Department of Electronics Engineering

Proposed Revised Curriculum Structure as per NEP2020

B. Tech. Electronics and Communication Engineering

Sr. No.	Subject	Code	Schemes	Credits	Notional hours
Fifth Semester					
1	**Mandatory Core** Digital Communication	EC301	3-1-2	05	100
2	**Mandatory Core** Digital Signal Processing	EC303	3-1-2	05	100
3	**Elective – I**	EC3XX	3-0-2	04	85
4	**Elective – II**	EC3XX	3-0-0	03	55
5	**Institute Elective – I**	EC3XX	3-0-0	03	55
6	**MOOC***	EC3XX	3-0-0	03	55
	Minimum Credit Requirement		**Total**	**23**	**450**
7	Minor / Honor (M/H#2)	EC3AA	3-0-2	4/**5**	70/85
8	Vocational Training/Professional Experience **(Optional) (Mandatory for Exit)**	ECV05/ ECP05	0-0-8	04	160 (20x8)
Sixth Semester					
1	**Mandatory Core** Microwave Components and Communication	EC302	3-0-2	04	85
2	**Mandatory Core** VLSI Design	VL312	3-0-2	04	85
3	**Elective – III**	EC3XX	3-0-2	04	85
4	**Elective – IV**	EC3XX	3-0-0	03	55
5	**Institute Elective – II**	EC3XX	3-0-0	03	55
6	**Project Phase – I**	EC304	0-0-4	02	70
	Minimum Credit Requirement		**Total**	**20**	**435**
7	Minor / Honor (M/H#3)	EC3AA	3-0-2	4/**5**	70/85
8	Vocational Training / Professional Experience **(Optional) (Mandatory for Exit)**	ECV06/ ECP06	0-0-8	04	160 (20x8)

***NPTEL, SWAYAM and other Massive Open Online Courses (MOOC) approved by DAAC. As per 66th IAAC, Dated 20th March 2024, Resolution No. 66.34 and 61st Senate resolution No. 4, 25th April, 2024**

Subject Pool:

B. Tech. EC Elective -I (3-0-2)				
Sr. No.	**Subject**	**Code**	**Scheme**	**Credits**
1	Data Communication Networks	EC321	3-0-2	4
2	Computer Architecture and Organization	VL321	3-0-2	4
3	Embedded Systems	VL323	3-0-2	4

B. Tech. EC Elective -II (3-0-0)				
Sr. No.	**Subject**	**Code**	**Scheme**	**Credits**
1	Digital Image Processing	EC341	3-0-0	3
2	Antenna Theory	EC343	3-0-0	3
3	Hardware Description Language	VL343	3-0-0	3

B. Tech. EC Institute Elective – I (3-0-0)				
Sr. No.	**Subject**	**Code**	**Scheme**	**Credits**
1	Sensors and Transducers	EC361	3-0-0	3

B. Tech. EC Elective -III (3-0-2)				
Sr. No.	**Subject**	**Code**	**Scheme**	**Credits**
1	Wireless and Mobile communication	EC322	3-0-2	4
2	Data Structures and Algorithms	EC324	3-0-2	4
3	Optical Fiber Communication	EC326	3-0-2	4
4	Machine Learning	EC328	3-0-2	4

B. Tech. EC Elective -IV (3-0-0)				
Sr. No.	**Subject**	**Code**	**Scheme**	**Credits**
1	Speech Processing and Human-Machine Communication	EC342	3-0-0	3
2	IoT and Applications	EC344	3-0-0	3
3	Global Navigation Satellite System	EC346	3-0-0	3
4	Adaptive Signal Processing	EC348	3-0-0	3

B. Tech. EC Institute Elective – II (3-0-0)				
Sr. No.	**Subject**	**Code**	**Scheme**	**Credits**
1	Computer Vision	EC362	3-0-0	3
2	MEMS	EC364	3-0-0	3

B.Tech.III EC Semester V DIGITAL COMMUNICATION EC301	Scheme	L	T	P	Credit
		3	1	2	05

1.	**Course Outcomes (COs):**
	At the end of the course the students will be able to:

CO1	Explain the principles of digital modulation techniques, including Amplitude Shift Keying, Phase Shift Keying, Frequency Shift Keying, and their variations.
CO2	Apply the principles of multicarrier modulation, particularly Orthogonal Frequency Division Multiplexing, to analyze and solve problems related to bandwidth efficiency, signal-to-noise ratio, and interference mitigation in wireless communication systems.
CO3	Analyze and compare the performance characteristics (e.g., probability of error, bandwidth efficiency, power efficiency) of different digital modulation and spread-spectrum techniques under various channel conditions (e.g., AWGN, bandlimited).
CO4	Design a basic digital communication system, selecting appropriate modulation, coding, and synchronization techniques to meet specific performance requirements for a given channel model.
CO5	Evaluate the trade-offs between different design choices in digital communication systems, considering factors such as complexity, cost, power consumption, and performance in the presence of noise and interference.

2.	**Syllabus:**	
	DIGITAL MODULATION IN AN AWGN BASEBAND CHANNEL	**(08 Hours)**
	Geometric representation of signal waveforms, Binary pulse modulation , optimum receiver for binary modulated signals in AWGN , M-ary pulse modulation, Probability of error for M-ary pulse modulation, Symbol synchronization	
	DIGITAL TRANSMISSION THROUGH BANDLIMITED AWGN CHANNELS	**(08Hours)**
	Digital transmission through bandlimited channels, Signal design for bandlimited channels, probability of error for detection of digital PAM, System design in presence of channel distortion	
	TRANSMISSION OF DIGITAL INFORMATION VIA CARRIER MODULATION	**(12 Hours)**
	Amplitude modulated digital signal: demodulation and detection of amplitude modulated digital signal, Phase-modulated digital signals: demodulation and detection of phase-modulated digital signal, probability of error for PSK and DPSK; Frequency modulated digital signals: demodulation and detection of frequency modulated signal, probability of error for non-coherent detection of FSK; comparison of modulation methods; Symbol synchronization for carrier-modulated signals.	
	SPREAD-SPECTRUM COMMUNICATION SYSTEMS	**(06 Hours)**
	Model of a Spread-spectrum digital communication systems, Direct sequence Spread-spectrum systems, Generation of PN Sequence, Frequency-Hopped spread spectrum, Code Division multiple Access	
	MULTI CARRIER MODULATION AND OFDM	**(11 Hours)**
	Fundamentals: Concept of Multicarrier Modulation, FDM as a precursor; Orthogonal Frequency Division Multiplexing: Principles of OFDM, OFDM Transmitter and Receiver, Cyclic Prefix; OFDM System Design Considerations: Subcarrier Allocation, Power Allocation, Peak-to-Average Power Ratio; Channel Estimation and Equalization: Channel Estimation in OFDM, Equalization; Applications and Standards: Wireless Communication: Wi-Fi (IEEE 802.11a/g/n/ac/ax), LTE and 5G cellular systems Wired Communication: Digital Subscriber Line, Powerline communication	
	PRACTICAL WILL BE BASED ON THE COVERAGE OF THE ABOVE TOPICS SEPARATELY	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	**List of Practicals:**
	1. Implement ASK modulation and demodulation using a function generator and oscilloscope. Analyze the impact of noise on signal recovery. 2. implement FSK and observe the frequency changes representing data bits. Compare error rates of ASK and FSK under varying noise conditions. 3. Implement basic Binary Phase Shift Keying and investigate the phase shifts associated with data bits. 4. Implement PAM and observe the effect of varying pulse amplitudes on signal quality. Analyze the impact of noise on different PAM levels. 5. Simulate a bandlimited channel and transmit a digital signal. Observe the effects of ISI on the received signal. 6. Implement an equalization technique to mitigate Intersymbol Interference 7. Implement a channel estimation algorithm (e.g., pilot-based) and an equalization technique (e.g., zero-forcing, least-squares) in an OFDM system simulation. Analyze their effectiveness in combating channel impairments. 8. Use software to generate an OFDM signal. Visualize the time and frequency domain representations. Experiment with different subcarrier numbers. 9. Simulate an OFDM system with and without a cyclic prefix. Analyze the impact of the cyclic prefix on Intersymbol interference in a dispersive channel. 10. Implement different subcarrier allocation schemes (e.g., fixed, adaptive) in an OFDM system simulation. Compare their performance in terms of data rate and error rate. 11. Implement DSSS using PN sequence generation. Analyze the spreading and despreading processes. Observe the processing gain and interference rejection capabilities. 12. Implement FHSS and observe the hopping pattern of the signal. Compare its performance to DSSS in a jamming environment (simulated interference).
4.	**Books Recommended:**
	1. John G. Proakis, Digital Communication, 5th Edition, McGraw Hill, 2014. 2. S. Haykin, "Digital Communications", Fourth edition, John Wiley & Sons, 2009. 3. Taub and Schilling, "Principles of Communication Systems", Second Edition, Tata McGraw Hill (34th reprint) 4. B. Sklar, Digital Communications: Fundamentals and Applications" Second Edition, Pearson education, 2009 5. A.B Carlson, "Communication Systems", Third Edition, McGraw Hill, 2002.
5.	**Reference Books:**
	1. Lathi B.P, and Ding Zhu, "Modern Digital and Analog Communication Systems", Fourth edition, Oxford University press, 2010.

B.Tech.III EC Semester V DIGITAL SIGNAL PROCESSING EC303	Scheme	L	T	P	Credit
		3	1	2	05

1. Course Outcomes (COs):

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

CO1	Describe Discrete Time Signal, System and Discrete Fourier Transform and other transformations.
CO2	Analyze the various discrete time system and digital systems in frequency domain.
CO3	Develop the various type of filter, which are used in real time application.
CO4	Evaluate various Realizations of filter structure.
CO5	Design different signal processing techniques.

2. Syllabus:

REVIEW OF DISCRETE TIME SIGNAL AND SYSTEMS **(07 Hours)**

Discrete - Time Signals, Signal classification, Discrete-time system & analysis of Discrete-time linear time invariant systems, Correlation of Discrete-time signals, Analysis of Linear Time invariant System in Z Domain, One sided Z-transform.

COMPUTATION OF THE DISCRETE FOURIER TRANSFORM **(06 Hours)**

Introduction, Direct evaluation of DFT, DFT symmetry relation, Fast Fourier Transform, Goertzel algorithm, Decimation-in-Time algorithm, Decimation-in-Frequency algorithm, Approaches to design radix-m algorithm. Implementation of DFT using convolution algorithm, The Discrete Time Cosine Transform, The Haar transform.

FIR FILTER DESIGN **(08 Hours)**

Causality and its implications, Linear Phase FIR filters, Frequency response of linear Phase FIR filters, Location of zeros of linear phase FIR filters, The Fourier Series method of designing FIR Filters, Design of FIR filter using different Windowing techniques, Digital differentiator, Hilbert transform, Frequency sampling method for designing FIR Filters, Various approach to design Optimum linear phase FIR filters.

IIR FILTER DESIGN **(08 Hours)**

Introduction, Frequency selective filter, Design of Digital Filter from Analog Filter, Analog low pass filter design, Analog low pass Butterworth filter, Analog low pass Chebyshev filter, Comparison between Butterworth filter and Chebyshev filter, Frequency transformation in analog domain, Design of high pass filter, bandpass and bandstop filters, Design of IIR filters From analog filters, Approximation of derivatives transformation method, Design of IIR filter using Impulse invariance technique, Design of IIR filter using Bilinear transformation, frequency transformation in digital Domain.

