Scheme of Instruction and Syllabi

Master of Engineering

A TWO YEAR (I – IV Semesters) PG Program

in

COMMUNICATION ENGINEERING

R26 Curriculum (with effect from AY 2026-27)

(R–26 Regulation)

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

(Autonomous Institution under UGC, Affiliated to Osmania University)

Department of Electronics and Communication Engineering

Accredited by NBA and NAAC-UGC

Chaitanya Bharathi (Post), Gandipet, Hyderabad–500075

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

OUR MOTTO: SWAYAM TEJASWIN BHAVA

VISION and MISSION of the INSTITUTE

Vision

To be a centre of excellence in technical education and research.

Mission

To address the emerging needs through quality technical education and advanced research.

VISION and MISSION of the DEPT. of ECE

Vision

To emerge as a vibrant model of excellence in education, research and innovation in Electronics and Communication Engineering.

Mission

M1: To impart strong theoretical and practical knowledge of the state of art technologies to meet growing challenges in the industry.

M2: To carry out the advanced and need based research in consultation with the renowned research and industrial organizations.

M3: To create entrepreneurship environment including innovation, incubation and encourage to patent the work.

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Program Educational Objectives of M.E (Communication Engineering) Program

PEO1	Graduates will Design & Develop Communication Systems either independently or in a group.
PEO2	Graduates will able to learn and adopt the emerging technologies in the area of Communication Engineering.
PEO3	Graduates will demonstrate the ability to do research and become a lifelong learner.
PEO4	Graduates will Develop rational approach to solve real world problems with Self-confidence and ethical & Societal Responsibilities.

Program Outcomes of M.E (Communication Engineering) Program

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO4	Students will be able to use modern engineering tools/software to design and develop advanced communication systems.
PO5	Students will be able to develop self-confidence, team work, skills for lifelong learning and committed to social responsibilities.

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY(A)

R26 Curriculum (with effect from AY 2026-27)

M.E (Communication Engineering)

SEMESTER – I

S.no	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	26ECC101	Advanced Communication and Networks	3	--	--	3	40	60	3
2	26ECC102	Wireless and Mobile Communications	3	--	--	3	40	60	3
3		Program Elective-I	3	--	--	3	40	60	3
4		Program Elective-II	3	--	--	3	40	60	3
5	26MEM101	Research Methodology and IPR	2	--	--	3	40	60	2
6		Audit Course-I	2	--	--	2	--	50	Non-Credit
PRACTICALS									
7	26ECC103	ACN and IoT Lab	--	--	2	--	50	--	1
8	26ECC104	Wireless and Mobile Communications Lab	--	--	2	--	50	--	1
9	26ECC105	Advanced Communications Lab	--	--	2	--	50	--	1
10	26ECC114	AI Workshop for Communication Engineering	--	--	2	--	50	--	1
Total			**16**	**--**	**8**	**17**	**400**	**350**	**18**
Clock Hours Per Week: 24									

L: Lecture **D: Drawing** **CIE: Continuous Internal Evaluation**

T: Tutorial **P: Practical/Mini Project /Dissertation** **SEE: Semester End Examination**

26ECC101

ADVANCED COMMUNICATION AND NETWORKS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Basic concepts of Communication.

COURSE OBJECTIVES:

This course aims :

1. To understand advanced modulation and wireless communication techniques.
2. To analyze Internet protocols, real-time communication, and QoS.
3. To explore advanced IP technologies and modern networking systems.

COURSE OUTCOMES:

After successful completion, students will be able to:

1. Analyze advanced modulation techniques and their performance in communication systems.
2. Evaluate modern wireless technologies such as OFDM and MIMO.
3. Analyze Internet protocols, congestion control, and real-time communication mechanisms.
4. Apply QoS, scheduling, and traffic control techniques in network design.
5. Understand advanced IP technologies and MPLS for efficient networking.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	1	2	2	2	2
CO 2	1	2	2	2	2
CO 3	1	2	2	2	2
CO 4	1	2	2	2	2
CO 5	1	2	2	2	2

UNIT - I

Advanced Modulation and Coding Techniques: M-ary modulation (M-PSK, M-QAM, M-FSK), OFDM, SC-FDMA, adaptive modulation and coding, channel capacity, spectral efficiency, BER in fading channels.

UNIT - II

Wireless Communication Systems for Networked Applications: Spread spectrum (DSSS, FHSS), MIMO systems, channel estimation and equalization, cognitive radio, Software Defined Radio (SDR), LTE/5G physical layer, wireless LAN.

UNIT - III

Internet Concepts and Real-Time Communication: Overview of Internet (ATM, TCP/IP), TCP congestion and flow control, throughput analysis, high bandwidth-delay networks, fairness in TCP, real-time communication issues, adaptive applications, latency and throughput, resource reservation protocol, LBAP traffic characterization, leaky bucket and token bucket algorithms

UNIT - IV

Packet Scheduling, QoS and IP Addressing: Packet scheduling algorithms (GPS, WFQ, rate proportional), latency and delay bounds, active queue management (RED, WRED), packet classification and flow identification, grid of tries, cross-producting algorithms, admission control, measurement-based admission control, Differentiated Services (DiffServ), DiffServ architecture

UNIT - V

Advanced IP Networks and MPLS: IPv4, IPv6, IP tunneling, IP switching, MPLS architecture and protocols, IP over ATM, evolution to IP switching, traffic engineering in MPLS, QoS in MPLS, integration with modern networks (SDN, NFV basics)

TEXTBOOKS:

1. S. Haykin, *Digital Communications*, 2nd ed. New York, NY, USA: Wiley, 2001.
2. T. S. Rappaport, *Wireless Communications: Principles and Practice*, 2nd ed. Upper Saddle River, NJ, USA: Prentice Hall, 2002.
3. J. F. Kurose and K. W. Ross, *Computer Networking: A Top-Down Approach*, 7th ed. Boston, MA, USA: Pearson, 2017.

SUGGESTED READING:

1. L. De Ghein, *MPLS Fundamentals*. Indianapolis, IN, USA: Cisco Press, 2007.
2. A. S. Tanenbaum and D. J. Wetherall, *Computer Networks*, 5th ed. Upper Saddle River, NJ, USA: Pearson, 2011.

26ECC102

WIRELESS AND MOBILE COMMUNICATION

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Basic concepts of Communication and Wave propagation.

