Bachelor of Technology

(B Tech)

5th Semester

Detailed Syllabus

2019 Batch

Fifth Semester

Theory

Sl. No.	Category	Subject Code	Subject Name	L-T-P	Credit
1	PCC	19EC5PC01T	**PCC-6:**Digital Signal Processing	3-0-0	3
2	PCC	19EC5PC02T	**PCC-7:**Control System Engineering	3-0-0	3
3	PCC	19EC5PC03T	**PCC-8:**Analog Communication Techniques	3-0-0	3
4	PEC	**Professional Elective-2:**			
		19EC5PE01T	Electronic Device Modeling	3-0-0	3
		19EC5PE02T	Microcontroller and Applications		
		19EC5PE03T	Information Theory & Coding Techniques		
		19EC5PE04T	Digital VLSI Design		
5	OEC	**Open Elective-1: [for other branch students]**		3-0-0	3
		19EC5OE01T	VLSI Design		
		19EC5OE02T	Microprocessor and Interfacing		
		Open Elective-1: [for ECE branch students]			
		19IT5OE01T	Java Programming		
		19CS5OE01T	Introduction to Python Programming		
		19EE5OE04T	Introduction to Electrical Properties of Materials		
		19EE5OE01T	Renewable Energy Systems		
		19ME5OE03T	Micro Electro Mechanical System		
6	OEC	**Open Elective-2: [for other branch students]**		3-0-0	3
		19EC5OE03T	Embedded System Design		
		19EC5OE04T	Radar System Engineering		
		Open Elective-2: [for ECE branch students]			
		19IT5OE02T	Computer Networks		
		19CS5OE02T	Database Management System		
		19EE5OE03T	Smart Grids		
		19EE5OE02T	Sensor and Instrumentation		

		19ME5OE04T	Nanoscience and Technology		
		19CE5OE03T	Geo-Environmental Engineering		
7	MC	19CM5MC01T	Constitution of India	3-0-0	0
		19CM5MC02T	Essence of Indian Tradition Knowledge		
Total Credit (Theory)					**18**
Practical					
1	PCC	19EC5PC01L	**PCC Lab-5:**Digital Signal Processing Lab	0-0-2	1
2	PCC	19EC5PC02L	**PCC Lab-6:**Control System Engineering Lab	0-0-2	1
3	PCC	19EC5PC03L	**PCC Lab-7:** Analog Communication Techniques Lab	0-0-2	1
4	PSI	19CM5PS01L	Summer Internship/Training	0-0-2	1
Total Credit (Practical)					**4**
Total Semester Credit					**22**

Subject Code:	Subject Name:	L-T-P:	Credit:
19EC5PC01T	DIGITAL SIGNAL PROCESSING	3-0-0	3

COURSE OBJECTIVE:

The objective of this course is to introduce students to

1. Understand thoroughly the frequency domain analysis of discrete time signals.
2. Mathematical modeling of digital filters.
3. Structural Implementation of digital filters.
4. Concepts of multi-rate signal processing and use of adaptive filter in real-time applications of DSP.

SYLLABUS:

Module-1 **(8 Hours)**

Z-Transform & its Applications:

Overview of Discrete time signals and systems. Z-Transform and Its Application to the Analysis of LTI Systems: Direct Z-Transform, Properties of the Z- Transform, Inverse Z-Transform by Power Series Expansion, and Partial-Fraction Expansion, Analysis of Linear Time Invariant Systems in the Z-Domain.

Module-2 **(10 Hours)**

Discrete Fourier Transform:

Frequency-Domain Sampling and Reconstruction of Discrete-Time Signals, DFT as a Linear Transformation, Relationship of DFT to other Transforms, Properties of DFT. Use of DFT in Linear Filtering: Sectional Convolution. Introduction to the Fast Fourier Transform (FFT) algorithm, Radix 2 Decimation in Time (DIT), Radix 2 Decimation in Frequency (DIF).

Module-3 **(8 Hours)**

Digital Filter Design:

Design of FIR filters: Impulse Response of ideal LPF, HPF, BPF and BSF, Frequency response of linear phase FIR filters by Windowing methods and Frequency Sampling method.

Design of IIR filters: Butterworth, and Chebyshev, Conversion to digital IIR Filter using Impulse Invariance Technique and Bilinear Transformation. Frequency transformation in analog and digital domain.

Module-4 **(6 Hours)**

Structure and Implementation of FIR and IIR Filter:

Structure of IIR Systems: Direct form – I realization Direct form – II realization. Structure of FIR Systems: Direct- Form Structure, Cascade-Form Structure, and Frequency Sampling Structure.

Module-5 **(10 Hours)**

Multi-rate DSP & Adaptive Filter:

Multi-rate DSP: Introduction to Multi-rate DSP, Decimation, Interpolation, Sampling rate conversion by rational factor, Implementation of sampling rate conversion.

Adaptive filters: Adaptive Wiener filter and LMS algorithm, Application of Adaptive Filters: System Identification or System Modeling, Adaptive Channel Equalization, Adaptive Line Enhancer, Adaptive Noise Cancelation.

COURSE OUTCOMES:

On Completion of this course, the students should be able to:

1. Apply the discrete time transform techniques to analyze the discrete time signals and systems.
2. Implement various digital signal processing algorithms for realization of efficient systems by reducing computational complexity.
3. Design, analyze and compare digital filters based on their complexity and stability.
4. Apply multi-rate signal processing and adaptive filter theory in practical applications used for signal processing

TEXT BOOKS:

1. J. G. Proakis and D. G. Manolakis, *Digital Signal Processing*, 4th Edition, Pearson Publication, 2012, New Delhi.
2. Tarun K. Rawat, *Digital Signal Processing*, 1st Edition, Oxford University Press, 2015, New Delhi.

REFERENCE BOOKS:

1. Sanjit K. Mitra, *Digital Signal Processing, A Computer-Based Approach*, 4th Edition, McGraw Hill Education, 2013, New Delhi.
2. S. Salivahan, A. Vallavraj and C. Gnanapriya, *Digital Signal Processing*, 2nd Edition, TMH, 2010, New Delhi .
3. H. Hayes, *Schaum's Outlines, Digital Signal Processing*, 2nd Edition, TMH, 2011, New Delhi.

DIGITAL LEARNING RESOURCES:

Course Name	Digital Signal Processing
Course Link	https://nptel.ac.in/courses/117/102/117102060/
Course Instructor	Prof. S. C. Dutta Roy, IIT Delhi

Course Name	Digital Signal Processing
Course Link	https://nptel.ac.in/courses/117/105/117105144/
Course Instructor	Prof. Govind Sharma, IIT Kanpur

Subject Code:	Subject Name:	L-T-P:	Credit:
19EC5PC02T	CONTROL SYSTEM ENGINEERING	3-0-0	3

COURSE OBJECTIVE:

Perusal of this course enforces the students for acquiring the knowledge to

1. Introduce the concept of feedback systems and analysis of physical systems.
2. Analyze the transfer function, characteristic equations, poles zeros in Laplace plane.
3. Study the systems performances in time-domain and frequency domain.
4. Analyze the system stability and relative stability deploying different approaches.
5. Introduce the concepts of state variable analysis, controllability and observability.

SYLLABUS:

Module-1 **(8 Hours)**

Introduction:

Basic Concepts of Control Systems, Open loop and closed loop systems. Feedback Characteristics of Control Systems: Feedback and Non-feedback System, effect of Feedback on Overall gain, stability, sensitivity, and external disturbance or noise. Types of feedback control systems, linearizing effect of feedback, regenerative feedback. Mathematical Modeling: Electrical and Mechanical system (Translation and Rotational systems), analogy between Mechanical and Electrical quantities.

Module-2 **(8 Hours)**

Transfer Function Representation and Time Response Analysis:

Transfer function representation: Impulse response and transfer functions of linear systems. Determination of Transfer functions by block diagram algebra, and Signal Flow Graphs. Time response Analysis: Typical test Signals for Time response of control systems Steady State Errors by Static Error Constants and Generalized error constant method. Unit step response of second order system and time domain specifications, Transient response of a prototype second order systems.

Module-3 **(8 Hours)**

Stability of Linear Control Systems:

Concept of stability, BIBO stability, Rout- Hurwitz Criterion, Relative Stability. Root locus Technique: Basic properties of the root loci, properties and construction of Root Loci-effect of adding poles and zeros to the transfer functions.

Module-4 **(8 Hours)**

Frequency Response Analysis and Stability in Frequency Domain:

Frequency Response Analysis: Frequency response of closed – Loop systems, frequency domain specifications. Correlation between time response and frequency Response of control system. **Stability in Frequency Domain:** Mathematical Preliminaries, , Stability analysis with the Bode plot, polar plot, Nyquist Stability Criterion, Assessment of Relative stability using Nyquist Criterion. **Closed loop frequency response:** Constant – M Loci in the G (jω) -plane, Constant – Phase Loci in the G (jω) – plane

Module-5 **(10 Hours)**

Design of Control Systems:

Design of control systems with PD, PI, PID, Phase – Lead, Phase – Lag, and Lead- Lag Controllers. State Space Analysis of Continuous Systems: Concepts of State, State Variables, State transition Matrix, and State Model from Block Diagram, Diagonalization – solving the time invariant state equations- state transition matrix and its properties – Concept of controllability and Observability..

COURSE OUTCOME:

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

1. Formulate mathematical model of systems and solve using reduction techniques.
2. Use the control system in time-domain and frequency domain.

3. Deploy the stability analysis techniques to design real-time control systems
4. Implement the state space approach for the analysis of control systems.

TEXT BOOKS:

1. Benjamin C. Kuo, *Automatic Control Systems*, 7th Edition, Prentice-Hall India, 1995
2. I. J. Nagrath and M. Gopal, *Control Systems Engg.*, 6th Edition, New Age International Publishers 2017

REFERENCE BOOKS:

1. U. A. Bakshi and V. U. Bakshi, *Control Systems*, 4th Edition, Technical Publications, 2019.
2. Raymond T. Stefani, Bahram Shahian, Late Clement J. Savant & Late Gene H. Hostetter, *Design of Feedback control systems*, 4th Edition, Oxford publications, 2006.
3. Katsuhiko Ogata, *Modern Control Engineering*, 5th Edition, Pearson publications, 2009.

DIGITAL LEARNING RESOURCES:

Course Name	Control Engineering
Course Link	https://nptel.ac.in/courses/108/102/108102043/
Course Instructor	Prof. Madan Gopal, Department of Electrical Engineering, IIT Delhi

Course Code:	Course Name:	L-T-P:	Credit:
19EC5PC03T	ANALOG COMMUNICATION TECHNIQUES	3-0-0	3

COURSE OBJECTIVES:

The object of this course is to introduce students to

1. Concept of time and frequency domain analysis of signals used in communication systems.
2. Understand various analog modulation techniques and their applications in real world scenario.
3. Apply the Sampling theorem in analog-to-digital conversion and understand the limits of practical sampling techniques.
4. Examine the performance of various modulation techniques in noisy environment

SYLLABUS:

Module-1 **(6 Hours)**

Signals and Spectra:

Introduction to Communication Systems, Elements of communication System, Power Spectral Density using Fourier series

Random Variables and Processes: Probability, Random variables: mean and variance, CDF, PDF, joint probability and distribution function, Useful Probability Density functions, Random Process: Autocorrelation and Power Spectral Density

Module-2 **(10 Hours)**

Amplitude Modulation Systems:

Need of modulation, linear and nonlinear type of modulation, Frequency translation, Amplitude Modulation: Time and frequency analysis of DSB-C, DSB-SC, SSB and VSB Modulation. Modulators and demodulators: Square law modulator, switching modulator, square law detection and envelope detection, Concept of Frequency Division Multiplexing.