REALIZATION OF FILTER STRUCTURE **(08 Hours)**

Realization of FIR filters, Transversal structure, Linear phase realization, Lattice structure of FIR filter, Poly-phase realization of FIR filter, Realization of Digital filter, Direct Form-I realization, Direct Form-II realization, Signal Flow Graph, Transposition theorem &Transposed structure, Cascade form, Parallel form structure, Lattice structure of IIR system, Comb Filter design, All-pass filter, Minimum phase, Maximum phase & Non-minimum phase systems. Tunable IIR digital filter.

FINITE WORD LENGTH EFFECT IN DIGITAL SYSTEM **(03 Hours)**

Floating point numbers representation, Block floating point numbers representation, Quantization noise, Input Quantization error, Product Quantization error, Coefficient Quantization error, Quantization In floating point realization of IIR digital filters, Finite word length effect in FIR digital filters, Signal to Noise ratio in low-order IIR filter, Limit cycle in IIR digital filter, Round-off error in FFT Algorithm.

MULTIRATE SIGNAL PROCESSING	(05 Hours)

Introduction, Down Sampling, Spectrum of down sampled signal, Up Sampling Spectrum of Up-sampled signal, Anti-Imaging filter, Cascading sample rate converters, Efficient transversal structure for decimator, Efficient transversal structure for interpolator, Polyphase structure of decimator, Polyphase decimation using Z-transform, Polyphase structure of interpolator, Polyphase interpolation using Z-transform, Multistage implementation of sampling rate conversion.

PRACTICAL WILL BE BASED ON THE COVERAGE OF THE ABOVE TOPICS SEPARATELY	(30 Hours)

(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

3. **List of Practical:**

1. Implementation of DFT & FFT algorithms
2. Finding the DFT and FFT for real-time signal.
3. Finding liner convolution and circular convolution for given signal.
4. Design FIR Filter for given specifications.
5. Design IIR Filter for given specification
6. Implementation of digital system and analysis finite word length effect for system.
7. Implementation of interpolation and decimation for given rate-conversion.
8. Speech and Musical sound processing.
9. Study of DSP Processor &Implement FIR Filter.
10. Linear prediction and optimum linear filter design using simulation & hardware.
11. Power spectrum analysis using the simulation.

4. **Books Recommended:**

1. Proakis J. G. and Manolakis D. G., "Digital Signal Processing: Principles, Algorithms And Applications", 4th Ed., Pearson Education, 2014.
2. Babu Ramesh P., "Digital Signal Processing", 4th Ed., SciTech Publication, 2008.
3. MitraSanjit K., "Digital Signal Processing: A Computer Based Approach", 4th Ed., Tata McGraw-Hill, 2011.
4. Oppenhein A. V. and Shafer R. W., "Discrete-Time Signal Processing", 3rd Ed., PHI, 2014.
5. Shaliwahan S., Vallavaraj A. and Gnanapriya C., "Digital Signal Processing", 2nd Ed., Tata McGraw-Hill, 2012.

5. **Reference Books:**

1. Padmanabhan K.,"A Practical Approach to Digital Signal Processing", 1st Ed., New Age International, 2001.
2. SudhankarRadhakrishna, “Application of Digital Signal Processing through practical Approaches”, 1st Ed., Intech Open, http:://dx.doi.org/10.5772/59529. 2015.
3. Fredric Cohen Tenoudji, “Analog and Digital Signal Analysis: From Basic to Applications”, Modern Acoustic and signal Processing. Ecllipse-Edition marketing, Paris-2012.

B.Tech. III EC Semester V DATA COMMUNICATION NETWORKS EC321	Scheme	L	T	P	Credit
		3	0	2	04

1. Course Outcomes (COs):

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

CO1	Understand the basic concepts and technologies used in networking.
CO2	Illustrate how data is transmitted over various mediums and assess the performance of these systems
CO3	Analyze the performance of various techniques and protocols in a given network topology, case study and problem solving as per given data.
CO4	Implement and simulate basic networking protocols using standard tools.
CO5	Create a local area network with specific requirements.

2. Syllabus:

DATA COMMUNICATION AND NETWORKING OVERVIEW **(08 Hours)**

Components of a Data Communication Network, Data Flow Types, Categories of topology and their comparison, Protocols and Standards: Need for Protocols and Standards.
OSI and TCP/IP Reference Models: Need of Protocol Layering, Layers, Functions of layers, and Protocol Stacks.
Transmission Media: Guided (Twisted Pair, Coaxial, Fiber Optic) vs. Unguided (Wireless, Satellite).
Performance Parameters: Latency, Packet Delivery Ratio, Throughput and Jitter
Switching Techniques: Circuit Switching, Packet Switching, and Virtual Circuit Switching.
Addresses: Physical Address (MAC Address), IP Addresses, Port Address, Specific Addresses

Data Link Layer **(12 Hours)**

Data Link Layer Functions: Framing: Bit Orientated framing and Byte oriented framing.
Flow Control and Error Control: Simplest, Stop and Wait, Stop and Wait ARQ, Go back N and Selective repeat Protocols.
Medium Access Control (MAC): Channelization Protocols: FDMA, TDMA and CDMA, Controlled Access Protocols: Reservation, Polling and Token Passing and Random Access Protocols: Pure Aloha, Slotted Aloha, CSMA 1-persistent, non-persistent and p-persistent, CSMA/CD, CSMA/CA.
Networking Devices: Hubs, Switches, Bridge: Learning Bridge, Loop Problem in Learning Bridge, Routers, and Gateways.
High-Level Data Link Control (HDLC) Protocol
Wired Networks: IEEE 802.3 Standard (Ethernet) and Wireless Networks: IEEE 802.11 Standard.

Network Layer **(12 Hours)**

IPv4 Addressing: Classful and Classless Addressing, Subnetting, and Supernetting, Special Addresses: Network Address, Broadcast Address, Default Gateway Address, Private IP Addresses, Loopback Address, Link-Local Addresses, Multicast Addresses, Reserved Addresses, Private vs. Public IP addresses, Network Address Translation,
IPv6 Addresses: IPv6 Address Types, IPv6 Address Scope, Stateless Address Autoconfiguration.
Unicast Routing Protocol: Static vs. Dynamic Routing, Intra-Domain Routing: Distance Vector Routing (RIP), Link State Routing (OSPF), Inter-Domain Routing: Path Vector Routing (BGP).
IPv4 Protocol: Datagram Format and explanation of its fields.
Address Resolution Protocol (ARP), Address Resolution Protocol (RARP), Internet Control Message Protocol (ICMP), Internet Group Management Protocol (IGMP)

Transport Layer **(6 Hours)**

	Transport Layer Protocols: UDP, TCP and SCTP Protocols and underlying concepts (Three-way handshaking, Congestion Control, Flow Control Techniques etc.)	
	Application Layer	**(7 Hours)**
	Network Virtual Terminal (TELNET), File Transfer Protocol (FTP), Hyper Transfer Protocol (HTTP), HTTPS, Network Management - SNMP, Domain Name Server (DNS), URL, WWW, DHCP, BOOTP. Email Architecture: Simple Mail Transfer Protocol (SMTP), Post Office Protocol version 3 (POP3), Internet Message Access Protocol (IMAP).	
	PRACTICAL WILL BE BASED ON THE COVERAGE OF THE ABOVE TOPICS SEPARATELY	**(30 Hours)**
		(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)
3.	**List of Practicals:**	
	1. Study of basic TCP/IP network commands using Command Window/Terminal. 2. Write a SCILAB program to do Bit stuffing and De-Stuffing for all the type. 3. Write a SCILAB program to generate Cyclic Redundancy Check (CRC) and Hamming code for Error Correction and Detection. 4. Write a SCILAB program to find the shortest path between the Nodes among the given networks. 5. Write a SCILAB program to calculate the Bit Error Rate (BER) in data transmission. 6. Demonstrate the difference between a Bridge and a Router using Cisco Packet Tracer. 7. Simulate Routing Information Protocol for intradomain routing using Cisco Packet Tracer. 8. Set up a DNS server to translate domain names into IP addresses for network devices using Cisco Packet Tracer. 9. Simulate the Stop-and-Wait ARQ protocol for reliable data communication. 10. Simulate the Go-Back-N ARQ protocol for error and flow control. 11. Simulate a Complete Wired Network 12. Simulate a Complete Wireless Network.	
4.	**Books Recommended:**	
	1. Tanenbaum Andrew S., "Computer Networks", PHI, 5th Ed., 2011. 2. Stalling William, "Data and Computer Communications", PHI, 10th Ed., 2014. 3. Forouzan Behrouz A., "Data Communications and Networking", Tata McGraw-Hill, 5th Ed., 2013. 4. Gallager R. G. And Bertsekas D., "Data Networks", PHI, 2nd Ed., 1992. 5. Garcia Leon and Wadjaja I., "Communication Networks", Tata McGraw-Hill, 2nd Ed., 2004.	
5.	**Reference Books:**	
	1. Doug Lowe, Networking All-in-One for Dummies, 7ed, 2018.	

B.Tech. III EC Semester V COMPUTER ARCHITECTURE AND ORGANIZATION VL321	Scheme	L	T	P	Credit
		3	0	2	04

1. Course Outcomes (COs):

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

CO1	Identify the functional architecture of computing systems.
CO2	Estimate the performance of various classes of machines, memories, pipelined architectures etc.
CO3	Compare CPU implementations, I/O methods etc.
CO4	Analyze fast methods of ALU, FP, and Control unit implementations.
CO5	Implement an instruction encoding scheme for an ISA and Build large memories using small memories for better performance.

2. Syllabus:

DESIGN OF INSTRUCTION SET ARCHITECTURE (ISA)	**(11 Hours)**

Various Addressing Modes and Designing of an Instruction Set, Concepts of Subroutine and Subroutine call and return, Introduction to CPU design, Instruction Interpretation and Execution, the instruction set of a modern RISC processor, including how constructs in high-level languages are realized, concept of pipeline

PROCESSING UNIT	**(13 Hours)**

The representation of both fixed- and floating-point numbers, together with hardware algorithms for fixed-point arithmetic operations; Basic processor organization, ALU sub-system, Data path in a CPU, Instruction cycle, Organization of a control unit - Operations of a control unit, Hardwired control unit, Micro-programmed control unit.

MEMORY SUBSYSTEMS	**(11 Hours)**

Memory Hierarchy; Cache memory design, Cache Mapping, Write and Replacement policy, Virtual Memory, A Real-World Example of Memory Management, DMA Controller, Overview of SRAM and DRAM Design; Memory bus between CPU and DDR3/DDR4 based SDRAM, Memory controller for DDR3/DDR4.

BUSES AND PROTOCOLS	**(10 Hours)**

Introduction to Input/output Processing, Programmed Controlled I/O transfer, Interrupt Controlled I/O transfer, Introduction to serial and parallel Bus systems, Popular bus architecture standard such as IDE, SCSI, ATA, SATA, USB and IEEE 1394, Network component and protocols such as Ethernet and CAN.

