ET301N ANALOG AND DIGITAL COMMUNICATION

Teaching Scheme	**:** 04, Total: 04 hours/week	**Credits :**	04
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course provides a thorough introduction to the basic principles and techniques used in analog and pulse communication. The course will introduce communication systems, analog modulation techniques, transmitters and receivers, noise analysis, and multiplexing techniques. The course also introduces analytical techniques of pulse and digital modulation.

DESIRABLE AWARENESS/SKILLS

Knowledge of signals, basic electronics and electrical engineering

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. demonstrate the understanding of the basic analog communication system.
2. analyze time domain and frequency domain analysis of modulated signal.
3. evaluate different analog and digital modulation methods.
4. explain different types of receivers.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2										3	1	
2	2	2	2	2	2								2	2	
3	2	2	3	2	2								3	2	
4	2		3	2									2	3	

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Communication System and Noise **[6 Hrs]**

Communication system, need and types of modulation; noise – classification, sources, to several amplifiers in cascade, reactive circuits; noise figure – calculation and from measurement; noise temperature; Case Study of electromagnetic spectrum.

Amplitude Modulation **[8 Hrs]**

Amplitude modulation (AM) - mathematical analysis, modulation index, frequency spectrum, power equation, efficiency, generation (Collector and Emitter modulator), transmitter, high and low level transmitter, demodulation; balanced modulator (using FET, BJT) :Single Side Band (SSB) generation - filter method and phase shift method; Vestigial Side Band (VSB) modulation and demodulation, forms of AM, Independent Side Band scheme (ISB), Case study VSB in television system.

Angle Modulation **[7 Hrs]**

Frequency modulation (FM) - mathematical analysis, noise triangle, pre-emphasis and de-emphasis; FM generation - direct and indirect method, reactance and varactor diode modulator, stabilized reactance modulator, Armstrong method; narrowband and wideband FM, FM demodulator – basic, balanced slope detector, phase discriminator and ratio detector; Phase modulation (PM) -mathematical analysis, Case study FM transmission.

Receivers **[7 Hrs]**

Characteristics, types - Tuned Radio Frequency (TRF) , super heterodyne; AM super heterodyne receiver- RF amplifier, mixer-self and separately excited mixer, IF amplifier, practical diode detector, Automatic Gain Control (AGC) and delayed AGC; FM super heterodyne receiver- comparison with AM super heterodyne receiver, amplitude limiting, performance of amplitude limiter

Pulse Modulation and Line codes **[5 Hrs]**

Sampling theorem, types of sampling - ideal, natural, flat top; Pulse Amplitude Modulation (PAM), Pulse Width Modulation(PWM), Pulse Position Modulation (PPM), Line codes

Pulse Code Modulation **[7 Hrs]**

Pulse Code Modulation - Quantization, uniform and non uniform quantizer, companding, bandwidth, quantization noise, signal to noise ratio, non uniform quantization and companding, differential , differential PCM, delta modulation(DM), adaptive delta modulation(ADM), Linear predictive coding

Digital Modulation Techniques **[8 Hrs]**

Digital Band pass Modulation techniques -Amplitude Shift Keying (ASK), Frequency Shift Keying(FSK) , Phase Shift Keying (PSK), Quadrature Phase Shift Keying (QPSK), Quadrature Amplitude Shift Keying(QAM). Coherent and non-coherent detection.
(For all digital modulation schemes following points should be discussed:
signal space, phasor and constellation diagram, Euclidean distance, frequency spectrum)

Text Books

1. Electronic Communication Systems, George D. Kennedy, 4th edition, Tata McGraw-Hill, 1999
2. Principles of Communication Systems, T. Schilling and G. Saha, 3rd edition, McGraw-Hill, 1995

.**Reference Books**

1. Communication Systems, A. B. Carlson, 4th edition, McGraw-Hill, 2006
2. Electronic Communication, D. Roddy and J. Coolen, 4thedition, Prentice Hall of India

ET302N Microprocessors, Microcontrollers and PLC

Teaching Scheme	**:** 03L, Total: 03 hours/week	**Credits :**	03
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

The course explores knowledge of microprocessors and microcontrollers fundamentals. The course comprises of architecture, assemble language programming and interfacing of peripherals and their applications etc. This course includes PLC (Programmable Logic Controller).

DESIRABLE AWARENESS/SKILLS

Knowledge of basic number systems and digital electronics fundamentals

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. demonstrate the understanding of the basic architecture and features of 8085 and 8086 microprocessors.
2. write and execute basic assembly language programs using 8085 instruction set.
3. explain the architecture and features of 8051 microcontroller.
4. develop assembly programs using timers, interrupts, and serial communication, and interface 8051 with devices like LEDs, sensors, and motors.
5. explain PLC structure and develop simple ladder diagrams for automation tasks.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2											3	1	
2	3	3	2		1								3	2	1
3	3	2											3	2	
4	3	3	2		2								3	3	
5	2	2	3	1	2								2		1

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Microprocessors **[12 Hrs]**

Introduction, Evolution of microprocessors, 8085, 8086/ 80xxx up to Pentium : 8085-architectural features, instruction set, addressing modes, simple machine language programming, timing diagrams, interrupt handling, interface of peripherals , applications, advance features like instruction queue, MN/MX mode of 8086 , virtual memory, floating point ALU, microprocessor system design

Microcontroller **[10 Hrs]**

Introduction, Overview of the microcontroller family, block diagram description of 8051, architectural features, memory and register organization, stack and its operation, stack related instructions, looping, conditional and unconditional jumps, subroutines, time delay calculations, CALL and RET Instruction.8051 pin diagram, understanding the function of each pin, I/O port structure and I/O port programming

Microcontroller 8051 programming **[10 Hrs]**

Assembly Language Programming Addressing Modes in 8051; Instruction set of 8051 microcontroller; Programs based on instructions; Timer, serial port and interrupt programming: Structure of Timer Mode Control Register (TMOD register), Mode 1 programming. Generation of large delay, Mode 2 programming counter programming, Timer Control Register (TCON register) structure; 8051 serial port programming; 8051 interrupts, interrupts programming Interfacing: switch, LED, LCD, ADC, DAC, sensors, stepper motor.

Programmable Logic Controller **[10Hrs]**

PLC Basics: PLC system, I/O modules and interfacing, CPU processor, programming equipment, programming formats, construction of PLC ladder diagrams, devices connected to I/O modules. PLC programming: Input instructions, outputs, operational procedures, programming examples using contacts and coils, drill press operation. Ladder diagram, Introduction to SCADA

Text Books

1. Microprocessor Architecture, Programming and Applications with 8085, R.Gaonkar, 6th edition, Penram International Publishing, 2013
2. The 8051 Microcontroller and Embedded Systems, M.A. Mazidi and J. G. Mazidi, 2nd edition, Pearson Education Asia, 2006
3. Microprocessor 8086, L. Gibbson, 4th edition, Tata McGraw
4. John W. Webb & Ronald A. Reiss, "Programmable Logic Controllers- Principles and Applications" 5th Edition, PHI, 2016.

Reference Books

1. Microprocessor 8086, Avtar singh, 4th edition, Tata McGraw Hill, 2009
2. Microcontrollers Architecture, Programming, Interfacing and System Design, Raj kamal, 1st edition, Pearson Education Asia, 2011 Digital Signal Processing: Fundamentals and applications, Li Tan, Jean Jiang, 2nd edition, Academic press, 2013
3. John W. Webb & Ronald A. Reiss, "Programmable Logic Controllers - Principles and Applications" 5th Edition, PHI, 2016.

ET303N DIGITAL SIGNAL PROCESSING

Teaching Scheme	**:** 03L, Total: 03 hours/week	**Credits :**	03
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course is designed to introduce students to fundamental principles and techniques for digital signal processing (DSP). This course covers representation of discrete signals and systems in time and frequency domain using discrete time Fourier transform (DTFT), discrete Fourier transform (DFT) and Z transform. In addition, it covers the design of finite impulse response (FIR) and infinite impulse response (IIR) filters. This course also introduces students to architecture of digital signal processor.

DESIRABLE AWARENESS/SKILLS

Knowledge of signals and systems and fundamentals of complex numbers

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. represent and analyze discrete systems in time domain.
2. analyze discrete signals and systems in frequency domain using DTFT and DFT.
3. apply Z-transform to analyze discrete signals and systems in frequency domain.
4. design FIR and IIR filters and realize them in Direct form, cascade form and parallel form.
5. demonstrate the knowledge of architecture of DSP processor and its applications.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2										3	1	
2	2	2	3	2	3								3	2	
3	2	2	3	2	3								3	2	
4	3		3	2									3	3	
5	2			3	2								2		2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

DSP Fundamentals **[07 Hrs]**

Sampling of analog signals, concept of frequency in continuous and discrete time sinusoids, mapping between analog frequencies to digital frequency, analytical treatment with examples, sampling theorem in time domain and its frequency domain implication (concept only), representation of signals as vectors, concept of Basis function and orthogonality basic elements of DSP systems, advantages of digital over analog signal processing, applications of DSP, representation of discrete systems using difference equations, concept of non-recursive and recursive systems.

Frequency Analysis of Discrete Time Signals **[08 Hrs]**

Discrete time Fourier transform – Definition and convergence conditions, energy density spectrum of aperiodic signals, Concept of frequency domain sampling, DFT, IDFT, properties of DFT, Use of DFT in linear filtering using overlap add and overlap save method, efficient computation of DFT using Radix-2 FFT algorithms (DITFFT and DIFFFT).

Z-Transform and its application to LTI system analysis **[08 Hrs]**

Need for Z-transform, definition, relation between Z transform and DTFT, concept and properties of RoC, properties of Z transform, rational Z transform - pole locations and time domain behavior, causality and stability considerations for LTI systems, Inversion of Z-transform, unilateral Z transform and its application to solution of difference equations.

FIR filters **[07 Hrs]**

Introduction to digital filters: Definition, types (FIR and IIR), frequency response of ideal and practical filters, FIR filters – linear phase response and its implications, types of linear phase FIR filters, design of FIR filters using rectangular Window, limitations of rectangular window, other important window functions – triangular, Hanning, Hamming, Blackman and their comparison, frequency sampling method of FIR filter design, FIR filter realization using direct form, cascade form and lattice form

IIR filters **[07 Hrs]**

IIR filters- Frequency response of analog and digital IIR filters, concept of analog filter design, design of IIR filters from analog filters - IIR filter design by impulse invariance method, Bilinear transformation method, warping effect, IIR filter design using Butterworth approximation, characteristics of Butterworth, Chebyshev and elliptical filters, frequency transformations, IIR filter realization using direct form, cascade form and parallel form, finite word length effects in design of FIR and IIR filters.

Digital Signal Processors **[03 Hrs]**

Introduction, special features of digital signal processors, selection criteria for digital signal processor, functional block diagram and important architectural features of TMS320C67xx

Text Books

1. Digital Signal Processing: Principles, algorithms and applications, J. G. Proakis, D.G. Manolakis, 4th edition, Pearson Prentice Hall, 2007
2. Fundamentals of Digital Signal Processing, Lonnie C Ludeman, 1st edition, Wiley India Pvt. Ltd., 2009

Reference Books

1. Digital Signal processing: Practical approach, Ifaeachor E.C, Jervis B. W., 2nd edition, Pearson Education, 2012
2. Digital Signal Processing, S. Apte, 2nd edition, Wiley India Publication, 2009
3. Digital Signal Processing: Fundamentals and applications, Li Tan, Jean Jiang, 2nd edition, Academic press, 2013
4. Digital Signal Processors: Architecture, Programming and Applications, B. Venkataramani, M. Bhaskar, 2nd edition, 4th reprint, Tata McGraw Hill Education Private Limited, 2012

ET304NA TELECOMMUNICATION SWITCHING SYSTEMS

Teaching Scheme	**:** 03L, Total: 03 hours/week	**Credits :**	03
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course is designed to explore fundamental principles of switching systems, practical aspects traffic engineering and basic concepts of wireless communication system. This course provides comprehensive coverage of GSM, advanced access techniques.

DESIRABLEAWARENESS/SKILLS

Knowledge of analog and digital communication

COURSE OUTCOMES

On the successful completion of this course; student shall be able to

1. describe the evolution of telecommunication and compare switching techniques like space, time, and hybrid switching.
2. apply traffic engineering principles to analyze network traffic, blocking probability, and performance metrics.
3. explain the architecture and components of telephone networks, signaling methods, and mobile telephony systems.
4. describe data networks, EPABX systems, and modern switching standards used in communication networks.
5. illustrate the architecture and protocols of ISDN, broadband networks, and wireless systems including GSM, CDMA, and multiple access techniques.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3												3	2	
2	3	2		2					1				2	3	
3	1	1	3			3							3	3	
4	3	3	2										3	2	
5		2										3		2	3

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Telephone switching **[05 Hrs]**

Evolution of telecommunication, simple telephone communication, basics of switching systems: strowger switching system ,crossbar switching system; Electronic Space Division Switching: Stored Program Control, Centralized SPC, Distributed SPC, Enhanced Services, Two stage networks, Three stage network n-stage networks; Time Division Switching: Time multiplexed Space Switching, Time Multiplexed time switching, combination Switching, Three stage combination switching, n-stage combination switching.