COURSE OBJECTIVES:

This course aims to:

1. Facilitate the understanding of wireless system requirements and challenges.
2. Elucidate the concepts of small-scale fading and channel capacity.
3. Provide an overview of receiver diversity and 4G/5G technologies.

COURSE OUTCOMES:

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

1. Understand the requirements and technical challenges of current wireless systems.
2. Gain an overview of the higher generation Cellular standards 4G/5G.
3. Analyze path loss, shadowing and multipath effects on wireless channels.
4. Interpret the capacity of wireless channels.
5. Appreciate the underlying principles of diversity techniques.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	1	2	2	1	1
CO 2	1	2	2	1	1
CO 3	1	2	2	1	1
CO 4	1	2	2	1	1
CO 5	1	2	2	1	1

UNIT - I

Introduction to Wireless and Mobile Communications: Current Wireless Systems: Cellular Telephone Systems, Wireless Local Area Networks, Wide Area Wireless Data Services, Broadband Wireless Access. Requirements for Wireless Services: Data Rate, Range and Number of Users, Mobility, Energy Consumption, Use of Spectrum, Direction of Transmission, Service Quality.

Technical Challenges: Multipath Propagation and Spectrum Limitations, Limited Energy, User Mobility.

UNIT - II

Overview of 4G/5G Wireless Communications: Evolution of Mobile Technologies, 3GPP Releases and its key aspects, Overview of 4G/5G, 5G vs. LTE-A Comparison, 5G frequency bands in fr1 and fr2, 5G simplified architecture, 5G Use cases,

Access Techniques: OFDM, NOMA.

UNIT - III

Wireless Propagation Channels: Path Loss and Shadowing: Simplified Path-Loss Model, Shadow Fading, Combined Path Loss and Shadowing, Cell Coverage Area. Small Scale Fading and Multipath: Impulse response model, Small Scale Multipath Measurements: Direct RF Pulse System, Spread Spectrum Sliding Correlator Channel Sounding, Parameters of Mobile Multipath Channels, Types of Small-Scale Fading, Rayleigh and Ricean Distributions.

UNIT - IV

Capacity of Wireless Channels: Capacity in AWGN, Capacity of Flat Fading Channels: Channel and System Model, Channel Distribution Information Known, Channel Side Information at Receiver, Channel Side Information at Transmitter and Receiver, Capacity with Receiver Diversity, Capacity of Frequency-Selective Fading Channels: Time-Invariant and Time-Varying channels.

UNIT - V

Diversity: Receiver Diversity: System Model, Selection Combining, Threshold Combining, Equal-Gain Combining, Transmitter Diversity: Channel Known at Transmitter, Channel Unknown at Transmitter.

TEXT BOOKS:

1. Andrea Goldsmith, “Wireless Communication”, Cambridge University Press, 2005.
2. T.S.Rappaport, “Wireless Communications Principles and Practice”, 2nd edition, PHI, 2010.
3. Saad Z. Asif, “5G Mobile Communications Concepts and Technologies” CRC Press, 2019.

SUGGESTED READING:

1. Molisch, Andreas F. “Wireless communications”. John Wiley & Sons, 2012.
2. David Tse and Pramod Viswanath, “Fundamentals of Wireless Communication”, Cambridge University Press, 2005.

26ECE101

DATA AND OPTICAL NETWORKS

(Program Elective - I)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Basic knowledge of Communication Systems and Electromagnetic Wave Propagation.

COURSE OBJECTIVES:

This course aims to:

1. To understand the principles of data communication, computer networks, protocol architectures, routing algorithms, TCP/IP protocols, and network communication mechanisms.
2. To analyze optical fiber communication systems, transmission characteristics, signal propagation, attenuation, dispersion effects, and performance of different optical fibers.
3. To study optical networking concepts, switching techniques, wavelength routing, network deployment architectures, and survivability mechanisms in modern communication networks.

COURSE OUTCOMES:

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

1. Analyze data communication fundamentals, network models, transmission media, and multiplexing techniques.
2. Evaluate networking protocols, routing algorithms, congestion control, and TCP/IP mechanisms.
3. Explain the principles and propagation characteristics of optical fiber communication systems.
4. Analyze attenuation, dispersion, and scattering effects in optical fiber transmission.
5. Assess optical network architectures, switching techniques, and deployment strategies.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	2	1	1	2
CO 2	3	3	2	2	2
CO 3	3	2	1	2	1
CO 4	3	3	1	2	1
CO 5	3	2	3	2	3

UNIT-I

Introduction to Data Communications: Data Representation, Data Flow, Network, Uses of Networks, Network Topologies, Categories of Networks, Multiplexing: FDM, TDM. Reference Models: TCP/IP Model, The OSI Model, Comparison of the OSI and TCP/IP reference model. Physical Layer: Guided Media, Unguided Media (wireless).

UNIT- II

Protocols and Algorithms: Data Link Layer: Design issues, Error Detection & Correction, Elementary Data Link Layer Protocols, Sliding window protocols. Multiple Access Protocols - ALOHA, CSMA, CSMA/CD, CSMA/CA, Collision free protocols.

Routing Algorithms: Optimality principle, shortest path, flooding, Distance Vector Routing, Count to Infinity Problem, Link State Routing, Hierarchical Routing; Congestion control algorithms, IP addresses, CIDR, Sub netting, Super Netting, IPv4 to IPv6.

Introduction to TCP, The TCP Service Model, The TCP Segment Header, The Connection Establishment, The TCP Connection Release, The TCP Sliding Window, The TCP Congestion Control Algorithm.

UNIT-III

Introduction to Optical Fiber Communication: Introduction - The General Systems - Advantages of Optical Fiber Communication- Ray Theory Transmission: Total Internal Reflection, Acceptance Angle, Numerical Aperture, Skew Rays - Electromagnetic Mode Theory for Optical Propagation: Modes in a Planar Guide, Phase and group velocity - Cylindrical Fiber: Step index fibers, Graded index fibers - Single mode fibers: Cutoff wavelength.

UNIT-IV

Transmission Characteristics of Optical Fibers: Attenuation - Material absorption losses in silica glass fibers: Intrinsic absorption, Extrinsic absorption - Linear scattering losses: Rayleigh scattering.

Mie Scattering -Nonlinear scattering losses: Stimulated Brillouin Scattering, Stimulated Raman Scattering – Fiber Bend Loss – Dispersion- Chromatic dispersion: Material dispersion, Waveguide dispersion- Intermodal dispersion: Multimode step index fiber, Multimode graded index fiber.