Module -3 **(10 Hours)**

Angle Modulation:

Angle Modulation, types of angle modulation (FM and PM), Comparison: modulation index, sidebands, power and phasor diagram, Tone Modulated FM Signal, Arbitrary Modulated FM signal, Concept of narrowband and wideband FM(PM), FM Modulators: Direct & Indirect methods, Demodulators: limiter and discriminator.

Radio Transmitter and Receiver: FM and AM Superheterodyne receiver, image frequency and its rejection, FM stereo broadcasting

Module -4 **(8 Hours)**

Digital Transmission of Analog Signal:

Concept of sampling, types of sampling, Time and frequency analysis of Sampling Theorem

Pulse Modulation: Pulse Amplitude Modulation: bandwidth, generation and recovery, Time division multiplexing of PAM signals, Pulse Width Modulation and Pulse Position Modulation. Digital Representation of Analog Signal: PCM, Quantization noise, companding

Module -5 **(10 Hours)**

Mathematical Representation of Noise:

Some Sources of Noise, Frequency-domain Representation of Noise, Superposition of Noises, Linear Filtering of Noise.

Noise in Amplitude Modulation System: Calculation of SNR for SSB-SC, DSB-SC, DSB-C under synchronous detection, Comparison of AM system in terms of SNR and Figure of Merit.

Noise in Frequency Modulation System: An FM Receiving System, Calculation of Signal to Noise Ratio, Comparison of FM and AM, Pre-emphasis and De-emphasis for SNR Improvement.

COURSE OUTCOMES:

On Completion of this Subject/ Course the students should be able to:

1. Analyze frequency response of signals and illustrate the concepts of random variables used in communication systems.
2. Explain the concept of continuous wave modulation techniques and evaluate in terms of power, bandwidth, etc.
3. Summarize the concept of analog to digital conversion and apply various pulse modulation techniques in signal transmission.
4. Explain and analyze the time and frequency-domain representation of noise and its effect on communication systems.

TEXT BOOK:

1. H. Taub, D. L Schilling, G. Saha, *Principles of Communication System*, 4th Edition, McGraw Hill, 2013, India.
2. B. P. Lathi, Zhi Ding, *Modern Digital and Analog Communication Systems*, 4th Edition, Oxford University Press, 2017, India.

REFERENCE BOOK:

1. Masoud Salehi, John G. Proakis, *Communication System Engineering*, 2nd Edition, Pearson Education, 2015, India.
2. P Ramakrishna Rao. *Analog Communication*, 1st Edition, Tata McGraw-Hill, 2013, New Delhi, India.

DIGITAL LEARNING RESOURCES:

Course Name	Analog Communication
Course Link	https://nptel.ac.in/courses/117/105/117105143/
Course Instructor	Prof. Goutam Das, Department of ECE, IIT Kharagpur

Subject Code:	Subject Name:	L-T-P:	Credit:
19EC5PE01T	ELECTRONIC DEVICE MODELING	3-0-0	3

COURSE OBJECTIVE

1. To understand the discrete semiconductor devices and their modeling.
2. Development of model and design technology files based on the physical properties of the discrete semiconductor devices.
3. To understand the compact modeling of small-signal, large-signal, distortion and noise in the discrete semiconductor devices.

SYLLABUS:

Module –1 **(8 Hours)**

PN–Junction Diode and Schottky Diode:

DC Current-Voltage Characteristics, Static Model, Large Signal Model, Small-Signal Model, Schottky Diode and its Implementation in SPICE2, Temperature and Area Effects on the Diode Model Parameters.

Module – 2 **(8 Hours)**

Bipolar Junction Transistor (BJT):

Transistor Conversions and Symbols, Ebers-Moll Static Model, Ebers-Moll Large-Signal and Small-Signal Model, Gummel-Poon Static Model, Gummel-Poon Large-Signal and Small-Signal Model, Temperature and Area Effects on the BJT Model Parameters.

Module –3 **(8 Hours)**

MOSFET Device Physics:

Basic operation of MOSFET, MOSFET capacitor, Equivalent circuit representation of MOST, RF modeling and high frequency behavior of MOS transistors, AC small signal modeling, Model parameter extraction.

Module – 4 **(8 Hours)**

Modeling of MOSFETs:

MOS Capacitance model, Threshold voltage modeling, large signal MOSFET models, Introduction to BSIM models. Extraction of MOSFET model parameters, Device Scaling, Short and narrow channel MOSFETs. MOSFET channel mobility model, DIBL, charge sharing and various non-linear effects. BSIM Model Parameter Extraction.

Module – 5 **(6 Hours)**

Noise and Distortions:

Noise in Diodes, Bipolar Transistors, and Field Effect Transistor: a concept. Flicker noise modeling, thermal noise model. Small-Signal Distortion Analysis in diodes, BJT, MOSFETs. DC operating-point sensitivity, AC small-signal sensitivity analysis.

COURSE OUTCOME:

After completion of the course, students will be able to

1. Analyze various diode model parameters for different models
2. Apply the large signal, small signal and static models of MOST for different applications
3. Design technology file by analyzing the characteristics of semiconductor devices.
4. Identify the impact of noise and distortion in IC technology.

TEXT BOOKS:

1. Giuseppe Massobrio and Paolo Antognetti, *Semiconductor Device Modeling with SPICE,* 2nd Edition, Tata McGraw-Hill Education, 2010.

2. Trond Ytterdal, Yuhua Cheng , Tor A. Fjeldly and Wayne Wolf, *Device Modeling for Analog and RF CMOS Circuit Design,* John Wiley & Sons Ltd, 2003.

REFERENCE BOOKS:

1. Richard S. Muller, Theodore I. Kamins and Mansun Chan, *Device Electronics for Integrated Circuits*, 3rd edn., John Wiley and Sons, New York, 2003.

2. Muhammad H. Rashid, *Spice for circuits and Electronics using PSPICE,* PHI Publication, 1994.

DIGITAL LEARNING RESOURCES:

Course Name	Semiconductor Device Modeling
Course Link	https://nptel.ac.in/courses/117/106/117106033/#
Course Instructor	Prof. S. Karmalkar, Department of Electrical, Engineering, IIT Madras

Subject Code:	Subject Name:	L-T-P:	Credit:
19EC5PE02T	MICROCONTROLLER AND APPLICATIONS	3-0-0	3

COURSE OBJECTIVES:

1. To introduce the architectures of microcontrollers and its role in embedded system
2. To familiarize the students with architecture and assembly language programming in 8051 microcontroller
3. To design the interfacing of peripherals interfacing with the 8051 microcontroller
4. To introduce industry standard microcontroller and its application

SYLLABUS:

Module -1 **(8 Hours)**

8051 Architecture:

Harvard & Von Neumann architecture, RISC & CISC comparison and its features Role of microcontroller in embedded System. Limitation of 8 bit microcontrollers.

8051 Architecture, pin and signals, Register organization, memory organization (internal/external), addressing mode, instruction set, programming examples,

Module -2 **(8 Hours)**

8051 I/O port, Timer and counter and Interrupt:

8051 I/O port programming, 8051 Timers and Counters – Timer counter registers and modes, programming timers using different timer modes, 8051 interrupts, Programming timer interrupt, external hardware, serial communication interrupt, Interrupt priority and Interrupt programming.

Module -3 **(10 Hours)**

MSP430 Architecture:

Introduction –Where does the MSP430 fit, The outside view, The inside view-Functional block diagram, Memory, Central Processing Unit, Memory Mapped Input and Output, Clock Generator, Resets, MSP430 family. Addressing Modes, Instruction set.

Module 4 **(10 Hours)**

MSP430 Clock System, Interrupts and Operating Modes:

Clock System, Interrupts, What happens when an interrupted is requested, Interrupt Service Routines, Low Power Modes of Operation, Watchdog Timer, Basic Timer1, Real Time Clock, Timer-A: Timer Block, Capture/Compare Channels, Interrupts from Timer-A.

Module-5 **(8 Hours)**

MSP430 Analog and Digital Input-Output:

Comparator-A, ADC10, ADC12, Sigma-Delta ADC, Internal Operational Amplifiers, DAC, Parallel Ports, Lighting LEDs, Flashing LEDs, Read Input from a Switch, Toggle the LED state by pressing the push button, LCD interfacing.

COURSE OUTCOME:

After completion of the course, the student will be able to

1. Outline comprehensive knowledge about architecture and assembly language programming.
2. Examine the inbuilt resources of 8051 Microcontroller
3. Describe the architectural features and instruction set of MSP430.
4. Investigate the design aspect and development of interfacing I/O devices with MSP430 microcontroller.

TEXT BOOKS:

1. M. A. Mazidi, J. G. Mazidi, *The 8051 Microcontroller and Embedded Systems using assembly and C*, Second edition, Pearson education , 2006, Noida

2. John H. Davies, *MSP430 microcontroller basics*, 1st Edition**,** Newnes Publication , 2008, Oxford USA

REFERENCE BOOKS:

1. Ajay V. Deshmukh, *Microcontrollers [Theory and applications]*, Sixth edition, McGraw Hill publication, 2005, New Delhi.
2. Manuel Jimenez, Rogelio Palomera, Isidoro Couvertier, *Introduction to Embedded Systems: Using Microcontrollers and the MSP430*, Springer-Verlog Newyork, ISBN13: 978-1-4614-3143-5, 2014, New York.
3. Chris Nagy, *Embedded Systems Design using TI MSP430 Series*, Newnes Publications, 2003. Oxford USA
4. User Guide from Texas Instruments: MSP430x2xx Family User's Guide (Rev. J) - Texas Instruments [*https://www.ti.com › lit]*

DIGITAL LEARNING RESOURCES:

Course Name	Introduction to Embedded System Design
Course Link	https://nptel.ac.in/courses/108/102/108102169/
Course Instructor	Prof. Dhananjay V. Gadre, Prof. Badri Subudhi, Netaji Subhas University of Technology, IIT Jammu

Course Name	Microcontrollers and Applications
Course Link	https://nptel.ac.in/courses/117/104/117104072/
Course Instructor	Dr. S. P. Das, Electronics & Communication Engineering, IIT Kanpur

Subject Code: 19EC5PE03T	Subject Name: INFORMATION THEORY AND CODING TECHNIQUES	L-T-P: 3-0-0	Credit: 3

COURSE OBJECTIVES:

The object of this course is to introduce students to

1. Fundamental concepts in information theory used in data communications
2. The concept of data compression with various source encoding and decoding techniques.
3. Examine the error detection and correction capabilities of various channel coding techniques.
4. Design and construction of encoder and decoder circuits for various coding schemes.

SYLLABUS:

Module-1 **(8 Hours)**

Introduction to Information Theory:

Concept of information, Average information or Entropy, joint entropy and conditional entropy, Relative Entropy and Mutual Information, Relationship Between Entropy and Mutual Information, Chain Rules for Entropy, Relative Entropy and Mutual Information, Data-Processing Inequality, Sufficient Statistics, Fano's Inequality

Module-2 **(8 Hours)**

Data Compression and Source Coding:

Asymptotic Equipartition Property Theorem, Consequences of the AEP: Data Compression, Definition and types of codes, Kraft Inequality, Construction of Huffman Codes, Shannon-Fano-Elias codes.

