and its effects-Types of pranayam

References

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

M.Tech, VLSI, 1st Year 2nd Semester:

Course Title: ANALOG VLSI IC DESIGN					
Course Code : VLSI5201					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
per week	**3**	**0**	**0**	**3**	**3**

Course Outcomes (COs):

The students would be able to:

1. Understand and analyze MOS-based analog VLSI sub-circuits, relevant small-signal equivalent circuit models and design them *eg.* current mirrors,
2. Design and analyze MOS circuits of practical importance *eg*., common-source amplifiers and differential amplifiers.
3. Understand the basic concepts in RF design and the geometry, models of passive devices used in the RFIC.
4. Understand the principle of operation, characterization of the data converter circuits and design them.
5. Understand and analyze the different topologies of switched-capacitor circuits and apply the concept for the analysis of circuits of practical applications.
6. Understand the principle of operation of the oscillator circuit and apply the concept for the analysis of circuits of practical applications.

Module I: Analog Sub-Circuits & Circuits using MOSFET : [16L]

Unit1(6L): Analog sub-circuits : Principle of operation, Small-signal analysis of MOS switch, resistors, current source, sink, current mirror, bandgap reference circuit.
Unit2 (6L): CMOS Amplifiers : Basic concepts, performance parameters, Single-stage amplifiers : different topologies of inverting type common-source amplifiers, common-gate, common-drain configuration; Differential amplifiers with passive and active load : Transfer characteristics curves, Common mode, differential mode, CMRR, small-signal analysis of relevant amplifier circuits ;
Unit 3 (4L): CMOS Operational Amplifiers & Comparators : Basic concepts, characterization & classification of op-amps, basic concept of boundary conditions & requirements for the design of op-amps, basic concept of necessity of compensation and Miller compensation technique; Comparators : Characterization, basic concept of Two-Stage open-loop comparator; Discrete-time Comparator : Switched capacitor comparators.

Module II: RFIC Fundamentals: [8L]

Unit1: Basic concepts in RF Design : General considerations : units in RF design, time variance, nonlinearity; Effects of nonlinearity : harmonic distortion, gain compression, cross modulation, inter-modulation, cascaded nonlinear stages, AM/PM conversion
Unit2: Passive Devices : General considerations, Inductors : Basic structure, geometries, parasitic capacitances, loss mechanisms, inductor modeling, transmission lines, varactors, constant capacitors : MOS capacitors, metal-plate capacitors.

Module III: Data Converter Fundamentals and Architecture [8L]

Unit 1 : D/A Converters : Introduction & characterization, Architecture : Parallel D/A converters, Serial D/A converters
Unit 2 : A/D Converters : Introduction & characterization, S/H circuit, Architecture : Serial A/D converters, Medium-speed A/D converters, High-speed A/D converters : Parallel or Flash ADC, Oversampling converters : performance limitations and design considerations.

Module IV: Special Circuits: [8L]

Unit1: Switched-capacitor circuits : general considerations, resistor emulation using different topologies, accuracy issues, switched capacitor integrators, filters.
Unit2: Oscillators : Ring oscillator, Voltage Controlled Oscillator, Phase Locked Loop.

Text Book:
1. Design of Analog CMOS Integrated Circuit, Behzad Razavi, Mc, Graw Hill .
2. CMOS Analog Circuit Design (second edition), Phillip E. Allen and Douglas R. Holberg (Oxford)
3. RF Microelectronics, Behzad Razavi, Prentice Hall

References:
4. Microelectronic Circuits, A.S. Sedra & K.C.Smith, Oxford International student edition.
5. Analog Design for CMOS VLSI Systems - Franco Maloberti, Kluwer Academic Publishers

Course Title: VLSI DESIGN, TESTING AND VERIFICATION					
Course Code : VLSI5202					
Contact Hours per week	L	T	P	Total	Credit Points
	3	0	0	3	3

CO (Course Outcome):

1. Students will learn embedded Memory Design in VLSI Chip
2. Students will learn VLSI Interconnect Design
3. Students will learn Industry Standard STA (Static Timing Analysis) Method
4. Students will learn Set-up and hold Checks for Timing Verification
5. Students will learn process variation and Clock skew concepts
6. Students will learn Si Testing/Debug Methods

Module I: VLSI Memory Design: [12L]
Types of Memory, Memory Organization, Memory Folding Criteria, Memory Cell Design Method for Write and Read Operation, Critical Path Analysis & Memory Access Time, DRAM 4T, 3T, 1T Cell Design Method, SRAM 8T, 6T Cell Design Method, Sense Amplifier Operation, Multiport Register File Design Challenges, Mask ROM, ROM Programming Techniques, Flash ROM

Module II: VLSI Interconnect Design: [6L]
Component of Interconnect, Interconnect Cross Section, Wire material, Interconnect Modelling, Interconnect Design Issues and WirePlan: Capacitance, Delay, Lumped Model vs Distributed Model, RC Scaling, Repeater, Interconnect Power, Interconnect Noise: Coupling, Cross Talk

Module III: VLSI Verification Flows and Static Timing Analysis: [12L]
Unit1: Logic Verification, Circuit Verification, Layout Verification (DRC, LVS), pre-layout simulation, parasitic Extraction and Back-annotation, post layout verification,
Unit2: Timing checks (set-up, hold), process variation study with PVT analysis, Library Cell characterization, Static Timing Analysis: Types of Path for Timing Analysis, Launch path, Capture Path, Longest Path, Shortest Path, Critical Path, Clock Skew

Module IV: Si-Testing: [10L]
Why Testing, Challenge of Si-Testing, Manufacturing Defects, Die (Inter and Intra) Variation, Yield, DPM, Combinational Circuit Testing: Logical Fault Modelling: Stuck at Faults (D-Algorithm), Bridging Fault, Transistor Stuck open/Stuck Short, ATPG, Path Delay Fault, Sequential Circuit Testing: DFT, Scan Design, SFF, LSSD-SSF, BIST

Text Book:

1. Principles of CMOS VLSI Design, A Systems Perspective, Author: Neil Weste, Kamran Eshraghian, Addison Wesley, 2nd Edition, 2000
2. VLSI Test Principles and Architectures, Design for Testability, Author: Laung-Terng Wang, Cheng-Wen Wu, Xiaoqing Wen, The Morgan Kaufmann series in Systems on Silicon. 2006 Elsevier

Reference Book:

3. CMOS VLSI Design, A Circuits and Systems Perspective (3rd Edition) Author: Neil Weste, David Harris, Ayan Banerjee. Pearson, 2011
4. Digital Integrated Circuit, Design Perspective, Author: .M. Rabaey, Prentice-Hall

Course Title: MEMORY TECHNOLOGIES					
Course Code : VLSI5231					
Contact Hours per week	L	T	P	Total	Credit Points
	3	0	0	3	3

CO (Course Outcome):

1. Students will learn SRAM Bit-cell Design
2. Students will learn SRAM architecture and periphery Circuits
3. Students will learn DRAM Bit cell Design
4. Students will learn DRAM architecture, periphery Circuits and Controller
5. Students will learn various ROM Design
6. Students will learn Future Memory Technologies like MRAM, FRAM

Module I: SRAM: [10L]
Random Access Memory Technologies: Static Random Access Memories (SRAMs), SRAM Cell Structures, MOS SRAM Architecture, MOS SRAM Cell and Peripheral Circuit, Bipolar SRAM, Advanced SRAM Architectures, Application Specific SRAMs.

Module II: DRAM: [10L]
MOS DRAM Cell, BiCMOS DRAM, Error Failures in DRAM, Advanced DRAM Design and Architecture, Application Specific DRAMs, DRAM Memory controllers.