PRACTICAL WILL BE BASED ON THE COVERAGE OF THE ABOVE TOPICS SEPARATELY	**(30 Hours)**

(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

3. List of Practicals:

1. Implementation of Binary Adders
2. Implementation of Booth’s Multiplier
3. Implementation of Wallace Tree Multiplier
4. Implementation of Division Unit
5. Implementation of Instruction Decoder
6. Implementation of Datapath with FSM
7. Implementation of Control Unit - Hardwired Control
8. Implementation of Control Unit - Microprogrammed Control

	9. ALU Design using existing blocks 10. Implementation of Cache Memory Design – Direct Mapped 11. Implementation of Cache Memory Design – Associative Mapped 12. Overall CPU design
4.	**<u>Books Recommended:</u>**
	1. David. A. Patterson and John L. Hennessy, “Computer Organization and Design: The Hardware/Software Interface”, 5th Ed., Morgan-Kaufmann Publishers Inc. 2014 2. Linda Null and Julia Lobur, “The Essentials of Computer Organization and Architecture”, 5th Ed., Jones & Bartlett Learning, 2018 3. Alan Clements, “Principles of Computer Hardware”, 4th Ed., Oxford University Press, 2013 4. C. Hamacher et al., “Computer organization,” 6th Ed., TMH, 2012
5.	**<u>Reference Books:</u>**
	1. Stephen Brown and Zvonko Vranesic, “Fundamentals of Digital Logic with Verilog Design”, 3rd Ed., McGraw-Hill, 2013 2. M. Morris Mano, “Digital Design”, 6th Ed., Pearson Education, 2018

B.Tech. III EC Elective-V EMBEDDED SYSTEMS VL323	Scheme	L	T	P	Credit
		3	0	2	04

1. Course Outcomes (COs):

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

CO1	Describe ARM processor, its modes, exception handling, instruction pipelining and basic programming
CO2	Implement Assembly and C language programming for ARM Cortex-M.
CO3	Analyze 32-bit ARM microcontroller architecture, External Memory, Counters & Timers, Serial Data Input/Output and Interrupts. Design for interfacing Keys, LED/LCD Displays, ADC And DAC
CO4	Evaluate concepts of RTOS and its functionalities.
CO5	Design a typical cost-effective real-world embedded system with appropriate hardware components and software algorithms

2. Syllabus:

OVERVIEW OF EMBEDDED SYSTEMS	**(06 Hours)**
Embedded Vs General computing system, Classification of Embedded systems, Major applications, Quality Attributes of Embedded Systems, Typical components, Embedded software development, Embedded OS, RISC Vs CISC Architectures	
ARM CORTEX M3/M4 ARCHITECTURE	**(10 Hours)**
Overview of ARM Cortex family, Operation modes and states, Registers, Special Registers, Floating point Registers, Application program status registers, Memory system and MPU, Exception and interrupts, System control block, OS support features	
PROGRAMMING CORTEX M3/M4IN ASSEMBLY/C	**(12 Hours)**
Assembly Instructions: Data Processing, SIMD and saturating, Multiply and MAC, Packing and unpacking, Floating point, Data conversion, Bit field processing, Compare and Test, Branching, Sleep mode, Memory barrier and other instructions, Assembly and Embedded C programming examples	
PERIPHERAL INTERFACING	**(08 Hours)**
Serial Communication interfacing such as USB, RS485, SPI, I2C, CAN and Ethernet, Motor control with PWM	
APPLICATION PROGRAMMING OF CORTEX M3/M4	**(09 Hours)**
Writing optimized ARM assembly/C code, Exception and fault handling routines, Handling floating point operations, Programming for DSP applications (such as Biquad filter, FIR filter, IIR filter, DFT, FFT etc.)	
PRACTICAL WILL BE BASED ON THE COVERAGE OF THE ABOVE TOPICS SEPARATELY	**(30 Hours)**

(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

3. List of Practicals:

	1. Write assembly code to perform Arithmetic and Logical operations. 2. Write a assembly language code to multiply 32-bit data stored on R1 and R2 and 64-bit result will generated and stored into R3(H) and R4(L). Please refer the below figure to implement the same. 3. Write assembly language code to program STM32F4(ARM cortex M4) transfer the data with memory 4. Write Assembly language code to perform switch-case on STM32F4 5. Interface LED with STM32F4 & write embedded C code for the same 6. Interface Switch and LED with STM32F4 & write embedded C code for the same. 7. Interface 4x4 Keypad and LEDs with STM32F4 & write embedded C code for the same. 8. Interface LCD with STM32F4 & write embedded C code for the same. 9. Interface UART with STM32F4 & write embedded C code for the same. 10. Interface DAC and ADC with STM32F4& write embedded C code for the same 11. Mini Project using STM32F4
4.	**Books Recommended:**
	1. Joseph Yiu, "A definitive guide to the ARM-Cortex M3 and Cortex-M4 Processors", 3rd Ed., Newnes, 2013. 2. ShibuK.V., "Introduction to Embedded Systems", 1st Ed., TMH 2009. 3. Y. Zhu, "Embedded Systems with Arm Cortex-M3 Microcontrollers in Assembly Language and C" E-Man Press LLC, 2014. 4. A.N.Sloss, D.Symes and C. Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Elsevier, 2004. 5. ARM Cortex M4 Technical Reference Manual.
5.	**Reference Books:**
	1. DVS Murthy, Transducers and Instrumentation, PHI 2nd Edition2013 2. Gary Johnson / Lab VIEW Graphical Programing II Edition /McGraw Hill 1997.

B.Tech. III EC Semester V DIGITAL IMAGE PROCESSING EC341	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):**
	At the end of the course, the students will be able to:

CO1	Discuss the Fourier transform for image processing in the frequency domain and compare the image compression techniques in spatial and frequency domains.
CO2	Apply techniques for image enhancement both in spatial and frequency domains for noise removal and better appearance.
CO3	Analyze causes for image degradation and apply restoration techniques.
CO4	Evaluate different image segmentation techniques.
CO5	Develop solutions using morphological concepts.

2. Syllabus:

DIGITAL IMAGE FUNDAMENTALS	(06 Hours)

Digital Image, Image Processing origins; Electromagnetic Spectrum, Imaging in X-rays, Ultraviolet, Visible Infrared, Visible, Microwave and Radio Bands; Components of Image Processing Systems. Visual Perception-Human Eye, Brightness Adaptation and Discrimination, Image Sensing and Acquisition, Image Formation Models; Image Sampling and Quantization - Basic Concepts, Representation of Image, Special and Gray Level Resolution, Relationships Between Pixels-Nearest Neighbour, Adjacency, Connectivity, Regions, and Boundaries; Distance Measures; Image Operations on a Pixel Basis; Linear and Nonlinear Operations.

IMAGE ENHANCEMENT	(12 Hours)

Gray Level Transformations-Image Negatives, Log, Power-Law and Piecewise Linear Transformation Functions; Histogram Processing-Equalization, Matching; Enhancement Operations - Arithmetic, Logic, Subtraction and Averaging; Spatial Filtering -Linear and order-statistics for Smoothing, First and Second Derivatives/Gradients for Sharpening, 2-D Fourier Transform, It's Inverse and Properties; Discrete and Fast Fourier Transform; Convolution and Correlation Theorems; Filtering in Frequency Domain-Low Pass Smoothing, High Pass Sharpening, Band Reject Filter, Homomorphic Filtering.

IMAGE RESTORATION	(10 Hours)

Image Degradation and Restoration Processes; Noise Models-Spatial Properties, Noise Probability Density Functions, Periodic Noise, Estimation of Noise Parameters; Restoration in the Presence of Noise and Mean Filters, Order-Statistics Filters, Adaptive Filters; Linear Position-Invariant Degradations and Estimation; Geometric Transformations-Spatial Transformation, Gray-Level Interpolation.

IMAGE COMPRESSION	(04 Hours)

Fundamentals of Compression, Image Compression Model, Error-free Compression, Lossy Predictive Coding, and Transform Coding.

MORPHOLOGICAL IMAGE PROCESSING	(04 Hours)

Preliminaries-Set Theory and Logic Operations in Binary Images; Basic Morphological Operations - Opening, Closing Operators, Dilation and Erosion; Morphological Algorithms - Boundary Extraction, Region Filling, Extraction of Connected Components, Convex Hull, Thinning, Thickening, Skeletons; Extension of Morphological Operations to Gray-Scale Images.

IMAGE SEGMENTATION	(09 Hours)

Detection of Discontinuities - Point, Line and Edges; Edge Linking and Boundary Detection-Local Processing, Global Processing Using Hough Transform; Thresholding - Local, Global and Adaptive;

	Region-Based Segmentation - Region Growing, Region Splitting and Merging; Motion Detection, Image Representation and Description.
	(Total Contact Time: 45 Hours)
3.	**<u>Books Recommended:</u>**
	1. Gonzalez R. C. and Woods R. E, "Digital Image Processing", 4th Edition, Pearson Education, 2018. 2. Sonka M. Hlavac V., Boyle R., "Image Processing, Analysis and Machine Vision", 4th Edition, Cengage Learning, 2017. 3. S. Sridhar, "Digital Image Processing", 2nd Edition, Oxford University Press, 2016 4. Jain A. K., "Fundamentals of Digital Image Processing",1st Edition, Pearson Education India, 2015. 5. William K. Pratt, "Introduction to Digital Image Processing", CRC Press, 2013.

B.Tech. III Semester V ANTENNA THEORY EC343	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

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

CO1	Explain the fundamentals and working principle of different antennas to their applications.
CO2	Apply the developed theories to model different radiating systems.
CO3	Compare the various antennas in terms of their design, functionality, use etc.
CO4	Evaluate the radiation and impedance characteristics of aperture, broadband, microstrip antennas and arrays.
CO5	Design suitable antennas and validate their performance for antenna arrays and smart antennas, mathematically analyze the types of antenna arrays.

2. Syllabus:

FUNDAMENTAL CONCEPTS **(10 Hours)**

Physical concept of radiation, Radiation pattern, Near- and Far-field regions, Reciprocity, Directivity and Gain, Effective Aperture, Polarization, Input Impedance, Efficiency, Friis transmission equation, Radiation integrals and Auxiliary Potential Functions.

RADIATION FROM WIRES AND LOOPS **(08 Hours)**

Infinitesimal dipole, Finite-length Dipole, Linear Elements near Conductors, Dipoles for Mobile Communication, Small Circular Loop Folded Dipole.

APERTURE AND HORN ANTENNAS **(06 Hours)**

Huygens' Principle, Radiation from Rectangular and Circular Apertures, Design Considerations, Babinet's Principle, Radiation from Sectoral and Pyramidal Horns, Design Concepts.

REFLECTOR ANTENNAS **(06 Hours)**

Parabolic Reflector, Paraboloidal Reflector, Aperture Pattern of Large Circular Apertures with Uniform Illumination, Off axis operation of Paraboloidal Reflectors, Cassegrain feed system.

BROADBAND ANTENNAS **(04 Hours)**

Broadband concept, Log-periodic antennas, Frequency independent antennas.

MICROSTRIP ANTENNAS **(06 Hours)**

Basic characteristics of microstrip antennas, Feeding methods, Methods of Analysis, Design of Rectangular and Circular Patch Antennas.

ANTENNA ARRAYS **(05 Hours)**

Analysis of Uniformly Spaced Arrays with Uniform and Non-uniform Excitation amplitudes, Extension to planar arrays.

(Total Contact Time: 45 Hours)

3. Books Recommended:

1. C. A. Balanis, "Antenna Theory and Design", 4th Ed., An Indian Adaptation, John Wiley & Sons., 2021.
2. J.D. Krauss, "Antennas for all Applications", 3rd Ed., Tata McGraw-Hill, 2016.