Module-3 **(8 Hours)**

Channel Capacity: Definition, examples**,** Symmetric Channels and its capacity, Properties of Channel Capacity

Channel Coding: basic definition, Channel coding theorem, Information capacity theorem, Zero-Error Codes, Fano's Inequality and the Converse to the Coding Theorem, Equality in the Converse to the Channel Coding Theorem, Hamming Codes, Feedback Capacity.

Module-4 **(8 Hours)**

Linear Binary Block Codes:

Introduction, Generator and Parity-Check Matrices, Error Detection with Linear Block Codes, Hard-decision and Soft-decision Decoding of Linear Block Codes Repetition and Single-Parity-Check Codes, Binary Hamming Codes.

Cyclic Codes: Encoding and decoding architecture, BCH Code: Code construction, decoding, RS Codes.

Module-5 **(8 Hours)**

Convolutional Codes:

Introduction, algebraic description, Encoder Realizations and Classifications, generator and parity-check matrix, Minimal Encoders, Trellis representation, MLSD and the Viterbi Algorithm, Bit-wise MAP Decoding

COURSE OUTCOMES:

On Completion of this Subject/ Course the students should be able to:

1. Explain the quantitative measure of information in a data communication system mathematically.
2. Characterize channel capacities and properties using Shannon's Theorems.
3. Design various source coding and decoding techniques to achieve data compression.
4. Construct efficient error detecting codes for data on imperfect communication channels

TEXT BOOK:

1. Thomas Cover, Joy Thomas, *Elements of Information Theory*, 2nd Edition (Wiley student ed.), Wiley, 2010, New Delhi, India.
2. William Ryan, Shu Lin, *Channel Codes: Classical and Modern*, 1st edition, 2009, Cambridge University Press

REFERENCE BOOK:

1. Robert Gallager, *Information Theory and Reliable Communication*, 1st edition, Wiley, 2003, New York.
2. Bernard Sklar, *Digital Communications: Fundamentals and Applications*, 2nd Edition, Pearson Education, 2001, India

DIGITAL LEARNING RESOURCES:

Course Name	Analog Communication
Course Link	https://nptel.ac.in/courses/108/102/108102117/
Course Instructor	Prof. Ranjan Bose, Department of Electrical Engineering, IIT Delhi

Subject Code:	Subject Name:	L-T-P:	Credit:
19EC5PE04T	DIGITAL VLSI DESIGN	3-0-0	3

COURSE OBJECTIVES:

1. Understand the VLSI technology and its design concepts, VLSI chip fabrication step, design rule, layout techniques and learn basic CMOS structure and operation.
2. Learn the operation of MOS inverters static characteristics as well as switching characteristics and interconnect effects.
3. Demonstrate knowledge of combinational MOS logic circuits and design VLSI sequential logic circuits at the transistor level.
4. Learn the concepts of VLSI dynamiclogic circuits design techniques and VLSI testability, and system reliability.

SYLLABUS:

Module-1 **(10 Hours)**

Introduction:

IC technology an overview, Classification of IC technology, VLSI Design challenges, VLSI Design Flow, Design Hierarchy, Concept of Regularity, Modularity and Locality, VLSI Design Styles. Fabrication Processes Flow–Basic Concepts, the CMOS n-Well and p-well Process, Layout Design Rules, Stick Diagrams, Mask Layout Design.

MOS Transistor: The MOS System under External Bias, Structure and Operation of MOS Transistor (MOSFET), MOSFET Current-Voltage Characteristics, SPICE models for MOS transistor, MOSFET Scaling, MOSFET Capacitance.

Module-2 **(10 Hours)**

MOS Inverters – Static Characteristics:

Introduction, Resistive-Load Inverters, Enhancement-Load nMOS Inverter, Depletion-Load nMOS Inverter, CMOS Inverter.

MOS Inverters– Switching Characteristics and Interconnect Effects: Introduction, Delay-Time Definitions, Calculation of Delay-Times, Inverter Design with Delay Constraints, Switching Power Dissipation of CMOS Inverters.

Module-3 **(8 Hours)**

Combinational MOS Logic Circuits:

CMOS Logic Circuits, Complex Logic Circuits, Layout of Complex CMOS Logic Gates, AOI and OAI Gates, Pseudo-nMOS Gate, CMOS Full-Adder Circuit, CMOS Transmission Gates (Pass Gates), Complementary Pass-Transistor Logic (CPL), Power dissipation.

Sequential MOS Logic Circuits: Static and Dynamic Latches and Registers, Timing issues, pipelines, clock strategies, Clocked Latch and Flip-Flop Circuits and CMOS D-Latch.

Module-4 **(6 Hours)**

Dynamic Logic Circuits:

Introduction, Basic Principles of Pass Transistor Circuits, Voltage Bootstrapping, Synchronous Dynamic Circuit Techniques, Dynamic CMOS Circuit Techniques, High Performance Dynamic CMOS Circuits.

Module-5 **(8 Hours)**

Design for Testability:

Introduction to Digital Testing, Faults in digital circuits, Fault Simulation, Digital test pattern generation, Combinational Circuit Testing, Sequential Circuit Testing and Scan Chains Logic, Built-In Self-Test (BIST) Techniques, Current Monitoring IDDQ Test.

COURSE OUTCOME:

Students should able to

1. Analyse the performance of VLSI technology and its design concepts, VLSI chip fabrication step, design rule, layout techniques and learn basic CMOS structure and operation
2. Ability to acquire knowledge about theMOS inverters static characteristics as well as switching characteristics and interconnect effects.
3. Identify and describe the performance of combinational MOS logic circuits and design VLSI sequential logic circuits at the transistor level.
4. Evaluate the performance of various VLSI dynamic logic circuits and get the idea about VLSI testability, and system reliability.

TEXT BOOKS:

1. Sung-Mo Kang, Yusuf Leblebici and Chul Woo Kim, *CMOS Digital Integrated Circuits: Analysis and Design*, 4th Edition, Tata McGraw-Hill Publishing Company Limited, 2015. **(Some portions of modules 1, 2, 3, 4 and 5)**

2. Debaprasad Das, *VLSI Design*, 2nd Edition, Oxford University Press, 2015, New Delhi. **(Some portions of modules 1, 2, 3, 4 and 5)**

REFERENCE BOOKS:

1. Neil h. e. weste, David harris and Ayan Banerjee, *CMOS VLSI design a circuits and systems perspective*, 4th Edition, Pearson Education, 2015.
2. Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, *Digital Integrated Circuits – A Design Perspective*, 2nd Edition , PHI Learning, 2016, New Delhi..
3. Wayne Wolf, *Modern VLSI Design System on Chip Design*, 3rd Edition, PHI Learning Publisher, 2016, New Delhi.
4. John P. Uyemura, *CMOS Logic Circuit Design*, 1st Edition, Springer, 2007, US.

DIGITAL LEARNING RESOURCES:

Course Name	Digital VLSI Design
Course Link	https://nptel.ac.in/courses/108/103/108103108/
Course Instructor	Prof. Chandan Karfa | IIT Guwahati

Course Name	CMOS Digital VLSI Design
Course Link	https://nptel.ac.in/courses/108/107/108107129/
Course Instructor	Prof. Sudeb Dasgupta | IIT Roorkee

Subject Code:	Subject Name:	L-T-P:	Credit:
19EC5OE01T	VLSI DESIGN	3-0-0	3

COURSE OBJECTIVE:

1. To understand the concept of VLSI Design Methodology, Design Flow, fabrication steps of NMOS as well as CMOS process and MOSFET the static and switching behavior of MOS Inverter.
2. To understand the design and working of combinational and sequential MOS circuits.
3. To understand the concept of semiconductor memories.
4. To understand the concept of Layout of CMOS Digital Circuits, DRC, LVS and RCX

SYLLABUS:

Module-1 **(8 Hours)**

Introduction, Historical perspective, VLSI Design methodologies, VLSI Design Flow, Design Hierarchy, Design Styles, CAD Technology .(Text Book 1 ,Chapter 1(1.1,1.4,1.5,1.6,1.8,1.11))
Fabrication of MOSFETS, Fabrication processes, NMOS Fabrication, CMOS n-well process, Layout Design rules, Stick Diagrams, Full Custom Mask Layout Design.
MOS Transistor, Review of structure and operation of MOSFET (n-MOS enhancement type), CMOS, MOSFET V-I characteristics, MOSFET scaling and small geometry effects, MOSFET capacitances.

Module-2 **(10 Hours)**

MOS Inverters:

Basic NMOS inverters, characteristics, inverters with resistive load and with n-type MOSFET load, CMOS inverter and characteristics.

MOS inverters: Switching characteristics and interconnect effects: Delay time definitions and calculation, inverter design with delay constraints, estimation of parasitic switching power dissipation of CMOS inverters.

Module- 3 **(8 Hours)**

Combinational MOS logic circuits:

CMOS logic circuits, state style, complex logic circuits, pass transistor logic. (Text Book 1, **Chapter 7 (7.3, 7.4, 7.5))**

Sequential logic circuit – introduction, SR latch, clocked latch & flip-flop circuits, CMOS D latch and edge triggered flip-flop**.**

Module-4 **(6 Hours)**

Semiconductor Memories:

Introduction, Read Only Memory Circuits, Static Read-Write Memory (SRAM) Circuits, Dynamic Read-Write Memory (DRAM) Circuits.

Module-5 **(8 Hours)**

Layout concepts and examples of CMOS Inverter, 2-Input NAND Logic Gate, 2-Input NOR Logic Gate, 2:1 Multiplexer using Transmission Gate, D-Latch using Transmission Gate, Concept of DRC, LVS and RCX.

COURSE OUTCOME:

After completion of the course, the student will be able to

1. Analyze the characteristic of MOSFET, understand the fabrication steps, design CMOS inverters, calculate the dimension of MOSFETs for delay and inverter threshold voltage.
2. Design combinational and sequential circuits using CMOS technology and verify their functionalities.
3. Analyze the memory cells and verify its functionality
4. Analyze the layout and verification of CMOS integrated circuits.

TEXT BOOKS:

1. Sung-Mo Kang, Yusuf Leblebici and Chul Woo Kim, *CMOS Digital Integrated Circuits: Analysis and Design*, 4th Edition, Tata McGraw-Hill Publishing Company Limited, 2015. **(Some portions of modules 1, 2, 3, 4 and 5)**

2. Debaprasad Das, *VLSI Design*, 2nd Edition, Oxford University Press, 2015, New Delhi. **(Some portions of modules 1, 2, 3, 4 and 5)**

REFERENCE BOOKS:

1. Neil h. e. weste, David Harris and Ayan Banerjee, *CMOS VLSI design a circuits and systems perspective*, 4th Edition, Pearson Education, 2015.
2. Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, *Digital Integrated Circuits– A Design Perspective*, 2nd Edition, PHI Learning, 2016, New Delhi
3. Douglas A. Pucknell and K. Eshraghian, *Basic VLSI Design*, 3rd Edition, PHI Learning, 2009, New Delhi

DIGITAL LEARNING RESOURCES:

Course Name	CMOS Digital VLSI Design
Course Link	https://nptel.ac.in/courses/108/107/108107129/
Course Instructor	Prof. Sudeb Dasgupta | IIT Roorkee

Course Name	Digital VLSI Design
Course Link	https://nptel.ac.in/courses/108/103/108103108/
Course Instructor	Prof. Chandan Karfa | IIT Guwahati

Subject Code:	Subject Name:	L-T-P:	Credit:
19EC5OE02T	MICROPROCESSOR AND INTERFACING	3-0-0	3

COURSE OBJECTIVE:

1. Understand the main components and working principle of the Intel 8086 microprocessor and its programming
2. Understand the Memory organization, interfacing and the interrupt concept of 16-bit microprocessor
3. To make the interfacing of the I/O devices using programmable interfacing devices
4. To enable the students to understand the basic components and working principle of the Intel 32-bit processor 80386

SYLLABUS:

Module-1 **(10 Hours)**

8086 Microprocessor:

Introduction: Overview of Microcomputer organization.