Traffic Engineering [06 Hrs]

Network Traffic load and parameters, Grade of service and blocking probability, Modeling Switching Systems, Incoming Traffic and Service Time Characterization, Blocking Models and Loss Estimates, Delay systems.

Telephone Networks [07 Hrs]

Subscriber Loop Systems, Switching Hierarchy and Routing, Transmission Plan, Transmission Systems, Numbering Plan, Charging Plan, Signaling Techniques, In channel signaling, common channel signaling, Cellular mobile telephony.

Data networks: **[07 Hrs]**

Block Diagram, features, working of EPABX Systems, Data transmission in PSTNs, Data Rates in PSTNs, Modems, Switching Techniques for data Transmission, Circuit Switching, Store and Forward Switching Data communication Architecture, Link to Link Layers, End to End Layers, Satellite based data networks, LAN, Metropolitan Area network, Fiber optic networks, and Data network standards**.**

Integrated Services Digital Networks **[08 Hrs]**

Network and Protocol architecture, Transmission Channels, User Network Interface, signaling, Numbering and Addressing, Service characterization, Interworking ,ISDN standards, Broadband ISDN ,Voice data Integration Wireless Communication System: paging, cordless telephone systems, Wireless Local Bluetooth and personal area networks, concept of frequency reuse, cell splitting: hand off mechanism ,access techniques: Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA) and Code Division Multiple Access (CDMA)

Digital cellular systems **[07 Hrs]**

Global System for Mobile (GSM), radio aspects, features of GSM, architecture details, channel structure, security aspects, authentication and ciphering key; different call flow sequences in GSM, North American CDMA cellular standard, radio aspect, forward link and reverse link structure

Text Books

1. Telecommunication switching systems and Networks, T. Vishwanathan, 2nd edition, Prentice Hall of India, 2015
2. Wireless and cellular Telecommunications, William C. Y. LEE, McGraw Hill, 3rd edition

Reference Books

1. Wireless communication, Rappaport, Prentice Hall of India.
2. Computer Networks, Andrew S Tanenbaum, 4th edition, Prentice Hall of / Pearson Education

ET304NB DATA STRUCTURE AND FILES

Teaching Scheme	**:** 03L, Total: 03 hours/week	**Credits :**	03
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

The course provides an introduction to the theory, practice and methods of data structures and algorithm design. The course covers elementary data structures such as stacks, queues, linked lists, trees and graphs in C language and the algorithms designed for manipulating these data structures. The course also introduces the concept of files in programming language.

DESIRABLE AWARENESS/SKILLS

Knowledge of Computer Fundamentals and C Programming

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. choose the data structures that effectively model the information in a problem
2. compare efficiency trade-offs among alternative data structure implementations or combinations
3. apply algorithm analysis techniques to evaluate the performance of an algorithm and to compare data structures
4. implement and know when to apply standard algorithms for searching and sorting
5. design programs using a variety of data structures including lists, stacks, queues, binary tree structures, search trees, graphs

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	2	2	2	2										1
2	2	2	2	2	2										1
3	2	2	2	2	2										1
4	1	1	1	2	2										1
5	3	3	3	2	2										1

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Introduction to Algorithm and Program Design **[08 Hrs]**

Fundamentals: basic terminology, elementary data organization, data structures, data structure operations, Abstract Data Type (ADT); Algorithm: **c**omplexity, time space tradeoff, algorithmic notations, control structures, complexity of algorithms, other asymptotic notations for complexity of algorithms, sub-algorithms; Searching algorithms: algorithms for sequential search, indexed sequential search and binary search

Arrays, Records and Pointers **[06 Hrs]**

Sorting algorithms: selection, bubble, insertion, quick, heap and merge; Records: structures in C, comparison with arrays as a data structure, array of structures, pointers and structures, polynomial representation using array of structures, unions, bitwise operators

Linked Lists **[06 Hrs]**

Singly linked lists: concept, linked list as ADT, representation in memory, traversing, searching, memory allocation; garbage collection, insertion into linked list, deletion from a linked list, doubly linked lists, circular linked lists

Stacks, Queues, Recursion **[08 Hrs]**

Stacks: concept, array representation of stacks, linked representation, stacks as ADT, arithmetic expressions; polish notation, application of stacks: recursion, implementation of recursive procedures by stacks; Queues: concept, array representation, linked representation, queue as ADT, circular queues, de-queue (double ended queue), priority queues and applications of queues: categorizing data, simulation of queues

Trees and Graphs **[09 Hrs]**

Binary trees: concept and terminologies, representation of binary tree in memory, traversing a binary tree, traversal algorithms using stacks, header nodes; threads, Binary Search Trees (BST), searching and inserting in BST, deleting in a BST, balanced binary trees, application of trees: expression tree, game trees

Graphs: Concept and terminology, sequential representation: Adjacency Matrix and path matrix, Shortest Path Algorithm: Warshall's algorithm, graph operations

Files **[05 Hrs]**

Introduction, terminology, files organization, file operations, sequential files, indexed sequential files, direct file organization, multiple-key access

Text Books

1. Data Structure with C Schaum's Outlines, S. Lipschutz, Revised 1st edition, McGraw Hill Education (India) Private Limited, 2014
2. Data structures using C and C++, Y. Langsam, M. J. Augenstein, Aaron M, Tenenbaum, 2nd edition, Prentice Hall of India Learning, 2009

Reference Books

1. Programming in ANSI C, E. Balgurusamy, 6th edition, McGraw Hill Education (India) Private Limited, 2012
2. Data Structures using 'C', ISRD Group, 2nd edition, McGraw Hill Education (India) Private Limited, 2012

ET304NC POWER ELECTRONICS

Teaching Scheme	**:** 03L+00T; Total: 03	**Credits:**	03
Evaluation Scheme	**:** 10 ISA + 30 MSE +60 ESE	**Total Marks:**	100
ESE Duration	**:** 3 Hrs.		

COURSE DESCRIPTION

This course is covering fundamentals of power semiconductor devices, their ratings characteristics and applications. The course will further strengthen the knowledge of construction, working principles, performance and application of power converters like AC to DC, DC to DC, DC to AC and AC to AC.

DESIRABLE AWARENESS/SKILLS

Knowledge of basic science and mathematics, electrical engineering, electronic devices

COURSE OUTCOMES

On successful completion of this course, student shall able to -

1. demonstrate the understanding of the construction, working principles, characteristics, and triggering methods of power semiconductor devices such as SCR, DIAC, and TRIAC.
2. analyze the performance of single-phase and three-phase controlled rectifiers with different types of loads and compute average and RMS output voltages.
3. explain the operation and classification of DC-DC converters (choppers), and evaluate their output parameters under various control strategies.
4. explain the working of various inverter topologies, including voltage and current source inverters, and assess their performance based on output voltage and waveform quality.
5. describe the working principles and applications of AC-AC converters, cyclo-converters, and UPS systems, including different configurations and battery considerations.

RELEVANCE OF PROGRAM OUTCOMES (POS) AND STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3				2								3	2	
2	3	2	2	2	2								2	3	
3	3	2	2	2	2								2	3	
4	3	2	2	2	3								3	3	2
5	2	1	2		2								2	2	2

1-Weakly correlated **2-Moderately correlated** **3- Strongly correlated**

COURSE CONTENT

Power Devices **[08 Hrs]**

Silicon Controlled Rectifier (SCR), Diode for Alternating Current (DIAC), TRiode for Alternating Current (TRIAC) - background, construction, working, V-I characteristics; SCR turn on and triggering methods - forward voltage, dv/dt, thermal, radiation, gate; protection circuits, commutation and its types, SCR data sheet - rating, electrical characteristics

AC to DC Converter **[08 Hrs]**

Single phase controlled half and full wave rectifiers with R and RL load, average and Root Mean Square (RMS) output voltage, semi-converter with R and RL load. Three phase half and full controlled bridge rectifiers with R and RL load

Choppers: DC to DC **[08 Hrs]**

Classification, basic chopper operation- step down, step up and step-up/down; control strategies- Time Ration Control (TRC), Current Limit Control (CLC), duty cycle, average and RMS output voltage, configuration - first, second, third and fourth quadrant operations

Inverters: DC to AC **[08 Hrs]**

Classification, Single phase half bridge and full bridge voltage Source Inverter (VSI) with R and RL load; performance parameters of inverters; Current Source Inverter (CSI), RMS output voltage and power, series inverter, Pulse Width Modulated (PWM) Inverters - single pulse, multi pulse, sinusoidal pulse

AC to AC Converter **[04 Hrs]**

Single phase half and full wave converter with R and RL load, average and RMS output voltage; principle of integral cycle control

Cyclo-convertors **[03 Hrs]**

Single phase step-down and step-up cyclo-convertors using mid-point type and bridge type

Uninterruptible Power Supply (UPS) **[03 Hrs]**

Basic principle, configurations - off-line, on-line, line interactive, reliability of UPS system, batteries for UPS - battery capacity, efficiency

Text Books

1. Power Electronics Circuit, Devices and Application, M. H. Rashid, 3rd edition, 13th Reprint, Pearson, 2013
2. Power Electronics Converters, Applications and Design, N. Mohan, 3rd edition, T. M. Undeland, W. P. Robbins, Wiley, 2016

Reference Books

1. Power Electronics, P. C. Sen, 1st edition, 30th reprint, Tata McGraw Hill, 2008
2. Principles of Power Electronics, J. G. Kassakian, M. F. Schlecht, G. C. Verghese, 1st Impression, Pearson, 2011
3. MatLab and Simulink for Engineers, A. K. Tyagi, 1st edition, Oxford University Press, 2012
4. Data Sheets: Power devices

ET305NX PRINCIPLES OF IoT

Teaching Scheme	**:** 02L, Total: 02 hours/week	**Credits :**	02
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course is designed to introduce students to fundamental principles and techniques for Internet of Things (IoT). This course covers fundamentals of IoT, components of IoT, sensors, actuators, and interfaces required in IoT. It also covers communication and modern networking aspects related to IoT. The typical application oriented case-studies of IoT also forms the scope of this course.

DESIRABLE AWARENESS/SKILLS

Since this course is open elective course and is designed for students of disciplines other than Electronics and Telecommunication engineering, the knowledge of basic science and engineering science courses is sufficient.

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. explain the fundamentals of IoT.
2. identify suitable hardware and interfaces for IoT deployments.
3. demonstrate the knowledge of communication and networking in IoT.
4. illustrate the typical case studies of applications of IoT.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2										3	1	
2	2	2	3	2	3								3	2	
3	2	2	3	2	3								3	2	
4	3		3	2									3	3	
5	2			3	2								2		2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

IoT Introduction and Fundamentals [5 Hours]
Principles of IoT, Applications of IoT deployment, Benefits/Challenges of deploying an IoT, IoT components: Digital Signal Processing, Data transmission, Choice of channel (wired/wireless), back-end data analysis. Packaging and power constraints for IoT implementation

Signals, Sensors, Actuators, Interfaces [6 Hours]
Introduction to sensors & transducers, Introduction to electrodes & biosensors, Different types of sensors, Selection criteria's for sensors / transducers, Signal conditioning modules of IoT system , Energy and power considerations, Introduction to actuators, Different types of actuators, Interfacing challenges, Modules of data acquisition system, Wireless sensor node structure

Communication and Networking in IoT [6 Hours]
Review of Communication Networks, Challenges in Networking of IoT Nodes, range, bandwidth, Machine-to-Machine (M2M) and IoT Technology Fundamentals, Medium Access Control (MAC) Protocols for M2M

Modern Networking [5 Hours]
Cloud computing: Introduction to the Cloud Computing, Cloud service options, Cloud Deployment models, Business concerns in the cloud, Hypervisors, Comparison of Cloud providers

IoT Applications and case-study [3 Hours]
IoT applications like Home Automation, Precision Agriculture, Smart vehicles, Smart Grid, Industry 5.0.

Text Books

1. Internet of Things, a hands on approach, Arshdeep Bahga and Vijay Madisetti, Universities Press (India) Pvt. Ltd. 2017.
2. Internet of Things Principles and Paradigms, Rajkumar Buyya, Amir Vahid Dastjerdi, Elsevier Inc. 2016.

Reference Books

1. Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud, William Stallings, Publisher: Addison-Wesley 2015.
2. Internet of Things: Architecture and Design Principles, Raj Kamal, McGraw Hill, 2017.

ET305NY FUNDAMENTALS OF MOBILE COMMUNICATION

Teaching Scheme	**:** 02L, Total: 02 hours/week	**Credits :**	02
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course introduces the fundamental concepts and technologies behind mobile communication systems, focusing on their evolution, architecture, and applications. Designed for students from non-electronics backgrounds, it covers key topics such as cellular structure, frequency reuse, multiple access techniques, and the progression from 1G to 5G networks. The course also explores mobile network components, mobile data services, and emerging trends like IoT and smart communication.