Module III: Non-Volatile Memories: [10L]
Masked ROMs, PROMs, Bipolar & CMOS PROM, EEPROMs, Floating Gate EPROM Cell, OTP EPROM, EEPROMs, Non-volatile SRAM, Flash Memories.

Module IV: Advanced Memory Technologies: [10L]
Ferroelectric Random Access Memories (FRAMs), Gallium Arsenide (GaAs) FRAMs, Analog Memories, Magneto Resistive Random Access Memories (MRAMs), Experimental Memory Devices.

Text Book:

1. Ashok K Sharma, "Advanced Semiconductor Memories: Architectures, Designs and Applications", Wiley Interscience

Reference Book:

1. Kiyoo Itoh, "VLSI memory chip design", Springer International Edition
2. Ashok K Sharma," Semiconductor Memories: Technology, Testing and Reliability , PHI

Course Title: LOW POWER VLSI DESIGN					
Course Code : VLSI5232					
Contact Hours per week	L	T	P	Total	Credit Points
	3	0	0	3	3

CO (Course Outcome):

1. Students will learn source of CMOS Dynamic Power Dissipation
2. Students will learn CMOS Dynamic Power Reduction Techniques
3. Students will learn source of CMOS Standby (leakage) Power Dissipation & Reduction Techniques
4. Students will learn Short Circuit Power Reduction Techniques
5. Students will learn Embedded Memory Power Reduction Techniques
6. Students will learn System and Architecture level Power Reduction Techniques

Module I: Dynamic Power Reduction: [12L]

Unit1: Introduction: Why Low Power ? Definition of dynamic power, Transition probability, Signal probability, Transition probability of basic gates, Glitch power, source of switching capacitance

Unit2: Dynamic Power reduction with Vdd, Delay vs Power Trade-off, Dual Vdd, Dynamic Voltage Scaling (DVS), Dynamic Power Management, Capacitance Scaling, Transistor sizing, Transition probability reduction by clock gating, Logic restructuring, Input Reordering, Glitch reduction

Module II: Standby Power Reduction: [12L]

Unit1: Leakage power definition, Gate Leakage, Channel Leakage, Junction Leakage. Channel leakage issue with Threshold Scaling, Leakage vs Dynamic power

Unit2: Technology Solution of Gate Leakage reduction: High-K, FinFET, Channel leakage reduction techniques: Multiple Threshold Voltage, Long Channel Transistor, Device Downsizing, Stacking, Power Gating, Dual Vdd, Dynamic Body-Biasing, Technology Solution: FinFET

Module III: Short Circuit Power Reduction: [6L]

Definition, Dependency on Load Capacitance, Various reduction techniques

Module IV: Power **Reduction at Various Design Phase: [10L]**

System level, Algorithm level, Architecture Level (Parallel vs Pipeline), Gate level, transistor level, Power Analysis Tool, Low Power Memory Circuit Example on DRAM, SRAM, ROM, Power issue with Dynamic Gates: Floating node and Keeper Solution.

Text Book:

3. Practical Low Power Digital VLSI Design, Author: Gary Yeap, KLUWER ACADEMIC PUBLISHERS, 2010

Reference Book:

4. Low Power CMOS VLSI Circuit Design, Author: Kuashik Roy and Sharat Prasad, John Wiley & Sons, Inc. 2009

Course Title: ADVANCED VLSI PROCESSOR					
Course Code : VLSI5241					
Contact Hours	L	T	P	Total	Credit Points
per week	3	0	0	3	3

CO (Course Outcome):

1. Students will learn basic structure of instruction set architecture (ISA)
2. Students will learn CISC and RISC Architecture
3. Students will learn sample DSP Processor Architecture
4. Students will learn Accelerator
5. Students will learn Multi-Threaded Processor
6. Students will learn use of Microprocessor cores in SOC Design

Module I: Fundamentals: [8L]
Architecture organization, basic structure of instruction set architecture (ISA arch) and Flynn's taxonomy. Comparison of Von-Neumann and Harvard architecture, Microcoded and hardwired control architecture, scalar and Vector processors architecture, CISC and RISC architecture. Basic of pipelining, pipeline hazards and solutions

Module II: The DSP and Its Impact on Technology: [12L]
Parallel computation using superscalar architecture, description of the very long Instruction word architecture (VLIW arch) , detail description of TI TMS320C5x DSP processor architecture.

Module III: Accelerator :[10L]
Need for accelerators, Accelerators and different types of parallelism, Processor architectures and different approaches to acceleration. General-Purpose Embedded Processor Cores: The ARM.

Module IV: Multiprocessor and multithreaded processor [10L]
Utilization of course-grain parallelism, chip-multiprocessors, multithreaded processors, SMT processor, A benefits analysis of processor customization, Using microprocessor cores in SOC design, Benefiting from microprocessor extensibility, how microprocessor use differs between SOC and board-level design

Text Book:
1. Computer Architecture: Pipelined and Parallel Processor Design – 2nd Ed Michael J. Flynn

Reference Book:
2. Digital Signal Processors: Architecture, Programming and Applications - B. Venkataramani, M. Bhaskar
3. ARM System-on-Chip Architecture – 2nd Ed Steve Furber
4. Computer System Design: System-on-Chip – 1st. Ed Michael J. Flyn, Wayne Luk

Course Title: ADVANCED NANO DEVICES					
Course Code : VLSI5242					
Contact Hours		T	P	Total	Credit Points
per week	3	0	0	3	3

CO (Course Outcome):

1. Students will learn various leakage phenomena in advanced MOS
2. Students will learn High K Plus Metal Gate Technology for advanced Process Nodes
3. Students will learn SOI MOS device
4. Students will learn FinFET Devices like DGMOS, Tri-gate
5. Students will learn Hetero-Structures
6. Students will learn CNT, Graphene Device

Module I: Leakage Current Mechanisms and Reduction (6+6=12L)

Unit 1: Sub-threshold leakage, band-to-band leakage, gate-oxide tunneling, gate-induced-drain leakage etc.
Unit 2: High-K gate dielectric and Metal-gate technology: Concept of EOT, leakage current control, use of various high-K oxides, work function engineering, Fermi-level pinning.

Module II: SOI MOSFETs [6L]

Partially-depleted SOI, Fully-depleted SOI, Advantages and disadvantages of SOI structure.

Module III: Multigate Structures [12L]

DG-MOSFETs, TRI Gate MOSFETs, FinFETs, Surround gate MOSFETs, Omega Gate MOSFETs, Volume inversion, Random Dopant Fluctuation, Concept of undoped body, Underlap device structure, Symmetry and asymmetry MOSFET structure.

Module IV: Hetero Structures and Quantum Well devices [10L]

Quantization and low-dimensional electron gas, band alignment in Si/SiGe hetero-structures, HEMTs, Carbon Nano-tube, Graphene device.

Text Book:

1. The MOS Transistor (second edition) Yannis Tsividis (Oxford)

Reference Book:

2. Fundamentals of Modern VLSI Devices by Yuan Taur & Tak H. Ning (Cambridge)
3. FinFETs and Other Multi-Gate Transistors by J.P. Colinge, Springer, 2008.

Course Title: Analog VLSI IC Design Lab					
Course Code : VLSI 5251					
Contact Hours per week	L	T	P	Total	Credit Points
	0	0	4	4	2

Course Outcomes (COs):

The students would be able to:

1. Understand the basic principle of operation of NMOS and PMOS
2. Analyze and design analog VLSI sub-circuits and amplifier circuits
3. Design layout and verify for analog VLSI sub-circuits and circuits
4. Realize and analyze some special circuits namely data converters, practical switched-capacitor circuits.