UNIT-V

Optical Networks: Introduction - Optical Network Concepts: Optical Networking Terminology, Optical Network Node and Switching Elements, Wavelength Division Multiplexed Networks, Optical Network Transmission Modes, Layers And Protocols: Synchronous Networks, Asynchronous Transfer Mode, Open System Interconnection Reference Model, Optical Transport Network, Internet Protocol - Wavelength Routing Networks: Routing And Wavelength Assignment - Optical Switching Networks: Optical Circuit Switched Networks, Optical Packet Switched Networks, Multiprotocol Label Switching, Optical Burst Switching Networks - Optical Network Deployment: Long Haul Networks, Metropolitan area networks, Access networks, Local Area Networks - Optical Ethernet: Network protection, restoration and survivability.

TEXT BOOKS:

1 Kurose James F, Keith W- Computer Networking A Top-Down Approach, 6th Edition, Pearson.
2 Behrouz A. Forouzan - Data Communications and Networking, 4th Edition, McGraw-Hill Education
3 John M. Senior, “Optical Fiber Communication”, Pearson Education, FouthEdition.2010.

REFERENCES:

1 Andrew S Tanenbaum - Computer Networks, 4th Edition, Pearson Education
2 Gred Keiser, "Optical Fiber Communication”, McGraw Hill Education (India) Private Limited. Fifth Edition, Reprint2013.
3 Govind P. Agrawal, “Fiber-Optic Communication Systems”, Third Edition, John Wiley & Sons, 2004.

26ECE102

GNSS AND AUGMENTATION SYSTEMS

(Program Elective - I)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: A prior knowledge of fundamental concepts of satellite communication is required.

COURSE OBJECTIVES:

This course aims to:

1. Explain the basic principles of various positioning techniques and introduce GPS operating principle, signal structure.
2. Make the students to understand errors affecting GNSS performance and analyze various parameters of RINEX data.
3. Make the students appreciate the significance of other GNSS systems, principle of DGPS and augmentation systems.

COURSE OUTCOMES:

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

1. Apply the concepts of satellite based navigation in various emerging technologies.
2. Analyze GPS signal structure and receiver functioning and compare coordinate systems and datum.
3. Interpret the effect of various error sources and satellite geometry on the performance of GNSS and explain the necessity of GPS modernization and importance of integration aspects.
4. Develop data processing methods using observation and navigation data for GNSS and Augmentation Systems.
5. Compare the performance of all GNSS systems and augmentation systems.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	2	3	3	3
CO 2	3	2	1	1	2
CO 3	1	2	1	2	1
CO 4	2	2	2	2	2
CO 5	2	2	2	3	2

UNIT - I

GPS Fundamentals: INS, Trilateration, Hyperbolic navigation, Transit, GPS principle of operation, architecture, operating frequencies, orbits, Keplerian elements. Solar and Sidereal days, GPS and UTC Time.

UNIT - II

GPS Signals and Error Models: Signal structure, C/A and P-Code, ECEF and ECI coordinate systems and WGS 84 and Indian Datums, Ionospheric error, Tropospheric error, Ephemeris error, Clock errors, Satellite and receiver instrumental biases, Antenna Phase center variation, Multipath, Important components of receiver and specifications, Link budget.

UNIT - III

GPS Data Processing and Positioning: RINEX Navigation and Observation formats, Ambiguity resolution, cycle slips, Position estimation. Estimation of Total Electron Content (TEC) using dual frequency measurements, Various DOPs, UERE. Modernization of GPS satellite signals and their benefits.

UNIT – IV

Other Constellations and Applications: GLONASS, Galileo, Beidou, COMPASS, MSAS and QZSS, IRNSS: Architecture, signals, advantages and limitations, GNSS aided Indoor Localization, Smart Phone Based Hybrid Indoor Positioning, GPS integration – GPS / GIS, GPS / INS, GPS / pseudolite, GPS / cellular.

UNIT - V

Augmentation Systems: Principle of operation of DGPS, Architecture and errors. WAAS, GAGAN, EGNOS, MTSAT and LAAS: Principle of Operations and Architecture, Relative advantages of SBAS and GBAS and limitations.

TEXT BOOKS:

1. B.HofmannWollenhof, H.Lichtenegger, and J.Collins, "GPS Theory and Practice", Springer Wien, New York, 2000.
2. Pratap Misra and Per Enge, "Global Positioning System Signals, Measurements, and Performance", Ganga-Jamuna Press, Massachusetts, 2001.

SUGGESTED READING:

1. Ahmed El-Rabbany, "Introduction to GPS", Artech House, Boston, 2002.
2. Bradford W. Parkinson and James J. Spilker, "Global Positioning System: Theory and Applications", Volume II, American Institute of Aeronautics and Astronautics, Inc., Washington, 1996.

26ECE103

FREE SPACE OPTICAL COMMUNICATIONS

(Program Elective - I)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Fundamentals of Electronics and Communication Engineering.

COURSE OBJECTIVES:

This course aims to:

1. To understand the fundamentals of free space optical communication and propagation of light through different channels.
2. To study optical sources, detectors, and modulation techniques used in FSO systems.
3. To analyze channel effects, receiver design, and overall link performance under various atmospheric conditions.

COURSE OUTCOMES:

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

1. Understand the principles of free space optical (FSO) communication and light propagation through the atmosphere.
2. Explain modulation and demodulation techniques used in FSO systems.
3. Analyze atmospheric/free-space channel characteristics under varying environmental conditions.
4. Analyze and compare optical transmitters, receivers, and detection techniques, and evaluate link performance in terms of bit error rate and channel capacity.
5. Evaluate the effects of atmospheric turbulence, weather conditions, and noise on FSO system performance.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	2	1	1	1
CO 2	1	1	2	3	1
CO 3	1	2	1	1	2
CO 4	1	1	3	2	1
CO 5	1	2	1	2	2

UNIT-I

Introduction to Free Space Optical (FSO) Communication System: FSO channels: atmospheric channel, underwater optical channel, atmospheric losses, weather condition influence, atmospheric turbulence effects i.e. scintillation, beam spreading, etc. FSO communication application areas, FSO challenges.

UNIT-II

Optical Sources and Detectors: LED structure, LED efficiencies, LASER diode, modes and threshold conditions, structure of common Laser Types: Fabry–Perot Laser, distributed feedback laser. PIN Photo detector, avalanche photo diode, photo detection noises, comparison of photo detectors.