	3. W. L. Stutzman, “Antenna Theory and Design”, 3rd Ed., John Wiley & Sons, 2012. 4. R. S. Elliot, “Antenna Theory and Design”, Revised edition, Wiley-IEEE Press., 2006. 5. John Kraus, “Antennas and Wave Propagation”, McGraw-Hill., 2017.

B.Tech. III EC Semester V HARDWARE DESCRIPTION LANGUAGE VL343	Scheme	L	T	P	Credit
		3	0	0	03

1.	**Course Outcomes (COs):**
	At the end of the course the students will be able to:

CO1	Understand the concept of structural, data flow and behavioral style of hardware description and model various delays
CO2	Implement register transfer and gate level Digital system circuits. Also, verify with HDL simulations, Sequential circuits and FSMs
CO3	Develop and implement combinational logic circuits such as mux, demux, encoder, decoder, adders using Verilog and VHDL.
CO4	Evaluate the synthesized hardware for area, power and speed
CO5	Design ALU, instruction decoder, FIFO using HDL

2.	**Syllabus**	
	INTRODUCTION	**(11 Hours)**
	Basic Concepts Of Hardware Description Languages, Hierarchy, Concurrency, Logic And Delay Modeling, Structural, Data-Flow And Behavioral Styles of Hardware Description, Architecture Of Event Driven Simulators	
	VHDL – Modelling and Analysis	**(16 Hours)**
	Syntax And Semantics Of VHDL, Variable And Signal Types, Arrays And Attributes, Operators, Expressions And Signal Assignments, Entities, Architecture Specification And Configurations, Component Instantiation, Concurrent And Sequential Constructs, Use Of Procedures And Functions, Examples of Digital Design Using VHDL	
	VERILOG – Digital Design and Synthesis	**(18 Hours)**
	Syntax And Semantics Of Verilog, Variable Types, Arrays And Tables, Operators, Expressions And Signal Assignments, Modules, Nets And Registers, Concurrent And Sequential Constructs, Tasks And Functions, Examples Of Design Using Verilog, Synthesis Of Logic From Hardware Description	
		(Total Contact Time: 45 Hours)
3.	**Books Recommended**	

1. Bhaskar J.,“VHDL Primer”,Pearson Education Asia, 3rd Edition, 2015
2. Perry D.,“VHDL”,Tata McGraw-Hill, 4th Edition, 2017
3. Navabi Z.,“VHDL”,McGraw Hill, 3rd Edition,2007
4. Palnitkar S.,“Verilog HDL: A Guide to Digital Design and Synthesis”, Pearson, 2nd Edition, 2003
   Bhaskar J.,“Verilog HDL Synthesis - A Practical Primer”,Star Galaxy Publishing, 2018

B.Tech. III EC Semester V SENSORS AND TRANSDUCERS EC361	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

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

CO1	Explain the different types of sensors and transducers with working principle.
CO2	Apply the concepts of sensors for various applications.
CO3	Analyze different sensors and transducers for various applications.
CO4	Evaluate the applications of sensors in measurements/instrumentation.
CO5	Design the basic sensors systems for different applications.

2. Syllabus:

INTRODUCTION **(05 Hours)**

General Concepts and Terminology, Definition of Transducer, Sensor and Actuator, Transducer/Sensor Classification, Criteria to Choose a Transducer/Sensor, Characteristics parameters of Sensors.

RESISTIVE TRANSDUCERS **(06 Hours)**

Resistive Potentiometers, Strain Gauges, Resistive Temperature Detectors, RTDs, PTD, Thermistors, Light-Dependent Resistors (LDRs), Resistive Hygrometers, Resistive Gas Sensors.

INDUCTIVE AND MAGNETIC TRANSDUCERS **(06 Hours)**

Inductive Transducers: Self-inductive transducer, Mutual inductive transducers, Linear Variable Differential Transformer-LVDT Accelerometer, Applications of Inductive Transducers such as proximity sensors for position measurement, dynamic motion measurement, Magnetic Sensors: Sensors based on Hall Effect, Performance Characteristics and Applications.

CAPACITIVE TRANSDUCERS **(04 Hours)**

Working Principle of Capacitive Transducer, Variable Distance based Capacitive Transducers, Variable Area based Capacitive Transducers, Variable Distance based Capacitive Transducers, Calculation of sensitivities, Applications of Capacitive Transducers for the measurement of different physical and bio-analytes.

SELF-GENERATING TRANSDUCERS **(06 Hours)**

Principle of operation, construction, theory, advantages and disadvantages and applications of following transducers: Thermocouple, Piezo-electric transducer, Pyroelectric transducers, Photo-voltaic transducer and Electrochemical transducer.

OPTICAL AND ACOUSTIC TRANSDUCERS **(04 Hours)**

Principle of Optical fiber based sensors, Types of optical sensors, Applications of optical sensors and biosensors. Principle Acoustic transducers, SAW and IDT sensors, Applications of Acoustic transducers, Ultrasonic Sensor.

BIOSENSORS **(03 Hours)**

Principle of Biosensors, Performance Criteria of Biosensors, Types of Biosensors such as Electrochemical, Thermal, Resonant, Ion-sensitive, Optical etc. and its applications.

PRESSURE, FLOW AND LEVEL TRANSDUCERS **(07 Hours)**

Pressure Transducers Like U-tube manometer, Bourdon tube, Diaphragm and Bellows, Membranes And Thin Plates, Piezo-resistive, Capacitive Sensors, VRP Sensors, Pirani vacuum gauge Vacuum Sensors. Flow Transducers Like Differential Pressure, Orifice Plate Flow meter, Flow Nozzle, Hot Wire

	Anemometer, Ultrasonic Flow meter, Vortex Flow meter. Level Transducers Like Displacer, Float, Pressure Gages, Capacitive, Resistive, Ultrasonic type level measurements, Level Switch.	
	ADVANCEMENTS IN SENSORS AND TRANSDUCERS	**(04 Hours)**
	Sensors Used In Smartphone, Sensors Used In Smart city, Sensors For Robotics, MEMS and Nano Sensors, Smart and Integrated Sensors, IoT Applications.	
	(Total Contact Time: 45 Hours)	
3.	**Books Recommended:**	

1. S. Vijayachitra, "Transducers Engineering", PHI Learning Pvt. Ltd., 1^{st} Ed., 2016
2. Ghosh Arun K., "Introduction to Transducers", PHI Learning Pvt. Ltd., 1^{st} Ed., 2014
3. Patranabis D., "Sensors and Transducers", 2nd Ed., Prentice-Hall India, 2004.
4. Shawhney A. K., "A Course in Electrical and Electronic Measurements and Instrumentation", Dhanpat Rai & Sons, January 2021.
5. Alok Barua, "Fundamental of Industrial Instrumentation", 1st Ed., Wiley India, 2011.
6. Jacob Fraden, "Handbook of Modern Sensors: Physics, Designs and Applications", 3rd Ed., Springer, 2004.

B.Tech. III EC Semester VI MICROWAVE COMPONENTS AND COMMUNICATION EC302	Scheme	L	T	P	Credit
		3	0	2	04

1. Course Outcomes (COs):

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

CO1	Explain the basic concepts of microwave components, working principle of waveguide based and microstrip based components, sources and their applications and its application.
CO2	Apply the knowledge of transmission line theory to waveguide components, microstrip components and antennas.
CO3	Analyze the electric and magnetic field modes in microstrip based and waveguide-based components in association with the communication systems.
CO4	Evaluate the different parameters of microwave communication system.
CO5	Design the matching networks, microstrip filters of different orders, waveguide-based hybrid circuits and Microwave integrated circuits.

2. Syllabus:

INTRODUCTION	**(02 Hours)**
Circuit-Field Relations, RF Behaviour of Passive Components, Chip Components.	
MICROWAVE WAVEGUIDES AND COMPONENTS	**(08 Hours)**
Introduction, Rectangular Waveguides, Rectangular Cavity Resonators, Microwave Hybrid Circuits: Waveguides Tees, Magic Tee, Directional Couplers.	
MICROWAVE NETWORK ANALYSIS AND IMPEDANCE MATCHING	**(06 Hours)**
Basic Definitions, Interconnecting Networks, Network Properties and Application, ABCD and Scattering Parameters, Impedance Matching using Discrete Components, Microstrip Line Matching Networks.	
POWER DIVIDERS AND DIRECTIONAL COUPLERS	**(07 Hours)**
The T Junction Power Divider, The Wilkinson Power Divider, The Quadrature (90°) Hybrid, Coupled Line Directional Couplers, Rat-race and Hybrid Ring.	
MICROWAVE FILTERS	**(08 Hours)**
Basic Resonator and Filter Configurations, Periodic Structures, Filter Design by the Image Parameter Method, Special Filter Realizations, Stepped-Impedance Low-Pass Filters, Coupled Line Filters.	
MICROWAVE DIODES AND TUBES	**(07 Hours)**
GaAs FET, HEMT, Varactor diodes, PIN diodes, IMPATT, TRAPATT and BARITT, Microwave Tunnel Diodes, Gunn Diodes, Schottky Diodes and Detectors, Microwave Unipolar and Bipolar Transistor: physical structure, principle of operation, characteristics, Klystrons, Magnetrons and TWT.	
MICROWAVE ANTENNAS	**(04 Hours)**
Fundamentals of Antenna, Antenna Arrays, Microstrip, Helical, Yagi-Uda, Log-Periodic and Reflector Antennas.	
MICROWAVE COMMUNICATION SYSTEMS AND OTHER APPLICATIONS	**(03 Hours)**
Overview of Radar, Cellular Communication, Satellite Communication	
PRACTICAL WILL BE BASED ON THE COVERAGE OF THE ABOVE TOPICS SEPARATELY	**(30 Hours)**

	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)
3.	**List of Practicals:**
	1. Introduction to Microwave Bench. 2. To determine the frequency & wavelength in a rectangular wave-guide working on TE10 mode 3. To obtain characteristics of Attenuator (Fixed and Variable type) 4. To verify properties of Magic Tee 5. To verify properties of Directional Coupler. 6. To obtain characteristics of Microstrip Band Pass and Band Stop Filters. 7. To obtain characteristics of Microstrip Power Divider. 8. To plot Mode Characteristics of Reflex Klystron. 9. To plot of V-I characteristics of Gunn Diode 10. To verify properties of Resonant Cavity 11. Study and analysis of EMI and EMC standards. 12. Experiments on Microwave Measurements: Power measurements: Calorimeter method, Bolometer bridge method Measurement of Cavity Q, Measurement of S parameters of a Network.
4.	**Books Recommended:**
	1. David M. Pozar, "Microwave Engineering: Theory and Techniques, An Indian Adaptation", 4th Ed., John Wiley & Sons, Inc., 4th Ed., 2020. 2. C. F. Free and Collin S. Aitchison, "RF and Microwave Circuit Design - Theory and Applications", 1st Ed., Wiley Publications, 2021. 3. C. A. Balanis, "Antenna Theory and Design", 4th Ed., John Wiley & Sons, 2016. 4. Ludwig Reinhold and Bretchko Pavel, "RF Circuits Design: Theory and Applications", 1st Ed., Pearson Education, Low Price ed., 2000. 5. Liao Samuel Y., "Microwave Devices and Circuits", 3rd Ed., PHI, 2nd Reprint, 2006.
5.	**Reference Books:**
	1. Annapurna Das, Sisir K Das, "Microwave Engineering", 3rd Ed., Mc Graw Hill, Reprint 2017. 2. Kumar A., "Microwave Techniques: Transmission Line", 1st Ed., New Age International, 1998.