DESIRABLE AWARENESS/SKILLS

Basic understanding of science and mathematics, familiarity with fundamental physics concepts related to waves and signals, general awareness of mobile phones, cellular services, and internet usage, interest in communication technology and emerging trends like 5G and IoT

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. demonstrate the understanding of the basic working principles of mobile communication systems.
2. differentiate between various generations of mobile communication.
3. explain the architecture and functioning of cellular systems.
4. recognize current trends in mobile technology, including 4G/5G and IoT.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2	1		1									
2	3	1	1	1	2	2									
3	2	3	3	2	1		1								
4	3	2	2	3	3	2	1					2			

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Introduction to Mobile Communication **[5 hours]**

History and evolution of wireless communication, applications and importance of mobile communication, overview of mobile devices and services.

Cellular Concepts and Frequency Reuse**:** Cell structure, frequency reuse, and handoff, concept of spectrum, bandwidth, and channel allocation, mobile network coverage and capacity.

Mobile Network Architecture **[4 hours]**

Components such as BTS, BSC, MSC, HLR, and VLR, GSM system architecture and signal flow, overview of SIM, IMSI, and IMEI, Multiple Access Techniques: FDMA, TDMA, CDMA

Generations of Mobile Networks **[6 hours]**

Principles of 2G to 5G characteristics and differences, key features of GSM (2G), EDGE, 3G, LTE (4G), and 5G.

Mobile Data and Internet Access **[5 hours]**

GPRS, EDGE, 3G and 4G data services, 5G use cases such as smart cities, autonomous vehicles, mobile communication in IoT, challenges including security, spectrum scarcity, and health concerns

Case Studies and Industry Insights **[5 hours]**

Role of mobile communication in disaster management, telecom service providers and regulatory bodies such as TRAI and DoT, real-life applications including mobile payments and e-health.

Text Books

1. Communication Systems: Analog and Digital, R.P. Singh and S. D. Sapre, Tata McGraw-Hill.
2. Mobile Communications, J. Schiller, 2nd Edition, Pearson Education.
3. Wireless Communications, Principles and Practice, T. Rappaport, Pearson Education, 3rd Edition.

Reference Books

1. Mobile Cellular Telecommunication Systems, William C.Y. Lee, 2nd Edition, TMH, New Delhi.
2. Wireless and Mobile Communications, Upena Dalal, 1st Edition, Oxford University Press.

ET307N Microprocessors, Microcontrollers and PLC Lab

Teaching Scheme	**:** 02P, Total: 02 hours/week	**Credits :**	01
Evaluation Scheme	**:** 30 ICA + 20 ESE	**Total Marks:**	50
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course provides hands on designing and programming with 8086, 8051 and PLC

DESIRABLE AWARENESS/SKILLS

Knowledge of ET302N Microprocessors, Microcontrollers and PLC

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. describe the basic working of microcontroller and PLC components like timers, counters, and controllers.
2. write simple programs to control devices such as LEDs, LCDs, motors, and sensors using a microcontroller.
3. test and check how different hardware parts work together in a microcontroller or PLC system.
4. create small automation tasks using microcontroller or PLC programming tools.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2										3	1	
2	2	2	3	2	3								3	2	
3	3		3	2									3	3	
4	2			3	2								2		2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Minimum ten experiment shall be performed to cover entire curriculum of course ET302N using simulation software / hardware. One can virtual lab also. The list given below is just a guideline.

- Simple manipulations
- Array manipulation
- Timer, serial port, interrupt programming
- Analog to digital converter interface and programming
- Digital to analog converter interface and programming
- Stepper motor, relay interface and programming
- LCD interface and programming 19
- Keyboard / display interface programming
- LEDs: Segment / dot matrix interface and programming
- CRT / Hard disc interface
- Flash programming
- Study hardware and software used in PLC Implementation Logic Gates
- Implementation of Off-Delay Timer
- Implementation of Up-Down Counter
- Implementation of PLC Arithmetic Instructions
- Implementation of PID Controller

Note

- **ICA –**Internal Continuous Assessment shall support for regular performance of practical and its regular assessment. In addition; it shall be based on knowledge/skill acquired and record submitted by student (journal) based on practical performed by him/her. The performance shall be assessed experiment wise using internal continuous assessment format**.**
- **ESE -** End Semester Examination (ESE) for this laboratory course shall be oral examination based on experiments performed / assignments covered in ET307N. It shall be evaluated by two examiners out of which one examiner shall be out of institute.

ET308N ANALOG AND DIGITAL COMMUNICATION LAB

Teaching Scheme	**:** 02P, Total: 02 hours/week	**Credits :**	01
Evaluation Scheme	**:** 30 ICA + 20 ESE	**Total Marks:**	50
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course deal with the practical performance on concept like modulation and demodulation, implementation of pre-emphasis and de-emphasis, PAM and PWM. This course also provides practical exposure of AM, FM receiver and basic communication concept, PCM and Digital modulation

DESIRABLE AWARENESS/SKILLS

Concepts and theory of the course ET301N Analog and Digital Communication

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. Explain the working principles of analog and digital modulation and demodulation systems.
2. Demonstrate the ability to set up and perform experiments on analog and digital modulation/demodulation circuits using standard communication ICs and discrete components.
3. Analyze the performance of superheterodyne receivers, RF/IF amplifiers, and modulation schemes based on observed waveforms and practical measurements.
4. Summarize the industrial practices observed during the transmitter site visit.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	2	2										3	2	
2	2	2	2	2	2								3	2	
3	2		2	2									3	3	
4	2			2	2								2		2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

Minimum ten experiments shall be performed to cover entire curriculum of course ET306N using simulation software like MATLAB/NETSIM etc or hardware. The list given below is just a guideline.

List of Experiments

- Amplitude modulation
- Amplitude demodulation
- Balanced modulation using IC 1496
- Frequency modulation (using IC/Varactor diode /BJT /FET)
- Amplitude demodulation (using IC/ratio detector /BJT /FET)
- Pre-emphasis and de-emphasis
- AM super heterodyne receiver
- RF amplifier
- IF amplifier
- FM super heterodyne receiver
- Flat top sampling
- Pulse amplitude modulation
- Pulse width modulation
- Pulse position modulation
- Pulse code modulation
- Delta modulation /adaptive delta modulation
- Amplitude Shift Keying
- Phase Shift Keying
- Frequency Shift Keying
- Line Codes
- Industrial visit to any transmitter.

Note

- **ICA –**Internal Continuous Assessment shall support for regular performance of practical and its regular assessment. In addition; it shall be based on knowledge/skill acquired and record submitted by student (journal) based on practical performed by him/her. The performance shall be assessed experiment wise using internal continuous assessment format.
- **ESE -** End Semester Examination (ESE) for this laboratory course shall be oral examination based on experiments performed / assignments covered in ET308N. It shall be evaluated by two examiners out of which one examiner shall be out of institute.

ET 309N DIGITAL SIGNAL PROCESSING LAB

Teaching Scheme	**:** 02P, Total: 02 hours/week	**Credits :**	01
Evaluation Scheme	**:** 30 ICA + 20 ESE	**Total Marks:**	50
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course is designed to introduce students to fundamental principles and techniques for digital signal processing (DSP). This course covers representation of discrete signals and systems in time and frequency domain using discrete time Fourier transform (DTFT), discrete Fourier transform (DFT) and Z transform. In addition, it covers the design of finite impulse response (FIR) and infinite impulse response (IIR) filters. This course also introduces students to architecture of digital signal processor and basics of implementation of discrete systems on digital signal processor.

DESIRABLE AWARENESS/SKILLS

Knowledge of signals and systems and fundamentals of complex numbers

COURSE OUTCOMES

On the successful completion of this course; student shall be able to practically -

1. represent and analyze discrete systems in time domain.
2. analyze discrete signals and DTLTI systems in frequency domain using DFT and Z transform.
3. design and simulate FIR and IIR filters.
4. demonstrate the understanding of implementation of DTLTI systems on DSP processor.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2										3	1	
2	2	2	3	2	3								3	2	
3	3		3	2									3	3	
4	2			3	2								2		2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

Course Content

Minimum eight experiments shall be performed to cover entire curriculum of course ET303N using simulation software like MATLAB/Scilab/Octave/C. The list given below is just a guideline.

- Sampling Theorem
- Convolution sum /Correlation
- Discrete Fourier Transform
- Properties of DFT.
- Pole zero plot of a transfer function
- To solve the difference equation and find the system response using Z transform (for non-relaxed LTI system).
- FIR filter using window / frequency sampling method
- IIR filter (Butterworth / Chebyshev Approximation)
- Effect of coefficient quantization on the impulse response of the filter using direct form I and II realization and cascade realization.(theory assignment)
- Interfacing DSP processor
- FIR filter on DSP processor
- IIR filter on DSP processor

Note

- **ICA –**Internal Continuous Assessment shall support for regular performance of practical and its regular assessment. In addition; it shall be based on knowledge/skill acquired and record submitted by student (journal) based on practical performed by him/her. The performance shall be assessed experiment wise using internal continuous assessment format**.**
- **ESE -** End Semester Examination (ESE) for this laboratory course shall be based on performance in one of the experiments performed by student in the semester followed by sample questions to judge the depth of understanding/knowledge or skill acquired by the student. It shall be evaluated by two examiners out of which one examiner shall be out of institute.

ET310NA TELECOMMUNICATION SWITCHING SYSTEMS LAB

Teaching Scheme	**:** 02P; Total: 02	**Credits**	:01
Evaluation Scheme	**:** 25ICA+25 ESE	**Total Marks**	:50
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course is designed to explore fundamental principles of switching systems, practical aspects traffic engineering and basic concepts of wireless communication system. This course provides comprehensive coverage of GSM, advanced access techniques.

DESIRABLE AWARENESS/SKILLS

Knowledge of analog and digital communication

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. explain the basic working principles of mobile communication systems, CD/DVD players, PA systems, FAX, and EPABX.
2. operate and test communication trainers such as GSM, CDMA, and mobile trainers for basic functionalities.
3. perform signal processing tasks such as speech signal digitization and TDMA simulation using MATLAB/SCILAB.
4. analyze traffic parameters and real-time communication processes observed during visits to TV transmitters, studios, and related setups.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	1	3	3		1	3							3		
2	3	2	3	1	1									2	
3	1	3	3			2	1								3
4			2	2	1									2	

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Minimum eight experiments shall be performed to cover entire curriculum of course ET304NA. The list given below is just a guideline.

List of Experiments

- Mobile trainer
- GSM trainer
- Visit to TV transmitter
- Digitization of speech signal by writing program in MATLAB / SCILAB/ NetSim
- TV transmitter/Studio
- CD/DVD players
- PA system with cordless microphone
- FAX
- CDMA trainer
- EPABX
- Calculation of basic parameters for traffic by writing programs in MATLAB / SCILAB
- Simulation of TDMA using MATLAB/SCILAB

Note

- **ICA –**Internal Continuous Assessment shall support for regular performance of practical and its regular assessment. In addition; it shall be based on knowledge/skill acquired and record submitted by student (journal) based on practical performed by him/her. The performance shall be assessed experiment wise using internal continuous assessment format**.**
- **ESE -** End Semester Examination (ESE) for this laboratory course shall be based on performance in one of the experiments performed by student in the semester followed by sample questions to judge the depth of understanding/knowledge or skill acquired by the student. It shall be evaluated by two examiners out of which one examiner shall be out of institute.

ET310NB DATA STRUCTURE AND FILES LAB

Teaching Scheme	**:** 02P, Total: 02 hours/week	**Credits :**	01
Evaluation Scheme	**:** 30 ICA + 20 ESE	**Total Marks:**	50
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This laboratory course provides practical exposure to the implementation of fundamental data structures such as arrays, linked lists, stacks, queues, trees, and graphs using C programming. The course is designed to reinforce theoretical concepts learned in the theory course and develop students' ability to write efficient, structured, and maintainable code. In addition, the course introduces file operations including reading from and writing to files, working with different file formats, and performing basic file-based data processing.

DESIRABLE AWARENESS/SKILLS

Knowledge of Computer Fundamentals and C Programming

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. implement fundamental data structures such as arrays, linked lists, stacks, queues, trees, and graphs using C programming.
2. apply searching, sorting algorithms, and expression conversions with complexity analysis to solve computational problems efficiently.
3. develop and manipulate structured data using arrays of structures and linked lists to perform operations such as insertion, deletion, modification, and traversal in real-world applications.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	2	2	2	2										1
2	2	2	2	2	2										1
3	2	2	2	2	2										1

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

Minimum eight experiments shall be performed to cover entire curriculum of course ET304NB using C programming. The list given below is just a guideline.

- Set operations like union, intersection and difference
- Searching methods-linear and binary
- Sorting methods-bubble, selection / insertion with complexity analysis
- Quick sort / merge sort/heap sort with complexity analysis
- Data base management using array of structure with operations: create, display, modify, append, search and sort
- Polynomial addition using array of structure / linked list
- Singly linked list with operations create, insert, delete, and search
- Doubly linked list
- Stack using arrays or linked lists
- Queue using array or linked lists
- Conversion of infix expression to postfix expression
- Circular queue operations
- Implementation of tree, graphs
- Tree operations

Note

- **ICA –** Internal Continuous Assessment shall support for regular performance of practical and its regular assessment. In addition; it shall be based on knowledge/skill acquired and record submitted by student (journal) based on practical performed by him/her. The performance shall be assessed experiment wise using internal continuous assessment format**.**

- **ESE –** The End Semester Examination (ESE) for this laboratory course shall be based on performance in one of the experiments performed by student in the semester followed by sample questions to judge the depth of understanding/knowledge or skill acquired by the student. It shall be evaluated by two examiners out of which one examiner shall be out of institute.