UNIT-III

Channel Modeling: linear time invariant model, channel transfer function, models of turbulence induced fading such as log-normal turbulence model, exponential, K distribution, gamma-gamma distribution, indoor optical wireless communication channel, LOS propagation model, Non-LOS propagation model, outdoor optical channel modelling.

UNIT-IV

Modulation Techniques: analogue intensity modulation, digital baseband modulation techniques: baseband modulations, on–off keying, error performance on Gaussian channels, power efficiency, BW efficiency, bit versus symbol error rates, different modulation schemes such as M-PPM, DPPM, DAPPM schemes, subcarrier modulation, optical polarization shift keying: binary PolSK.

UNIT-V

Detection Techniques and Link Performance Analysis: direct detection optical receivers, coherent techniques i.e. homodyne and heterodyne, bit error rate evaluation in presence of atmospheric turbulence, visible light communication system, range equation of FSO link, atmospheric turbulence, effect of turbulence and weather conditions i.e. drizzle, haze fog on error performance and channel capacity.

TEXT BOOKS:

1. Hemani Kaushal, V.K. Jain, Subrat Kar, Free Space Optical Communication Springer (India), 2017, 1st Edition.
2. Z.Ghassemlooy, W.Popoola, S.Rajbhandari, Optical Wireless Communications, CRC Press, 2013, 1st Edition.

SUGGESTED READING:

1. Arun K. Majumdar, Zabih Ghassemlooy, A. Arockia Bazil Raj, Principles and Applications of Free Space Optical Communications, IET publisher, 2019,1st Edition.
2. L.C.Andrews, R.L.Phillips, Laser Beam Propagation through Random Media, SPIE Press, USA, 2005, 2nd Edition.
3. Gerd Keiser, Optical Fiber Communication, Tata McGraw-Hill Ltd., 2008, 4th Edition.

26ECE104

INFORMATION THEORY AND CODING TECHNIQUES

(Program Elective – I)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Concepts of source coding and error control coding.

COURSE OBJECTIVES:

This course aims to:

1. Provide the concepts of source coding techniques.
2. Familiarize the channel coding theorem & various error control codes.
3. Introduce Block and Turbo control coding.

COURSE OUTCOMES:

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

1. Illustrate the notion of information in the quantitative sense to construct compact codes for a given data ensemble.
2. Analyze the mathematical modelling and calculate the capacity of typical digital communication channels and interpret the result in terms of theoretical limits to channel coding performance.
3. Apply the principles of abstract algebra to design error control codes.
4. Construct BCH and RS codes and with suitable examples.
5. Design convolution and turbo codes and analyse performance analysis for reliable communication.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	1	3	2	3
CO 2	3	2	2	2	3
CO 3	3	1	3	2	3
CO 4	3	3	2	2	3
CO 5	3	3	3	2	3

UNIT - I

Information Theory and Source Coding: Introduction, Uncertainty, Information and Entropy, Shannon's Source coding theorem, The Shannon's limit, The Kraft Inequality, Huffman, Shannon – Fano, Arithmetic, Adaptive coding, RLE, Lempel-Ziv-Welch Algorithm (LZW), Lempel-Ziv Algorithms: LZ-77, LZ-78.

UNIT - II

Discrete Memory Less Channels: Channel Models – BSC, BEC, Mutual Information, Channel Capacity, Channel coding theorem, Differential entropy and mutual information for continuous ensembles.

UNIT - III

Algebra of Finite Fields: Group, Ring & Field, Vector Spaces, GF addition, multiplication rules, Construction of Galois Fields of Prime Order, Primitive elements, Conjugacy Classes, Cyclotomic Cosets, Minimal polynomials.

UNIT - IV

Linear Codes: Introduction to BCH codes, Generator polynomials in terms of Minimal polynomials, some examples of BCH codes, Decoder, Reed- Solomon codes & Decoder, CIRC (Cross-interleave Reed-Solomon Code) for Compact Disc (CD) digital audio system.

UNIT - V

Convolution and Turbo Codes: Linear convolution encoders, Structural properties of Convolution codes, Parallel concatenation, Interleavers, Turbo encoder, Iterative decoding using BCJR algorithm, Performance analysis.

TEXT BOOKS:

1. Man Young Rhee, “Error Correcting Coding Theory”, McGraw-Hill Publishing, 1989.
2. Charles Lee, “Error-control Block Codes for Communications Engineers”, Artech House, 2000.
3. Shu Lin, Daniel J.Costello, Jr, "Error Control Coding- Fundamentals and Applications", Prentice Hall, Inc., 2012.

SUGGESTED READING:

1. Arijit Saha, Nilot Pal Manna and SurajitMandal, “Information Theory, Coding and Cryptography”, Pearson, 2013.
2. R.P. Singh and S.D. Sapre, “Communication Systems”, 2nd edition, Tata McGraw-Hill Education, 2008.
3. Simon Haykin, “Communication Systems”, John Wiley and Sons, 4th Edition, 2001.

26ECE105

INDUSTRIAL INTERNET OF THINGS

(Program Elective-I)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Basic knowledge of electronics, microcontrollers, C programming, and communication protocols, networking, and operating system fundamentals.

COURSE OBJECTIVES:

This course aims:

1. To provide fundamental knowledge of the Internet of Things (IoT), including architecture, communication models, and enabling tools.
2. To develop understanding of IoT hardware platforms, data analytics techniques, and cloud-based data processing frameworks.
3. To introduce Industrial IoT (IIoT), Cyber-Physical Systems (CPS), and their applications in smart manufacturing and Industry 4.0 environments.

COURSE OUTCOMES:

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

1. Understand the concepts, architecture, and communication models of IoT systems.
2. Apply IoT tools and platforms for device configuration and system deployment.
3. Analyze IoT data using big data analytics frameworks such as Hadoop, Spark, and Storm.
4. Evaluate the design and modeling of Cyber-Physical Systems and Industrial IoT applications.
5. Design smart automation solutions using CPS, IIoT architectures, and communication networks.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	2	2	2	1
CO 2	3	2	3	3	2
CO 3	3	2	3	3	1
CO 4	3	2	3	2	1
CO 5	3	3	3	3	2

UNIT-I

Introduction to Internet of Things: Overview, definitions, and characteristics of IoT; physical and logical design aspects of IoT; functional blocks of IoT; communication models and APIs; IoT levels and deployment templates.

Tools for IoT: Introduction to tools such as Chef and Puppet, along with their respective case studies; NETCONF-YANG; and related case studies.