Intel 8086 Microprocessor: Introduction, 8086 Programmer's model: Register organization, **Hardware Architecture**: Bus interface unit (BIU), Execution unit (EU), Pipelined operation, physical address generation and Memory segmentation.

8086 Pin description: Common, Minimum and maximum mode Pin and Signals, Bus cycle and System configuration.

Module-2 **(8 Hours)**

8086 Memory Interfacing and Interrupt technique:

8086 Memory Interfacing: External Memory addressing, EPROM and RAM interface with 8086.

8086 Interrupt: Interrupt Processing, sources of interrupt in 8086, Interrupt Instructions, Interrupt types, IVT, Hardware Interrupts and Interrupt priorities.

Module-3 **(8 Hours)**

8086 Instruction set and programming:

8086 Addressing modes, Instruction set: data transfer, arithmetic, bit manipulation, branch and processor control, assembler directives and programming

Module-4 **(10 Hours)**

Peripheral interfacing and its programming:

Introduction to basic I/O interface, I/O interfacing techniques in 8086.

Interfacing devices: 8255 PPI, 8254 Timer, 8251 USART, ADC-0808/0809, and DAC-0800 interfacing using PPI.

Module-5 **(8 Hours)**

32-bit Microprocessor 80386:

Salient features of 80386, Architecture and Signal Description of 80386. Register Organization of 80386, Hardware Memory organization 80386 Memory management: Real mode, Segment translation, protected mode, Memory paging mechanism and Virtual 8086 Mode

COURSE OUTCOME:

After completion of the course, the student will be able to

1. Gain deep knowledge on 8086 microprocessor architecture and pin and signals and demonstrate the memory interfacing and illustrate the use of interrupts.
2. Identify the addressing modes and illustrate the different classification and functions of 8086 microprocessor instructions and apply the knowledge in assembly language programming.
3. Illustrate the design aspect of I/O interface and Design and development of interfacing various I/O devices using programmable peripheral devices with the 8086 microprocessor.
4. Study and understand the architecture and memory management system of 80386 advanced microprocessors.

TEXT BOOKS:

1. A. K. Ray and K. M. Bhurchandi, **"***Advanced Microprocessors and Peripherals***",**3rd Edition, Tata McGraw Hill Education,2000, New Delhi.
2. Walter A Triebel and Avtar Singh, "*The 8088 and 8086 Microprocessors, Programming, Interfacing, Software, Hardware and Applications*", 4th edition, Pearson Education, 2014, Noida

REFERENCE BOOKS:

1. Barry B. Brey, *The Intel Microprocessors, Architecture, Programming and Interfacing*, 8th Edition, Pearson Education, 2009, Noida
2. Doughlas.V.Hall, *Microprocessor and Interfacing : Programming and Hardware*, 2nd Edition, McGraw Hill, 1992, Noida
3. Yu-chengliu and Glenn a. Gibson, *Microcomputer Systems: The 8086/8088 Family Architecture, Programming & Design*-, 2ndEdition, Prentice Hall of India, 2007, New Delhi

DIGITAL LEARNING RESOURCES:

Course Name	Microprocessors and interfacing
Course Link	https://nptel.ac.in/courses/108/103/108103157/
Course Instructor	Prof. Shaik Rafi Ahmed, Department of Electronics and Electrical Engineering, IIT Guwahati

Subject Code:	Subject Name:	L-T-P:	Credit:
19EC5OE03T	EMBEDDED SYSTEM DESIGN	3-0-0	3

COURSE OBJECTIVES:

1. To get the knowledge of the Embedded technology and its utility to the society.
2. Understanding the architecture and programming of embedded processor (ARM or FPGA) or microcontroller
3. Familiarization with the embedded computing platform design and analysis.
4. To acquire the knowledge in interfacing protocols and related Hardwires.

SYLLABUS:

Module-1 **(10 Hours)**

Introduction to Embedded Systems:

Hardware and Software Concepts: Embedded Systems, Application and characteristics of Embedded System, Overview of Processor and Hardware Units in Embedded System, Embedded Software into a system, Introduction to Embedded SystemDesign,Introduction to Embedded System Architecture.

System-on-Chip, NoC, Embedded Hardware Modeling and Design: System-on-chip (SoC),Network-on-chip (NoC), Levels of Hardware modeling, Embedded Hardware Design and Development.

Module-2 **(8 Hours)**

8051, AVR ATmega and ARM Microcontrollers:

Microcontrollers, AVR Microcontrollers, ARM processor –based system Design

Sensors, A/D–D/A Converters, Actuators and Interfacing:

Sensors, A/D–D/A Converters, Actuators, interfacing Techniques, Network Embedded System, Internet-Enable Systems-Network Protocols, Wireless and Mobile System Protocols

Module- 3 **(8 Hours)**

Real-Time Operating System (RTOS) and Real-Time task scheduling:

RTOS: concepts, types of Real time Task and their characteristics, task scheduling, Feature of RTOS, device driver, interrupts and Service mechanism

Module – 4 **(8 Hours)**

IoT System- System Architecture and Design:

IoT, Internet connectivity and IoT connectivity, Edge computing Architecture and Application, IoT communication module Protocols, Rapid prototype designing using open source Boards.

Module – 5 **(8 Hours)**

EMBEDDED AI- System Architecture and Design:

Artificial Intelligence Embedded AI hardware and Software Development, Embedded AI Application

COURSE OUTCOME:

After completion of the course, the student will be able to

1. Design an embedded system application
2. Implement the peripheral interfacing.
3. Use system design techniques to develop firmware
4. Develop embedded system solution to automation and IoTs Application.

TEXT BOOKS:

1. K. V. SHIBU, *Introduction to Embedded Systems*, McGraw Hill Publication Company Limited, 2009, New Delhi.

REFERENCE TEXT BOOKS:

1. Raj Kamal, *Title Embedded Systems*, 4th Edition, McGraw Hill Publication Company Limited, 2020, New Delhi.

2. David E. Simon, Addition Wesley, *An Embedded Software Primer*, Wiley, 1999, New Delhi.

3. K. Short, *Embedded Microprocessor Systems Design: An Introduction Using the Intel 80C188EB*, Prentice Hall,1998, ISBN-10 : 0132494671,ISBN-13 : 978-0132494670.

DIGITAL LEARNING RESOURCES:

Course Name	Embedded System Design
Course Link	https://nptel.ac.in/courses/106/105/106105159/
Course Instructor	Prof. Anupam Basu, Department of Computer Science and Engineering, IIT Kharagpur

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Subject Code:	Subject Name:	L-T-P:	Credit:
19EC5OE04T	RADAR SYSTEM ENGINEERING	3-0-0	3

COURSE OBJECTIVE:

1. To learn the basics of the RADAR fundamentals and familiarization with various components of Transmitter and receiver.
2. To understand the concept of radar signal and its processing techniques under ambiguity conditions.
3. To learn about different types of RADARs and their operational principles.
4. To understand basic detection theory and tracking principles of a Radar systems.

SYLLABUS:

Module-1 **(10 Hours)**

Introduction to Radar:

Basic radar, maximum unambiguous range, building blocks of radar, simple form of radar equation, Block diagram of Radar transmitter, Radar frequencies, Applications to radar and related Problems.

Radar Equation : Prediction of Range Performance, Minimum Detectable Signal, Receiver Noise and SNR, Integration of Radar Pulses, Radar Cross Section of Targets (simple targets - sphere, cone-sphere), Transmitter Power, PRF and Range Ambiguities, System Losses (qualitative treatment). Related Problems.

Module-2 **(8 Hours)**

CW and Frequency Modulated Radar:

Doppler Effect, CW Radar – Block Diagram, Isolation between Transmitter and Receiver, Non-zero IF Receiver, Receiver Bandwidth Requirements, Applications of CW radar.

FM-CW Radar:

Range and Doppler Measurement, Block Diagram and Characteristics (Approaching/ Receding Targets), FM-CW altimeter, Measurement Errors, Multiple Frequency CW Radar.

Module-3 **(10 Hours)**

MTI and Pulse Doppler Radar:

Introduction, Principle, MTI Radar with - Power Amplifier Transmitter and Power Oscillator Transmitter, Delay Line Cancellers – Filter Characteristics, Blind Speeds, Double Cancellation, Staggered PRFs. Range Gated Doppler Filters. MTI Radar Parameters, Limitations to MTI Performance. Non-coherent MTI, MTI versus Pulse Doppler Radar.

Module-4 **(8 Hours)**

Tracking Radar:

Tracking with Radar- Types of Tracking Radar Systems, Monopulse Tracking- Amplitude Comparison Monopulse (one-and two-coordinates), Phase Comparison Monopulse. Sequential Lobing, Conical Scan Tracking, Block Diagram of Conical Scan Tracking Radar, Tracking in Range, Comparison of Trackers.

Module-5 **(6 Hours)**

Radar Receiver:

Block Diagram of Radar Receiver & Radar Displays- A-scope and PPI.

Modern Radars:

Height Finding Radars, Synthetic Aperture Radar, Air borne Radar, Secondary surveillance Radar

COURSE OUTCOME:

After completion of the course, the student will be able to

1. Demonstrate the understanding of radar fundamentals and various factors affecting the detection process.

2. Differentiate between various types of radar based on their working principles and field of application.
3. Familiarize with different displays and their applications on real time basis.
4. Analyze radar signals and various building blocks affecting it and also the detection process by applying different target centric tracking principles.

TEXT BOOK:

1. Merrill I. Skolnik, *Introduction to Radar Systems*, Third Edition, Tata McGraw-Hill, 2001, New Delhi.

REFERENCE BOOKS:

1. Byron Edde, *Radar Principles, Technology, Applications*, First Edition, Pearson Education, 2007, New Delhi.
2. Nathanson, *Radar Design Principles,* Second Edition, Mc-Graw Hill, 1991, New York.
3. Peyton Z. Peebles, *Radar Principles*, First Edition, Wiley, 1998, New York.
4. Mark A. Richards, James A. Scheer, William A. Holm. Yesdee, *Principles of Modern Radar: Basic Principles*, First Edition, Scitech Publishing, 2013, Raleigh, North California

DIGITAL LEARNING RESOURCES:

Course Name	Radar System Engineering
Course Link	https://nptel.ac.in/courses/108/105/108105154/
Course Instructor	Prof. Amitabha Battacharya, Department of Electronics and Electrical Communication Engineering, IIT Kharagpur

Subject Code:	Subject Name:	L-T-P:	Credit:
19EC5PC01L	DIGITAL SIGNAL PROCESSING LAB	0-0-2	1

COURSE OBJECTIVE:

The object of this course is to introduce students to

1. Learn the software simulation tool like MATLAB for digital signal processing.
2. Familiarize about the architecture of DSP Processor (TMS 320C6748) and its applications.
3. Implementation of FIR and IIR filters using both hardware and software.
4. Practical implementation of various signal processing applications using Multi-rate Signal Processing and Adaptive filter theory.