B.Tech. III EC Semester VI VLSI DESIGN VL312	Scheme	L	T	P	Credit
		3	0	2	04

1. Course Outcomes (COs):

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

CO1	Describe VLSI Design flow and circuit characterization for performance estimation.
CO2	Demonstrate dynamic Logic circuits.
CO3	Compare different semiconductor memories.
CO4	Evaluate the circuit performance using Logical efforts.
CO5	Design arithmetic building blocks (data-path) from the system's perspective along with the design of FSM (Control-path).

2. Syllabus:

INTRODUCTION OF VLSI DESIGN **(06 Hours)**

Historical Perspective, Design Hierarchy, Concepts of Regularity, Modularity and Locality, VLSI Design Styles, VLSI Design Flow, Semi-Custom- Full Custom IC Design Flow, Data Path, Control Path Programmable Logic Array, CMOS and Bipolar Transistor Gate Arrays and Their Limitations, Standard Cells, FPGA/CPLD Architecture.

DYNAMIC LOGIC CIRCUITS **(06 Hours)**

Voltage Bootstrapping, Synchronous Dynamic Circuit Techniques, Dynamic and High Performance Dynamic CMOS Circuit, Dynamic Latches and Registers.

CIRCUIT CHARACTERIZATION FOR PERFORMANCE ESTIMATION **(08 Hours)**

Interconnect, Estimation of Interconnect Parasites, Delay Estimation, Logical Efforts and Transistor Sizing, Power Dissipation, Design Margin, Reliability.

SEMICONDUCTOR MEMORIES **(08 Hours)**

Type of Memories, design and analysis of ROM Cells, Static and Dynamic Read - Write Memories, Memory Peripheral Circuits, Power Dissipation in Memory, Flash Memory.

DESIGN OF ARITHMETIC BUILDING BLOCKS **(12 Hours)**

Data Path Operations: Adders, Shifter, Multiplier, Power and Speed Trade-off in Data-path Structures, Control Path and FSM.

INPUT-OUTPUT CIRCUITS **(05 Hours)**

ESD Protection, Input Circuits, Output Circuits, Pad Drivers and Protection Circuit, On-Chip Clock Generation/Distribution, Latch-up and its Prevention.

(Total Contact Time: 45 Hours)

3. List of Practicals:

1. Introduction to Verilog HDL and FPGA.
2. Implementation and Simulation of Logic Gate using Verilog HDL on FPGA
3. Design and Implementation of Half adder and Full Adder using Verilog HDL on FPGA.
4. Design and Implementation of Half subtractor and Full Subtractor using Verilog HDL on FPGA.
5. Design and Implementation of Ripple Carry Adder using Verilog HDL on FPGA.
6. Design and Implementation of Multiplexer using Verilog HDL on FPGA.
7. Design and Implementation of Flip-Flops using Verilog HDL on FPGA.

	8. Design and Implementation of Registers using Verilog HDL on FPGA. 9. Design and Implementation of Four Bit Up-Down Counter using Verilog HDL on FPGA. 10. Design and Implementation of Array Building Blocks.
4.	**<u>Books Recommended:</u>**
	1. Rabaey Jan M., Chandrakasan Anantha and Borivoje Nikolic, "Digital Integrated Circuits (Design Perspective)", 2nd Ed., Prentice Hall of India, 2016 (Reprint). 2. Kang and Leblebici,“CMOS Digital Integrated Circuits: Analysis and Design”, Tata McGraw-Hill, 4th Edition, 2019 3. Baker R. Jacob, Li H. W. & Boyce D. E.,“CMOS Circuit Design, Layout And Simulation”, Wiley, 4th Edition, 2009 4. Weste and Harris,“CMOS VLSI Design: A Circuits and Systems Perspective”, Pearson Education, 4th Edition, 2020 5. Pucknell and Eshraghian: “Basic VLSI Design”, Prentice Hall of India, 3rd Edition, 2003

B.Tech. III EC Semester VI WIRELESS AND MOBILE COMMUNICATION EC322	Scheme	L	T	P	Credit
		3	0	2	04

1.	**Course Outcomes (COs):**
	At the end of the course the students will be able to:

CO1	Describe the terminology related to mobile cellular system, traffic, diversity, channel and established standards
CO2	Explain the wireless channel scenario with latest techniques, Cellular structure applied in the Mobile Technology by illustrating the various methods and open challenges for the improvement of wireless communication link.
CO3	Experiment with the traffic calculation formulas to design and optimize the load at the cellular network with the coverage area optimization using various techniques
CO4	Classify the evolution of the various generation of the Mobile standards
CO5	Evaluate the major breakthrough in the field mobile communication standards by exploring various applications and use cases

2.	**Syllabus:**	
	INTRODUCTION TO WIRELESS CHANNEL	**(06 Hours)**
	AWGN Channel, Multipath and Fading Effects, maximum delay spread, RMS delay spread, coherence bandwidth, coherence time, Large and Small Scale Fading, Flat and Frequency Selective Fading, Slow and Fast Fading, BER performance of communication systems, Channel Models: ground wave propagation model, Terrain Models, City Models, Rayleigh, Rician and Nakagami Channel Models, BER performance of wireless channel, channel estimation, equalization.	
	CELLULAR SYSTEM DESIGN FUNDAMENTALS	**(04 Hours)**
	A Basic Cellular System, Cellular Communication Infrastructure: Cells, Clusters, Cell Splitting, Frequency Reuse Concept and Reuse Distance Calculation, Cellular System Components, Operations of Cellular Systems, Call Setup, Handoff/Handover, Channel Assignment-Fixed and Dynamic, Cellular Interferences: Co-Channel and Adjacent Channel, Antennas for The Base Stations, Sectorization, Mobile Traffic Calculation	
	DIVERSITY TECHNIQUES	**(03 Hours)**
	Introduction to Diversity, Types of Diversity- Space, Time, Frequency, Transmit Diversity, Receive diversity, selection diversity, combining diversity, equalization.	
	MIMO TECHNOLOGY	**(03 Hours)**
	Introduction to MIMO technology, Beamforming, space time signal processing, Massive MIMO concept	
	EARLY MOBILE COMMUNICATION STANDARDS (2G-3G)	**(04 Hours)**
	Overview of 2G 3G, Key capabilities, GSM: Global System for Mobiles Communications, GPRS: General Packet Radio Service, EDGE: Enhanced Data - Rates for Global Evolution, UMTS: Universal Mobile Telecommunication System, WCDMA	
	MOBILE COMMUNICATION STANDARD (4G)	**(10 Hours)**
	LTE Technology, Key capabilities, Access Technology, LTE Network Architecture, Channel Structure, LTE Protocol Structure, Radio Resource Management, Security in LTE, Performance measures- Outage, average snr, average symbol/bit error rate.	
	MOBILE COMMUNICATION STANDARD (5G)	**(12 Hours)**

	Introduction to 5G, 5G Standardization and Regulation: Frequencies , Standardization, Regulation, Three pillars of 5G: eMBB, , mMTC, URLLC, 5G Network: Design Principles, Features and Functions, 5G Network Architecture, 5G Access Networks: 5G Network Architecture, RAN (Radio Access Network), Open-RAN (O-RAN), 5G Core Network: Basic System Architecture and Protocols, Core Network Functions , Service Based Architecture (SBA), Network Slicing, 5G System: 4G/5G Migration, 5G and IMS , Access Networks and Fixed Mobile Convergence (FMC), 5G and IoT, 5G Campus Networks, 5G System in an Overall View , 5G and Security : Security for the Communication Network , Security in the Cloud Infrastructure, 3GPP Security Architecture for 5G, 5G and Environment : New Issues through 5G Technology, Electromagnetic Radiation and Health, Exposure and Limit Values, Influences of the Network Architecture , Energy Requirements, Raw Materials, and Sustainability
	FUTURE DEVELOPMENTS TOWARDS 6G **(03 Hours)**
	Further Development of 5G, Network 2030 , Research, Regulation, and Standardization on 6G, 6G Use Cases and Usage Scenarios, 6G Requirements, Technologies for 6G and Network Architectures
	PRACTICAL WILL BE BASED ON THE COVERAGE OF THE ABOVE TOPICS SEPARATELY **(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)
3.	**List of Practicals:**

1. Implement and simulate the various modulation schemes and analyze their performance.
2. Implement and simulate M-PSK modulation technique with OFDM on an AWGN channel with the help of MATLAB where M=2,4,16. Plot BER vs SNR.
3. Implement and simulate M-PSK modulation technique with OFDM on a single-tap Rayleigh fading channel with AWGN where M=2,4,16. Plot BER vs SNR.
4. Implement and simulate M-PSK modulation technique with OFDM on a single-tap Rician fading channel with AWGN where M=2,4,16. Plot BER vs SNR for different values of the Rician K factor.
5. Simulate a multi-tap Rayleigh fading channel with inter-symbol interference (ISI). Perform time-domain block-wise zero-forcing equalization to eliminate ISI at the receiver and plot BER vs SNR for an M-QAM system.
6. Implement and simulate an Orthogonal Frequency Division Multiplexing (OFDM) communication system with a multi-tap fading channel. Perform frequency domain equalization on each subcarrier at the receiver and plot BER vs SNR for M-QAM symbols.
7. Simulate a single-tap Rayleigh fading channel with imperfect channel state information (CSI) for an M-QAM communication system for M=4. Perform channel estimation at the receiver using pilot symbols and decode the information symbols using the channel estimates. Plot BER vs SNR for various number of pilot symbols (per block of transmitted symbols).
8. Implement an OFDM system with frequency diversity on a multi tap Rician fading channel. Transmit the same M-QAM symbols on multiple subcarriers and perform maximal ratio combining (MRC) at the received frequency-domain symbols. Plot BER vs SNR and observe the effect of increasing the number of repeated symbols.
9. Implement and simulate multi-antenna Spatial Diversity techniques using a 2x1, 3x1 and 4x1 Single Input Multiple Output (SIMO) communication system on a single tap Rician fading channel. Plot BER vs SNR for Selection Combining and Maximal Ratio Combining (MRC) techniques.
10. Implement and simulate a 2x2 Multiple Input Multiple Output (MIMO) communication system on a single tap Rayleigh fading channel. Plot BER vs SNR for Zero-Forcing (ZF) and Linear Minimum Mean Square Error (LMMSE) receivers.
11. Implement and simulate a Direct Sequence Spread Spectrum (DSSS) communication system with a multi-tap Rayleigh fading channel. Implement Rake receiver and plot BER vs SNR for different number of channel taps L (L = 1, 3, and 5). 12. To study the 4G trainer Kit.
12. Introduction to 5G infrastructure

4. **Books Recommended:**

	1. Mobile Cellular Telecomm. B y William C. Y. Lee. 2. Andreas F. Molisch, “Wireless Communications” 2nd Ed., Wiley, 2011. 3. Dalal Upena," Wireless and Mobile Communication ", 1st Ed., Oxford University Press, 2016. 4. Ajay R. Mishra, “Cellular Technologies For Emerging Markets”, A John Wiley and Sons, Ltd., Publication, first edition, 2010. 5. Erik Dahlman, Stefan Parkvall, Johan Sko, “4G, LTE-Advanced Pro and The Road to 5G”, Elsevier publication, Third Edition, 2016 6. Ulrich Trick, “5G”, Walter de Gruyter publisher, 2nd Edition, 2024.
5.	**Reference Books:**
	1. Rodriguez, Jonathan. Fundamentals of 5G mobile networks. John Wiley & Sons, 2015.