UNIT-II

IoT Physical Devices and End Points: Fundamental building blocks of IoT devices; overview of the Raspberry Pi board and its interfaces (Serial, SPI, I2C); introduction to the BeagleBone Black board and its internal architecture.

Data Analytics for IoT: Concepts of Apache Hadoop; use of MapReduce for batch data processing; Apache Oozie; Apache Spark; Apache Storm; real-time data analytics using Apache Storm.

UNIT - III

Understanding Industrial Internet of Things (IIoT): Industrial Internet of Things and Cyber Manufacturing Systems, application map for Industrial Cyber Physical Systems, and Cyber Physical Electronics production.

UNIT - IV

Modeling of CPS and CMS: Modeling of Cyber-Physical Engineering and Manufacturing Systems, model-based engineering of supervisory controllers for Cyber-Physical Systems, evaluation models for assessment of Cyber-Physical Production Systems.

UNIT – V

Architectural Design Patterns for CMS and IIoT: CPS-based manufacturing and Industry 4.0 concepts. Integration of knowledge base, databases, and machine vision systems. Interoperability in smart automation systems; Enhancing resiliency in production facilities using CPS: communication and networking in IIoT.

TEXTBOOKS:

1. Arshdeep Bahga and Vijay Madisetti, “Internet of Things - A Hands-on Approach," Universities Press, 2015.
2. Jane W.S. Liu, “Real Time Systems," Pearson Education, Asia, 2018.
3. Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat, “Industrial Internet of Things Cyber Manufacturing Systems," Springer, 2016.
4. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things," Apress, 2017.

SUGGESTED READING:

1. C. M. Krishna and Kang G. Shin, *Real-Time Systems*, McGraw-Hill, 1st Edition (Reprint 2017).
2. The Internet of Things: Key Applications and Protocols, Olivier Hersent Actility, David BoswarthickETSI, Omar Elloumi Alcatel-Lucent, 2nd Edition, Wiley Publications. 2012.

26ECE106

HIGH PERFORMANCE NETWORKS

(Program Elective -II)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: The knowledge in Data Communication and Computer Networks.

COURSE OBJECTIVES:

This course aims to:

1. Provide Concepts of types of networks, services and VoIP system architecture and applications.
2. Enable the students to understand the topics on VPN Remote access and Traffic modeling.
3. Provide the knowledge on Network Security and Management.

COURSE OUTCOMES:

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

1. Understand and design different types of networks and apply the services.
2. Distinguish between and analyze various VoIP Protocols.
3. Design, implement, and analyze protocols for the transport of voice over IP networks.
4. Identify the types of VPN and tunneling protocols used for security.
5. Apply network security principles across various types of networks.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	2	2	2	2
CO 2	2	2	1	2	2
CO 3	2	2	2	1	2
CO 4	2	1	1	1	1
CO 5	1	2	2	2	1

UNIT - I

Types of Networks: Network design issues, Review of OSI, TCP/IP; Multiplexing, Modes of Communication, Switching, Routing. SONET – DWDM – DSL – ISDN – BISDN, ATM. Streaming stored Audio and Video, Best effort service, protocols for real time interactive applications, Beyond best effort, scheduling and policing mechanism, integrated services and RSVP-differentiated services.

UNIT - II

Multimedia Networking Applications: Streaming stored Audio and Video – Best effort service – Protocols for real time interactive applications – Beyond best effort – Scheduling and policing mechanism – Integrated services – RSVP- differentiated services.

UNIT - III

VoIP System Architecture: protocol hierarchy, Structure of a voice endpoint, Protocols for the transport of voice media over IP networks. Providing IP quality of service for voice, signaling protocols for VoIP, PSTN gateways, VoIP applications.

UNIT - IV

VPN-Remote-Access VPN: site-to-site VPN, Tunneling to PPP, Security in VPN. MPLS operation, Routing, Tunneling and use of FEC, Traffic Engineering, MPLS based VPN, Overlay networks-2P connections.

UNIT - V

Network Security and Management: Principles of cryptography, Authentication, integrity, Key distribution and certification, Access control and firewalls, Attacks and counter measures, Security in many layers. Infrastructure for network management. The internet standard management framework – SMI, MIB, SNMP, Security and administration, ASN.1.

TEXT BOOKS:

1. Nader F. Mir, "Computer and Communication Networks", Second Edition, 2015.
2. Douskalis B., "IP Telephony: The Integration of Robust VoIP Services", Pearson Edition, Asia, 2000.
3. William Stalling, "Network security, essentials", Pearson education Asia publication, 4th Edition, 2011.

SUGGESTED READING:

1. Larry Peterson & Bruce David, "Computer Networks: A System Approach", Morgan Kaufmann, 2003.
2. J.F. Kurose & K.W. Ross, "Computer Networking- A top-down approach featuring the internet", Pearson, Sixth Edition, 2013.
3. Fred Halsall and Lingana Gouda Kulkarni, "Computer Networking and the Internet", 5th Edition, Pearson Education, 2005.

26ECE107

MIMO WIRELESS COMMUNICATIONS

(Program Elective - II)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Knowledge on communication systems, Probability theory.

COURSE OBJECTIVES:

This course aims to:

1. Understand the principles of multi-antenna systems, diversity techniques, and wireless channel characteristics.
2. Analyze MIMO system models, channel behavior, and capacity using signal processing techniques.
3. Explore space-time coding and advanced MIMO technologies for modern wireless communication systems.

COURSE OUTCOMES:

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

1. Understand multi-antenna systems, diversity techniques, and wireless channel characteristics.
2. Analyze MIMO system models and channel behavior under different fading environments.
3. Apply signal processing techniques such as SVD, precoding, and water-filling in MIMO systems.
4. Analyze space-time coding and detection techniques for reliable MIMO communication.
5. Evaluate advanced MIMO technologies such as multi-user and massive MIMO for modern wireless systems.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	1	3	1	3
CO 2	3	2	3	1	3
CO 3	3	3	3	1	3
CO 4	3	3	3	1	3
CO 5	1	1	3	1	3

UNIT - I

Introduction to Multi Antenna System: Types of Diversity Techniques, SISO system: Impact of fading on system performance, principle of diversity, Array and Diversity Gain, Multiplexing Capability, Interference Management, Diversity-multiplexing trade-off, SIMO system (Receive Diversity): Selection Combining, Equal Gain Combining, Maximal ratio Combining, Hybrid Combining, MISO (Transmit Diversity): : basic concepts. Introduction to MIMO systems, advantages and applications of MIMO systems.