ET310NC POWER ELECTRONICS LAB

Teaching Scheme	**:** 02P; Total: 02 hours/week	**Credits**:	01
Evaluation Scheme	**: 3**0 ICA + 20 ESE	**Total Marks:**	50

COURSE DESCRIPTION

This course deal with the practical exposure to fundamentals of power semiconductor devices, construction, working principles, their ratings, characteristics, performance and application of power converters like AC to DC, DC to DC, DC to AC and AC to AC

DESIRABLE AWARENESS/SKILLS

Concepts and theory of the course ET304NC Power Electronics

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. demonstrate the V-I characteristics and switching behavior of power semiconductor devices such as SCR, TRIAC, and IGBT.
2. **i**mplement and analyze triggering techniques for SCR, TRIAC, and GTO to control power flow in different circuits.
3. **d**esign and test AC-DC, DC-DC, DC-AC, and AC-AC converter circuits using physical setup and simulation tools like MATLAB, PSpice, or Proteus.
4. **i**nterpret output waveforms and calculate key performance parameters (average voltage, RMS values, etc.) for various converter and inverter circuits under different load conditions.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2										3	1	
2	2	2	3	2	3								3	2	
3	2	2	3	2	3								3	2	

1-Weakly correlated **2-Moderately correlated** **3- Strongly correlated**

COURSE CONTENT

Minimum eight experiments shall be performed to cover entire curriculum of course ET304NC. For simulation, MatLab, SciLab, Proteus, PSpice, PSim, etc. one of the available tool may be used. Following list of experiments is just a guideline.

- SCR, TRIAC, IGBT V-I characteristics
- SCR/TRIAC/GTO - triggering methods
- Converter - single phase half wave and full wave
- Converter - single phase half controlled (semi-converter)
- Chopper - step up, step down
- Inverter – series, parallel, bridge
- Converter- single phase AC to AC
- Simulation - AC to DC, DC to DC, DC to AC, AC to AC converters

Note

- **ICA -** It shall support for regular performance of practical and its regular assessment. In addition; it shall be based on knowledge/skill acquired and record submitted by student (journal) based on practical performed by him/her. The performance shall be assessed experiment wise using internal continuous assessment format.

- **ESE –** It shall be based on performance in one of the experiments performed by student in the semester followed by sample questions to judge the depth of understanding/knowledge or skill acquired by the student. It shall be evaluated by two examiners out of which one examiner shall be out of institute.

ET311N BIOMEDICAL ENGINEERING
(Honours Course)

Teaching Scheme	**:** 03L, Total: 03 hours/week	**Credits :**	03
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course provides necessary background to understand the history and appreciate the field of biomedical engineering. It includes introduction to the biomedical instrumentation and measurement, anatomy and function of heart, the human nervous and muscular system, human respiratory system and its measurements, imaging techniques and telemetry system. The course is designed to introduce the students to the basic principles and applications of sensors, medical oscilloscopes, analog and digital instruments. This course provides instruction in the theory and application of biomedical instruments.

DESIRABLE AWARENESS/SKILLS

Knowledge of basic electronics instrumentation, electronics measurement, component devices and instrument technology

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. demonstrate the knowledge of the modern health care system and role played by biomedical engineers.
2. evaluate the sources of biomedical signals, basic medical instrumentation system.
3. analyze man-instrument system and implement the problems encountered in attempting to obtain measurement from living body.
4. explain the fundamental principles of X-ray generation and the physics underlying X-ray imaging.
5. demonstrate an understanding of various medical imaging techniques and their underlying physical principles.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3		1										3	2	
2	2	2	1		2								3	2	
3	2	2	2		2								3	2	2
4	3		1										3	2	
5	3		1										3	2	

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Biomedical Engineering **[07 Hrs]**

The evolution of modern health care system, modern health care system, role played by biomedical engineers, recent advances in biomedical engineering, prosthetics, orthopedic, neural, tissue engineering, stem cell research, professional status of biomedical engineering, professional societies, the American institute for medical and biological engineering, IEEE engineering in medicine and biology society, the biomedical engineering society.

Introduction to Human Body and Related Measurement **[07 Hrs]**

Basics of biomedical instrumentation system, anatomy and physiology of the human body, physiological systems of the body, sources of biomedical signals, basic medical instrumentation system; Transducers and sensors: pressure transducers, transducer for temperature measurement, displacement, position and motion transducers, photoelectric transducers, optical fiber sensors, biosensors, smart sensors.

Cardiovascular System **[08 Hrs]**

Heart and cardiovascular system, heart, blood pressure, characteristics of blood flow, heart sound. Cardiovascular measurement: electrocardiography, Electrocardiogram (ECG) amplifiers, electrodes and leads, ECG recorder principles, types of ECG recorder, single channel, three channel, vector electrocardiographs, electrocardiograph system for stress testing, electrocardiograph for computer processing, continuous ECG recording .measurement of blood pressure, measurement of blood flow and cardiac output, measurement of heart sounds, pacemakers.

Biomedical Recorders **[07 Hrs]**

Electrocardiograph, block diagram of electrocardiograph, ECG leads, microprocessor based ECG machine, multi-channel ECG machine, Vector Cardiograph (VCG), Phonocardiogram (PCG) machine, origin of heart sounds, microphones for phonocardiography, amplifiers for phonocardiography, writing method for phonocardiography, Electroencephalogram (EEG) machine, Electromyogram (EMG) machine.

X-ray Machines and Digital Radiography **[07 Hrs]**

Basis of diagnostic radiology, generation of ionizing radiation, detection of radiation, instrumentation for diagnostic X ray, visualization of X -ray, fluoroscopy, X-ray films, image intensifier, nature of X-ray, production of X-rays, X-ray machine, visualization of X-ray machines, portable and mobile X-ray units, digital radiography.

Ultrasonic Imaging Systems and Others **[06 Hrs]**

Diagnostic ultrasound, physics of ultrasonic waves, medical ultrasound, basic pulse-echo apparatus, A-scanner, B-scanner, real time ultrasonic imaging system, biological effects of ultrasound, audiometer and audiometric tests and types, defibrillator, pacemakers,

computerized monitoring system, grounding and safety.

Text Books

1. Bio-medical Instrumentation, R. S. Khandpur, 2nd edition, TMH, 2012
2. Biomedical Instrumentation and Measurements, Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, 2nd edition, PHI1980

Reference Books

1. Introduction to Biomedical Engineering, John D. Enderle and Bronzino, 3 rd edition, AP, 2014
2. Biomedical Signal Analysis: A Case study approach, R. M. Rangayyan, IEEE Press, 2001

ET312N BIOMEDICAL ENGINEERING LAB
(Honours Course)

Teaching Scheme	**:** 02P, Total: 02 hours/week	**Credits :**	01
Evaluation Scheme	**:** 30 ICA + 20 ESE	**Total Marks:**	50
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course provides necessary background to understand the history and appreciate the field of biomedical engineering. It includes introduction to the biomedical instrumentation and measurement, anatomy and function of heart, the human nervous and muscular system, human respiratory system and its measurements, imaging techniques and telemetry system. The course is designed to introduce the students to the basic principles and applications of sensors, medical oscilloscopes, analog and digital instruments. This course provides instruction in the theory and application of biomedical instruments.

DESIRABLE AWARENESS/SKILLS

Knowledge of basic electronics instrumentation, electronics measurement, component devices and instrument technology

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. explain the working principles of biomedical electrodes and sensors used for measuring physiological parameters like ECG, blood pressure, pulse rate, and body temperature.
2. **d**emonstrate the operation and clinical relevance of biomedical instruments such as ECG machines, pacemakers, audiometers, spectrophotometers, and blood cell counters.
3. **a**nalyze the application of imaging and diagnostic tools including ultrasound, X-ray, fluoroscopy, and ionizing radiation in medical practice.
4. **e**valuate biomedical measurement systems with respect to safety, grounding, and data transmission (e.g., telemetry), and gain practical exposure through hospital/medical equipment visits.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2		1										2	2	
2	2	2	1										2	2	2
3	2		1										2	2	
4	2	2	1										2	2	

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Minimum eight experiments shall be performed to cover entire curriculum of the course ET311N. The list given below is just a guideline.

- Study different biomedical electrodes.
- Measurement of Blood Pressure by direct and indirect method.
- ECG amplifier to measure amplitude and frequency
- Record of PQRST waveform using ECG machine.
- Measurement of pulse rate.
- Study of measurement of temperature of human body direct and indirect method.
- Study of pace maker unit to compare the operation of heart with the normal functioning of heart.
- Study of audiometer, audiogram.
- Study of blood cell counter to measure cell counts.
- Study of spectrophotometer.
- Use of ultrasound in medical electronics.
- Study of generation of ionizing radiation.
- Study of visualization of X -ray, fluoroscopy.
- Study of temperature telemetry system to measure the received data.
- Study of grounding and safety issues.
- Visits to hospital/ medical college for the study of instruments which are included in above practical

Note

- **ICA –** Internal Continuous Assessment shall support for regular performance of practical and its regular assessment. In addition; it shall be based on knowledge/skill acquired and record submitted by student (journal) based on practical performed by him/her. The performance shall be assessed experiment wise using internal continuous assessment format.
- **ESE -** End Semester Examination (ESE) for this laboratory course shall be oral examination based on experiments performed / assignments covered in ET312N. It shall be evaluated by two examiners out of which one examiner shall be out of institute.

ET351N ELECTROMAGNETIC FIELDS AND ANTENNAS

Teaching Scheme	**:** 03L, Total: 03 hours/week	**Credits :**	03
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course is designed to lay the foundation for studies in areas such as microwave communication, antenna and wave propagation etc. This will explore the basic concepts of electromagnetic fields and vector algebra. This will allow learning and understanding Cartesian, cylindrical and spherical coordinate systems. They will learn to visualize in a three dimensional coordinate system. In this course, more emphasis is given on understanding basics, visualizing the system and solving a large number of numerical problems.

DESIRABLE AWARENESS/SKILLS

Knowledge of basic mathematics, vector algebra, visualization skills, and an aptitude to solve problems

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. demonstrate the understanding of the basics of electromagnetic fields and be able to apply these basics in a variety of applications.
2. visualize along three axes and develop visual thinking capability.
3. demonstrate the skill of understanding hidden messages in any mathematical equation.
4. apply different laws such as Faraday's law, Biot-Savart law, Maxwell's equations to solve numerical examples.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2	2	2	3	2	3	3				3		
2	3	2	2	2	2								3		
3	3	2	2	2	2								3		
4	3	2	2	2	2								3		

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Vector Calculus, Electrostatics and Transmission Lines [12 Hrs]

Coordinate system, transformations of coordinate systems, coulomb's law, electric field intensity, field due to a continuous volume charge distribution, field of a line charge, field of a sheet of charge and volume charge densities, electric flux density, Gauss's law and divergence theorem, work done, potential and potential gradient, dipole and its electric field, dipole moment, energy density in electrostatic field, introduction to transmission lines, concept of distributed elements, equations of voltage and current, standing waves and impedance transformation, applications of transmission lines, introduction to smith chart

Conductor, Dielectrics and Capacitance [6 Hrs]

Current and current density, current continuity equation, properties of conductors, boundary conditions, boundary conditions for perfect dielectric materials, capacitance, capacitance of a two wire line, Poisson's and Laplace's equations

Magneto Statics [10 Hrs]

Biot-Savart's law and its vector form, magnetic field due to infinitely long current carrying conductor, ampere's circuital law, curl, Stoke's theorem, magnetic flux and magnetic flux density, scalar and vector magnetic potential, Faraday's law, Maxwell's equations (in point form and integral form), uniform plane waves, representation of wave motion in free space, perfect dielectrics and lossy dielectrics (wave equations), Poynting theorem and power density, propagation in good conductor: skin effect, reflection of uniform plane waves, standing wave ratio

Waveguides and Antennas [12 Hrs]

Parallel plane waveguide: Transverse Electric (TE) mode, Transverse Magnetic (TM) mode, cut off frequency, phase velocity and dispersion, Transverse Electromagnetic (TEM) mode, analysis of waveguide: general approach, rectangular waveguides, modes in rectangular waveguides, boundary conditions; Radiation resistance, radiation pattern, calculation of radiation resistance for short dipole, short monopole, half wave dipole and quarter wave monopole antennas, directivity, reciprocity between transmitting and receiving antennas, Hertzian dipole, near field far field, total power radiated by hertz dipole, folded dipole antenna, Yagi-Uda antenna

Text Books

1. Engineering Electromagnetics, William H. Hayt and John A. Buck, Tata McGraw Hill, 8th Revised edition, 2011.
2. Antenna and Wave Propagation, K. D. Prasad, Satya Prakashan, 3rdedition, Tech Publications, 2001
3. Microwave Devices and Circuits, S.Y.Liao, 3rdedition, Prentice Hall of India,1996.
4. Electromagnetism problems with solutions, Ashutosh Pramanik, 3rd edition, Prentice Hall of India, 2012

Reference Books

1. Engineering Electromagnetics, Nathan Ida, 3rd edition, Springer, 2015.
2. Engineering Electromagnetics, N. Rao, 6th edition, Prentice Hall, 2004.
3. Foundations for Microwave Engineering, R.E.Collin, 2ndedition, Tata McGraw- Hill Publication, 1992.