B.Tech. III EC Semester VI DATA STRUCTURES AND ALGORITHMS EC324	Scheme	L	T	P	Credit
		3	0	2	04

1. Course Outcomes (COs):

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

CO1	Understand linear data structures like arrays, stacks, queues, and linked lists and non-linear data structures like trees and graphs.
CO2	Implement sorting, searching, and hashing algorithms.
CO3	Analyze the complexity of algorithms in terms of time and space.
CO4	Apply recursive techniques in problem-solving.
CO5	Create a modified data structure for a specific requirement.

2. Syllabus:

INTRODUCTION TO DATA STRUCTURES **(04 Hours)**

Algorithms as opposed to programs, Measures for performance Analysis, Asymptotic Notations: Big-O, Theta (Θ), Omega (Ω). Time and space complexity, Best, worst, and average case analysis.

Types of Data Structures: Linear and Non-linear data structures.

LINEAR DATA STRUCTURES **(10 Hours)**

Arrays: Definition, types, and operations (insertion, deletion, traversal).

Linked Lists: Definitions, structure, and basic operations (insertion, deletion, traversal) of Singly Linked List, Doubly Linked List and Circular Linked List.

Stacks and Queues: Stacks: Definition, operations (push, pop, peek etc.), and applications, Stack implementation using arrays and linked lists. Queues: Definition, types of queues (simple, circular, and priority queues), operations (enque, dequeue etc.) Queue implementation using arrays and linked lists.

Time and Space Complexity analysis of operations on the above data structures.

NON LINEAR DATA STRUCTURES **(12 Hours)**

Binary Trees: Need of Binary Trees, Definition, properties, types (full, complete, perfect, skewed, balanced), Binary tree traversal techniques (inorder, preorder, postorder, level order).

Binary Search Trees (BST): Need of BST, Definition, properties, operations (insertion, three cases of deletion, traversal).

Red-Black Trees: Need of Red-Black Trees, Definition, Properties, Left, Right and Double rotations in Red-black trees, Operations (Insertion and deletion) in Red-Black trees.

AVL Trees: Need of AVL Trees, Definition, Properties, Single and Double rotations in AVL trees, Operations (Insertion and deletion) in AVL trees.

Heaps: Need of Heaps, Definition, Properties, Max-heap and Min-heap, operations (insertion, deletion and heapify) in AVL trees, Priority Queue.

Hashing: Need of Hashing, Hash functions, collision resolution techniques (Chaining, Open Addressing: Linear Probing, Quadratic Probing, Double Hashing), Rehashing.

Time and Space Complexity analysis of operations on the above data structures.

GRAPHS **(7 Hours)**

	Introduction to Graphs: Need of Graphs, Definitions, types (directed, undirected, weighted), Representations of graphs (adjacency matrix, adjacency list). Graph Traversal Algorithms: Breadth-First Search (BFS), Depth-First Search (DFS). Shortest Path Algorithms: Need of Shortest Path Algorithm, Dijkstra's algorithm, Bellman-Ford algorithm. Minimum Spanning Trees: Need of Minimum Spanning Trees, Prim's algorithm, Kruskal's algorithm.
	SEARCHING AND SORTING ALGORITHMS **(12 Hours)**
	Searching Algorithms: Need of Searching Algorithm, Linear Search, Binary Search. Sorting Algorithms: Need of Sorting Algorithms, Comparison-based sorting algorithms: Bubble Sort, Selection Sort, Insertion Sort, Merge Sort, Quick Sort, Heap Sort. Non-comparison-based sorting algorithms: Radix Sort. Time and space complexity analysis of above sorting algorithms.
	PRACTICAL WILL BE BASED ON THE COVERAGE OF THE ABOVE TOPICS SEPARATELY **(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)
3.	**List of Practicals:**

1. Write a program to perform Insertion and Deletion in an unsorted Array when the number and the positions are given.
2. Write a program to search an element in a sorted array using binary search and search the same element in the same array using linear search.
3. Perform Insertion and Deletion in a Linked List when the number and the positions are given.
4. Given two linked lists List1 = {A1, A2……….,An} and List2 = {B1,B2,……Bm} with data (both lists) in ascending order. Write a program to merge the given lists so that the merged list will be:
   {A1,B1,A2,B2,……..Am,Bm,Am+1,……..An} if n >= m
   {A1,B1,A2,B2,……..An,Bn,Bn+1,……..Bm} if m >= n
5. Write the programs to perform a stack's push, pop, top and isEmpty functions.
6. Write a program to find the height of a binary tree.
7. Write a program to insert and delete an element in a binary search tree.
8. Given a sorted doubly linked list, write a program to convert it into a balanced binary search tree.
9. Write a program to find the shortest path in a weighted graph using the Dijkstra algorithm.
10. Write a program to sort an array using mergesort algorithm.
11. Write a program to implement a separate chaining collision resolution technique.
12. Write the enqueue and deque functions for a queue implemented using a linked list.
13. Write a program to implement heap sort algorithm.
14. Write a program to solve the traveling salesman problem using greedy algorithm

4. **Books Recommended:**

1. Narasimha Karumanchi, "Data Structures and Algorithms Made Easy", CareerMonk Publications, 2021.
2. Mark A. Weiss, "Data Structures and Algorithm Analysis in C++", 4th Ed., Published by Pearson (June 13th 2013).
3. Gilles Brassard, "Fundamentals of Algorithms", Pearson Education 2015.
4. E. Horowitz, S. Sahni and S. Rajasekaran, "Computer Algorithms/C++", Second Edition, University Press, 2007.
5. A. V. Aho, J. E. Hopcroft, and J. D. Ullman. Data Structures and Algorithms. Addison-Wesley, Reading, Massachusetts, 1983.

	6. Anany Levitin "Introduction to the Design and Analysis of Algorithms" Pearson Education, 2015.
5.	**<u>Reference Books:</u>**
	1. Richard F. Gilberg, Behrouz A. Forouzan, "Data Structures – A Pseudocode Approach with C++", Thomson Brooks / COLE, 1998.

B.Tech. III EC Semester VI OPTICAL FIBER COMMUNICATION EC326	Scheme	L	T	P	Credit
		3	0	2	04

1. Course Outcomes (COs):

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

CO1	Explain the different types of fibers and optical components of an optical communication link.
CO2	Apply the concepts of light transmission in optical fiber communication link.
CO3	Analyze fiber, optical source, detector and components.
CO4	Evaluate optical fiber communication link parameters.
CO5	Design the basic optical fiber communication system.

2. Syllabus:

LIGHTWAVE TRANSMISSION	**(07 Hours)**
Nature Of Light, Basic Optical Laws, Propagation Of Light In Fiber, Elements Of Fiber Optic Communication, Optical Spectrum, Optical Power, Types of Optical Fiber, Fiber Fabrication, Fiber Cables.	
SIGNAL DEGRADATION AND MEASURMENTS	**(07 Hours)**
Degradation Of Signals In Optical Fiber, Attenuation, Absorption Losses, Scattering Losses, Bending Losses, Effect Of Dispersion On Pulse Transmission, Intermodal, Intramodal and Waveguide Dispersion, Total Dispersion And Maximum Transmission Rates, Nonlinear Effects In Fiber, Numerical Aperture Measurements, Attenuation Measurement, Dispersion Measurement, OTDR Field Applications.	
OPTICAL SOURCES	**(08 Hours)**
Basic Structure, Principle And Operation and Types of Light Emitting Diode, Laser Diode, Comparison Between LED And LD.	
PHOTO DETECTORS AND RECEIVER SYSTEM	**(06 Hours)**
PIN Photodiode, Avalanche Photodiode, Comparison Between PIN Photodiode And APD, Fundamental Receiver Operation, Receiver Sensitivity, System Performance Evaluation Criteria, Eye Diagram, BER, OSNR, And Q-Factor.	
POWER LAUNCHING, COUPLING AND LINK DESIGN	**(04 Hours)**
Source To Fiber Power Launching, Lensing Schemes, Fiber To Fiber Joints, Connectors, Splicing, Point To Point Link, System Design Considerations, Power Budget, Rise Time Budget, Power Penalty.	
OPTICAL AMPLIFIERS	**(05 Hours)**
Principle of Optical Amplification, Semiconductor Optical Amplifiers, Erbium-Doped Fiber Amplifiers, Raman Amplifiers.	
WDM CONCEPTS AND COMPONENTS	**(08 Hours)**
Principles Of WDM, WDM System Configuration, Types of WDM System, WDM Components, Applications of WDM Systems.	
PRACTICAL WILL BE BASED ON THE COVERAGE OF THE ABOVE TOPICS SEPARATELY	**(30 Hours)**

(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

3. List of Practicals:

	1. To implement and plot the I-V and I-P characteristics of LED. 2. To implement and plot the I-V and I-P characteristics of LASER Diode. 3. To implement and plot the I-V and I-P characteristics of Photo Detector. 4. To implement, study and analyze numerical aperture and losses in optical fiber. 5. To study and analyze modes and power in optical fiber using software. 6. To implement and study FM and PWM through optical link. 7. To implement and study free space optics using LASER module. 8. To implement and find the BER and EYE Pattern. 9. To implement and study power margin and sensitivity of optical system. 10. Design and performance analysis of a single channel link using Optisystem. 11. Design and performance analysis of a WDM link using Optisystem. 12. Link budget and rise time budget analysis of a single channel optical link using Optisystem.
4.	**Books Recommended:**
	1. Gerd Kaiser, "Optical Fiber Communication", McGraw Hill, 5th Ed., 2017. 2. Senior J. M., "Optical Fiber Communication - Principle And Practice", PHI, 3rd Ed., 2018 3. Govind P. Agrawal, “Fiber-Optic Communication Systems”, 5th Edition, 2021 4. C.S. Gupta, “Optical Fiber Communication and Its Applications”, PHI, 1st Ed., 2021 5. Gp Capt KS Mathur (Retd.), “Fiber Optics Fundamentals and Advances in Optical Communications”, Bluerose Publishers Pvt. Ltd., 1st Ed., 2021.

B.Tech. III EC Semester VI MACHINE LEARNING EC328	Scheme	L	T	P	Credit
		3	0	2	04

1. Course Outcomes (COs):

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

CO1	Describe the differences in approaches and applicability of regression, classification, and clustering.
CO2	Demonstrate and learn to apply supervised learning algorithms
CO3	Demonstrate and learn to apply unsupervised learning algorithms
CO4	Implement feature extraction and selection to represent data as features to serve as input to machine learning models build an application that is based on machine learning.
CO5	Design an application based on suitable machine learning task.

2. Syllabus:

INTRODUCTION **(10 Hours)**

Introduction, Machine learning basics, Supervised Learning: Artificial Neural Network, classifying with k-Nearest Neighbour classifier, Support vector machine classifier, Decision Tree classifier, Naive Bayes classifier, Bagging, Boosting, Improving classification with the AdaBoost meta algorithm.

FORECASTING AND LEARNING THEORY **(09 Hours)**

Regression, Linear Regression, Multivariate Regression, Logistic regression, Principal Component Regression, Tree-based regression. Bias/variance trade-off,

UNSUPERVISED LEARNING **(09 Hours)**

Grouping unlabeled items using k-means clustering, Association analysis with the Apriori algorithm, efficiently finding frequent item sets with FP-growth.