LIST OF EXPERIMENTS

(AT LEAST 10 EXPERIMENTS SHOULD BE DONE)

1. Familiarization with the architecture of a standard DSP kit (Preferably TMS 320C6XXX DSP kit of Texas Instruments)
2. To find DFT / IDFT of given DT signal using MATLAB and DSK 6748 KIT.
3. Program to obtain Linear Convolution of Long duration sequences using Overlap Add and Overlap Save using MATLAB.
4. Implementation of FFT of given sequence using MATLAB.
5. Generation of Real time SIN, COS AND RAMP signals using DSK 6748 KIT.
6. Implementation of Low Pass FIR filters using different window for a given sequence using MATLAB and DSK 6748 KIT.
7. Implementation of High Pass FIR filters using different window for a given sequence using MATLAB and DSK 6748 KIT.
8. Implementation of Low Pass IIR filters for a given sequence using MATLAB and DSK 6748 KIT.

9. Implementation of High Pass IIR filters for a given sequence using MATLAB and DSK 6748 KIT.
10. Implementation of Decimation Process using MATLAB and DSK 6748 KIT.
11. Implementation of Interpolation Process using MATLAB and DSK 6748 KIT.
12. To Implement and analyze the sampling and reconstruction principle and the effect of sampling on the frequency-domain using MATLAB.
13. Implementation of LMS algorithm using MATLAB.
14. Design and implementation of Adaptive noise cancellation.
15. Design and implementation of adaptive channel equalization.

COURSE OUTCOME

On Completion of this Subject/ Course the students should be able to:

1. Implements various signal processing applications using MATLAB (Signal Processing tool box).
2. Apply discrete-time transform techniques to analyze the discrete time signals and systems.
3. Design and analyze digital filters for processing of discrete time signals.
4. Employ digital signal processing techniques for multidisciplinary applications (such as System Identification, Adaptive Channel Equalization, Adaptive Line Enhancer, and Adaptive Noise Cancelation).

Subject Code: 19EC5PC02L	Subject Name: CONTROL SYSTEM ENGINEERING LAB	L-T-P: 0-0-2	Credit: 1

COURSE OBJECTIVES:

By performing the experiments the students will able to

1. Learn time response analysis and determine the time domain specifications.
2. Realize the necessity of PID Controller in various control systems
3. Understand compensators and its effect on stability of the given system
4. Determine the time response and stability analysis with MATLAB

SYLLABUS

Select any 6 experiments from Control, 2 experiments form instrumentation and 2 from MATLAB from the list of 12 experiments

CONTROL:

1. Study of a dc motor driven position control system
2. Study of speed torque characteristics of two phase ac servomotor and determination of its transfer function
3. Obtain the frequency response of a lag and lead compensator
4. To observe the time response of a second order process with P, PI and PID control and apply PID control to servomotor
5. To determine the transfer function of a system (network) using transfer function analyser.
6. To study the position control system using Synchros
7. To study and validate the controllers for a temperature control system

INSTRUMENTATION:

1. To plot the displacement-voltage characteristics of the given LVDT
2. Measurement of temperature-voltage characteristics of J-type thermocouple

3. Use a strain gauge to plot the curve between strain applied to a beam and the output voltage
4. Study of resistance-voltage characteristics of Thermistors

MATLAB

1. Determine the time response of given system using MATLAB
2. Determine the stability of a 2^{nd} order system by Routh Hurwitz Criterion using MATLAB
3. Determine the stability of a given system by Bode-plot using MATLAB.
4. Determine the stability of a given system by Nyquist-plot using MATLAB.

COURSE OUTCOMES:

At the end of this course, students will demonstrate the ability to

1. Determine the time domain specifications of the given system
2. Understand the importance of PID technique for a control system.
3. Design the Lead, Lag compensator for the given system.
4. Design the time response and stability analysis using MATLAB.

Subject Code: 19EC5PC03L	Subject Name: ANALOG COMMUNICATION TECHNIQUES LAB	L-T-P: 0-0-2	Credit: 1

COURSE OBJECTIVES:

The object of this course is to introduce students to

1. Realization of the generation and reception of amplitude or angle modulated signals
2. Understand the use of sampling process in analog pulse modulation techniques
3. Use the basic capabilities of MATLAB and Simulink for modeling and simulation of analog communication systems.
4. Design and construction of modulators and demodulators circuits for analog modulation techniques.

LIST OF EXPERIMENTS

1. Design and analysis of Amplitude modulation and demodulation technique.
2. Generation and reception of DSB-SC signal and analyze its various parameters.
3. Generation and reception of SSB AM signal and analyze its various parameters.
4. Design, analysis and comparison of NBFM and WBFM.
5. Spectrum analysis of various modulated signal with spectrum analyzer.
6. Implement and analyze Frequency division multiplexing and demultiplexing.
7. Verify Sampling theorem by performing sampling and reconstruction of signals.
8. Examine the process of pulse modulation in PAM, PPM and PWM signals.
9. Analyze the process of quantization and encoding in PCM.
10. Design and analysis of Pre-emphasis and De-emphasis circuits if FM system to increase SNR.

Along with the above experiments which are going to be conducted with experimental kits, the following should also be performed by the students (in/out of the Lab)

* *Using MATLAB simulate modulation and demodulation techniques mentioned in Ex-1, Ex-2, Ex-3, Ex-4, Ex-8, and Ex-9. Verify the process of modulation and demodulation and analyze frequency spectrum of the signal after modulation and demodulation*

* *Circuit design of (i) AM modulator(Transistor based Modulator and Bridge modulator for DSB-C and DSB-SC) (ii) FM receiver*

COURSE OUTCOMES:

On Completion of this Subject/ Course the students should be able to:

1. Design and analyze modulator and demodulator circuits for different analog modulation techniques.
2. Demonstrate transmission of analog signals through pulse modulation techniques.
3. Implement sampling and multiplexing of analog signal.
4. Design and analyze of various analog modulation techniques using computer skills (MATLAB).

Open Elective Courses for ECE Students offered by other Branches

Open Elective-1

Subject Code: 19IT5OE01T	Subject Name: JAVA PROGRAMMING	L-T-P: 3-0-0	Credit: 3

Course Objective:

1. Learn the syntax, semantics and idioms of the Java programming language.
2. Gain confidence in object oriented programming principles through lots of practical exercises that provide useful exposure to the core Java class libraries.

Module– 1 **[8 Hrs]**

Introduction to Java and Java programming Environment. Object Oriented Programming Concepts: Encapsulation, Abstraction, Inheritance ,Polymorphism.

Fundamental Programming Structure: Data Types, variable, keywords, typecasting, Arrays, Operators and their precedence.

Control Flow: Java's Control Statements (if, switch, iteration, statement, while, do-while, for, Nested loop). Concept of Objects and Classes, Using Existing Classes building your own classes, constructor overloading, static , final, this keyword.

Module – 2 **[8 Hrs]**

Inheritance: Introduction, types of inheritance. Use of super keyword. Method overriding, Dynamic method Dispatch, Using Abstract Classes, Using final with inheritance. The Object Class.

Packages & Interfaces: Packages, Access Protection, Importing package, Interface, Implementing Interfaces, variables in Interfaces, Interfaces can be extended.

Module –3 **[8 Hrs]**

Exception Handling: Fundamentals, Types Checked , Unchecked exceptions, Using try & catch, Multiple catch, throw , throws, finally, Java's Built in exceptions, user defined exception.

String Handling: String constructors, String length, Character Extraction, String Comparison, Modifying a string.

Module 4 **[6 Hrs]**

Java I/O: Classes & Interfaces, Stream classes, Byte streams, Character streams, Serialization.
Multi-Threading: Java Thread Life Cycle, Thread Priorities, Synchronization, Creating a thread, Runnable interface, Creating Multiple threads, Using isAlive () and join (), wait () & notiCS().

Module-5 **[10 Hrs]**

Wrapper Classes: Wrapper classes and its methods.
Collection Framework: Introduction, interfaces, List, Set, Map etc, List interfaces and its classes.
Event Handing: Event Delegation Model, Event Classes, Event Listener Interfaces, Adapter classes.
AWT: AWT Classes window fundamentals, component, container, panel, Window, Frame, working with Graphics , Control Fundamentals , Layout managers, Handling Events by Extending AWT components.

Course Outcome:

1. Implement and apply various Object Oriented programming concepts.
2. Applying Collection Classes and Files, Multiple Threads, & handle Exceptions in developing a java applications.
3. Developing a Java standalone application having front end design and back end.

Text Books:

1. Java: One Step Ahead by Anita Seth (Author), B.L. Juneja (Author) Oxford University Press.
2. Head First Java 2nd edition Kathy Sierra & Bert Bates
3. JAVA Complete Reference (9th Edition) Herbert Schildt.

Reference Books:

1. https://www.udemy.com/java-the-complete-java-developer-course/
2. Java Programming Masterclass for Software Developers Created by Tim Buchalka, Tim Buchalka's Learn Programming Academy, Goran Lochert

Digital Learning Resources

Course Name	Foundation Engineering
Course Link	https://nptel.ac.in/courses/105/105/105105176/
Course Instructor	Prof. Koushik Deb, Department of Civil Engineering, IIT Kharagpur

Subject Code: 19CS5OE01T	Subject Name: INTRODUCTION TO PYTHON PROGRAMMING	L-T-P: 3-0-0	Credit: 3

Course Objective:

1. Identify/characterize/define a problem.
2. Design a program to solve the problem.
3. Create executable code.
4. Read most Python code and write basic unit tests.

Module–1: [10 Hrs]

Features and History of python, Literal constants, variables and identifiers, data types, Input operations, comments, reserve words, indentation, operators and expressions, operations on strings, other data types, conditional branching statements, loop structures, break, continue, pass, else. Functions in python.

Module–2: [10 Hrs]

Concatenating, appending and multyplying strings, string formatting operator, built in string methods and functions, slice operation, ord() and chr(), in and not in operations, comparing strings, iterating strings, string module, match(), search() and sub(), findall() and finditer().

Data structures: sequence, lists, functional programming, tuple, sets, dictionaries,

Module–3: [10 Hrs]

Classes and objects: class methods and self arguements, the _init_(), class variable and object variable, _del_(),public and private data members, calling a class method from another class method, builtin funcitons to set,get and delete class attributes

Inheritance, types, composition or containership, abstract classes or interfaces

Operator overloading: implementing Operator overloading, reverse adding, overriding _getitem_() and _setitem_() methods, overriding the in operator, overloading the misc functions

Module–4: [10 Hrs]

Error and exception handling: handling exceptions, multiple exception blocks, multiple exceptions in a single block, except block without exception, else clause, raising exception, instantiating exceptions, handling exceptions in invoked functions, builtin and user defined exceptions, the finally block, predefined cleanup action.

Course Outcome:

1. To understand why Python is a useful scripting language for developers.
2. To learn how to design and program Python applications.
3. To learn how to use lists, tuples, and dictionaries in Python programs.
4. To learn how to identify Python object types.

Text Books

1: Python programming, Reema Thareja, Oxford publications

2: learning python , Mark lutz, oreilly

Reference Books:

3: Statistics and Machine Learning in Python Release 0.1, Edouard Duchesnay, Tommy Löfstedt

4: Python data Analytics , Fabio Nelli, Apress.

Digital Learning Resources

Course Name	Programming Data Structures and Algorithm in Python
Course Link	https://nptel.ac.in/courses/106/106/106106145/
Course Instructor	Prof. Madhavan Mukund, Chennai Mathematical Institute

Subject Code: 19EE5OE04T	Subject Name: INTRODUCTION TO ELECTRICAL PROPERTIES OF MATERIALS	L-T-P: 3-0-0	Credit: 3

COURSE OBJECTIVES:

1. To understand the conducting properties of metal.
2. To give knowledge about semiconductor materials.
3. To give knowledge about the insulating materials and their applications.
4. To acquire the knowledge about the dielectric materials.
5. To have knowledge about magnetic materials.
6. To have knowledge about special purpose materials.