ET352N MOBILE COMMUNICATION

Teaching Scheme	**:** 02L, Total: 02 hours/week	**Credits :**	02
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course will explore the basic concepts of mobile communication. It is designed to understand and learn various concepts of mobile termination, terminal equipment and mobile equipment. It emphasizes is given on analysis of performance of mobile communication systems. This course is designed to lay the foundation for further studies in areas such as advanced communication systems.

DESIRABLE AWARENESS/SKILLS

Knowledge of basic mathematics and communication systems

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. demonstrate the knowledge of principles and concepts of mobile communication.
2. illustrate the principles of frequency management, channel assignments and hand-off.
3. explain the principles and architecture of GSM, GPRS and EDGE.
4. explain the principles and architecture of UMTS, WCDMA and CDMA-2000.
5. demonstrate the knowledge of principles and concepts of 4G and 5G technologies.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2	1		1							3	3	2
2	3	1	1	1	2	2							2	3	1
3	2	3	3	2	1		1						3	2	
4	3	2	2	3	3	2	1					2	1	3	3
5		3	3		2							2	3	3	2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Fundamentals of Mobile Communication **[6 hours]**

Introduction, mobile radio telephony, examples of wireless communication systems, related design problems, frequency reuse, channel assignment strategies, interface and system capacity, trunking and grade of service, improvement of coverage and capacity in cellular systems, Fading

Frequency Management and Channel Assignments **[5 hours]**

Frequency management, frequency spectrum utilization, set up channels, fix channel assignment schemes, non-fixed channel assignment schemes, delaying of handoff, forced and soft handoff, dropout calls

Second Generation Technology **[5 hours]**

Introduction to GSM, GPRS and EDGE architecture, radio specifications channels, IS-95: architecture of CDMA system, CDMA air interface, power control in CDMA system, handoff, rake receiver

Third Generation Technology **[6 hours]**

UMTS: Objectives, standardization, network architecture, air interface specifications, channels security procedure, W-CDMA air interface, attributes of W-CDMA system; CDMA-2000 cellular technologies: forward and reverse Channels, handoff and power control

LTE, 4G, 5G Technologies **[6 hours]**

Introduction, system overview, physical layer, logical and physical channels; Physical layer procedures: establishing a connections, retransmissions and reliability, power control and handover, introduction to 4G and 5G technologies, future aspects of mobile communication and scope

Text Books

1. Wireless Communications, Principles and Practice, T. Rappaport, Pearson Education, 3rd Edition.
2. Mobile Communications, J. Schiller, 2nd Edition, Pearson Education.

Reference Books

1. Mobile Cellular Telecommunication Systems, William C.Y. Lee, 2nd Edition, TMH, New Delhi.
2. Wireless and Mobile Communications, Upena Dalal, 1st Edition, Oxford University Press.
3. 4G, LTE advanced, E. Dahlman, 3rd Edition, Academic Press.

ET353N LINEAR INTEGRATED CIRCUITS

Teaching Scheme	**:** 02L, Total: 02 hours/week	**Credits :**	02
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course is designed to introduce students to the basic concepts of operational amplifier (Op-amp), linear and nonlinear application of op-amp. It covers design and analysis of frequency selective and tuning circuits like oscillators, active filters, regulated power supply, Phase Locked Loop (PLL) and its use for communication applications. Course content finds a due scope to learn Integrated Circuit (IC) based design of switching applications like comparators.

DESIRABLE AWARENESS/SKILLS

Knowledge of electronic components/devices and their applications in analog electronics

COURSE OUTCOMES

On the successful completion of this course; student shall be able to

1. discuss the operation and parameters of op amp.
2. predict the component values of the linear and non-linear circuits of op-amp.
3. compute the component values of frequency selective circuits and oscillators.
4. describe PLL and its basic applications.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	2	2	1									1	1	
2	3	3	3	1									2	3	
3	3	3	3	1									2	3	
4	3	3	3	1									2	2	

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Operational Amplifier (Op-amp): [**6 Hrs]**

Introduction, block schematic, dc level shifting stage, constant current and voltage sources, output power stage, ac and dc op-amp parameters, offset null techniques of op-amp, data sheet interpretation of IC 741, frequency response and stability, frequency and phase compensation techniques.

Applications of Op-amp: **[10 Hrs]**

Linear applications: Inverting and non-inverting amplifier, voltage follower, peak amplifier, analog adder, differential/instrumentation amplifier, bridge amplifier, integrator and differentiator, voltage to-current and current-to-voltage converters, log/antilog amplifiers.

Non-linear Applications: Comparators – basic configurations and characteristics, comparator IC 710, comparator applications – peak detectors, window detector, multi-vibrators and Schmitt's trigger. Timer IC 555 – block schematic, pin diagram, operation, applications – timer circuit, multi-vibrators and Schmitt's trigger.

Frequency Selective Circuits and Oscillators: **[8 Hrs]**

Active filters – types and responses, analysis and synthesis of first, second and higher order Butterworth's active filters.

Oscillators: Square-triangle wave oscillators, relaxation oscillators, pulse generators, and Schmitt's trigger. Sine wave oscillators - R- C phase shift and Wien bridge oscillators; voltage to frequency convertor - voltage controlled oscillator IC 566, frequency to voltage convertor.

Phase Lock Loop (PLL): **[4 Hrs]**

PLL – operating principles, lock and capture range, PLL IC 565; PLL applications – am and fm detection, Frequency Shift Keying (FSK) decoder, frequency synthesizer.

Text Books

1. Op-amps and Linear Integrated Circuits, Ramakant. A. Gayakwad Contributor: Rekha S., revised 4th edition, Pearson, 2021

2. Linear Integrated Circuits, D. Roy Choudhari, Shail Bala Jain, 6th edition, New Age International (P) limited, 2021

3. Operational Amplifiers and Linear ICs, D. A. Bell, 3rd edition, Oxford University Press, 2011

Reference Books

1. Design with Operational Amplifiers and Analog Integrated Circuits, S. Franco, 4th edition, Tata McGraw Hill, 2014

2. Operational Amplifiers & Linear Integrated Circuits: Theory and Application, James M. Fiore, 3rd edition, Version 3.2.6, ISBN13: 978-1796856897, 2021

ET355NA COMPUTER NETWORKS

Teaching Scheme	**:** 03L, Total: 03 hours/week	**Credits :**	03
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course explores the basic concepts of computer communication, transmission modes, networks, interconnection of networks, network models, application of different layers and logical addressing. The course also covers the introduction to system and network security, security attacks, firewalls, intrusion detection systems and designed to lay the foundation for further studies in areas such as advanced communication systems.

DESIRABLE AWARENESS/SKILLS

Knowledge of basic electronics engineering, analog and digital communication systems

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. describe the basic concepts of computer networks, including types, topologies, models, transmission media, and network devices.
2. explain data link layer functions such as framing, error control, flow control, and MAC techniques for wired and wireless LANs.
3. analyze network layer operations including IP addressing, sub-netting, routing protocols, and address resolution.
4. illustrate transport and application layer protocols, including TCP, UDP, congestion control, QoS, and common internet applications.
5. demonstrate the understanding of network security concepts, threats, cryptographic techniques, and security mechanisms across network layers.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2										3	1	
2	2	2	3	2	3								3	2	
3	2	2	3	2	3								3	2	
4	3		3	2									3	3	
5	2			3	2								2		2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Introduction to Computer Communication [06 Hrs]

Types of Networks: Local area networks (LAN), Metropolitan area networks (MAN), Wide area networks (WAN), Wireless networks, Networks Software, Protocol, Design issues for the Network layers. Network Models: The OSI Reference Model, TCP/IP Model, Network Topologies, Types of Transmission Medium. Network Architectures: Client-Server, Peer To Peer, Hybrid. Network Devices: Bridge, Switch, Router, Gateway, Access Point, Frequency Hopping (FHSS) and Direct Sequence Spread Spectrum (DSSS)

Data Link Layer [09 Hrs]

Physical layer: Guided and unguided transmission media (co-axial cable, Unshielded Twisted Pair (UTP), Shielded Twisted Pair (STP), fiber optic cable); Data Link Layer: Framing, flow control (stop and wait, sliding window flow control) error control, error detection(check sum, Cyclic Redundancy Check (CRC), bit stuffing, High-level Data Link Control (HDLC); Media access control: Ethernet (802.3), Carrier-Sense Multiple Access with Collision Detection (CSMA/CD), logical link control, Wireless Local Area network (LAN) (802.11), Carrier-Sense Multiple Access with Collision Avoidance (CSMA/CA)

Network Layer [09 Hrs]

Network layer logical addressing: Internet Protocol (IPv4 and IPv6); Address Resolution Protocols (ARP), Reverse Address Resolution Protocols (RARP); Subnetting, Classless Inter-Domain Routing (CIDR), Internet Control Message Protocol (ICMP), Internet Group Management Protocol (IGMP), Dynamic Host Configuration Protocol (DHCP), Virtual LAN,Routing Algorithm:Routing: Routing and forwarding, static and dynamic routing, routing algorithms, protocols: Routing Information Protocol (RIP), Open Shortest Path First (OSPF), Border Gateway Protocol (BGP), Multi-Protocol Label Switching (MPLS)

Transport and Application Layer [08 Hrs]

User Datagram Protocol (UDP), TCP/IP-1; data traffic, congestion, congestion control, Quality of Services (QoS) and flow characteristics; Application Layer: Domain Name System (DNS), Remote logging (Telnet), Simple Mail Transfer Protocol (SMTP), File Transfer Protocol (FTP), World Wide Web (WWW), Hyper Text Transfer Protocol (HTTP), Post Office Protocol-3 (POP3), Multipurpose Internet Mail Extensions (MIME), Simple Network Management Protocol (SNMP)

Security [08 Hrs]

Security services, Need of Security, Key Principles of Security, Threats and Vulnerabilities, Types of Attacks, ITU-T X.800 Security Architecture for OSI, Security Policy and mechanisms, Operational Model of Network Security, Symmetric and Asymmetric Key Cryptography. Security in Network, Transport and Application: Introduction of IPSec, SSL, HTTPS, S/MIME, Overview of IDS and Firewall

Text Books

1. Data Communications and Networking, B. A. Forouzan, 4th Edition, Tata McGraw-Hill, 2008
2. Computer Network, A. S. Tanenbaum and D. J. Wetherall, 5th Edition, Pearson, 2011
3. Data and Computer Communications, W. Stallings, 8th Edition, Pearson, Prentice Hall of India, 2007

Reference Books

1. Cryptography and Network Security , B. A. Forouzan, 4th Edition, Tata McGraw-Hill, 2008
2. Computer Network - A System Approach, L. Peterson and B. S Davie, 4th Edition, Elsevier India, 2011
3. An Engineering Approach to Computer Networking, S. Keshav, 5th Edition, Pearson Education, 2010

ET355NB WIRELESS SENSOR NETWORKS

Teaching Scheme	**:** 03L, Total: 03 hours/week	**Credits :**	03
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course provides a comprehensive knowledge of Wireless Sensor Networks (WSN), sensor node hardware architecture, network protocols as well as the applications of wireless sensor networks.

DESIRABLE AWARENESS/SKILLS

Knowledge of basic concepts in digital communication and computer networking

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. demonstrate the knowledge of basic concepts of wireless sensor networks.
2. illustrate various operating systems required for WSN.
3. explain the design constraints and principles of network architecture.
4. compare different network and routing protocols.
5. identify different data manipulation techniques suitable for the applications of wireless sensor networks.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	3	2	3									1	3	2
2	2	3	1	3									1	3	2
3	2	3	2	3									1	3	2
4	2	3	2	2									1	3	2
5	2	3	2	3									1	3	2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Introduction **[6 Hours]**

Motivation for a Network of Wireless Sensor Nodes, Definitions and Background, Challenges and Constraints, Applications, Node Architecture

Operating System for WSN **[6 Hours]**

Operating Systems, Functional and Nonfunctional Aspects of OS, OS for WSN.

Basic Architectural Framework **[12 Hours]**

Physical Layer: Source Encoding, Channel Encoding, Modulation.

Medium Access Control (MAC): Wireless MAC Protocols, Characteristics of MAC Protocols.

Network Layer: Routing Metrics, Data-Centric Routing, Proactive Routing, On-Demand Routing, Hierarchical Routing, Location-Based Routing.

Node and Network Management **[8 Hours]**

Power Management: Local Power Management Aspects, Dynamic Power Management.

Localization: Ranging Techniques, Range-Based Localization, Range-Free Localization.