UNIT - II

MIMO System & Channel Models: MIMO System model, Open loop MIMO systems: Spatial multiplexing, Spatial modulation, Closed loop MIMO system: Power allocation, Transmit antenna selection, Analytical MIMO channel models: Independent and identically distributed (uncorrelated), Fully correlated, Separately correlated (Kronecker) and Uncorrelated (keyhole) MIMO fading models, parallel decomposition of MIMO channel.

UNIT - III

Capacity of MIMO Channels: Definition of Capacity, Fast and Slow Fading, Channel State Information(CSI), Narrowband MIMO Model, Capacity of the Time-Invariant Channel: SISO, SIMO, MISO, MIMO channel, Singular Value Decomposition (SVD) of channel matrix H, Equivalent MIMO system: Multi Pre and Post Processing, Waterfilling algorithm and Capacity, Performance of Eigenmode Transmission, Ergodic Capacity, Capacity of the Fast fading Channel (Time-variant) with CSIR & distribution of CSIT: SIMO, MISO, MIMO, Capacity for a Rayleigh i.i.d. MIMO Channel

UNIT - IV

Space-Time Codes: Introduction, System model, Alamouti space-time codes, Performance analysis for Alamouti space-time codes over fading channels, Space-Time Block and Trellis Codes, Performance analysis of space-time codes over fading channels, Beamforming fundamentals and precoding concepts.

UNIT - V

Advances in MIMO Wireless Communications: Spatial modulation, Single user MIMO and Multiuser MIMO, Massive MIMO and mmWave massive MIMO, MIMO based V2x communication V2x MIMO, cognitive-femtocells and large MIMO systems for 5G wireless, Implementation challenges.

TEXT BOOKS:

1. Rakhesh Singh Kshetrimayum, “Fundamentals of MIMO Wireless Communications” Cambridge University Press, 2017. Unit 2
2. Brijesh Kumbhani, Rakhesh Singh Kshetrimayum, “MIMO wireless communications over generalized fading channels” CRC Press T&F, 2017. Unit 2 & 5
3. Bruno Clerckx Claude and Oestges, "MIMO Wireless Networks. Channels, Techniques and Standards for Multi-Antenna", 2nd ed. Elsevier Academic Press, 2013. Unit 1
4. Tim_Brown, Persefoni Kyritsi, Elizabeth De_Carval “Practical Guide to the MIMO Radio Channel with MATLAB” John Wiley & Sons, 2012. Unit 3

SUGGESTED READING:

1. Jerry R.Hampton, “Introduction to MIMO Communications”, Cambridge university press, 1st Edition, 2014.

26ECE108

STATISTICAL DECISION AND ESTIMATION THEORY

(Program Elective - II)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Concepts of probability theory and signals.

COURSE OBJECTIVES:

This course aims to:

1. Study and understand the importance of random variables and random processes in the communications.
2. Understand random signal modelings and statistical decisions.
3. Acquire the knowledge about estimation theory.

COURSE OUTCOMES:

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

1. Apply random variables and random process concepts in communications.
2. Demonstrate mathematical modelling of random processes such as noise.
3. Analyze various random processes modeling's such as AR processes, MA processes, ARMA processes and including Markov chains.
4. Understand binary hypothesis techniques.
5. Compare parameter estimation techniques.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	1	3	1	3
CO 2	3	2	2	1	3
CO 3	3	1	3	1	3
CO 4	3	3	2	1	3
CO 5	3	3	3	1	3

UNIT - I

Random Variables: Probability distribution and density functions, moments, independent, uncorrelated and orthogonal random variables.

Random Process: Temporal characteristics: Stationary and independence, Time averages. Mean Ergodic and correlation Ergodic processes. Auto-correlation function and its properties, Cross correlation function and its properties. Power spectral density and its properties.

UNIT - II

Random Signal Modeling: AR processes, MA processes, ARMA processes, Markov chains: Discrete time Markov chains and continuous time Markov chains.

UNIT - III

Statistical Decision Theory: Introduction, Baye's binary Hypothesis testing, Mini-max hypothesis testing and Neyman-Pearson hypothesis testing.

UNIT - IV

Parameter Estimation Theory: Introduction, Maximum likelihood estimation, Baye's Estimation: Minimum mean square error estimates, Minimum Mean Absolute value of error estimate, Least-Square Estimation and Recursive Least Square Estimator.

UNIT - V

Filtering: Introduction, Linear transformation and orthogonality principle, Wiener Filters: The optimum unrealizable filter, The optimum realizable filter, Kalman Filter.

TEXT BOOKS:

1. Payton. Z. Peebles Jr., "Probability Random variables and Random signal principles", TMH, 4th edition 2003.
2. Mourad Barkat, "Signal Detection and Estimation", Artech House, 2nd Edition, 2005.
3. D. G. Manolakis, V. K. Ingle and S.M. Kogon, "Statistical and Adaptive Signal Processing", McGraw Hill, 2000.

SUGGESTED READING:

1. Papoulis and S. U. Pillai, "Probability, Random Variables and Stochastic Processes", 4th Edition, McGraw-Hill, 2002.

26ECE109

VEHICULAR COMMUNICATIONS

(Program Elective - II)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Basic knowledge of Communication Systems, Computer Networks, Embedded Systems, and Wireless Communication.

COURSE OBJECTIVES:

Students will be able to:

1. Understand the fundamentals of vehicular communication, including wireless principles, RADAR, GPS, and IEEE standards.
2. Analyze automotive communication protocols and VANET routing techniques used in in-vehicle and inter-vehicle networks.
3. Evaluate advanced vehicular technologies such as Safe-by-Wire, DSRC, LTE-V2X, and security mechanisms for intelligent transportation systems.

COURSE OUTCOMES:

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

1. Explain the need, requirements, and fundamentals of automotive embedded systems.
2. Analyze the need, requirements, and architecture of automotive hardware modules.
3. Examine the need, requirements, and functionality of automotive software modules.
4. Analyze the requirements, operation, and applications of vehicular communication systems.
5. Describe various automotive communication protocols and their applications in intelligent transportation systems.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	1	3	1	3
CO 2	3	2	2	1	3
CO 3	3	1	3	1	3
CO 4	3	3	2	1	3
CO 5	3	3	3	1	3

UNIT-I

Basics of Vehicular Communication: Fundamental concepts – Bandwidth, Power Measurement, Signal, to, Noise ratio, Transmission Rate Constraints, Radio, frequency spectrum allocation.