SYLLABUS

Module-1 **(8 Hours)**

Conductivity of Metal: Introduction, factors affecting the resistivity of electrical materials, motion of an electron in an electric field, Equation of motion of an electron, current carried by electrons, mobility, energy levels of a molecule, emission of electrons from metals, thermionic emission, photo electric emission, field emission.

Module-2 **(6 Hours)**

Dielectric Properties: Introduction, effect of a dielectric on the behaviour of a capacitor, polarization, the dielectric constant of monatomic gases, frequency dependence of permittivity.

Module-3 **(9 Hours)**

Dielectric losses, significance of the loss tangent, dipolar relaxation, frequency and temperature dependence of the dielectric constant. Dielectric properties of polymeric system, ionic conductivity in insulators, insulating materials, Ferro-electricity, piezoelectricity.

Module-4 **(8 Hours)**

Magnetic properties of Materials: Introduction, Classification of magnetic materials, diamagnetism, para-magnetism, ferromagnetism, magnetization curve, the hysteresis loop, factors affecting permeability and hysteresis loss, common magnetic materials, magnetic resonance. Superconductivity and its origin, Zero resistance and Meissner Effect, critical current density.

Module-5 **(8 Hours)**

Semiconductors: energy band in solids, conductors, semiconductors and insulators, types of semiconductors, Intrinsic semiconductors, impurity type semiconductor, diffusion, the Einstein relation, hall effect, thermal conductivity of semiconductors, electrical conductivity of doped materials.

COURSE OUTCOMES:

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

1. Understand the various kinds of materials and their applications in ac and dc fields.
2. Understand the conductivity of superconductivity of materials.
3. Explain the electrical properties of different materials and metallic behavior of materials on the basis of band theory.
4. Explain the properties and applications of all kind of magnetic materials.
5. Explain the properties of electrical conducting and insulating materials.
6. Assess a variety of approaches in developing new materials with enhanced performance to replace existing materials.

TEXT BOOKS:

1. C. S. Indulkar and S. Thiruvengadam, S., "An Introduction to Electrical Engineering
2. Kenneth G. Budinski, "Engineering Materials: Prentice Hall of India, New Delhi
3. ELECTRICAL PROPERTIES OF MATERIALS, 9th Edition (L. Solymer, Donald Walsh,R. R .A. Syms)

4. Electrical and Electronic Engineering Materials by SK Bhattacharya, Khanna Publishers, New Delhi.

REFERENCE BOOKS:

1. Electrical Engineering Materials Adrianus J Dekker, Phi Learning Publishers.
2. Introduction to Electrical Engineering Materials 4th Edn. 2004 Edition by Indulkar C, S. Chand & Company Ltd-New Delhi.

DIGITAL LEARNING RESOURCES:

Course Name	Processing of Semiconducting Materials
Course Link	http://nptel.ac.in
Course Instructor	Dr. Pallab Banerji,Department of Metallurgy and Material Science,IIT Kharagpur.

Subject Code: 19EE5OE01T	Subject Name: RENEWABLE ENERGY SYSTEMS	L-T-P: 3-0-0	Credits: 3

COURSE OBJECTIVE:

The program is expected to enable the students to

1. Design and develop innovative products and services in the field of Renewable Energy.
2. Keeps abreast with the latest technology and toolset.
3. Communicate effectively to propagate ideas and promote teamwork
4. Attain intellectual leadership skills to cater to the changing needs of power industry, academia, society and environment

SYLLABUS

Module- 1 **(4 Hours)**

Introduction: Causes of Energy Scarcity, Solution to Energy Scarcity, Factors Affecting Energy Resource Development, Energy Resources and Classification, Renewable Energy – Worldwide Renewable Energy Availability, Renewable Energy in India.

Quality of Energy: Measure of Quality of energy, Identification of potential energy resources in terms of their quality. Dependency of Efficiency of energy conversion on Quality of energy. Cogeneration, Dispersed or Distributed generation.

Module- 2 **(8Hours)**

Energy from Sun: Sun- earth Geometric Relationship, Solar radiation geometry, Layer of the Sun, Earth – Sun Angles and their Relationships, Solar Energy Reaching the Earth's Surface, Sunpath diagram and evaluation of insolation quality at a location using Sunpath, Solar Thermal Energy Applications.

Solar Thermal Energy Collectors: Types of Solar Collectors, Configurations of Certain Practical Solar Thermal Collectors, Material Aspects of Solar Collectors, Concentrating

Collectors, Parabolic Dish – Stirling Engine System, Working of Stirling or Brayton Heat Engine, Solar Collector Systems into Building Services, Solar Water Heating Systems, Passive Solar Water Heating Systems, Applications of Solar Water Heating Systems, Active Solar Space Cooling, Solar Air Heating, Solar Dryers, Crop Drying, Space Cooing, Solar Cookers, Solar pond.

Module-3 **(7Hours)**

Solar Photovoltaic Cells: Components of Solar Cell System, Elements of Silicon Solar Cell, Equivalent Circuit of a PV Cell, Impact of parameters of PV cell performance, Solar Cell materials, Practical Solar Cells, I – V Characteristics of Solar Cells, Maximum Power Point Tracking (MPPT), MPPT algorithms: P&O, Incremental Conductance, Efficiency of Solar Cells, Photovoltaic Panels, Shading & Mitigation techniques, Applications of Solar Cell Systems.

Module- 4 **(10Hours)**

Wind Energy Conversion System (WECs): Energy content in wind, extractible content of energy through WECs. Types of wind turbines with respect to axis of rotation (Horizontal & vertical axis wind turbine), working principle (lift and drag type) etc.

Airfoil terminology - Blade element theory - Blade design - Rotor performance and dynamics- Balancing technique (Rotor &Blade), significant parameters determining efficiency of WECs, Pitch angle, No of blades, solidity, Tip Speed ratio.

Constant speed Constant frequency - Variable speed variable frequency - Up wind-Down wind - Stall control-Pitch control - Gear coupled generator type - Direct generator drive/PMG/Rotor excited sync generator.

Module-5 **(10Hours)**

Integrated Energy Systems: System Aspects of Integration: voltage effects, thermal effects, fault level. Islanding. Stand Alone Systems: Network voltage and system efficiency, Case studies of standalone system. Hybrid Energy Systems and its economic evaluation. Technological aspects of power electronic systems connection to the grid. Hybrid and

integrated energy systems, Total energy concept and waste heat utilization, Energy modeling to optimize different systems.

COURSE OUTCOMES:

1. Appraise the need and possibility of extracting solar energy and converting into electrical energy using PV cell.
2. Design and analyze stand-alone and grid connected PV system.
3. Describe the dynamics of wind turbine and electrical generator.
4. Select and design suitable configuration of the wind energy conversion system based on application.
5. Suggest, design and analyze hybrid energy systems.

TEXT BOOKS:

1. Non-conventional Energy Sources by G.D. Rai (Author), Khanna Publishers.
2. Renewable Energy, by Boyle, Godfrey. Oxford University Press.
3. Renewable Energy Systems – Design and Analysis with Induction Generators, by M.GodoySimoes, Felix A.Farret, CRC press.
4. Micro-grid: A Conceptual Solution, Robert Lasseter, Paolo Piagi, PESC 2004, June 2004.

REFERENCE BOOKS:

1. Renewable Energy Resources by John Twidell and Tony Weir, Taylor Francis Group.
2. Renewable Energy Sources for fuels and Electricity by Laurie Barrtom, Island Press.

DIGITAL LEARNING RESOURCES:

Course Name	Solar, Wind and Biomass Energy Systems
Course Link	https://nptel.ac.in/courses/103/103/103103206/
Course Instructor	Prof. R. Anandalakshmi Prof. Vaibhav Vasant Goud, Department of Chemical Engineering, IIT

	Guwahati
Course Name	Solar & Wind Energy
Course Link	https://nptel.ac.in/courses/103/107/103107157/
Course Instructor	Prof. P. Mondal, Department of Chemical Engineering, IIT Roorkee
Course Name	Energy Resources
Course Link	https://www.youtube.com/watch?v=cZSYukWvpsE
Course Instructor	Prof. Rangan Benarjee, Department of Energy Science & Technology, IIT Bombay
Course Name	Design of Photovoltaic system
Course Link	https://www.youtube.com/watch?v=hr2sId412zU&list=PLuv3GM6-gsE2KyXoBTQ6lbrwn22Z3SiVm&index=2
Course Instructor	Prof. L. Umanand, Department of Electronic System Engineering, IISC Bangalore

Course Code:	Course Name:	L-T-P:	Credit:
19ME5OE03T	MICRO ELECTRO-MECHANICAL SYSTEMS [MEMS]	3- 0- 0	3

Course Objectives:

1. Learning fundamental concepts for design of micro-electromechanical devices (MEMS), including mechanical and thermal behavior of materials and structures, transduction principles, transducer design, and modeling.
2. Learn about the current and future trends of MEMS in the industry. Types of MEMS devices, their application areas.
3. Acquire comprehensive knowledge of microfluidic devices.
4. Learn different techniques for fabrication of MEMS devices, materials used and their properties.
5. Learn analytical/mathematical modeling of a MEMS device. Gain knowledge on capabilities of different tools used in the industry.

Module-1 **[7 hours]**

Introduction to MEMS

History of micro system technology, overview of commercial MEMS products, future trends, Case study, Micro-fabrication basics and materials used. Miniaturization : Moore's law, Effects of scaling: on mechanical strength, heat transfer, vibrational and magnetic characteristics. Benefits and limitations of the materials and miniaturization.

Module-2 **[8 hours]**

MEMS types, application areas

Mechanical Transducer: Inertial Sensors (Accelerometer, Gyroscope), Pressure Sensors, Flow Sensors, Force Sensors (SPM), Magnetic Transducers: Magnetic Field Sensors, Magnetic Actuators, Proximity sensor; Chemical/Biological Transducers : Gas sensor, Thermal Transducers: Thermometers, IR Sensors; Applications of MEMS: smart homes, electrical

systems, material transport, condition monitoring, biomedical prosthesis. Packaging of MEMS devices : Standard Packages, Packaging Concepts, Packaging Examples

Module-3 **[7 hours]**

Microfluidics:

Fundamentals of fluid mechanics, Basic components of a micro-fluidic system, Micro flows, Micro pumps, Capillarity and Surface Tension, Micro pumping methods, Micro dispensers, Micro nozzles

Module-4 **[7 hours]**

Materials and Fabrication techniques of MEMS

Properties of materials used in MEMS fabrication : silicon, polymers, metals, ceramics. Their structure and properties. Structure of silicon and other materials (polymers), Silicon wafer processing, Bulk micro machining and Surface micro machining, Wafer-bonding. Thin-film deposition, Lithography, wet etching and dry etching.

Module-5 **[9 hours]**

Modeling of MEMS structures

System modeling of MEMS : Analytical vs Numerical Modeling, Lumped Element modeling, Finite element modeling; MEMS simulation packages : MEMS pro, MEMS+, SUGAR, Coventor, SoftMEMS, COMSOL etc. Demonstration of MEMS pro-Ansys integration

Course Outcomes:

1. Understand the operation of micro devices, micro systems and their applications.
2. Select whether the particular situation requires the use of a MEMS device. If required, select an appropriate device.
3. Analyze a chemical/biological system to select the right microfluidic device.
4. Apply knowledge of physical, chemical and biological principles to engineer MEMS devices using different materials and techniques. Select appropriate MEMS fabrication techniques for a particular design and application.