Sub-Micron and Deep Sub-Micron Technology based Experiments:

List of Experiments:

1. Familiarization with Cadence Virtuoso and Assura tool
2. Study of Transfer and Drain Characteristics of NMOS and PMOS
3. Study of MOS as a Capacitor, diode, and active resistor in implementing voltage divider circuit
4. Study of Current Mirror and Cascode Current Mirror Circuits
5. Layout design and verification of current mirror circuit using Common Centroid technique.
6. Circuit analysis of Single Stage Amplifiers
7. Layout design and verification of single-stage amplifier
8. Design and analysis of Differential Amplifier
9. Layout Design of Differential Amplifier
10. Introduction to Texas Instruments Analog Systems Laboratory Starter Kits (ASLK) and realization of data converter circuits.
11. Design and analysis of a switched-capacitor filter.

Course Title: VLSI Design, Testing and Verification Lab					
Course Code : VLSI5252					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**4**	**4**	**2**

CO (Course Outcome):

1. Students will learn Critical Path Modeling and Analysis
2. Students will learn Sizing in Digital Design
3. Students will learn CMOS Design of Combinational Circuits and Modules
4. Students will learn CMOS Design of Sequential Circuit, Setup and Hold Check
5. Students will learn Layout of a system, DRC, LVS, Extraction using Cadence Virtuoso/Assura
6. Students will learn Back-annotation and Post Layout Timing Analysis using Spectra

List of Experiments:

Sub Micron and Deep Sub Micron Technology based Experiments:

1) Combinational Circuit Example (**Cadence Virtuoso and Assura Tools**)
    a. Circuit Design,
    b. Critical Path Timing Analysis,
    c. Layout Design and Verification,
    d. Parasitic Extraction, Back-annotation and Post Layout Timing Analysis
2) Sequential Circuit Example (**Cadence Virtuoso and Assura Tools**)
    a. Circuit Design,
    b. Setup and Hold Analysis,
    c. Layout Design and Verification,
    d. Parasitic Extraction, Back-annotation and Post Layout Timing Analysis
3) **Cadence Semi Custom Design** Flow
    a. **Incisive Logic Simulation**: Verilog Coding and Test Bench Verification
    b. **Encounter RTL Compiler**: Logic Synthesis
    c. **Encounter Physical Design Implementation**: Floor-planning, Power-planning, Placement, CTS, Routing, Static Timing Analysis
    d. **ASIC views** - .lib, .lef, .gds, .sdf
    e. **Std. cells**- Design, layout, characterization
    f. **Logical Equivalence checking**

Course Name: Nanomaterials and Nanotechnology					
Course Code : VLSI6131					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course outcomes:

At the end of the course the students would be able to:

1. Understand the basic science behind the design and fabrication of nano-scale systems
2. Gain knowledge regarding the structures of nanomaterials
3. Learn about the preparation of nanoparticles
4. Acquaint themselves with carbon nanotubes and porous materials
5. Understand and formulate engineering solutions for present-day problems and competing technologies for future applications
6. Gather detailed knowledge of the fabrication process.

Module 1: (9 lectures)

Introduction: Introduction to nanomaterials and nanotechnology, top-down and bottom-up methods of synthesis of nanomaterials, self-assembly, Structure of nanomaterials, synthesis of nanoparticles, homogeneous nucleation.

Module 2: (9 lectures)

Preparation of nanoparticles, carbon fullerenes, synthesis of nanowires, nanorods and nanotubes.

Module 3: (9 lectures)

Nanotubes: nanotubes of different materials, carbon nanotubes: graphene, SWNTs, MWNTs, structure of carbon nanotubes, carbon nanotube composite materials, carbon nanotube reactors.

Module 4: (9 lectures)

Porous materials and nano-lithography: classification of pores, synthesis of porous materials, photolithography, soft-lithography, DPN on various materials, toxic effects of nanomaterials.

Books:

1) Introduction to Nanotechnology Paperback – 2007 by Frank Owens Charles Poole – Wiley
2) Nanoscience and Nanotechnology: Fundamentals of Frontiers Paperback – 2013 , Shubra Singh M.S. Ramachandra Rao , Wiley
3) An Introduction to Nanomaterials and Nanoscience (PB) Paperback – 2005 , Das A , CBS Publishers

Course Name: RF IC Design and MEMS Technology					
Course Code : VLSI6132					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

COURSE OUTCOMES:

Students should be able to:

1. Specify noise and interference performance metrics like noise figure, IIP3 and different matching criteria.
2. Comprehend different multiple access techniques, wireless standards and various transceiver architectures.
3. Design various constituents' blocks of RF receiver front end.
4. Describe MEMS fabrication technologies.
5. Critically analyze micro-systems technology for technical feasibility as well as practicality.
6. Comprehend the working of various systems and design electronic circuits for various applications.

Module I: [10L]

Prerequisite: RFIC design tradeoffs; Fading,Diversity; Multiple Access Schemes; S and ABCD parameters; Resonance in LC circuit; Concept of transmission lines-Reflection Coefficient; Impedance transformation and matching.

Unit1: RF Devices: Design of RF passive devices- capacitor, inductors; Design of RF MOS devices; Spectre RF ,BJT, MOS spice modeling in RF.

Unit2: RF Systems basics: Nonlinearity in RF Systems; IIP3, SFDR; Classical two port network theory of Noise; Noise in MOSFETs; Testing of RF System – Noise, Distortion Measures and Mitigation Methods.

Module II: [12L]

Unit1: RF System Blocks: Wideband amplifier design; LNA Design; Mixer Design, Gilbert mixer; Linearization techniques; Design Overview of oscillator and Mixer, Frequency Synthesizer; VCO design; power amplifier design – A,B,AB,C,D,E,F;

Unit2: Transmitter Architecture- PLL/CDR Loop, Frequency Divider Unit2: Receiver architectures- direct conversion, heterodyne, image reject architectures; Unit3: Applications- GSM,CDMA architectures.

Module lll: [9L]

Unit1: Introduction to MEMS technology: Basics of MEMS; Areas of application; Silicon as Design material; Important Material Properties and Physical Effects;Other design materials (GaAs,Quartz, SiC, Polymer etc.,)

Unit2: MEMS Fabrication: Bulk micromachining; Surface micromachining; Different types of etchants and etching methods; Nonlithographic Microfabrication Technologies

Module IV: [9L]

Unit1: MEMS Structures and Systems for sensors and actuators: Sensing and Actuation methods; Sensors of different types with example of each type (Mechanical, temperature, chemical , Lab on Chip, microfluidic, bio-sensors);micro pump; 3D Accelerometer, Digital Light Projector

Unit2: MEMS structure and systems for RF applications: Passive Electrical Components: Capacitors and Inductors; Surface-Micromachined Variable Capacitors;Bulk-Micromachined Variable Capacitors ;Micromachined Inductors; Microelectromechanical Resonators; Microelectromechanical Switches

Books:

1)MEMS- Fundamental Technology and Applications, Edited by Vikas Choudhury, CRC Press

2) MEMS Based Circuits and Systems for Wireles Communication, Christian C. Enz, Andreas Kaiser (Editors), Springer

3) RFIC and MMIC design and Technology, Edited by Robertson and S.Lucyzyn, IET publishers

Course Title: Design And Technology For Photonic Integrated Circuit					
Course Code : ECEN 6125					
Contact Hours per week	L	T	P	Total	Credit Points
	3	0	0	3	3

Course Objectives:

1. Students will be able to solve problems associated with wave propagation through anisotropic mediums.
2. Students will be able to design different components such as planar and rectangular waveguides, bends, Y- section, couplers, filters etc.
3. Students will be able to design coupled waveguides and resonators.
4. Students will be able to design photonic band-gap devices.
5. Students will understand the fabrication process for different optical devices.
6. Students will be able to characterize the basic photonic components using simple python coding

Module 1: Introduction (12L)

Importance of photonic integrated circuit. **Components and materials for photonic integrated circuits**. **Review of EM wave propagation;** isotropic medium, wave impedance, Poynting vector, polarisation, reflection. **Electromagnetic properties of materials;** Lorentz oscillator model, Lorentz model for dielectrics, Kramers-Kronig relation, Drude model for metals. **Anisotropic medium;** dispersion, phase and group velocity, index ellipsoids, polarisation, optical axes.