REINFORCEMENT LEARNING **(08 Hours)**

Markov decision process (MDP), Linear quadratic regulation, Linear Quadratic Gaussian, Q-learning, Value function approximation, Policy search, Reinforce,

DIMENSIONALITY REDUCTION **(09 Hours)**

Feature extraction - Principal component analysis, Singular value decomposition. Feature selection – feature ranking and subset selection, filter, wrapper and embedded methods.

PRACTICAL WILL BE BASED ON THE COVERAGE OF THE ABOVE TOPICS SEPARATELY **(30 Hours)**

(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

3. List of Practicals:

1. 1. Implement and demonstrate the FIND-S algorithm for finding the most specific hypothesis based on a given set of training data samples. Read the training data from a .CSV file.
2. For a given set of training data examples stored in a .CSV file, implement and demonstrate the Candidate-Elimination algorithm to output a description of the set of all hypotheses consistent with the training examples.
3. Write a program to implement the naïve Bayesian classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets.

	4. Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample. Compare results with random forest classifier. 5. Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions. Java/Python ML library classes can be used for this problem. 6. Write a program to implement the Linear Regression for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets. 7. Write a program to implement the Logistic Regression for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets. 8. Write a program to implement the support vector machine for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets. 9. Write a program to implement the K-mean clustering for a sample training data set stored as a .CSV file. 10. Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets.
4.	**<u>Books Recommended:</u>**
	1. E. Alpaydin, “Introduction to Machine Learning”, 2nd Ed., MIT Press, 2009. 2. T. M. Mitchell, “Machine Learning”, McGraw-Hill, 1997. 3. Christopher M. Bishop, “Pattern Recognition and Machine Learning”, 2nd Ed., Springer; 2011. 4. Miroslav Kubat , “An Introduction to Machine Learning”, Springer (2017) 5. GopinathRebala, Ajay Ravi, Sanjay Churiwala, “An Introduction to Machine Learning”, Springer (2019).
5.	**<u>Reference Books:</u>**
	1. Kevin Patrick Murphy Probabilistic Machine Learning: An Introduction MIT Press, March 2022.

B.Tech. III EC Semester VI SPEECH PROCESSING AND HUMAN-MACHINE COMMUNICATION EC342	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

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

CO1	Define the fundamentals of speech and the speech production system.
CO2	Describe the different parameters of speech signal.
CO3	Apply different algorithm to extract different speech parameters
CO4	Analyze different speech processing algorithm.
CO5	Design a speech based system for different applications.

2. Syllabus:

INTRODUCTION	**(05 Hours)**

Application of speech processing; Speech signal representation and measurement; Stationary and non-stationary analysis of speech

SPEECH PRODUCTION AND PERCEPTION	**(07 Hours)**

Speech production mechanism; Speech production model; Speech perception; Classification of speech sounds: voiced, unvoiced, silence, vowel, semi-vowel, consonants, diphthongs, nasal, fricative, affricative, stops etc.

ANALYSIS OF SPEECH SIGNAL	**(11 Hours)**

Short-term processing, Time domain analysis: short-time energy, short-time autocorrelation, short-time zero crossing; Frequency domain analysis; Short-term Fourier transform (STFT); Filter-bank analysis; Spectrogram analysis; Cepstrum analysis; Pitch estimation: autocorrelation based, cepstrum based and LP analysis based; Formant estimation

LINEAR PREDICTION ANALYSIS	**(10 Hours)**

All pole model; Pole zero model; Autocorrelation and covariance method; Levinson-Durbin algorithm; Inverse filtering; LP residual; Pitch frequency and formant frequency analysis using LP analysis, Comparison of LP model with non-linear speech production models

TEXT-TO-SPEECH SYNTHESIS	**(06 Hours)**

Components of TTS, Speech synthesis methods: Concatenative and waveform based; Intelligibility and naturalness of synthesized speech; Applications and present status; WORLD vocoder

AUTOMATIC SPEECH RECOGNITION	**(06 Hours)**

Statistical and machine learning Approaches; Acoustic models; Language models

(Total Contact Time: 45 Hours)

3. Books Recommended:

1. L. R. Rabiner and R. W. Schafer, “Digital Processing of Speech Signals”, 1st Ed., Pearson Education India, 2003.
2. J. Benetsy, M. M. Sondhi and Y. Huang, “Springer Handbook of Speech Processing”, 1st Ed., Springer Verlag, 2008.
3. J. R. Deller, Jr., J. H. L. Hansen and J. G. Proakis “Discrete-Time Processing of Speech Signals”, Wiley-IEEE Press, IEEE Edition, NY, USA, 1999.

	4. D. O'Shaughnessy, "Speech Communications: Human and Machine", 2nd Ed., University Press, 2005. 5. Thomas F Quatieri, "Discrete-Time Speech Signal Processing – Principles and Practice", 1st Ed., Pearson Education, 2004.

B.Tech. III EC Semester VI IOT AND APPLICATIONS EC344	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

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

CO1	Explain the key concepts and architecture of IoT systems.
CO2	Understand the hardware and software used in IoT systems.
CO3	Design and implement IoT-based applications using sensors, microcontrollers, and communication protocols
CO4	Evaluate the Performance of various protocols used in IoT systems.
CO5	Develop IoT systems for smart environments, such as smart cities, healthcare, and industrial automation.

2. Syllabus:

INTRODUCTION TO INTERNET OF THINGS **(06 Hours)**

Definition and characteristics of IoT, Evolution of IoT, key technologies, and drivers.
IoT architecture: Layers (perception, network, application).
Network topologies for IoT (star, mesh, peer-to-peer), Addressing schemes in IoT.
Applications of IoT: Overview of IoT applications in various domains (smart homes, smart cities, healthcare, agriculture, industry).

SENSORS, ACTUATORS, AND IOT DEVICES **(10 Hours)**

Overview of Sensors and Actuators: Types of sensors (temperature, pressure, humidity, light, proximity, motion, etc.), Types of actuators: motors, relays, servos.
Microcontrollers and Development Platforms: Introduction to popular IoT hardware platforms (Arduino, Raspberry Pi, ESP32), Integration of sensors and actuators with microcontrollers, Overview of communication interfaces: I2C, SPI, UART, GPIO.
Power Management in IoT Devices: Energy efficiency considerations in IoT systems.
Low-power communication technologies (BLE, LoRa, Zigbee).

IoT ARCHITECTURE AND PROTOCOLS **(12 Hours)**

Communication Models and IoT Protocols: Machine-to-Machine (M2M), Device-to-Device (D2D), Device-to-Cloud communication.
IoT Communication Protocols: Application Layer Protocols: MQTT, CoAP, HTTP/HTTPS. Transport Layer Protocols: TCP, UDP, MQTT-SN. Network Layer Protocols: IPv4, IPv6, 6LoWPAN. Data Link Layer Protocols: IEEE 802.15.4, LoRa, Bluetooth Low Energy (BLE), Zigbee, Wi-Fi.

CLOUD AND EDGE COMPUTING IN IoT **(10 Hours)**

Cloud Platforms for IoT: Overview of cloud services for IoT: AWS IoT, Google Cloud IoT, Microsoft Azure IoT Hub, Data storage, processing, and analytics using cloud platforms.
Edge and Fog Computing: Introduction to edge and fog computing in IoT, Role of edge devices for local processing, Hybrid cloud-edge architecture.
Data Analytics in IoT: Big data analytics for IoT-generated data, Data visualization tools for IoT.

IoT Applications and Case Studies **(7 Hours)**

Smart Homes and Buildings: IoT-based home automation (lighting, HVAC, security), IoT for smart energy management.
Smart Cities: IoT for urban planning (traffic management, smart parking, waste management), IoT for environmental monitoring.

	Healthcare and Wearables: IoT applications in healthcare (remote patient monitoring, fitness tracking), Integration of wearable devices with healthcare systems. Industrial IoT (IIoT): IoT for industrial automation (predictive maintenance, supply chain management), IoT for smart manufacturing (Industry 4.0).
	(Total Contact Time: 45 Hours)
3.	**Books Recommended:**
	1. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", 1st Ed., CRC Press, 2017. 2. Arshdeep Bahga and Vijay Madisetti, "Internet of Things: A Hands-on Approach", 1st Ed., Universities Press, x 2014. 3. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos and David Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1st Ed., Academic Press, 2014. 4. Rahul Dubey, "An Introduction to Internet of Things: Connecting Devices, Edge Gateway, and Cloud with Applications", 1st Ed., 2019. 5. Brian Russell and Drew Van Duren, "Practical Internet of Things Security", Packt Publishing, 2016.

B.Tech. III EC Semester VI GLOBAL NAVIGATION SATELLITE SYSTEMS EC346	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

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

CO1	Explain global as well regional navigation systems.
CO2	Apply knowledge of different signal and system structures of diverse navigation systems.
CO3	Analyse position of GNSS receiver using acquisition and tracking.
CO4	Differentiate various GNSS positioning techniques.
CO5	Design GNSS based solution for societal applications.

2. Syllabus:

INTRODUCTION TO GNSS **(06 Hours)**

Introduction to GNSS systems, GNSS terminologies, GNSS Architecture, Augmentation System, Various Navigation Systems: Global Navigation systems: GPS, GLONASS, GALILEO, Beidou Regional Navigation systems: QZSS, IRNSS/NavIC, GNSS System Architecture & Signals, Error correction coding, Navigation Message Structures, Frequency band allocation.

GNSS SIGNAL STRUCTURE AND PROPAGATION **(09 Hours)**

Satellite orbits: MEO, GEO, GSO, visibility of satellites, Ranging stations, Power budget and received signal levels, Ionospheric and Tropospheric propagation of GNSS signals and introduced errors, Multipath propagation and introduced errors, Total Error budget, CNR of received signal, Interference from other GNSS signals, Spectrum of GNSS signals, PRN codes, baseband and passband structure and mathematical representation of GNSS signals.

NAVIGATION RECEIVERS **(11 Hours)**

Generalized GNSS Receiver Architecture, IF and baseband signal processing, IF/baseband filtering, Different Acquisition techniques, GNSS Signal Tracking, Signal tracking loops (DLL, PLL, FLL), Navigation Data Demodulation, Decoding and Processing, Measurement of pseudo range.

POSITION DETERMINATION TECHNIQUES **(08 Hours)**

Principle of GNSS Operation: Satellite constellation and Dilution of Precision, Trilateration Concept, Ephemeris and Almanac, Determination of satellite position, velocity, visibility and ground tracks, Use of Pseudo-Ranges in Position Calculation: Estimation accuracy and precision of pseudo range, Position, Velocity and Time determination techniques, Errors in GNSS measurements and its mitigation

TECHNOLOGIES FOR ADVANCED RECEIVERS AND AUGMENTED SYSTEMS **(09 Hours)**

Jamming and Interference, GNSS Spoofing & Receiver Anti Spoofing Techniques, Challenges and techniques for weak signal acquisition and tracking, carrier measurement aiding, Dual frequency receivers, Basic Concepts of Differential GNSS (DGNSS), Real Time and Post Processing DGNSS: Real Time Kinematics (RTK), Need for Augmentation Systems, Satellite-Based Augmentation Systems (SBAS), Ground-Based Augmentation Systems (GBAS), GNSS Networks, Signal properties and receiver processing of BOC-modulated navigation signals

APPLICATIONS OF GNSS **(04 Hours)**

Aviation Ground-based Augmentation, Marine Navigation, Space Navigation, Vehicle Navigation, Precision Agriculture, Military Applications, Geodesy, Surveying and Mapping, Atmospheric and Ionospheric Science

	(Total Contact Time: 45 Hours)
3.	**Books Recommended:**
	1. John W. Betz, "Engineering Satellite-based Navigational Timing", IEEE Press, 442 Hoes Lane, Piscataway, NJ 08854, 2015. 2. Elliott_D._Kaplan, Christopher_Hegarty "Understanding GPS Principles and Applications", 3rd Ed., Archtech House, Artech House, 2017. 3. Pratap Misra, Per Enge, "Global Positioning System_ Signals, Measurements, and Performance", 1st Ed., Ganga-Jamuna Press, 2006. 4. Scott Madry, "Global Navigation Satellite Systems and Their Applications", Springer series 10058, 2015. 5. Teunissen, Montenbruck, "Handbook of Global Navigation Satellite Systems", 1st Ed., Springer-Verlag, 2017.