5. Apply knowledge of MEMS analysis to evaluate suitability of MEMS designs for particular applications. Select a suitable tool for a

Text Books:

1. Smart Material Systems and MEMS:Design and Development Methodologies, Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, Wiley, 2006
2. Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture" Tata McGraw Hill, New Delhi, 2002

Reference Books:

1. MEMS Sensors, Design and Application, Siva Yellampalli, IntechOpen, 2018
2. MEMS : Design and Fabrication, Mohamed Gad-el-Hak, CRC Press, 2005
3. Microsystem Design, Stephen D. Senturia, Springer US, 2001

Open Elective-2

Subject Code:	Subject Name:	L-T-P:	Credit:
19IT5OE02T	COMPUTER NETWORKS	3-0-0	3

Course Objective:

1. Understand the concepts of data communication, layered model, wireless devices in computer networks.
2. Explain the various techniques used to access a shared channel in the network and IEEE specifications for LANs.
3. List types of networking devices, backbone networks and Internet Protocol (IP) addressing.
4. Explain the responsibilities of network, transport and application layers.

Module – 1 **[12 Hrs]**

Overview of Data Communication Networks, Protocols and standards, OSI Reference model, TCP/IP Protocol.

Physical Layer: Analog Signals, Digital Signals, Data Rate Limits, Transmission Impairment, Data rate limit, Digital Transmission: Digital-to-Digital conversion, Analog-to-Digital conversion, Transmission modes, Analog Transmission: Digital-to-Analog conversion, Analog-to-Analog conversion, Multiplexing: Frequency Division Multiplexing (FDM), Wave Division Multiplexing (WDM), Time Division Multiplexing (TDM), Transmission Media: Guided Media (Twisted-Pair Cable, Coaxial Cable and Fiber-Optic Cable) and unguided media (wireless), Switching: Circuit Switched Network, Datagram Network, Virtual-Circuit Network.

Module – 2 **[12 Hrs]**

Error Detection and correction: Types of Errors, Error Detection mechanism (Linear codes, CRC, Checksum), Error Correction mechanism: Hamming Encoding. Data Link Control and Protocols: Flow and Error Control, Stop-and-Wait ARQ. Go-Back-N ARQ, Selective Repeat ARQ, HDLC and Point-to-Point Protocol Multiple Access: Random Access (ALOHA, CSMA, CSMA/CD, CSMA/CA), Controlled Access (Polling, Reservation, Token Passing).

Module – 3 **[6 Hrs]**

Wireless LANs: IEEE 802.11 and Bluetooth.

Connecting Devices: Passive Hub, Repeater, Active Hub, Bridge, Two layers Switch, Router, Three layers Switch, Gateway.

Virtual Circuit Networks: Frame Relay, Architecture & layers, ATM: Design goals, Architecture & layers.

Module – 4 **[6 Hrs]**

Network Layer: IPV4 addresses, IPV6 addresses, Internet Protocol: Internetworking, IPV4 datagram, IPV6 packet format and advantages. Network Layer Protocols: ARP, RARP, IGMP and ICMP. Routing: Unicast Routing Protocols and Multicast Routing Protocols.

Transport Layer: Process to Process Delivery, User Datagram Protocol (UDP) and Transmission Control Protocol (TCP).

Module – 5 **[6 Hrs]**

Domain Name System (DNS): Name Space, Domain Name Space, DNS in Internet, Resolution and Dynamic Domain Name System (DDNS), Remote logging, Electronic Mail (SMTP) and file transfer (FTP), WWW: Architecture & Web document.

Course Outcome:

1. Explain computer network reference models, networking devices and different transmission techniques.
2. Reason the need for flow and error control at the data link layer and explain the associated protocols; enumerate the shared channel access methods, associated protocols and Wired LAN standards and implementations.
3. Explain how network layer, transport layer and application layer facilitates the transfer of message from one node to another in a global network.

Text Books:

1. Data Communications and Networking, Behrouz A. Forouzan, Tata McGraw-Hill, 5th Edition(2013).
2. Computer Networks, A. S. Tannenbum, D. Wetherall, Pearson Education, 5th Edition(2014).
3. Data and Computer Communications, William Stallings, Pearson Education, 10th Edition(2018).

Reference Books:

1. Computer Networking, A Top-Down Approach, James F. Kurose, Keith W. Ross, Pearson publication, 6th Edition(2017).
2. http://www.nptelvideos.in/2012/11/computer-networks.html, Prof. Sujoy Ghosh, IIT, Kharagpur.
3. https://nptel.ac.in/courses/106105183/, Prof. SoumyaKantiGhosh, IIT, Kharagpur.
4. https://www.classcentral.com/course/stanford-openedx-introduction-to-computer-networking-1578, Prof. Philip Levis and Professor Nick McKeown, Stanford University.

Digital Learning Resources

Course Name	Foundation Engineering
Course Link	https://nptel.ac.in/courses/105/105/105105176/
Course Instructor	Prof. Koushik Deb, Department of Civil Engineering, IIT Kharagpur

Subject Code:	Subject Name:	L-T-P:	Credit:
19CS5OE02T	DATABASE MANAGEMENT SYSTEM	3-0-0	3

Course Objectives:

1. To learn data models, conceptualize and depict a database system using ER diagram
2. To understand the internal storage structures in a physical DB design
3. To know the fundamental concepts of transaction processing techniques

Module–1: **[5 hours]**

Introduction: Purpose of Database System –– Views of data – data models, database management system, three-schema architecture of DBMS, components of DBMS. E/R Model - Conceptual data modelling - motivation, entities, entity types, attributes relationships, relationship types, E/R diagram notation, examples.

Module–2: **[10hours]**

Relational Model: Relational Data Model - Concept of relations, schema-instance distinction, keys, referential integrity and foreign keys, relational algebra operators, SQL - Introduction, data definition in SQL, table, key and foreign key definitions, update behaviours. Querying in SQL, notion of aggregation, aggregation functions group by and having clauses, embedded SQL

Module–3: **[7 hours]**

Database Design: Dependencies and Normal forms, dependency theory - functional dependencies, Armstrong's axioms for FD's, closure of a set of FD's, minimal covers, definitions of 1NF, 2NF, 3NF and BCNF, decompositions and desirable properties of them, algorithms for 3NF and BCNF normalization, 4NF, and 5NF

Module–4: **[10hours]**

Transactions: Transaction processing and Error recovery - concepts of transaction processing, ACID properties, concurrency control, locking based protocols for CC, error recovery and logging, undo, redo, undo-redo logging and recovery methods.

Module–5: **[8 hours]**

Implementation Techniques: Data Storage and Indexes - file organizations, primary, secondary index structures, various index structures - hash-based, dynamic hashing techniques, multi-level indexes, B+ trees.

Course Outcomes

1. Ability to Install, configure, and interact with a relational database management system
2. Ability to master the basics of SQL and construct queries using SQL
3. Ability to design and develop a large database with optimal query processing

Text Books:

1. A. Silberschatz, Henry F. Korth, and S. Sudharshan, "Database System Concepts", 7thEd, Tata McGraw Hill, 2019.
2. C. J. Date, A. Kannan and S. Swamynathan, "An Introduction to Database Systems", 8thed, Pearson Education, 2006

Reference Books:

3. RamezElmasri and Shamkant B. Navathe, "Fundamentals of Database Systems", 7thEdition, Pearson/Addisionwesley, 2016
4. Raghu Ramakrishnan, "Database Management Systems", Third Edition, McGraw Hill, 2003

Digital Learning Resources

Course Name	Database Systems Course
Course Link	https://nptel.ac.in/courses /106/104/106104135/
Course Instructor	Dr. Arnab Bhattacharya, IIT,Kanpur

Course Name	Introduction to Database Systems
Course Link	https://nptel.ac.in/courses/106 /106/106106220/
Course Instructor	Prof. P.Sreenivasa Kumar, IIT,Madras

Subject Code: 19EE5OE03T	Subject Name: SMART GRIDS	L-T-P: 3- 0- 0	Credit: 3

COURSE OBJECTIVES:

The objectives of the course are to make the students,

1. To understand the basic concepts, components and architecture of smart grid
2. To understand the various measurement technologies in smart grid
3. To educate the importance of renewable energy in smart
4. To know about battery technology and energy storage
5. To brief about role of Electric Vehicles in smart grid
6.

SYLLABUS

Module-1 **(6Hours)**

Introduction to Smart Grid

Basics of power systems, definition of smart grid, need for smart grid, smart grid domain, enablers of smart grid, smart grid priority areas, regulatory challenges, smart-grid activities in India, differences between traditional grid and smart grid.

Module-2

Concept of Microgrids **(7 Hours)**

Introduction to the concept of microgrid, the overview of the structure and architecture of microgrid with brief control, operational aspects. Recent pilot microgrid projects and their outcomes.

Module-3

Control of Smart Power Grid System **(8 Hours)**

Load Frequency Control (LFC) in Micro Grid System – Voltage Control in Micro Grid System – Reactive Power Control in Smart Grid

Module-4 **(7 Hours)**

Energy Storage Systems

Batteries, Super Conducting Magnetic Energy Storage System, Pumped Hydro, Compressed Air Energy Storage, Flywheel, Ultra capacitors.

Module-5 **(8Hours)**

Phasor Measurement Units Importance of PMUs, Phasor Measurement Units and Phasor Data Concentrators Wide Area Monitoring: WAMS concept, data collection, WAMS architecture, Advanced data processing, optimal placement of PMUs.

COURSE OUTCOMES:

After completion of the course, the student will be able to

1. Understand the features of Smart Grid.
2. Understand the basic concepts of micro grid and characteristics of energy storage devices.
3. Understand the concepts of Phasor measurements in power system.
4. Analyze the power system behavior using synchronized phasor measurements.

TEXT BOOKS:

1. S. Borlase, “Smart Grids, Infrastructure, Technology and Solutions”, CRC Press, 1st Edition, 2013.
2. N. D. Hatziargyriou, “Microgrids Architecture and control”, IEEE Press Series, John Wiley & Sons Inc, 1st Edition, 2013.
3. A. R. Messina, “Wide Area Monitoring of Interconnected Power Systems”, IET publisher, 1st Edition, 2015.

REFERENCE BOOKS:

1. Arun G. Phadke, James S. Thorp, "Synchronized Phasor Measurements and Their Applications", Springer International Publishing AG 2008, 2nd Edition, 2017.
2. Ali Keyhani, "Design of Smart power grid renewable energy systems", Wiley IEEE,2011.
3. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRCPress, 2009.
4. Stuart Borlase, "Smart Grid: Infrastructure, Technology and solutions " CRC Press.
5. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley.
6. Andres Carvallo, John Cooper, "The Advanced Smart Grid: Edge Power Driving", Artech House Publishers July 2011

DIGITAL LEARNING RESOURCES:

Course Name	Introduction to Smart Grid
Course Link	https://nptel.ac.in/courses/108/107/108107113/
Course Instructor	Prof. N P Padhy & Prof. Premalata Jena, Department of Electrical Engineering, IIT Roorkee

Subject Code:	Subject Name:	L-T-P:	Credit:
19EE5OE02T	SENSOR AND INSTRUMENTATION	3-0-0	3

COURSE OBJECTIVES:

The students will

1. Understand the concepts of measurement technology.
2. They learn the various sensors used to measure various physical parameters.
3. They will learn the fundamentals of signal conditioning and data acquisition.
4. Learn how to use virtual instrumentation for measurement.