Module 2: Optical waveguide (8L)

Planar waveguides; TE and TM Modes, propagation constants, field distribution, dispersion equation. **Rectangular waveguide;** basic equation, dispersion relation, Kumar's method, effective index method. **Multimode interference (MMI) devices.**

Module 3: Coupled mode theory and applications (8L)

Coupled mode equations. Co directional and contra-directional couplers.
Derivation of coupling coefficients; slab waveguide and rectangular waveguide. **Interferometers;** Febry-perot, Mach-Zehnder. **Ring resonator. Bragg Gratings. Photonic band-gap devices;** periodic dielectric structure in two dimensions, square and honeycomb lattice, dispersion, wave guiding, directional coupler, left-hand propagation, self collimation.

Module 4: Fabrication and characterization (8L)

Materials, technology and process. Device fabrication flow; ion exchange-Glass, diffusion-LiNbO3 (dynamic device), etching -Silicon. **Numerical analysis using Python**; meshgrid, rectangles and the centering

algorithm, bars and rectangles via linear meshgrids, lines & fills via linear meshgrids, circles & ellipses via Radial meshgrids, Pie Wedges via azimuthal meshgrids, Boolean operations.

Text books:

1. Fundamentals of Photonics by **Bahaa E. A. Saleh, Malvin Carl Teich**
2. Theory of Optical Processes in Semiconductors: Bulk and Microstructure by **P. K. Basu**
3. Fundamentals of Optical Waveguides by **Katsunari Okamoto**
4. Waves and Fields in Inhomogeneous Media by **Weng Cho Chew**

Reference books:

1. Photonic Crystals: Molding the flow of light by **John D. Joannopoulos**
2. Silicon Photonics Design: From Device to Systems by **Lukas Chrostowski, Michael Hochberg**

List of Open Electives offered by different Departments
M Tech, Second Year, Semester III

A. Theory							
Department	**Course Number**	**Subject**	**Scheme Of Studies Per Week**			**Total**	**Credits**
			L	**T**	**P**		
			3	**0**	**0**	**3**	**3**
AEIE	**AEIE6121** **AEIE6122**	**Biosignal and Biomedical Image Processing** **Intelligent Control**					
BT	**BIOT6121**	**Engineering Mathematics and Biostatistics**					
ChE	**REEN6121** **REEN6122**	**Composite Material for Renewable Energy** **Safety and Hazards in Energy Industry**					
CSE	**CSEN6121** **CSEN6122**	**Business Analytics** **Advanced Artificial Intelligence**					
ECE	**ECEN6121** **ECEN6122** **ECEN6123** **ECEN6124**	**AD HOC Networks and Uses** **Design of Embedded Systems** **Cognitive Radios** **Automation in VLSI Design**					
IT	**INFO6123**	**Information Theory and Coding**					
MATH	**MATH6121**	**Optimization Techniques**					

Subject Name: BIOSIGNAL AND BIOMEDICAL IMAGE PROCESSING					
Paper Code: AEIE6121					
Contact hrs per week:	L	T	P	Total	Credit points
	3	0	0	3	3

Course Outcomes:

On completion of this course you should be able to:

1. Understand acquisition, general properties and clinical applications of biomedical signals such as ECG, EEG, EMG, EP and speech signal.
2. Learn the fundamentals of different modes of 2D and 3D medical imaging, including fluoroscopic, ultrasound imaging, computed tomography and magnetic resonance imaging.
3. Demonstrate advanced knowledge of filtering, transforms and spectral analysis of biomedical signal and images.
4. Apply image processing techniques for enhancement, filtering, segmentation and registration biomedical images.
5. Gain skill set to compress biomedical signals and images using loss less and lossy compression techniques as well as modern compressed sensing technique.
6. Perform signal analysis and classification using PCA, ICA, LDA, Bay's classifier, KNN and k-means clustering algorithm.

Module I – [8L]

Acquisition, General Properties and Clinical Applications of Biomedical Signals and their signal processing aspects:

Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Evoked Potential (EP)and Speech Signals.

*Physics, Signal Processing and Clinical Applications of major modalities for medical imaging:*Ultrasound, X-ray, CT, MRI, PET, and SPECT.

Module II – [10L]

Fundamentals of Biomedical Signal and Image Processing Techniques:

Signal acquisition- Sampling in time, aliasing, quantization, interpolation and noise; Convolution, Correlation and Covariance of signals.

Signal Transform: Discrete Fourier transform (DFT) and its properties, the fast Fourier transform (FFT), Short Time Fourier Transform (STFT), Time-Frequency analysis- Continuous wavelet transform and discrete wavelet transform, Discrete Cosine Transform (DCT)- Application of these transforms and examples with MATLAB.

Digital Filters: FIR and IIR digital filters design criteria, signal averaging, MATLAB implementation. Spectral Analysis: Nonparametric Estimators of PSD and Parametric Estimators.

Module III – [9L]

Medical Image Processing Techniques:

Extension of filtering and Transforms methods to 2-D signals and systems.

Image enhancement, Image Registration, Image Segmentation-pixel based, region based, edge based and morphological methods of segmentation with example in MATLAB.

Module IV – [9L]

Emerging topics:

Biomedical Data Compression- Need for data compression, Lossless and lossy compression, Compressive Sensing Algorithms– Sampling, representation and reconstruction for Signal and Image Processing Applications.

Multivariate Analyses: Principal Component Analysis and Independent Component Analysis.

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Classification: Bayes' rule, detection, statistical classification, Linear Discriminant Analysis (LDA), Cluster Analysis- K-means clustering, K-nearest neighbour (KNN) classifier; Evaluation of classifier performance.

References:

1. J. L. Semmlow and B. Griffel, Biosignal and Medical Image Processing, 3rd Eds., 2014.
2. J. L. Semmlow, Biosignal and Medical Image Processing: MATLAB based Applications, Marcel Dekker, Inc., Yew York, USA, 2004.
3. Amine Naït-Ali (Ed.), Advanced Biosignal Processing, Springer, 2009.
4. H. Liang, J. D. Bronzino and D. R. Peterson (Eds.), Biosignal Processing- Principle and Practices, CRC Press, 2013.
5. K. J. Blinowska, J. Zygierewicz, Practical Biomedical Signal Analysis Using MATLAB, CRC Press, 2012

SUBJECT NAME: INTELLIGENT CONTROL					
Paper Code: AEIE6122					
Contact hrs per week:	L	T	P	Total	Credit points
	3	0	0	3	3

Course Outcomes:

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

1. Explain the concept of intelligent control and their applications.
2. Learn basics of Neural Network and control systems based on it.
3. Gain knowledge about fuzzy set theory and control scheme based on it.
4. Apply Genetic Algorithm to solve optimization problems in different control systems.
5. Provide detailed theoretical and practical aspects of intelligent modeling, optimization and control of non- linear systems.
6. Design Neural Network based predictor of nonlinear system.