Case Studies of WSN Applications **[8 Hours]**

Detecting unauthorized activity using a sensor network, WSN for Habitat Monitoring, Building automation, industrial automation, medical applications

Text Books

1. Fundamentals of Wireless Sensor Networks: Theory and Practice, W. Dargie and C. Poellabauer, John Wiley and Sons, India, 2011.
2. Protocols and Architectures for Wireless Sensor Networks, H. Karl and A. Willig, John Wiley and Sons, India, 2012.
3. Wireless Sensor Networks, C. S. Raghavendra, K. M. Sivalingam, and T. Znati, Editors, Springer Verlag, 1st Indian reprint, 2010.

Reference Books

1. Wireless sensor Network and Applications, Yingshu Li, MyT. Thai, Weili Wu, Springer series on signals and communication technology, 2008
2. Wireless sensor Network: Technology, Protocols and Application, Kazem, Sohraby, Daniel Minoli, TaiebZanti, 1st edition, John Wiley and Sons, 2007
3. Wireless Sensor Networks: An Information Processing Approach, F. Zhao and L. Guibas, Morgan Kaufmann Publishers, 1st Indian reprint, 2013

ET355NC Digital Audio Processing

Teaching Scheme	**:** 03L, Total: 03 hours/week	**Credits :**	03
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course introduces students to the principles and techniques of digital audio processing. It covers the fundamentals of audio signals, transforms, and digital filters, leading to advanced concepts such as audio compression, enhancement, and effects. The course provides an in-depth theoretical foundation, preparing students for advanced studies or industry applications in audio technology.

DESIRABLE AWARENESS/SKILLS

Knowledge of digital signal processing

Course Outcomes

On the successful completion of this course; student shall be able to -

1. demonstrate the understanding of the nature and characteristics of audio signals.
2. analyze audio signals using mathematical techniques.
3. design digital filters for audio applications.
4. explain the principles behind audio effects and enhancement systems.
5. demonstrate the knowledge of modern audio coding, compression techniques, and audio system.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2										3	1	
2	2	2	3	2	3								3	2	
3	2	2	3	2	3								3	2	
4	3		3	2									3	3	
5	2			3	2								2		2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Introduction to Digital Audio [5 Hours]

Physics of sound and audio signals – sound, wavelength, frequency, harmonics, phase, octaves, spectrum, decibels, reference levels, acoustic power; Human auditory perception and psychoacoustics - Sensitivity of ear, anatomy and physiology of ear, sound perception, response of the ear to complex stimuli, localization of sound sources, pitch versus frequency and timbre versus spectrum; Sound level perception - loudness versus freq, loudness versus Sound Pressure Level (SPL), loudness versus bandwidth, audibility of loudness changes; Audio signal acquisition - Analog to digital conversion of audio, sampling rate, quantization, and bit depth, auditory freq ranges for speech and music

Speech Processing [5 Hours]

Speech production – anatomy and physiology of speech organs, acoustic theory of speech production; Digital models for speech signals – vocal tract, radiation, excitation, complete model; articulatory phonetics, acoustic phonetics, co-articulation, prosody, pitch, formant

Audio Signal Analysis [8 Hours]

Short-Time Fourier Transform (STFT), Spectrograms and time-frequency analysis of audio and speech, Wavelet transforms for audio analysis; Basic speech features – loudness features, timbral features, rhythmic features, statistical features; Pitch estimation by time-domain (autocorrelation), frequency domain (Fourier transform) and cepstral domain (cosine transform) methods, Feature extraction techniques - LPC, MFCC, PLP, DWT

Digital Filters for Audio [5 Hours]

Audio filters: low-pass, high-pass, band-pass, notch filters, octave filters, shelving and peak filters, weighting filters; filter structures - canonical, state variable, phase response; Recursive filter, parametric filter structure, phase delay and group delay; Parametric EQ (gain (boost), center (primary) frequency and bandwidth (Q-factor)); recursive and non-recursive design with different filter structures

Audio Effects and Enhancement [6 Hours]

Noise and distortion, SNR, additive vs convolution noise, Room acoustics - room impulse response – measurement and simulation, principles of reverb, echo, and delay; Audio effects – wah wah effect, phasing effect, delay-based effects - vibrato, chorus, flanger effects; Dynamic range processing: limiting, compression and expansion, Audio restoration – click removal, background noise removal, enhancement techniques - spectral subtraction and filtering, harmonic filtering, parametric re-synthesis

Audio Coding and Compression [5 Hours]

Lossless and lossy audio compression, Perceptual coding models and psychoacoustic masking; Overview of audio codecs: MP3, AAC, Ogg Vorbis, FLAC, Bit rate management and quality trade-offs

Audio System Design and Applications [7 Hours]

Music signal processing basics – music transcription, note transcription, structure detection; spatial sound theory – concepts of spatial hearing, spatial effects for stereophonic loudspeaker and headphone playback, Binaural techniques in spatial audio; Sound Source Separation – General principles, beam forming and frequency domain independent component analysis, statistically motivated approaches, perceptually motivated approaches; Real-time audio processing considerations – latency, scalability, upgradeability, adaptive algorithms, hardware acceleration

Text Books

1. Master Handbook of Acoustic, F. Alton Everest and Ken Pohlmann, McGraw Hill, 7th edition, 2021.
2. Speech Communications, Douglas O'Shaughnessy, Wiley-IEEE Press, 2nd edition, 2000.
3. DAFX: Digital Audio Effects, Zölzer, Udo, John Willey & Sons, 2nd edition, 2011
4. Audio Processing and Speech Recognition – Concepts, Techniques and Research Overview, Soumya Sen, Anjan Dutta, Nilanjan Dey, Springer Briefs in Applied Sciences and Technology, 1st edition, 2019

Reference Books

1. Digital Processing of Speech Signals, L. R. Rabiner and R.W.Schafer, Prentice Hall, 1978
2. Introduction to Digital Filters: with Audio Applications, Smith, Julius O., W3K Publishing, 2007.
3. Pohlmann, Ken C., Principles of Digital Audio, McGraw-Hill, 6th edition, 2010.
4. Hack Audio: An Introduction to Computer Programming and Digital Signal Processing in MATLAB, Eric Tarr, Focal press, 2010
5. Digital Audio Signal Processing, Zölzer, Udo, John Wiley & Sons, 2008.

ET356NA AUDIO VIDEO ENGINEERING

Teaching Scheme	**:** 03L, Total: 03 hours/week	**Credits :**	03
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course is designed to explore fundamental principles and practical aspects of audio and video engineering. The course covers basic concept of microphones ,loudspeakers ,sound recording , reproduction, monochrome and color television. It provides comprehensive coverage of advanced Television (TV) systems, different advanced broadcasting systems compression techniques.

DESIRABLE AWARENESS/SKILLS

Knowledge of basic concepts of analog and digital communication

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. demonstrate the understanding of principles of acoustics and sound reproduction systems.
2. explain the basic principles of black-and-white television systems.
3. demonstrate an understanding of color television systems.
4. describe digital television systems and transmission techniques.
5. evaluate advanced broadcasting technologies.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2										3	1	
2	2	2	3	2	3								3	2	
3	2	2	3	2	3								3	2	
4	3		3	2									3	3	
5	2			3	2								2		2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Acoustics **[09 Hrs]**

Acoustics and reverberation, monophony, stereophony, High Fidelity (Hi-Fi) system, public address (PA) system: Block diagram, requirement, characteristics, its planning for various uses ; Microphones: Introduction, characteristics of a Microphone, requisites of a Good Microphone, comparisons of various types of Microphones; Loudspeakers: Characteristics of loudspeakers, introduction to various types of loudspeakers; Optical recording : Types of optical recording of sound, methods of optical recording of sound on Film, reproduction of sound from Films, compact disc, playback process, introduction to Blu-ray disc

Television Fundamentals : **[09 Hrs]**

Scanning, synchronization, aspect ratio, resolution, bandwidth, composite video signal, modulation of video and audio signals, compatibility, luminance and Chrominance signal, Introduction to Picture tubes and camera tubes

Fundamentals of Color Television **[08 Hrs]**

The basic Television system and scanning principles, Composite video signal and television standards, color TV systems, fundamentals, mixing of colors, color perception, chromaticity diagram, Introduction to different system concepts: Phase Altering Line (PAL), Sequential Color and Memory (SECAM), National Television Systems Committee (NTSC) system, color TV transmitter and receiver block diagram

Digital TV and Display Devices **[08 Hrs]**

Introduction to Digital TV, digital TV signals and parameters, digital TV Transmitters, digital TV receivers, High-Definition TV (HDTV) transmitter and receiver, Basic principles of digital video compression techniques, JPEG, MPEG techniques . Display devices: LED, OLED, LCD, Plasma

Advanced Broadcasting Systems **[06 Hrs]**

Introduction to digital cable TV, Conditional Access System (CAS), Direct to Home (DTH) system, video on demand, introduction to 3D Digital Terrestrial TV (DTV) system, study of Closed Circuit TV (CCTV) and DTV, introduction to Internet Protocol (IPTV) and mobile TV, Introduction to CATV

Text Books

1. TV and video Engineering, A. M. Dhake, 2nd Edition, McGraw Hill,
2. Modern Television Practice, R. R. Gulati, 2nd Edition, McGraw Hill, 2002
3. Audio and Video Systems, R. G .Gupta, 2nd Edition, McGraw Hill, 2010
4. Telecommunication Switching Systems and Networks, Thiagarajan Viswanathan, 36th printing, PHI Learning Private Limited, 2012

Reference Books

1. Television Engineering and Video Systems, R. G. Gupta, 2nd Edition, McGraw Hill,
2. Television and video Engineering, A. M. Dhake, McGraw Hill, 2nd Edition, 2007,
3. Basics Television and Video Systems, Bernard Grob, 5th Edition, McGraw Hill,1998

ET356NB VLSI DESIGN

Teaching Scheme	**:** 03L, Total: 03 hours/week	**Credits :**	03
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course introduces the way digital circuits are designed in practice today. The emphasis is on modern design methodology using Computer Aided Design (CAD) to meet desired specifications. This course is extension to digital logic design. This course introduces the role of Hardware Description Language (HDL), Verilog Hardware Description Language (VHDL) and Verilog in conceptual structures, descriptions and processing in VLSI system design.

DESIRABLE AWARENESS/SKILLS

Knowledge of digital electronics and digital system design

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. design a system, component or process as per needs and specifications.
2. model digital system using HDL.
3. analyze complex microelectronics circuits and systems.
4. demonstrate the understanding of architectures of complex systems such as FPGAs and CPLDs.
5. explore various issues and constraints in design of an ASIC.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	3		2								3	1	2
2	2	2	3	2	3								3	2	2
3	2	3	3	2	3								2	2	2
4	3	2	2	1									3	3	2
5	2	3	3	3	2								2	3	2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Introduction to HDL Design **[09 Hrs]**

Structure of the Hardware Description (HDL) module, data types; operators, Structure of various description styles, signal declaration and signal assignment statements, concurrent signal assignment statements, constant declaration and assignment statements, variable assignment statements, HDL Description of Combinational Networks, Modeling of Flip-flops, VHDL models for Multiplexers, Modeling a sequential machine.

Digital CMOS Circuits **[06 Hrs]**

N-MOS, P-MOS and Complementary Metal Oxide Semiconductor (CMOS), MOSFET parasitic, technology scaling, channel length modulation, hot electron effect, velocity saturation, CMOS inverter, device sizing, CMOS combinational logic design, power dissipations, power delay product, body effect, rise and fall times, latch up effect, transmission gates.

Digital Design and Issues **[08 Hrs]**

Sequential synchronous machine design, Moore and Mealy machines, HDL code for machines, FIFO, metastability and solutions, noise margin, fan-out, skew, timing considerations, hazards, clock distribution, clock jitter, supply and ground bounce, power distribution techniques, power optimization, interconnect routing techniques; wire parasitic, signal integrity issues; design for testability.

Programmable Logic Devices **[07 Hrs]**

Complex Programmable Logic Devices (CPLD) architecture, organization of Field Programmable Gate Arrays (FPGAs), FPGA programming technologies, programmable logic block architectures; programmable interconnects, programmable input output blocks in FPGAs, dedicated specialized components of FPGAs, and applications of FPGAs.

Application Specific Integrated Circuit (ASIC) Design **[10 Hrs]**

ASIC design flow, CMOS Fabrication process, steps and Layout: Inverter Cross-Section, Fabrication Process, Layout Design Rules, Gate Layouts, Stick Diagrams, Physical Design: Floor-planning, Standard Cells, Pitch Matching, Slice Plans, Arrays, Area Estimation.

Text Books

1. HDL Programming Fundamentals VHDL and Verilog, N. Botros, Thomson Learning Inc., 2005
2. CMOS VLSI Design: A Circuit and System Perspective, E. Weste, D. Harris, 4th Edition, Pearson Publication, 2011

Reference Books

1. Digital Systems Design using VHDL, C. Roth, PWS Publishing Company, 2007
2. Digital Design, M. Morris Mano, 3 rd Edition, Pearson, 2017
3. Digital Design Principles and Practices, J. Wakerly, 4 th Edition, Prentice Hall, 2008

ET356NC Information Theory and Coding Techniques

Teaching Scheme	**:** 03L, Total: 03 hours/week	**Credits :**	03
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course imparts the basic concepts of information theory and coding techniques. In the course, emphasis is given on information theory, entropy, various source coding techniques for data compression and various channel coding techniques for error detection and correction. This course also briefly introduces contemporary issues and applications of coding techniques.