SYLLABUS

Module-1 **(8 Hours)**

Sensors & Transducer: Definition, Classification & selection of sensors, Elements of a general measurement system: Static Characteristics: systematic characteristics, statistical characteristics, calibration; Dynamic characteristics of measurement systems: transfer functions of typical sensing elements, step and frequency response of first and second order elements, and dynamic error in measurement systems.

Module-2 **(8 Hours)**

Measurement of displacement using Potentiometer, LVDT & Optical Encoder, Measurement of force using strain gauge, Measurement of pressure using LVDT based diaphragm & piezoelectric sensor

Module-3 **(8 Hours)**

Signal Conditioning Elements: Deflection bridges: design of resistive and reactive bridges,push-pull configuration for improvement of linearity and sensitivity. Amplifiers:Operational amplifiers-ideal and non-ideal performances, inverting, non-inverting anddifferential amplifiers,

instrumentation amplifier, filters. A.C. carrier systems, phasesensitive demodulators and its applications in instrumentation

Module-4 **(10 Hours)**

Virtual Instrumentation: Graphical programming techniques, Data types, Advantage of Virtual Instrumentation techniques, Concept of WHILE & FOR loops, Arrays, Clusters & graphs,Structures: Case, Sequence & Formula nodes, need of software based instruments for industrial automation.

Module – 5 **(4 Hours)**

Data Acquisition Methods: Basic block diagram, Analog and Digital IO, Counters, Timers, Types of ADC: successive approximation and sigma-delta, Types of DAC: Weighted Resistor and R-2R Ladder type, Use of Data Sockets for Networked Communication

COURSE OUTCOMES:

After completion of the course, the student will be able to

1. Apply the use of sensors for measurement of displacement, force and pressure.
2. Employ commonly used sensors in industry for measurement of temperature, position, accelerometer, vibration sensor, flow and level.
3. Demonstrate the use of virtual instrumentation in automation industries.
4. Identify and use data acquisition methods.
5. Comprehend intelligent instrumentation in industrial automation.

TEXT BOOKS:

1. J.P. Bentley, Principles of Measurement Systems- 3rd edition, Pearson Education, New Delhi,2007.

2. Jovitha Jerome,Virtual Instrumentation Using LabVIEW,PHI Learning Pvt. Ltd., New Delhi-1100012010

REFERENCE BOOKS:

1. Introduction to Measurement and Instrumentation- A.K. Ghosh (3/e), PHI Learning,New Delhi, 2009.

2. Patranabis D, Sensors and Transducers, 2nd Edition, PHI, New Delhi, 2010

Digital Learning Resources:

Course Name	Sensor and Transducer
Course Link	https://nptel.ac.in/courses/108/108/108108147/ https://nptel.ac.in/courses/108/105/108105064/
Course Instructor	Dr. Hardik Jeetendra Pandya, Department of Electronic Systems Engineering, IISc Bangalore Prof. Alok Barua, Department of Electrical Engineering, IIT Kharagpur.

Course Code:	Course Name:	L-T-P:	Credit:
19ME5OE04T	NANOSCIENCE AND TECHNOLOGY	3- 0- 0	3

Course Objectives:

1. Learn about the background on Nanoscience and nanomaterials.
2. Understand the synthesis of nanomaterials and their application and the impact of nanomaterials on environment
3. Recognize the different functionalities of nonamaterials.
4. Understand the fundaments of Biomimetic nanomaterials and its application.
5. Understand the different applications of nanomaterials.

MODULE – I **[10 hours]**

General introduction and theory of nanomaterials- History of nanomaterials; Size and shape dependant properties and their uniqueness; Energy at nanoscale - surface characteristics and electrostatic and steric stabilization - Quantum confinement - zero dimensional, one dimensional and two dimensional nanostructures

MODULE – II **[8 hours]**

Synthesis of nanomaterials- Introduction to nanoparticle synthesis – top-down and bottom up approaches - physical nanofabrication techniques (PVD, MBE, CVD, self-assembly, lithographic techniques etc.) and wet chemical methods for the synthesis of zero dimensional one dimensional and two dimensional nanostructures-metal nanoparticles, quantum dots, nanoclusters, nanowires and rods, thin films

MODULE – III **[12 hours]**

Functional nanomaterials- Synthesis, properties and applications of organic, inorganic, hybrid nanomaterials – core-shells, nanoshells, self-assembled nanostructures, superlattices, nanoceramics metallic, polymeric and ceramic nanocomposites, nanoporous materials, nanofluids, nanolayers and carbon based nano materials - Occurrence, production, purification, properties and applications of fullerene, carbon nanotube, graphene, carbon onion, nanodiamond and films

MODULE – IV **[8 hours]**

Biomimetic nanomaterials - introduction to biomimetics, mimicking mechanisms found in nature, synthesis and applications of bioinspired nanomaterials and self-assemblies

MODULE – V **[8 hours]**

Applications of nanomaterials- Application of nanomaterials in healthcare, biosenors, coatings environment, catalysis, agriculture, automotives, sensors, electronics, photonics, information technology, quantum computing, energy and aerospace sectors.

Course Outcomes:

1. To develop a foundational knowledge of the Nanoscience and related fields.
2. Apply their learned knowledge to develop Nanomaterial's.
3. Evaluate the different functional properties of nanomaterials.
4. Understand the details about Biomimetic nanomaterials and its application.
5. Utilize the knowledge of nanomaterial in solving engineering problems.

Text Books:

1. K. J. Klabunde and R.M. Richards (Eds.), Nanoscale Materials in Chemistry, 2nd Edn., John Wiley & Sons, 2009.
2. T. Pradeep, Nano: The Essentials, McGraw-Hill (India) Pvt Limited, 2008.
3. Bharat Bhushan, (Ed.), Handbook of Nanotechnology, Springer, 2007.

Reference Books:

1. Carl C. Koch (Ed.), Nanostructured Materials: Processing Propertiesand Applications, William Andrew Inc., 2007.
2. Anke Krueger, Carbon Materials and Nanotechnology, Wiley-VCH Verlag GmbH & Co. KGaA, 2010.
3. Cao, G., Nanostructures and Nanomaterials Synthesis, Properties, and Applications, Imperial College Press, 2004.
4. Wang, Z. L., (Ed.), Characterization of nanophase materials, Wiley-VCH Verlag GmbH, 2000.

5. Garcia-Martinez, J., (Ed.), Nanotechnology for the Energy Challenge. Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2009.
6. Goddard III W.A., et. al.,(Ed.), Handbook of Nanoscience, Engineering, and Technology, Taylor & Francis Group, 2007.
7. B.P.S. Chauhan **(**Ed**)**, **Hybrid Nanomaterials**: Synthesis, Characterization, and Applications,Wiley-VCH Verlag GmbH, 2011.
8. J. Lei andF.Lin, Bioinspired Intelligent Nanostructured Interfacial Materials, World Scientific Publishing Company, 2010.
9. Challa S. S. R. Kumar (Ed.) Biomimetic and Bioinspired Nanomaterials, Wiley-VCH Verlag GmbH, 2010.

Subject Code: 19CE5OE03T	Subject Name: GEO-ENVIRONMENTAL ENGINEERING	L3-T0-P0	Credit: 3

Course Objective:

1. To know the sub-surface contamination, geo- synthetics types and its application.
2. To gain comprehensive knowledge solid and hazardous waste management.
3. To provide knowledge on contaminant transport.
4. To understand about the remediation techniques.
5. To know the basic concept of Landfill design.

Module: I **(8 hrs)**

Introduction: Scope, importance, waste generation, subsurface contamination, Geo-synthetics: Types, manufacturing functions, applications and economics.

Module: II **(8 hrs)**

Solid and Hazardous Waste Management: Classification of waste, Characterization solid wastes, Environmental Concerns with waste, waste management strategies.

Module: III **(8 hrs)**

Contaminant Transport: Transport process, Mass-transfer process, Bioremediation, Phytoremediation.

Module: IV **(8 hrs)**

Remediation Techniques: Objectives of site remediation, various active and passive methods, Soil washing, Emerging Remediation Technologies.

Module: V **(8 hrs)**

Landfills: Types of landfills, Site Selection, Waste Containment Liners, Leachate collection system, Cover system, Gas collection system

Course Outcome:

After completion of the course the student can

1. Understand surface contamination, geo-synthetic types and its function.
2. Analyze the classification of waste and waste management strategies.
3. Identify contaminant transport mechanisms in soils.
4. Understand the principles of soil treatment techniques
5. Get idea about different landfill concepts.

Text Books:

1. K. R. Reddy and H D Sharma, "*Geoenvironmental Engineering: Site Remediation, waste containment, and emerging waste management technologies*", John Willey , New Jersey, USA
2. R N. Yong, "*Geo Environmental Engineering: Contaminated Ground: Fate of Pollutions and Remediation*"., Thomson Telford , London, UK

Reference Books:

1. L N Reddy and H.I. Inyang, "*Geoenvironmental Engineering: Principles and Applications*", Marcel Dek , New York, USA
2. R. W. Sarsby, "*Environmental Geotechnics*", Thomson Telford , London, UK

Digital Learning Resources

Course Name	Geo-Environmental Engineering
Course Link	https://nptel.ac.in/courses/105/102/105102160/
Course Instructor	Prof. Manoj Datta, Department of Civil Engineering, IIT Delhi

Course Code: 19CS5MC02T	**Course Name:** Essence of Indian Tradition Knowledge	**L-T-P** 1- 0- 0	**Credit** 0

Course Objectives:

1. To facilitate the students with the concepts of Indian traditional knowledge and to make them understand the Importance of roots of knowledge system.

2. To make the students understand the traditional knowledge and analyze it and apply it to their day to day life.

Syllabus

Module-I **[8 hours]**

Introduction to traditional knowledge: Define traditional knowledge, nature and characteristics, scope and importance, kinds of traditional knowledge, Indigenous Knowledge (IK), characteristics, traditional knowledge vis-a-vis indigenous knowledge, traditional knowledge Vs western knowledge traditional knowledge

Module-II **[6 hours]**

Protection of traditional knowledge:The need for protecting traditional knowledge Significance of TK Protection, value of TK in global economy, Role of Government to harness TK.

Module-III **[8 hours]**

Legal framework and TK: The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, Plant Varieties Protection and Farmer's Rights Act, 2001 (PPVFR Act); The Biological Diversity Act 2002 and Rules 2004, the protection of traditional knowledge bill, 2016.

Module-IV **[8 hours]**

Traditional knowledge and intellectual property: Systems of traditional knowledge protection, Legal concepts for the protection of traditional knowledge, Patents and traditional knowledge, Strategies to increase protection of traditional knowledge

Module-V **[10 hours]**

Traditional Knowledge in Different Sectors: Traditional knowledge and engineering, Traditional medicine system, TK in agriculture, Traditional societies depend on it for their food and healthcare needs, Importance of conservation and sustainable development of environment, Management of biodiversity, Food security of the country and protection of TK.

Course Outcomes: At the end of the Course, Student will be able to:

1. Identify the concept of Traditional knowledge and its importance.
2. Explain the need and importance of protecting traditional knowledge.
3. IIllustrate the various enactments related to the protection of traditional knowledge.
4. Interpret the concepts of Intellectual property to protect the traditional knowledge.
5. Explain the importance of Traditional knowledge in Agriculture and Medicine.

Text Books:

1. Traditional Knowledge System in India, by Amit Jha, 2009.
2. Traditional Knowledge System in India by Amit Jha Atlantic publishers, 2002.
3. Knowledge Traditions and Practices of India" Kapil Kapoor1, Michel Danino2.