Module I – [10L]

Introduction to Intelligent Systems and Neural Networks:

Introduction and motivation, Approaches to intelligent control, Architecture for intelligent control, Expert systems. Artificial Neural Networks: Concept of ANN and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feedforward multilayer perceptron. Learning and training of the neural network, Adaptive learning rate, weight update rule, Radial basis function networks.

Module II - [10L]

Fuzzy Logic and Model Based Fuzzy Control:

Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Self organizing fuzzy logic control. Fuzzy logic control for nonlinear time- delay system.

Module III - [8L]

Evolutionary Computation Techniques:

Genetic Algorithm: Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters, Evolutionary design of controllers. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like tabu search and ant-colony search and simulated annealing techniques for solving optimization problems.

Module IV - [8L]

Hybrid Computing Technique:

Neuro-Fuzzy Hybrid System, Adaptive Neuro-Fuzzy Inference System, Genetic Neuro Hybrid System, Genetic Fuzzy hybrid and Fuzzy Genetic hybrid system, Applications in system identification and control.

Introduction to Quantum Computation: Quantum neural network for fuzzy classifier, Quantum Neuro-Fuzzy classifier.

References:

1. Y.C. Shin and C. Xu, Intelligent Systems: Modeling, Optimization and Control, CRC Press, 2008.
2. Kazumi Nakamatsu and Roumen Kountchev Eds., “New Approaches in Intelligent Control- Techniques, Methodologies and Applications”, Springer, 2015.
3. Michael Negnevitsky, “Artificial Intelligence : a Guide to Intelligent Systems”, Addison Wesley, 2005.
4. Robert E. King, “Computational Intelligence in Control Engineering”, Control Engineering Series.
5. Marzuki Khalid, “Artificial Intelligence : Fuzzy Logic Module”, University Technology Malaysia.
6. Marzuki Khalid, “Artificial Intelligence : Artificial Neural Networks Module”, Universiti Teknologi Malaysia

Subject Name: Engineering Mathematics and Biostatistics					
Paper Code: BIOT6121					
Contact Hours Per Week	L	T	P	Total	Credit Points
	3	0	0	3	3

Course Outcomes:

After completion of this course, students will be able to:

1. Understand and apply the basic principles of engineering mathematics.
2. Estimate men, median, mode and other parameters of central tendency in biological samples.
3. Evaluate the probability of occurrence by different methods in an experimental set-up.
4. Solve problems regarding differences in parameters between experimental and control groups by testing hypothesis.
5. Analyze the relationship between experimental groups in biological samples with the help of correlation and regression.
6. Estimate the difference between and within biological parameters in same or different groups by analysis of variance.

Module-I [9L] Introduction to Engineering Mathematics

Linear Algebra: Matrices and Determinants, Eigen values and Eigen vectors; Definite integration with Applications; Differential equations with applications; Numerical solution of ODEs: different methods.

Module-II [9L] Central tendency and theoretical distribution

Statistics of dispersion: Variability, Central tendency, Mean deviation, Standard Deviation, Variance; Probability Distribution for discrete random variables and continuous random variables; Skewness, Kurtosis, theoretical probability distributions: binomial, poisson, normal.

Module-III [9L] Testing of hypothesis

Testing Hypothesis: Concepts and importance in experimental research, type of errors; testing means, Significance of difference between means using Z score; Large sample tests based on normal distribution – Test based on t and F distributions, Chi square test for goodness of fit, independence of attribute, homogeneity, and variance of a normal population.

Module-IV [9L] Correlation, Regression & Anova

Correlation and Regression analysis; Analysis of Variance: One way and two way classifications of Anova – Applications in Biological Sciences.

Text books:

1. Introduction to Biostatistics. Pranab K Banerjee. (2nd edition). S. Chand & Co.

2. P.N. Arora, P.K. Malhan, Biostatistics, Himalaya Publishing House.
3. B.K. Pal and K. Das. Engineering Mathematics. Vol. 1 and 2. U.N. Dhur & Sons Pvt. Ltd.

Reference books:

1. Debajyoti Das and Arati Das. Statistics in Biology and Psychology, Academic Publishers.
2. P. Kandasamy, K. Thilakavthy and K. Gunavathy. Numerical Methods. S. Chand and Co., New Delhi, 1999.
3. B.S. Grewal, J.S. Grewal. Numerical Methods in Engineering and Science. Khanna Publishers, New Delhi, 1999.
4. M.K. Jain, S.R.K. Iyengar and R.K. Jain. Numerical Methods for Engineering and Scientific Computation (3rd

Edition). New Age International (P) Ltd., New Delhi, 1995.

5. C.F. Gerald, P.O. Wheatley. Applied Numerical Analysis (5th Edition), Addison – Wesley, Singapore, 1998.
6. S. Narayanan, K. Manickavachakam Pillai and G. Ramanaiah. Advanced Mathematics for Engineering Students-Vol.-III. S. Viswanathan Pvt. Ltd., Chennai, 1993.

Subject Name: Composite Materials					
Paper Code: REEN 6121					
Contact Hours Per Week	L	T	P	Total	Credit Points
	3	0	0	3	3

Course Outcome:

By the end of the course the students will be able to

1. Impart updated knowledge and provide strong foundation to the M. Tech. students on the preparation, structure, fabrication, properties and applications of different advanced composite materials.
2. Acquire vast ideas and strong confidence in applications of high tech materials in modern devices used in both renewable and non-renewable energy sector.
3. Carry out R & D activities for developing newer advanced materials for use in renewable energy sector.
4. Solve stringent industrial problems and needs wherever applicable more economically.
5. Pursue higher studies & carry out research works effectively in the field of materials science & engineering.
6. Acquire sound employability in different eminent academic, R & D institutes and industries.

Module–I: 9 L

Learning objective; Introduction: Definition; Classification and characteristics of Composite materials; Advantages and application of composites for both general engineering & renewable energy engineering purpose; Functional requirements of reinforcement and matrix; Effect of reinforcement (size, shape, distribution, volume fraction, and orientation of particles and fibres/whiskers) on overall composite performance;

Module II: 9 L

Applications of composites/nano-composites in renewable energy engineering: Wind turbine, Gas turbine; hydro- turbine; electrical double layer capacitors used in storage devices (conducting polymer carbon nano-tube composites), tandem & hot carrier solar cells: transition metal- chalcogenides; perovskite-based solar cells, nano- diamond based solar energy converter, graphene-silicon batteries; black phosphorous-based solar photo voltaic; Nickel sulphide anchored graphene composites for high performance super capacitors electrode materials for fuel cell applications; Chromium-doped poly-aniline –CNT nano-composites as super capacitors electrode materials.

Module III: 9 L

Reinforcements: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers, Silicon carbide fibres & Alumina whiskers. Properties and applications of whiskers, particle reinforcements. Mechanical behaviour of composites: Rule of mixtures, Inverse rule of mixtures. Iso-strain and Iso- stress conditions. 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.

Module IV: 9 L

Preparation of Metal Matrix Composites: Casting– Solid State diffusion technique, Cladding – Hot iso-static pressing; Properties and applications; Preparation of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering; Preparation of Carbon–Carbon composites: Knitting, Braiding, Weaving, Properties and applications; Preparation of Polymer Matrix Composites: Preparation of Moulding compounds and pre-pregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding; Properties and applications.