DESIRABLE AWARENESS/SKILLS

Knowledge of digital communication, probability and fundamentals of communication systems

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. demonstrate the knowledge of information theory and entropy.
2. design the source coding for the given information source using algorithms such as Shannon-Fano and Huffman coding.
3. design the channel coding scheme for the given requirements using techniques of block, cyclic and convolution codes.
4. select a suitable source and channel coding scheme for the given requirements.
5. demonstrate the knowledge of contemporary issues related to information coding.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	3	3	2							2	3	2	2
2	3	2	3	2	2								3	2	3
3	2	3	3	2	2								2	2	2
4	3	2	2	2	1								3	2	2
5	2		2		1							2	3	2	2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

Course Content

Introduction to Information Theory [06 Hrs]

Concept of information, entropy and its properties, Measure of information: self-information, average information, discrete memory-less sources, Shannon's Information Measures: Mutual information, channel capacity and data rate of a communication channel

Source Coding [08 Hrs]

Source coding theorem, coding techniques for memory-less sources: Huffman coding, optimality of Huffman coding, Shannon-Fano coding, arithmetic coding, Average code length, coding efficiency; coding techniques for sources with memory: LEMPEL-ZIV algorithm, Run length encoding

Channel coding and Linear Block Codes [10 Hrs]

Channel coding: Channel models, channel coding, noisy channel coding theorem, information capacity theorem, Shannon Limit.

Linear Block Codes: Introduction to error correcting codes, basic definitions, matrix description, coding using generator matrix and parity check matrix, decoding of linear block codes, syndrome decoding, error probability after coding, perfect codes, Hamming codes, maximum distance separable codes.

Cyclic Codes [07 Hrs]

Properties of cyclic codes, Introduction to cyclic code polynomials, the division algorithm, generation of code vectors in systematic and nonsystematic form, generator matrix for cyclic codes, decoding of cyclic codes using syndrome vector, burst error correction, cyclic redundancy check (CRC) codes

Convolutional Codes [07 Hrs]

Introduction, encoder, trellis and state diagram; polynomial description for convolutional codes, generating functions, decoding methods: Viterbi algorithm, distance bounds for convolution codes, calculation of free distance using transfer function

Applications and Contemporary Issues [04 Hrs]

Coding in wireless communication, Application of coding in satellite communication, digital television, audio and video compression standards

Text Books

1. Information Theory, Coding and Cryptography, Ranjan Bose, 2nd edition, McGraw Hill Publication, 2008
2. Modern Digital and Analog Communication, B.P. Lathi and Zhi Ding, 5th edition, Oxford University Press, 2018

Reference Books

1. Error Correction Coding, Todd K. Moon, Wiley India Edition, 2006
2. Introduction to Error Control Codes, Salvatore Gravano, 1st edition, Oxford University Press, 2007

ET357N MOBILE COMMUNICATION LAB

Teaching Scheme	**:** 02P, Total: 02 hours/week	**Credits :**	01
Evaluation Scheme	**:** 30 ICA + 20 ESE	**Total Marks:**	50
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course deals with practice performance on concept like GSM architecture, CDMA and various emerging technologies. The laboratory exercises are designed to give ability of 2G, 3G and basic communication concept.

DESIRABLE AWARENESS/SKILLS

Concept and theory of the course analog and digital communication

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. explain the fundamental architecture and working principles of GSM, CDMA, and VoIP systems.
2. demonstrate the use of AT commands to initiate voice and video calls and configure mobile devices.
3. analyze the signal processing involved in DSSS generation/demodulation and DTMF tone recognition.
4. measure and interpret hardware parameters such as test point voltages and identify functional components of a mobile phone.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2										2	3	2	2
2	2				3					2		2	2	2	3
3	2	3		2	2								3	3	2
4	2	2		3	3								2	3	2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Minimum eight experiments from list shall be performed to cover entire curriculum of course ET352N. The list given below is just a guideline.

- Mobile transmitter and receiver
- GSM architecture
- Study & use of AT commands (Voice/Video Calling)
- CDMA
- Voice over Internet Protocol (VoIP)
- J2ME
- Generation and Demodulation of DSSS
- Introduction to parts of mobile phone
- Measurement of test point voltages of mobile phone
- DTMF tones

Note

- **ICA –**Internal Continuous Assessment shall support for regular performance of practical and its regular assessment. In addition; it shall be based on knowledge/skill acquired and record submitted by student (journal) based on practical performed by him/her. The performance shall be assessed experiment wise using internal continuous assessment format**.**
- **ESE** - End Semester Examination (ESE) for this laboratory course shall be based on performance in one of the experiments performed by student in the semester followed by sample questions to judge the depth of understanding/knowledge or skill acquired by the student. It shall be evaluated by two examiners out of which one examiner shall be out of institute.

ET358N LINEAR INTEGRATED CIRCUITS LAB

Teaching Scheme	**:** 02P, Total: 02 hours/week	**Credits :**	01
Evaluation Scheme	**:** 30 ICA + 20 ESE	**Total Marks:**	50
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course deal with the practical exposure to basic concepts of operational amplifier (op-amp), linear and non-linear application of op-amp, frequency selective circuits, active filters, PLL, regulated power supply and various signal generators, etc.

DESIRABLE AWARENESS/SKILLS

Knowledge of electronic components, devices and op-amps

COURSE OUTCOMES

On the successful completion of this course; student shall be able to

1. measure and verify op amp parameters.
2. build the various linear and non linear circuits of op-amp and test their performance.
3. design frequency selective circuits and oscillators.
4. implement regulated power supply and use PLL in communication circuits.
5. prepare IC based circuits in above areas according to specifications.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	2	2	1									1	1	
2	3	3	3	1									2	3	
3	3	3	3	1									2	3	
4	3	3	3	1									2	2	
5	3	3	3	1									1	3	

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT:

Minimum eight experiments shall be performed to cover entire curriculum of the course ET353N . The list given below is just a guideline.

- Op-amp parameter measurement
- Inverting and non-inverting amplifier
- Differential amplifier
- Integrator
- Differentiator
- Precision rectifiers
- Clippers
- Clampers
- Schmitt trigger and the hysteresis voltage.
- Square wave and/or triangular wave generator using Op-amp
- Multi-vibrators using timer IC 555
- Voltage Controlled Oscillator (VCO) using IC 566
- Phase Locked Loop (PLL) using IC 565
- Zero crossing and window detector
- Second order Butterworth filters

NOTE

- **ICA** – It shall support for regular performance of practical and its regular assessment. In addition; it shall be based on knowledge/skill acquired and record submitted by student (journal) based on practical performed by him/her. The performance shall be assessed experiment wise using internal continuous assessment format.

- **ESE –** It shall be based on performance in one of the experiments performed by student in the semester followed by sample questions to judge the depth of understanding/knowledge or skill acquired by the student. It shall be evaluated by two examiners out of which one examiner shall be out of institute

ET360NA COMPUTER NETWORKS LAB

Teaching Scheme	**:** 02P, Total: 02 hours/week	**Credits :**	01
Evaluation Scheme	**:** 30 ICA + 20 ESE	**Total Marks:**	50
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course provides hands on network components and troubleshooting of networks. The laboratory exercises are designed to give ability of configuring various network commands and using differ rent protocols.

DESIRABLE AWARENESS/SKILLS

Concepts of digital and analog Communication

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. differentiate among different network components and use it accordingly.
2. configure hardware components with PC used in networking.
3. troubleshoot the network connection using different tools

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2										3	1	
2	2	2	3	2	3								3	2	
3	3		3	2									3	3	

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

Minimum eight experiments shall be performed to cover entire curriculum of course ET355NA using simulation software like MATLAB/NetSim. The list given below is just a guideline.

- Various network components
- Various Network cables
- Configuration of LAN card (Ethernet)
- Establishment of PC-LAN
- Trouble shooting of networks
- Installation of network device drivers
- Use/installation of proxy server
- Various routing algorithms
- Various protocols using NS2/MATLAB
- Network address conflict and resolution
- Network management and security (A case study)
- Data center networking (A case study)

Note

- **ICA –**Internal Continuous Assessment shall support for regular performance of practical and its regular assessment. In addition; it shall be based on knowledge/skill acquired and record submitted by student (journal) based on practical performed by him/her. The performance shall be assessed experiment wise using internal continuous assessment format**.**
- End Semester Examination (ESE) for this laboratory course shall be based on performance in one of the experiments performed by student in the semester followed by sample questions to judge the depth of understanding/knowledge or skill acquired by the student. It shall be evaluated by two examiners out of which one examiner shall be out of institute.

ET359NB WIRELESS SENSOR NETWORKS LAB

Teaching Scheme	**:** 02P, Total: 02 hours/week	**Credits :**	01
Evaluation Scheme	**:** 30 ICA + 20 ESE	**Total Marks:**	50
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course is designed to acquire hands-on experimentation of wireless sensor networks with suitable simulation software. It helps to understand and validate the theory behind wireless sensor networks and covers experiments on installation of network simulator, simulation of sensor nodes, communication between mobile nodes, and different routing protocols.

DESIRABLE AWARENESS/SKILLS

Fundamentals of the course wireless sensor networks and computer networking

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. implement wireless sensor networks in a simulator.
2. demonstrate the understanding of design constraints and principles of network architecture.
3. simulate and compare different network and routing protocols.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2		3										3	2	2
2	2	2	3	2	2								3	2	2
3		2	3		2								3	2	2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Minimum eight experiments shall be performed to cover entire curriculum of course ET360NB using NetSim simulation software. The list given below is just a guideline.

List of Experiments

1. Creating a simple network scenario
2. Generate different types of data in WSN
3. Implementation of simple routing protocol
4. Implementation of AODV protocol
5. Implementation of LEACH protocol
6. Implementation of PEGASIS protocol
7. Implementation of TEEN protocol
8. Implementation of MAC protocol
9. Implementation of any mobility model
10. Optimization of energy / delay / throughput of the network using any routing protocol

Note

- **ICA –**Internal Continuous Assessment shall support for regular performance of practical and its regular assessment. In addition; it shall be based on knowledge/skill acquired and record submitted by student (journal) based on practical performed by him/her. The performance shall be assessed experiment wise using internal continuous assessment format**.**
- **ESE** - End Semester Examination (ESE) for this laboratory course shall be based on performance in one of the experiments performed by student in the semester followed by sample questions to judge the depth of understanding/knowledge or skill acquired by the student. It shall be evaluated by two examiners out of which one examiner shall be out of institute.

ET359NC Digital Audio Processing Lab

Teaching Scheme	**:** 02P, Total: 02 hours/week	**Credits :**	01
Evaluation Scheme	**:** 30 ICA + 20 ESE	**Total Marks:**	50
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This laboratory course offers hands-on experience in analyzing, processing, and synthesizing audio signals using digital signal processing techniques. The course also emphasizes real-world applications including noise removal, echo cancellation, speech detection, audio compression, and spatial sound generation. Students also gain exposure to algorithm development for audio feature extraction and enhancement, thereby bridging theoretical signal processing concepts with practical implementation using modern tools and software platforms.

DESIRABLE AWARENESS/SKILLS

Knowledge of digital signal processing

Course Outcomes

On the successful completion of this course; student shall be able to practically -

1. analyze audio signals in time and frequency domains using appropriate signal processing techniques.
2. design and implement digital filters and signal enhancement algorithms to improve audio quality and remove distortions.
3. develop basic systems for speech/audio signal processing such as echo cancellation, voice activity detection, and audio compression.
4. demonstrate hands-on skills in synthesizing, modifying, and separating audio components using real-world audio data and tools.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2										3	1	
2	2	2	3	2	3								3	2	
3	2	2	3	2	3								3	2	
4	3		3	2									3	3	

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

Minimum eight experiments shall be performed to cover entire curriculum of course ET355NC using simulation software like MATLAB/Scilab/Octave/C. The list given below is just a guideline.

List of Experiments

- Generate an audio signal for playing "happy birthday" tune.
- Change sampling rate of given audio and observe the effects of aliasing
- Plot the Spectrogram of given audio signal and determine the frequency contents in various temporal regions of signal. Compare the same with frequencies obtained through DFT computation across the complete signal.
- Design FIR Filter to remove generator (any small fixed frequency band) noise from given audio signal
- Implement Wiener filter for echo removal
- Design VAD to distinguish between speech and silence regions
- Apply simple filtering approach for vocal and instrumental sound separation in a simple concert audio
- Use head transfer function to generate realistic stereo signal.
- Speech compression algorithms

Note

- **ICA –**Internal Continuous Assessment shall support for regular performance of practical and its regular assessment. In addition; it shall be based on knowledge/skill acquired and record submitted by student (journal) based on practical performed by him/her. The performance shall be assessed experiment wise using internal continuous assessment format**.**
- **ESE -** End Semester Examination (ESE) for this laboratory course shall be based on performance in one of the experiments performed by student in the semester followed by sample questions to judge the depth of understanding/knowledge or skill acquired by the student. It shall be evaluated by two examiners out of which one examiner shall be out of institute.