RADAR: operation and types, Forward radar, Side radar, Wireless networking: transmitter and receiver. GPS, Cellular transmission, Data recorder, IEEE wireless LAN's and IEEE standards

UNIT, II

Automotive Communication Protocols: Controller Area Network (CAN): Introduction, CAN Transceiver, frame, applications, Local Interconnect Network, FlexRay, MOST, Automotive Ethernet and applications of different communication protocols.

Wireless Communications: Bluetooth, evolution, Classes, Operation, Spectrum Utilization., Operational Modes, And Vehicle applications, Vehicle interior system, Adhoc Networking, Communication Technologies., Vehicle frequency utilization for different devices. Infrastructure, to, Vehicle communication. Vehicle-to-Vehicle communication.

UNIT-III

Safe-by-Wire: Motorola Interconnect (MI), Distributed Systems Interface (DSI) - [Multimedia] DB2 (similar to MOST), Domestic Digital Bus (D2B), Mobile Multimedia Link (MML), IDB-1394 (Automotive Firewire) – USB, Wired Technologies, TDMA based networks – TTP, TT-CAN - FlexRay; TT Ethernet.

UNIT-IV

Routing Techniques: Routing in VANETs, flooding and the Broadcast Storm Problem, Traditional MANET routing, topology based / table-driven routing protocols, proactive (DSDV) vs. reactive / on-demand (DSR – AODV- DYMO) routing protocols, Geographic routing protocols, Beaconing – DTN and peer-to-peer ideas for VANET routing, Vehicular communication simulations (VEINS, OMNET++, SUMO, SimuLTE) , mobility models, traffic flow models.

UNIT-V

DSRC: Security And Privacy Protection, Low Latency, Coverage with scalability, 5.850ghz – 5.925ghz band, Basic Safety messaging, Collective Perception Messaging, Maneuver coordination, Platooning messaging, vulnerable road users - NPRM, LTE-V2X, AFAI (Alliance For - Automotive Innovation) – OSEK / VDX.

TEXT BOOKS:

1. Mikael Fallgren, Markus Dillinger, Toktam Mahmoodi, Tommy Svensson, “Cellular V2X for Connected Automated Driving”, Wiley, 2021.
2. Christophe Sommer and Falko Dressler, “Vehicular Networking”, Cambridge University Press, 2014.
3. Hannes Hartenstein and Kenneth Laberteaux (eds.), “VANET Vehicular Applications and Inter-networking Technologies”, John Wiley & Sons, 2009.

SUGGESTED READING:

1. Fei Hu and Xiaojun Cao, “Vehicle-to-Vehicle and Vehicle-to-Infrastructure Communications”, CRC Press, 2014.
2. William Stallings, “Wireless Communications and Networking”, Pearson Education, 2nd Edition, 2005.
3. Claudia Campolo, Antonella Molinaro and Riccardo Scopigno, “Vehicular Ad Hoc Networks: Standards, Solutions, and Research”, Springer, 2015.

26ECE110

QUANTUM COMMUNICATIONS

(Program Elective - II)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	2

PREREQUISITES: Basic knowledge of linear algebra and probability and Quantum Mechanics.

COURSE OBJECTIVES:

Students will be able :

1. To understand the fundamental principles of quantum mechanics and their application to communication systems.
2. To analyze quantum information concepts such as qubits, superposition, entanglement, and quantum communication protocols.
3. To explore quantum communication technologies, including quantum key distribution, quantum channels, and real-world applications.

COURSE OUTCOMES:

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

1. Explain the basic principles of quantum mechanics used in communication systems.
2. Analyze quantum information concepts such as qubits, entanglement, and quantum states.
3. Apply quantum communication protocols like teleportation, superdense coding, and QKD.
4. Evaluate the effects of noise and implement quantum error correction techniques.
5. Understand modern quantum networking technologies and future communication applications.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	1	3	1	-
CO 2	2	1	3	2	1
CO 3	3	2	3	2	1
CO 4	3	1	3	3	1
CO 5	2	2	3	2	2

UNIT- I

Fundamentals of Quantum Mechanics for Communication: Introduction to classical vs quantum communication, Basic postulates of quantum mechanics, Quantum states and state vectors, Bra-ket notation, Superposition principle, Measurement postulate, Probability amplitudes, Uncertainty principle, Quantum bits (Qubits), Bloch sphere representation

UNIT- II

Quantum Information Theory: Classical bits vs qubits, Multiple qubit systems, Tensor product states, Pure and mixed states, Density matrix formalism , Quantum entropy, Von Neumann entropy, Quantum information measures, No-cloning theorem, Quantum teleportation basics.

UNIT- III

Quantum Entanglement and Communication Protocols: Entanglement fundamentals, Bell states, EPR paradox, Bell's inequalities, Quantum teleportation protocol, Super dense coding, Quantum key distribution (QKD), BB84 protocol, E91 protocol, Security analysis of QKD

UNIT- IV

Quantum Channels and Error Correction: Quantum channels and transmission models, Decoherence and noise in quantum systems, Bit flip, phase flip, depolarizing channels, Quantum error detection, Quantum error correction codes, Shor code, Steane code.

UNIT- V

Quantum Networks and Applications: Quantum repeaters, Quantum internet architecture, Quantum cryptography applications, Secure communication systems, Satellite-based quantum communication, Optical quantum communication, Recent advances in quantum networking.

TEXTBOOKS:

1. M. Hajdusek and R. Van Meter, Quantum Communications, first edition, MIT Press, 2023.
2. T. Vidick and S. Wehner, Introduction to Quantum Cryptography, Cambridge University Press, 2023.
3. M. K. Pasupuleti, Quantum Networks and Secure Communication, National Education Services, 2024.
4. R. Bassoli, Quantum Communication Networks, Springer, 2021.

REFERENCE BOOKS:

1. M. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum Information, 10th edition, Cambridge University Press, 2010.
2. S. Khatri and M. M. Wilde, Principles of Quantum Communication Theory: A Modern Approach, 2020.
3. H. Dutta and A. K. Bhuyan, Quantum Communication: From Fundamentals to Recent Trends, Challenges and Open Problems, 2024.