TEXT BOOKS:

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

References:

1. Hand Book of Composite Materials by Lubin George(Ed)
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.

Subject Name: Safety and Hazards in Energy Industry					
Paper Code: REEN 6122					
Contact Hours Per Week	L	T	P	Total	Credit Points
	3	0	0	3	3

Course OutcomeS:

By the end of the course the students will be able to

1. Analyze the effect of release of toxic substances
2. Understand the industrial laws, regulations and source models.
3. Apply the methods of prevention of fire and explosions.
4. Understand the advantages of preventive maintenance.
5. Understand the relief and its sizing methods.
6. Understand the methods of hazard identification and preventive measures.

Module I: 9L

Definition of safety, Hazard and Risk, Safety program, Inherent safety, Safety regulations, OSHA, Process safety management, mechanical and electrical hazards, types, causes and preventive steps/procedure, Hazards due to fire, Distinction between fire and explosion, Upper Flammability limit and Lower Flammability Limit, Fire Triangle, Fire prevention and firefighting, equipment and methods, Safety color codes..

Module II: 9L

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Service life of equipment. Tools for hazards identification: HAZOP, Fault Tree, Event Tree, FMEA, Wear and Corrosion and their prevention, Application of lubrication and different methods of lubrication, Types of corrosion, corrosion prevention methods.

Module III: 9L

Risk analysis concept and methodology: Risk concept and measure of risk, Risk acceptance criteria, Quantitative risk analysis, 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.

Module IV: 9L

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.
5. Chemical Process Safety: Fundamentals with Applications: D. A. Crowl and J.F.Louvar, Prentice Hall, 1990

Course Name :Business Analytics					
Course Code : CSEN6121					
Contact hours per week	L	T	P	Total	Credit Points
	3	0	0	3	

Course Outcomes:

1. Students will demonstrate knowledge of data analytics.
2. Understand and critically apply the concepts and methods of business analytics
3. Students will demonstrate the ability to use various techniques to support data driven business decision-making.
4. Student will demonstrate how to recognize trends, detect outliers, summarize data sets and analyze relationships between variables
5. Able to develop and test hypotheses
6. Initiate interest to learn various tools used in this area on his/her own.

Module I [8 L]

Introduction: Overview of Business analytics, Business analytics vs Business Analysis vs Data Science, Scope of Business analytics, Business Analytics Process, Organization structure needed for effective Analytics, Competitive advantages of Business Analytics, Data and models for Business analytics

Data Visualization : Summarizing Data (Mean, Mode, Variance, Standard Deviation, Skewness), Tools for Single variable (histogram), Tools for Pairs of variables (box plot, scatter plot, contour plot), Tools for Multiple variables. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modeling, sampling and estimation methods overview.

Module II [10 L]

Types of Statistical Analysis: Descriptive type of statistical Analysis, Inferential Type of Statistical Analysis, Predictive Analytics, Perspective Analytics and its step in the business analytics Process, Causal Analysis, nonlinear Optimization.

Trendiness and Regression Analysis: Modeling Relationships and Trends in Data, simple Linear Regression.

Data Mining techniques: Classification, clustering, Association rules, Outer detection, Sequential Patterns used in business analytics.

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.

Module III [10 L]

Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New- Product Development Model, News vendor Model, Overbooking Model, Cash Budget Model.

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

Module IV [8 L]

Recent Trends in Business Analytics: Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

Business Analytics Tool – R: Overview of R, Some basic coding syntax of R, Discuss some Modeling Techniques in Business Analytics with R for simple problems.

Reference:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

SUBJECT NAME: Advanced Artificial Intelligence					
Paper Code: CSEN6122					
Contact hrs per week:	L	T	P	Total	Credit points
	3	0	0	3	3

Course Outcomes:

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

1. Understand the building blocks of artificial intelligence, knowledge representation, reasoning, and machine learning techniques to real-world problems.
2. Formulate and solve problems with uncertain information using Bayesian approaches.
3. Learn supervised and unsupervised learning techniques and criteria of their performance assessment.
4. Employ fuzzy logic for development of artificial intelligent systems.
5. Familiar with AI search algorithms like genetic algorithms.
6. Develop artificial neural network model for different classification problems as well as understand basic of some of the more advanced topics of AI such as deep learning and convolutional neural network.

Module I – [9L]

Introduction to AI: Logic foundations of Artificial Intelligence, Constraint reasoning, Qualitative reasoning, Probabilistic reasoning- Bayesian probability, Steps of Bayesian problem solving, Naïve Bayesian Learning Model, Boosting of naïve Bayesian model-AdaBoost Algorithm.

Module II - [9L]

*Learning:*Supervised, Unsupervised and Reinforcement learning; Learning decision trees; Generalization and over fitting, Cross validation, Loss function, Regularization, Complexity versus goodness of fit.

Regression and classification with linear Models- Univariate linear regression, Multivariate linear regression, Linear classification with logistic regression; Perceptron Learning Algorithm (linear model), Adaline and Madaline; K-nearest neighbor model.

Module III - [9L]

*Emergent Intelligence:*Fuzzy expert systems- Fundamentals of Fuzzy sets, membership functions, Linguistic variables and hedges, operations on fuzzy sets, fuzzy rules, fuzzy inference, examples of building fuzzy expert system, fundamental issues with Fuzzy systems;

Evolutionary computation- Formal model of evolution system theory, Darwin's evolutionary algorithm, Classifier system; Genetic algorithm - basic principles of genetic algorithm, genetic operators, simple illustration of genetic algorithm with examples.

Module IV - [9L]

Neural Networks & Deep Learning: Introduction- Basic models of artificial neurons, activation functions, Simple perceptron, multilayer perceptron, Backpropagation learning algorithm, Applications of neural networks in classification and estimation.

Deep learning – Concepts of deep learning, deep networks, training of deep networks, applications of deep learning;

Convolutional neural network, recurrent neural network

References:

1. Stuart J. Russell and Peter Norvig, *Artificial Intelligence A Modern Approach*, 3rd Edition, Pearson, 2016.
2. Toshinory Munakata, *Fundamentals of the New Artificial Intelligence- Neural, Evolutionary, Fuzzy and More*, Second Edition, Springer, 2008.
3. Richard E. Neapolitan, Xia Jiang, *Artificial Intelligence- With an Introduction to Machine Learning*, Second Edition, CRC Press, 2018.
4. Michael Negnevitsky, *Artificial Intelligence- A Guide to Intelligent Systems*, Addison-Wesley.
5. Neural Networks and Learning Machines, Simon Haykin, Third Edition, PHI Learning, 2009.
6. Y. S. Abu-Mostafa, M. Magdon-Ismail, H. T. Lin, Learning from Data A short Course, AMLbook.com.
7. J. Han and M. Kamber, Data Mining Concepts and Techniques, 3rd, Edition, Morgan Kaufmann Publishers, July 2011.

Course Title : AD HOC Networks and Uses					
Course Code : ECEN6121					
Contact Hours per week	L	T	P	Total	Credit Points
	3	0	0	3	3

Course outcomes:

1. Students will develop the ability to apply knowledge of mathematics, science and engineering in the areas of communication engineering.
2. They will be able to analyze a situation and interpret a data in ad hoc networks.
3. Students will acquire knowledge to learn and apply modeling based approach through the extensive use of simulator tools.
4. Students will be able to compare and decide about different routes.
5. They will analyse the performance of routes.
6. Students will be able to understand and develop ability to participate in research work.

Module I: [10 L]

Ad hoc Network: Introduction, Basic concept on ad hoc network, static and mobile ad hoc network, transmitter- receiver constraints, Applications.

MAC protocol: Hidden terminal, Exposed terminal, IEEE802.11 in ad hoc mode.