ET361NA AUDIO VIDEO ENGINEERING LAB

Teaching Scheme	**:** 02P, Total: 02 hours/week	**Credits :**	01
Evaluation Scheme	**:** 30 ICA + 20 ESE	**Total Marks:**	50
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course is designed to explore fundamental principles and practical aspects of audio and video engineering. The course covers basic concept of sound recording and reproduction, monochrome and color television. It provides comprehensive coverage of advanced Television (TV) system, different advanced broadcasting systems.

DESIRABLE AWARENESS/SKILLS

Knowledge of basic concepts of analog and digital communication

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. describe the basic working principles and components of audio and video systems such as microphones, loudspeakers, color TV receivers, and PA systems.
2. demonstrate the functioning and testing of audio-video equipment including color TVs, set-top boxes, DVD/CD players, and MP3 players using appropriate tools and software..
3. analyze waveforms, signal paths, and faults in color TV systems and digital TV systems using pattern generators and signal measurement techniques.
4. summarize the working of modern communication and broadcasting systems such as DTH, HDTV, and telephone exchanges based on field visits and system observations.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2										3	1	
2	2	2	3	2	3								3	2	
3	3		3	2									3	3	
4	2			3	2								2		2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Minimum eight experiments shall be performed to cover entire curriculum of course ET356NA. The list given below is just a guideline.

- Color TV receiver
- Voltage and waveform analysis for color TV
- Alignment and fault finding of color TV using pattern generator
- HDTV
- Digital TV
- DTH and set top box
- CD/DVD players
- PA system
- Microphone
- Loudspeaker
- digitization of sound signal and edit it using Computer Software
- MP3 Player
- Visit to telephone exchange
- Visit to TV transmitter/Studio

Note

- **ICA –**Internal Continuous Assessment shall support for regular performance of practical and its regular assessment. In addition; it shall be based on knowledge/skill acquired and record submitted by student (journal) based on practical performed by him/her. The performance shall be assessed experiment wise using internal continuous assessment format.
- End Semester Examination (ESE) for this laboratory course shall be oral examination based on experiments performed / assignments covered in ET361NA. It shall be evaluated by two examiners out of which one examiner shall be out of institute.

ET360NB VLSI DESIGN LAB

Teaching Scheme	**:** 02P, Total: 02 hours/week	**Credits :**	01
Evaluation Scheme	**:** 30 ICA + 20 ESE	**Total Marks:**	50
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course will impart the knowledge about implementation of various digital circuits on FPGA. In this lab course, emphasis is given on realization of frontend VLSI circuits. The course also introduces the preparation of layout of simple digital circuits. The course is designed to lay the foundation for further studies in VLSI Domain.

DESIRABLE AWARENESS/SKILLS

Knowledge of Digital Electronics and VLSI Design

COURSE OUTCOMES

On the successful completion of this course, student shall be able to practically -

1. describe the digital circuits in Hardware Description Language.
2. prepare the layout of basic digital circuits.
3. implement the digital circuits on FPGA.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	1	3	3	3	3								3	1	
2	1	3	2	2	1								3	2	
3	3	1	1	3	2								3	3	

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

Minimum 8 experiments from list shall be performed to cover entire curriculum of course ET356NB. Perform experiments using software and verify them on FPGA/CPLD board. The list given below is just a guideline.

List of Experiments

- Logic Gates
- Binary to gray converter/ BCD to seven segment decoder
- Multiplexer
- Decoder
- Full adder circuit Realization flip-flops
- 4 bit binary up down counter with Asynchronous reset
- 4 bit BCD counter with Synchronous reset
- Arithmetic and Logical Unit
- CMOS Inverter and basic gates
- Half/Full Adder
- 2:1 multiplexer using logic gates and transmission gates
- Layout of basic combinational circuits

Note

- **ICA** –Internal Continuous Assessment (ICA) shall support for regular performance of practical and its regular assessment. In addition, it shall be based on knowledge/skill acquired and record submitted by the student (journal) based on practical performed by him/her. The performance shall be assessed experiment wise using internal continuous assessment format.
- **ESE** – End Semester Examination (ESE) for this laboratory course shall be based on performance in one of the experiments performed by student in the semester followed by sample questions to judge the depth of understanding/knowledge or skill acquired by the student. It shall be evaluated by two examiners out of which one examiner shall be out of institute.

ET360NC Information Theory and Coding Techniques Lab

Teaching Scheme	**:** 02P, Total: 02 hours/week	**Credits :**	01
Evaluation Scheme	**:** 30 ICA + 20 ESE	**Total Marks:**	50
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course imparts the basic concepts of information theory and coding techniques. In the course, emphasis is given on information theory, entropy, various source coding techniques for data compression and various channel coding techniques for error detection and correction. This course also briefly introduces contemporary issues and applications of coding techniques.

DESIRABLE AWARENESS/SKILLS

Knowledge of digital communication, probability and fundamentals of communication systems

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. demonstrate the knowledge of information theory and entropy
2. design the source coding for the given information source using algorithms such as Shannon-Fano and Huffman coding
3. design the channel coding scheme for the given requirements using techniques of block, cyclic and convolution codes
4. select a suitable source and channel coding scheme for the given requirements
5. understand contemporary issues related to information coding

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	3	3	2							2	3	2	2
2	3	2	3	2	2								3	2	3
3	2	3	3	2	2								2	2	2
4	3	2	2	2	1								3	2	2
5	2		2		1							2	3	2	2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

Course Content

Minimum eight experiments shall be performed so as to cover entire curriculum of course ET356NC. Experiments may be performed using hardware set-up or using software / simulator, as per the availability. The list given below is just a guideline.

List of Experiments

- Evaluation of amount of information and entropy for a given message and information source
- Huffman algorithm for source coding
- Shannon-Fano algorithm for source coding
- Encoding for block code
- Error correction using block code
- Encoding for cyclic code
- Error correction using cyclic code
- Encoding for convolution code
- Error correction using convolution code (Viterbi algorithm)
- Design of a source and a channel code for the given bit-stream and given information source.

Note

- **ICA –** Internal Continuous Assessment shall support for regular performance of practical and its regular assessment. In addition; it shall be based on knowledge/skill acquired and record submitted by student (journal) based on practical performed by him/her. The performance shall be assessed experiment wise using internal continuous assessment format**.**
- **ESE -** End Semester Examination (ESE) for this laboratory course shall be based on performance in one of the experiments performed by student in the semester followed by sample questions to judge the depth of understanding/knowledge or skill acquired by the student. It shall be evaluated by two examiners out of which one examiner shall be out of institute.

ET361N Mini Project

Teaching Scheme	**:** 04P, Total: 04 hours/week	**Credits :**	02
Evaluation Scheme	**:** 30 ICA + 20 ESE	**Total Marks:**	50
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

The mini project is one of the most important single piece of work in the program. It is introduced in curriculum to put into practice some of the techniques and skills that have been taught and/or acquired in earlier years of study. It also provides the opportunity to students to demonstrate independence and originality, to plan and organize a large project over a long period. The project topic should be selected to ensure the satisfaction of the need to establish a direct link between the techniques they learn and productivity. It should reduce the gap between the world of work and study, leading to a development project for solution of societal problems.

DESIRABLE AWARENESS/SKILLS

Knowledge of concepts, principles and techniques studied in all earlier courses

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. develop ability to synthesize knowledge and skills previously gained and to put some of them into practice.
2. make students capable to select from different methodologies, methods and forms of analysis studied to produce a suitable system or sub-system.
3. inculcate ability to present the findings of the technical solution in a written report.
4. plan and organize a large project over a long period.

COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS) MAPPING WITH STRENGTH OF CO-RELATION

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	3	3	2	2	2	3	2	2	3	2	3	2	2
2	1	2	3	2	2	2	1	2	2	2	3	2	3	2	3
3	2	3	3	2	2	2	2	2	3	3	2	2	2	2	2
4	2	2	2	2	1	2	2	2	3	3	2	2	3	2	2

1-Weakly correlated **2 – Moderately correlated** **3 – Strongly correlated**

COURSE CONTENT

- The mini project shall be preferably carried out in-house i.e. in the departmental laboratories with emphasis on societal / field problems by a group of 2 - 4 students.
- The mini project shall consist of design and implementation of any suitable electronic system, sub system or circuit based on knowledge and skills previously gained.
- The mini project outline (brief or condensed information) on the selected topic should be submitted to the course coordinator for approval within one week from the commencement of the term.
- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation.
- **Deliverables:** A report as per the specified format (available on the institutes website), developed system in the form of hardware and/or software. In addition, student shall maintain a record of attendance and continuous progress (log book in appropriate format available on institute / department's web site) duly signed by course coordinator and present as project deliverable along with report.

EVALUATION SYSTEM

It includes Internal Continuous Assessment (ICA) and End Semester Examination (ESE). Guidelines for ICA and ESE are given below.

- **ICA -** The ICA shall be evaluated by course coordinator. Course coordinator shall judge the students on the principle of continuous evaluation and contribution of individual student in the group. It shall be evaluated on the basis of deliverables of development engineering project and depth of understanding. Course coordinator shall maintain the record of continuous evaluation in appropriate format available on institute/department's web site.

- **ESE -** The End Semester Examination for this course shall be based on demonstration of the system or sub system developed by the group of students, deliverables of the project and depth of understanding (oral examination). It shall be evaluated by two examiners out of which one examiner shall be out of institute.

ET362N NANO-ELECTRONICS
(Honours Course)

Teaching Scheme	**:** 03L, Total: 03 hours/week	**Credits :**	03
Evaluation Scheme	**:** 10 ISA +30 MSE + 60 ESE	**Total Marks:**	100
ESE Duration	**:** 03 Hrs		

COURSE DESCRIPTION

This course will help the students understand the basics of nano-electronics followed by the understanding of the nano-micro fabrication. It provides understanding of the device electronics for integrated circuits, a foundation for the device fabrication and various applications in the field of sensors technology, optoelectronics, communication and nanotechnology etc.

DESIRABLE AWARENESS/SKILLS

Knowledge of solid state physics

COURSE OUTCOMES

On the successful completion of this course; student shall be able to -

1. demonstrate the understanding of Tunnel junctions.
2. exhibit the knowledge of field emission techniques.
3. explain the various aspects of lithography.
4. illustrate the concepts and design process of MEMS and NEMS.
5. demonstrate the knowledge of nano-electronic devices.

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1	2	2	3	2	1							2	2	2	3
2	2	2	3	2	1							2	2	2	3
3	2	2	3	2	1							2	2	2	3
4	2	2	3	2	1							2	2	2	3
5	2	2	3	2	1							2	2	2	3

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COURSE CONTENT

Tunnel Junctions [7 Hrs]

Tunnel junction and applications of tunnelling, Tunnelling Through a Potential Barrier, Metal-Insulator, Metal-Semiconductor, and Metal-Insulator-Metal Junctions, Coulomb Blockade, Tunnel Junctions, Tunnel Junction Excited by a Current Source. Spintronics and foundation of nano-photonics.

Field Emission [6 hrs]

Introduction to Field Emission, Gate—Oxide Tunnelling and Hot Electron Effects in nano MOSFETs, Theory of Scanning Tunnelling Microscope, Double Barrier Tunnelling and the Resonant Tunnelling Diode.

Lithography [8 hrs]

Introduction to lithography- Contact, proximity printing and Projection Printing, Resolution Enhancement techniques, overlay-accuracies, Mask-Error enhancement factor (MEEF), Positive and negative photoresists, Electron Lithography, Projection Printing, Direct writing, Electron resists. Lithography based on Surface Instabilities: Wetting, De-wetting, Adhesion, Limitations, Resolution and Achievable / line widths etc. Lift off process, Bulk Micro machining.

MEMS and NEMS [10 hrs]

Introduction to MEMS and NEMS, working principles, as micro sensors (acoustic wave sensor, biomedical and biosensor, chemical sensor, optical sensor, capacitive sensor, pressure sensor and thermal sensor), micro actuation (thermal actuation, piezoelectric actuation and electrostatic actuation–micro gripers, motors, valves, pumps, accelerometers, fluidics and capillary electrophoresis, active and passive micro fluidic devices, Piezo-resistivity, Piezo-electricity and thermoelectricity, MEMS/NEMS design, processing, Oxidation, Sputter deposition, Evaporation, Chemical vapor deposition etc.

Nano-Electronic Devices [10 hrs]

Introduction – Scaling of physical systems – Geometric scaling & Electrical system scaling. The Single-Electron Transistor: The Single- Electron Transistor Single-Electron Transistor Logic, Other SET and FET Structures, Carbon Nanotube Transistors (FETs and SETs), Semiconductor Nanowire FETs and SETs, Coulomb Blockade in a Nanocapacitor, Molecular SETs and Molecular Electronics.

Text Books

1. Microsystem Design, Stephen D. Sentaria, Kluwer Academic Press.
2. Fundamentals of micro-fabrication & Nano-fabrication, Marc Madou, CRC.

Reference Books

1. Micro Mechanical system Principle & Technology, T. Fukada & W. Mens, Elsevier.
2. Nano Terchnology and Nano Electronics – Materials, devices and measurement Techniques by WR Fahrner – Springer.
3. Nano: The Essentials - Understanding Nano Science and Nanotechnology by T. Pradeep; Tata Mc.Graw Hill.