B.Tech. III EC Semester VI ADAPTIVE SIGNAL PROCESSING EC348	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

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

CO1	Define the different theory/concepts required for adaptive algorithm
CO2	Describe the different algorithms used in adaptive filtering problem
CO3	Solve the problem related to different adaptive filtering techniques
CO4	Analyze different adaptive filtering techniques
CO5	Design different filtering techniques in practical scenario

2. Syllabus:

INTRODUCTION **(06 Hours)**

Introduction to Filters, Filtering Problem, Linear Optimum Filters, Adaptive Filers, Linear Filter Structures, Different Approaches of Linear Adaptive Filters, Applications

RANDOM VARIABLES AND RANDOM PROCESS **(07 Hours)**

Random Variables, Probability Density Function and Distribution Function, Joint Random Variable, Random Process, Ensemble Averages, Correlation, Covariance, Power Spectral Density, Ergodicity, Time Averages, Biased & Unbiased Estimators, Consistent Estimators

WIENER FILTERING **(07 Hours)**

Problem Statement of Optimum Filtering, Orthogonality Principles, Minimum Mean-Square Error, Wiener- Hopf equations and Solutions, Wiener smoothing and prediction filters

LINEAR PREDICTION **(08 Hours)**

Forward Linear Prediction, Backward Linear Prediction, Prediction Error Filters, Lattice Structure, All-pole Lattice Structure, Pole-Zero Lattice Structure, Adaptive Lattice Structure, Autoregressive modelling, Predictive Modeling of Speech

LEAST-MEAN-SQUARE ADAPTIVE FILTERING **(06 Hours)**

Steepest-Descent Algorithm, Least-Mean-Square-Adaptation Algorithm (LMS), Canonical Model of the LMS Algorithm, Normalized LMS Adaptation Algorithm, Stability Analysis for Normalized LMS Filter

METHOD OF LEAST-SQUARES AND RECURSIVE LEAST-SQUARES **(06 Hours)**

Linear Least-Squares Estimation Problem, Orthogonality principles, Normal Equations and Least-Squares Filters, Singular Value Decomposition, Matrix Inversion Lemma, Recursive Least-Squares Algorithm

KALMAN FILTERING **(05 Hours)**

Statement of the Kalman Filtering Problem, The Innovation Process, Estimation of State using the Innovation Process, Kalman Filtering

(Total Contact Time: 45 Hours)

3.	**Books Recommended:**	
	1. Simon Haykin "Adaptive filter theory", Pearson Education India, 2003. 2. 2. Bernard Widrow and Samuel Stearns, "Adaptive Signal Processing", Pearson Education, 1985 3. 3. Ali H. Sayed, "Fundamentals of adaptive filtering" John Wiley & Sons, 2003. 4. 4. Behrouz Farhang-Boroujeny, "Adaptive filters: theory and applications" John Wiley & Sons, 2013. 5. 5. Tülay Adali and Simon Haykin, "Adaptive signal processing: next generation solutions" Vol. 55. John Wiley & Sons, 2010.	

B.Tech. III EC Semester VI COMPUTER VISION EC362	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

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

CO1	Understand concept of Image Formation.
CO2	Apply different transformations on images for processing.
CO3	Analyze segmentation problem for an image and apply different segmentation techniques.
CO4	Evaluate different feature extraction and pattern analysis methods and apply them on real world computer vision problems
CO5	Design algorithms for real world computer vision problems.

2. Syllabus:

IMAGE FORMATION **(09 Hours)**

Pinhole and Perspective Projection, Image Magnification, Vanishing Point, Image Formation using Lenses, Gaussian Lens Law, Focal Length, Two Lens System, Aperture of the Lens, Lens Defocus, Blur Circle, Depth of Field, Lens Related Issues, Radiometry, Light Flux, Radiant Intensity, Surface Irradiance, Surface Radiance, BRDF, Reflectance Models, Photometric Stereo.

LOW-LEVEL PROCESSING **(06 Hours)**

Transformations: Orthogonal, Euclidean, Affine, Projective, etc; Fourier Transform, Convolution and Filtering, Deconvolution, Image Enhancement, Restoration, Histogram Processing.

SEGMENTATION **(08 Hours)**

Binary Segmentation, Segmentation by Humans, Segmentation as Clustering: k-Means Segmentation, Mean-Shift Segmentation, k-Medoid Segmentation, Gaussian Mixture Model (GMM), Expectation Maximization (EM) for GMM.

FEATURE EXTRACTION **(09 Hours)**

Edges- Canny, LOG, DOG; Line Detectors (Hough Transform); Corner Detectors, SIFT, SURF, HOG, GLOH, Principal Component Analysis (PCA).

PATTERN ANALYSIS **(08 Hours)**

Clustering Algorithms, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised, Bayes classifier, K-Nearest Neighbor (KNN), Linear Classifiers, Logistic Regression, Support Vector Machine.

APPLICATION USING PYTHON AND MATLAB **(05 Hours)**

Introduction to Python and MATLAB Programming, Libraries Related to Computer Vision, Real Life Computer Vision Applications.

(Total Contact Time: 45 Hours)

3. Books Recommended:

1. Richard Szeliski, “Computer Vision: Algorithms and Applications”, 2nd Ed, Springer Nature, 2022.
2. David Forsyth, Jean Ponce, “Computer Vision: A Modern Approach”, 2nd Ed., Pearson Education, 2015.

	3. King-Sun Fu, Rafeal C. Gonzalez, C. S. George Lee, “Robotics: Control, Sensing, Vision and Intelligence”, 1st Ed, McGraw Hill Education Pvt. Ltd. 2013. 4. E. Tresso and A. Verri, “Introductory Techniques for 3-D Computer Vision,” Prentice-Hall, 1998. 5. Berthold Horn, “Robot Vision,” 1st Ed, MIT Press, 1986.
4.	**Reference Book:**
	1. E. R. Davies: “Computer and Machine Vision - Theory, Algorithms and Practicalities,” 4th Ed., Elsevier (Academic Press), 2012.

B.Tech. III EC Semester VI MEMS EC364	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

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

CO1	Understand the MEMS fabrication process and characterization
CO2	Describe MEMS materials & their properties for device applications
CO3	Interpret elasticity in materials
CO4	Analyze MEMS capacitive switch
CO5	Design MEMS devices for different application

2. Syllabus:

INTRODUCTION TO MICRO-FABRICATION (09 Hours)

Cleaning, Oxidation, Diffusion, Mask making, Lithography, Etching, Ion Implantation, CVD, PVD, Metallization; Surface micromachining and Bulk Micromachining, DRIE, LIGA, Fabrication of high aspect ratio deformable structures, wafer bonding

UNDERSTANDING MEMS MATERIALS & THEIR PROPERTIES FOR DEVICE APPLICATIONS (06 Hours)

Conductivity of Semiconductors, Crystal Plane and Orientation, Tensile Stress and Strain, Mechanical Properties of Silicon and Thin Films, Flexural Beam Bending Analysis Under Loading Conditions, Torsional Deflection, Intrinsic Stress, Dynamic System, Resonance and Quality Factor.

ELASTICITY IN MATERIALS (06 Hours)

Stress, strain calculations, Normal and Shear strains and constitutive relations, Plane stress, biaxial stress, residual stress, energy relations, Load-deflection calculations in beams, cantilevers (rectangular cross section), Elastic deformation in square plate, Resonant frequency calculations: Rayleigh-Ritz method

MEMS CAPACITIVE SWITCH (12 Hours)

Lumped model, pull-in voltage, Electromechanical deflection modeling, pull-in instability, switching time and pull-in voltage scaling, Physical effects in nanoscale gap-size, squeeze-film damping , perforated MEMS Capacitive switch, Comb actuators, Accelerometer, Pressure sensor, Energy approach: Lagrangian Mechanics applicable to MEMS capacitive switches, Reliability in RF-capacitive switch

MEMS DEVICES (09 Hours)

Architecture, working and basic quantitative behaviour of Cantilevers, Microheaters, Accelerometers, Pressure Sensors, Micromirrors in DMD, Inkjet printer-head. Thermal sensor design, Bio-MEMS, MEMS memory, Optical MEMS: 2-D, 3-D switches.

MEMS DEVICES (03 Hours)

Architecture, working and basic quantitative behaviour of Cantilevers, Microheaters, Accelerometers, Pressure Sensors, Micromirrors in DMD, Inkjet printer-head. Thermal sensor design, Bio-MEMS, MEMS memory, Optical MEMS: 2-D, 3-D switches.

(Total Contact Time: 45 Hours)

3. Books Recommended:

	1. E. S. Kim, “Fundamentals of Microelectromechanical Systems (MEMS)”, McGraw Hill, 2021. 2. Tai–Ran Hsu, “Mems & Microsystems Design and Manufacturing”, John Wiley & Sons, 2nd Edition, 2008 3. Chang Liu, “Foundations of MEMS”, Pearson Education Inc., 2006. 4. Sandana A., “Engineering biosensors: kinetics and design applications”, Academic Press 2002 5. Marc J. Madou, “Fundamentals of Microfabrication”, 2nd Edition, CRC Press Taylor and Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL33487- 2724, 2002.
4.	**<u>Reference Book:</u>** 1. Ville Kaajakari, “Practical MEMS”, Small Gear Publishing, 2009 2. S. Senturia “Microsystem Design”, 1^{st} Edition, Springer, 2000 3. Minhang Bao, “Analysis and Design Principles of MEMS Devices”, 1^{st} Edition, - Elsevier Science, 2005 4. J. Allen, “Micro Electro Mechanical System Design”, 1^{st} Edition, CRC Press, 2005 5. G. Kovacs, “Micromachined Transducers Sourcebook”, 2^{nd} Edition, McGraw-Hill, 2000

B.Tech. III EC Semester VI Project Phase - 1 EC304	Scheme	L	T	P	Credit
		0	0	4	02

1.	**Course Outcomes (COs):**
	At the end of the course the students will be able to:

CO1	Develop habit of studying and understanding research paper and other literature
CO2	Make good presentations, communication and develop interpersonal skills
CO3	Become aware of recent research and development in the respective field
CO4	Compare various methodologies and techniques available literature
CO5	Predict future enhancement/upgradation in technology and understand its impact

2.	**Syllabus:**
	This course provides a platform for students to explore current trends, challenges, and innovations in engineering. Students will engage in literature survey, participate in discussions, and present on relevant topics in their fields of interest.
	(Total Contact Time: 70 Hours)