Routing protocols: Proactive, Reactive and hybrid routing protocol, DSDV algorithm, Dynamic source routing, Ad hoc on-demand routing, Location aided routing, Link reversal routing.

Module II: [10L]

Analysis of TCP performance in wireless ad hoc network: TCP window management and problems, different solution schemes, QoS in wireless ad hoc network – analysis of degradation of receiver SNR, practical solutions.

Achieving energy efficiency in wireless ad hoc network: Different schemes to increase the lifetime of the node in ad hoc network – MAC layer protocol, Routing protocol.

Module III: [8 L]

Localization Management: Location acquisition technique, location sensing technique, location aware routing protocol. Primary and secondary source , Different principles like weighted centriod algorithm to locate sources. Security for wireless ad hoc network: Security goals, threats and challenges, Different schemes of security in ad hoc network, routing security. Spectrum utilization – Generic Access Network (GAN) and other methods, Hotspots and uses.

Module IV: [6 L]

Sensors- sensor networking, WSN, hardware and software platforms, OS for WSN, distributed sensor network, healthcare monitoring, environmental sensing, industrial monitoring, smart city concept.

References

1. ”Ad Hoc Wireless Networks – Architectures and Protocols” - C.Siva Ram Murthy and B.S. Manoj – Pearson Education
2. Mobile Ad Hoc Networking – Stefano Basagni, Marco Conti, Silvia Giardano, Ivan Stojmenovic – Wiley India
3. Security and Quality of Service in Ad Hoc Wireless Networks – Amitabh Misra – Cambridge University Press

Course Title: Design of Embedded Systems					
Course Code: ECEN 6122					
Contact Hrs	L	T	P	Total	Credit Points
per week	3	0	0	3	3

Course Outcomes:

1. Students will learn Embedded System Design Methodology
2. Students will learn Embedded Processor Design
3. Students will learn 8051 Micro-Controller
4. Students will learn Embedded Memory and I/O Device interface
5. Students will learn Real time OS
6. Students will learn ARM Micro-Controller and PIC Micro-Controller

Module I: Introduction to embedded systems: [8L]

Embedded systems overview with various type of examples in different domains such as in communication systems, robotics application and in control application, Design challenge – optimizing design metrics, embedded processor technology, Difference between embedded computer systems and general purpose computer Systems, Design methodology.

Module II: Embedded system processor design: [10L]

Custom single-purpose processors design: using finite state machine model and RTL model. Standard single- purpose processors design: Timers, and watchdog timers, LCD controller. Interfacing of Embedded Processors: Hardware protocol basics, interfacing with a generalpurpose processor, RS232, I2C, CAN protocol.

Module III: Introduction to 8051 microcontroller: [10L]

8051 architecture, pin configuration, I/O ports and Memory organization. Instruction set and basic assembly language programming. Interrupts, Timer/Counter and Serial Communication in 8051, Introduction to PIC and ARM micro-controllers.

Module IV: Interfacing with Memory and I/O Devices: [8L]

Different types of embedded memory devices and interfacing: SRAM, DRAM, EEPROM, FLASH, CACHE memory. Different types of I/O devices and interfacing: Keypad, LCD, VGA. Square wave and pulse wave generation, LED, A/D converter and D/A Converter interfacing to 8051.

Text Books:

1. Embedded System Design: A Unified Hardware/Software Approach – 2nd Ed. by Ed Frank Vahid and Tony Givargis

2. Embedded Systems: A Contemporary Design Tool by James K. Peckol
3. Embedded / Real-Time Systems: Concepts, Design and Programming by K.V.K. Prasad
4. Embedded Systems by Raj Kamal

Reference Book:

1. Computers as Components: Principles of Embedded Computing System Design – 2nd Ed. by Wayne Wolf.

Course Title : COGNITIVE RADIOS					
Course Code : ECEN6123					
Contact Hours per week	L	T	P	Total	Credit Points
	3	0	0	3	3

Course Outcomes:

The following outcomes are expected from the students after completion of the course –

1. An ability to apply knowledge of mathematics, science and engineering in the emerging areas of RF communication.
2. An ability to analyze a situation.
3. An ability to learn and apply modular approach.
4. An ability to understand research work in new areas of cognitive radios and spectrum hole sensing.
5. Development of a passion to pursue next generation wireless communication.
6. An ability to design intelligent radios for future.

Module I: [9 L] INTRODUCTION TO SOFTWARE DEFINED RADIO

Definitions and potential benefits, software radio architecture evolution, technology tradeoffs and architecture implications. Differences between software enable radio and software defined radio. Essential functions of the software radio, basic SDR, hardware architecture, Computational processing resources, software architecture, top level component interfaces, interface topologies among plug and play modules.

Module II: [9 L] COGNITIVE RADIO TECHNOLOGY

Introduction – Radio flexibility and capability – Aware – Adaptive – Comparison of Radio capabilities and Properties – Available Technologies – IEEE 802 Cognitive Radio related activities – Application, position awareness in cognitive radios, optimization of radio resources, Artificial Intelligence Techniques.

Module III: [10 L] COGNITIVE RADIO DESIGN AND CHALLENGES

Cognitive Radio – functions, components and design rules, Cognition cycle – orient, plan, decide and act phases, Inference Hierarchy, Architecture maps, Building the Cognitive Radio Architecture on Software defined Radio Architecture. Design Challenges associated with CR – Hardware requirements – Hidden primary user problem – detecting spread spectrum primary users – sensing duration and frequency – security

Module IV: [8 L] SPECTRUM SENSING

Spectrum sensing, spectrum management, spectrum mobility, spectrum sharing, upper layer issues, cross – layer design, applications of cognitive radios to optimize spectrum utilization, to reduce transmit power reduction and to improve data rate even in noisy conditions. Matched filter – waveform based sensing – cyclostationary based sensing – Energy detector based sensing – Radio Identifier – Cooperative sensing-other sensing methods.

References:

1. Joseph Mitola III, "Software Radio Architecture: Object-Oriented Approaches to wireless system Engineering", John Wiley & Sons Ltd. 2000
2. Thomas W. Rondeau, Charles W. Bostain, "Artificial Intelligence in Wireless communication", ARTECH HOUSE. 2009.
3. Bruce A. Fette, "Cognitive Radio Technology", Elsevier, 2009.
4. Ian F. Akyildiz, Won- Yeol Lee, Mehmet C. Vuran, Shantidev Mohanty, "Next generation / dynamic spectrum access / cognitive radio wireless networks: A Survey" Elsevier Computer Networks, May 2006
5. Simon Haykin, "Cognitive Radio: Brain-Empowered Wireless Communication", IEEE Journal on selected areas in communications, Feb 2005.

Course Name: Automation in VLSI Design					
Course Code : ECEN6124					
Contact Hours per week	L	T	P	Total	Credit Points
	3	0	0	3	3

Course Outcome:

1. Students will understand MOS Transistor Based Digital VLSI Circuits
2. Students will understand Physical Layout Design of Digital VLSI Design
3. Students will understand VLSI Design Cycle
4. Students will learn Verilog HDL (Hardware Description Language)
5. Students will learn High level and Logic level Synthesis Algorithm
6. Students will learn Floorplan, Placement and Routing Algorithm

Module I: VLSI Circuits and Physical Layout: [10L]

Unit 1: MOS Transistor Characteristics, MOS as Digital Switch, NMOS Logic Family, CMOS Logic Family, CMOS Inverter Characteristics (VTC), Inverter Delay, CMOS Gates like NAND and NOR gates, Pass Transistor Logic and Transmission Gate, CMOS Sequential Circuits, CMOS D-Latch and D-Flip-Flop

Unit 2: CMOS Cross Section, Layout and Mask layers, Inverter Layout, Lambda Rule vs Micron Rule, Std Cell Layout Topology, Stick Diagram, Euler Path Algorithm, Layout Legging.

Module II: VLSI Design Methodology: [6L]

Unit1: Moore's Law, Scale of Integration (SSI, MSI, LSI, VLSI, ULSI, GSI), Technology growth and process Node,

Unit2: Full Custom Design, Std Cell based Semi Custom Design, VLSI Design Cycle, Y-Chart.

Module III: EDA Tools: High level Synthesis and HDL: [8L]

Unit 1: High level Synthesis EDA Flow, Control and Data Flow Graph, Scheduling, Allocation, Binding, RTL

Unit 2: Why HDL ? Frontend Design Flow using HDL (Behavioral, RTL and Gate Level), Verilog Modeling: Behavioral, Data-Flow, Structural and Mixed, Test Bench, FSM Example: Mealy Machine and Moore Machine. Pipeline Example.

Module IV: EDA Tools: Logical Synthesis and Physical Design Automation: [12L]

Unit 1: Combinational Logic Optimization: BDD: Binary Decision Diagram, OBDD, ROBDD, Technology Mapping: Pattern DAG, Subject DAG, Sequential Logic Optimization

Unit 2: Physical Layout Automation EDA Flow, Partitioning: KL Algorithm, Floor-planning cost function, Placement, Detailed Routing: Channel Routing, Horizontal Constraint Graph, Vertical Constraint Graph, Cyclic Constraint, Left-edge Algorithm, Global Routing: Steiner Tree, Maze Routing.

Text Book:

1. Principles of CMOS VLSI Design, A Systems Perspective, Author: Neil Weste, Kamran Eshraghian, Addison Wesley, 2nd Edition, 2000
2. Algorithms for VLSI Physical Design Automation, Author: N. Sherwani, KLUWER ACADEMIC PUBLISHERS (3rd edition)

Reference Book:

1. CMOS Digital Integrated Circuits, Analysis and Design, Author: Sung-Mo Kang, Yusuf Leblebici, Tata McGraw Hill (3rd Edition), 2006
2. CMOS VLSI Design, A Circuits and Systems Perspective (3rd Edition) Author: Neil Weste, David Harris, Ayan Banerjee. Pearson, 2011
3. Digital Integrated Circuit, Design Perspective, Author: .M. Rabaey, Prentice-Hall
4. VLSI Design and EDA TOOLS, Author: Angsuman Sarkar, Swapnadip De, Chandan Kumar Sarkar, SCITECH PUBLICATIONS (India) Pvt. Ltd., 2011
5. Algorithms for VLSI Design Automation, Author: Gerez, Wiley, 2011

Subject Name: Information Theory and Coding					
Paper Code: INFO6123					
Contact Hours per week	L	T	P	Total	Credit Points
	3	0	0	3	3

Course Outcomes:

Students who complete the course will demonstrate the ability to do the followings.

1. Derive equations for entropy, mutual information and channel capacity for all types of channels.
2. Compare among different types of error correcting codes.
3. Evaluate the channel performance using Information theory.
4. Formulate the basic equations of linear block codes.
5. Apply convolution codes for performance analysis .
6. Design BCH code for Channel performance improvement.

Detailed Syllabus:

Module I: (9 L)

Entropy and Mutual Information: Entropy, Joint and Conditional Entropy, Relative Entropy and Mutual Information, Chain Rules, Fano's Inequality, Information measures for continuous random variables, Markov chains.

Source coding: Huffman coding, Kraft Inequality, Shannon-Fano Coding, Shannon-Fano-Elias Coding, Arithmetic Coding and Run length coding.

Channel Capacity: Channel models, Discrete memoryless channels, Shannon's noisy coding theorem, The Shannon limit.

Module II: (11 L)

Linear Block Codes: Design of linear block codes, introduction of linear block codes, Matrix description of linear block codes, parity check matrix, syndrome and error detection, minimum distance of a block code, error detecting and error correcting capability of a block code, design of encoder and syndrome decoder for linear block codes. Hamming codes.

Cyclic Codes: Polynomials, division algorithm for polynomials, a method for generating cyclic codes, matrix description of cyclic codes, generator and parity check polynomials, syndrome and error detection.

Module III : (8 L)

BCH Codes: Primitive elements, minimal polynomials, generator polynomials in terms of minimal polynomials, Error Syndrome,Error location polynomial,examples of BCH codes, Reed-Solomon Codes, Interleaved and Concatenated Codes.

Module IV : (8 L)

Convolutional Codes: Tree codes, trellis codes, polynomial description of convolutional codes, distance notions for convolutional codes, the generating function, matrix representation of convolutional codes, decoding of convolutional codes – Viterbi Algorithm, distance and performance bounds for convolutional codes, Turbo codes, Turbo decoding.

References:

1. Information theory, coding and cryptography - Ranjan Bose; TMH.
2. Information and Coding - N Abramson; McGraw Hill.
3. Elements of Information Theory - T. M. Cover and J. A. Thomas, John Wiley, New York.
4. Information Theory - R B Ash; Prentice Hall.

Subject Name: Optimization Techniques					
Paper Code: MATH6121					
Contact Hours per week	L	T	P	Total	Credit Points
	3	0	0	3	3

Course Outcomes:

Students who complete the course will demonstrate the ability to do the followings.

1. Describe the way of writing mathematical model for real-world optimization problems.
2. Identify Linear Programming Problems and their solution techniques
3. Categorize Transportation and Assignment problems
4. Apply the way in which Game Theoretic Models can be useful to a variety of real-world scenarios in economics and in other areas.
5. Convert practical situations into non-linear programming problems.
6. Solve unconstrained and constrained programming problems using analytical techniques.

MODULE I: Linear Programming Problem (LPP)-I (9L)

Formulation of an LPP; Graphical Method of solution of an LPP; Convex Combination and Convex Set; Convex Hull and Convex Polyhedron; Canonical and Standard form of an LPP; Basic Solution of a system of linear equations; Simplex Method; Big-M Method; Concept of Duality; Mathematical formulation of duals.

MODULE II: Linear Programming Problem (LPP)-II (9L)

Transportation Problems (TP) ; Representation of Transportation Problems as LPP; Methods of finding initial basic feasible solution of TP: North-West Corner Rule, Matrix Minima Method, Vogel's Approximation Method; Optimality test of the basic feasible solution; Assignment Problems; Hungarian Method.

MODULE III: Game Theory (9L)

Introduction; Strategies; The Minimax and Maximin Criterion; Existence of Saddle Point; Two person zero some Games; Games with saddle Point – Pure Strategies; Games without a Saddle Point – Mixed Strategies; Symmetric Games; Dominance Principle; Graphical Method of Solution; Algebraic Method of Solution.

MODULE IV: Non-Linear Programming Problem (NLPP) (9L)

Single-variable Optimization; Multivariate Optimization with no constraints: Semidefinite Case, Saddle Point; Multivariate Optimization with Equality Constraints: Method of Lagrange Multipliers; Multivariable Optimization with inequality constraints: Kuhn-Tucker Conditions.

Suggested Readings:

1. *Linear Programming and Game Theory* by J. G. Chakraborty and P. R. Ghosh, Moulik Library.
2. *Operations Research* by Kanti Swarup, P. K. Gupta and Man Mohan, S. Chand and Sons.
3. *Engineering Optimization* by S. S. Rao, New Age Techno Press.
4. *Operations Research by J K Sharma, Macmillan India Ltd*