26MEM101

RESEARCH METHODOLOGY AND IPR

Instruction	2 Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	2

COURSE OBJECTIVES:

Students will be able to:

1. Motivate to choose research as career
2. Formulate the research problem, prepare the research design
3. Identify various sources for literature review and data collection report writing
4. Equip with good methods to analyze the collected data
5. Know about IPR copyrights

COURSE OUTCOMES:

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

1. Define research problem, review and asses the quality of literature from various sources
2. Improve the style and format of writing a report for technical paper/ Journal report, understand and develop various research designs.
3. Collect the data by various methods: observation, interview, questionnaires.
4. Analyze problem by statistical techniques: ANOVA, F-test, and Chi-square.
5. Understand apply for patent and copyrights.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	2	1	2	1
CO 2	3	3	3	1	1
CO 3	3	2	2	1	1
CO 4	3	1	2	2	1
CO 5	3	3	3	1	1

UNIT - I

Research Methodology: Research Methodology: Objectives and Motivation of Research, Types of Research, research approaches, Significance of Research, Research Methods verses Methodology, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India, Benefits to the society in general. Defining the Research Problem: Selection of Research Problem, Necessity of Defining the Problem

UNIT - II

Literature Survey Report writing: Literature Survey: Importance and purpose of Literature Survey, Sources of Information, Assessment of Quality of Journals and Articles, Information through Internet. Report writing: Meaning of interpretation, layout of research report, Types of reports, Mechanics of writing a report. Research Proposal Preparation: Writing a Research Proposal and Research Report, Writing Research Grant Proposal.

UNIT- III

Research Design: Research Design: Meaning of Research Design, Need of Research Design, Feature of a Good Design, Important Concepts Related to Research Design, Different Research

Designs, Basic Principles of Experimental Design, Developing a Research Plan, Steps in sample design, types of sample designs.

UNIT - IV

Data Collection and Analysis: Data Collection: Methods of data collection, importance of Parametric, non parametric test, testing of variance of two normal population, use of Chi-square, ANOVA, Ftest, z-test.

UNIT - V

Patents and Copyright: Patent: Macro economic impact of the patent system, Patent document, How to protect your inventions. Granting of patent, Rights of a patent, how extensive is patent protection. Copyright: What is copyright. What is covered by copyright? How long does copyright last? Why protect copyright? Related Rights: what are related rights? Enforcement of Intellectual Property Rights: Infringement of intellectual property rights, Case studies of patents and IP Protection.

TEXT BOOKS:

1. C.R Kothari, "Research Methodology, Methods & Technique"; New Age International Publishers, 2004
2. R. Ganesan, "Research Methodology for Engineers", MJP Publishers , 2011
3. Y.P. Agarwal, "Statistical Methods: Concepts, Application and Computation", Sterling Publs., Pvt., Ltd., New Delhi, 2004.

SUGGESTED READING:

1. Ajit Parulekar and Sarita D' Souza, "Indian Patents Law – Legal & Business Implications"; Macmillan India ltd , 2006
2. B. L.Wadehra; "Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications"; Universal law Publishing Pvt. Ltd., India2000.
3. P. Narayanan; "Law of Copyright and Industrial Designs"; Eastern law House, Delhi 2010.

26ECC103

ADVANCED DIGITAL SIGNAL PROCESSING LAB

Instruction	2 P Hours Per Week
Duration of SEE	--
SEE	--
CIE	50 Marks
Credits	1

PREREQUISITE: The knowledge of signal processing algorithms and MATLAB.

COURSE OBJECTIVES:

This course aims to:

1. Simulation of FFT, Multirate concepts using MATLAB.
2. Spectral analysis of noisy signals using MATLAB.
3. Implementation of digital filters using MATLAB.

COURSE OUTCOMES:

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

1. Implement FFT algorithms for linear filtering and correlation using MATLAB.
2. Design and realize of the digital filters and adaptive filters using MATLAB.
3. Experiment with multirate techniques using MATLAB.
4. Perform parametric and non-parametric estimation of PSD using MATLAB.
5. Interpret feature extraction models for preprocessing signals in ML models.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	3	1	2	2
CO 2	2	3	1	2	2
CO 3	1	3	--	2	1
CO 4	2	3	1	2	2
CO 5	1	3	1	2	1

List of Experiments:

1. FFT of input sequence and comparison with DFT.
2. Design of IIR Butterworth, Chebyshev type-I &II, Elliptic LPF, HPF, BPF &BSF.
3. Design of FIR LPF, HPF, BPF &BSF using windows and Multiband FIR filter.
4. State space matrix representation from difference equation
5. Solution of normal equation using Levinson Durbin
6. Decimation and Interpolation using rational factors
7. Design a Multistage decimator multirate filter
8. Uniform DFT filter bank
9. Cascade and parallel realization of digital IIR filter
10. Parametric Estimation of PSD
11. Nonparametric Estimation of PSD
12. Design of Adaptive filter using LMS algorithm.
13. Generation and visualization of signals in time and frequency domain using MATLAB
14. Feature extraction from signals (mean, variance, energy, FFT-based features)
15. Spectrogram analysis of speech signals using MATLAB

Sample Mini Projects:

1. Design the best IIR band pass filter to meet the given specifications:
   Pass band cut off frequencies: [500 600] Hz
   Stop band cut off frequencies: [525 675] Hz
   Pass band ripple: ≤ 2dB
   Stop band attenuation: ≥ 60dB
   Phase response: Approximately linear in pass band Consider Butterworth, Chebyshev, Elliptic and Bessel filters

2. Design a three stage multirate filter to meet the given specifications:
   Pass band cut off frequency: 450 Hz
   Stop band cut off frequency: 500 Hz
   Pass band ripple: ≤ 3dB
   Stop band attenuation: ≥ 40dB
   Sampling frequency: 40 KHz
   Compare with single stage filter.

3. Consider a clean speech signal of length 5000 samples and compute the Power Spectrum. Now add 0dB random noise. Compute the power spectrum using Welch and Eigen value Estimation method and also compare with the original spectrum.

4. Design a speech signal compression using octave filter banks and also calculate the compression ratio.

Note: A minimum of ten experiments should be performed from the list.

SUGGESTED READING:

1. Vinay K. Ingle and John G. Proakis, "Digital Signal Processing using MATLAB", 4th edition, Cengage learning, 2011.
2. S. Tanwar, *"Machine Learning in Signal Processing: Applications, Challenges, and the Road Ahead,* Hoboken", Wiley, 2021.

26ECC104

WIRELESS AND MOBILE COMMUNICATIONS LAB

Instruction	2 P Hours Per Week
Duration of SEE	--
SEE	--
CIE	50 Marks
Credits	1

PREREQUISITE: Basic knowledge of Digital Communication, Wireless Communication, and MATLAB programming.

COURSE OBJECTIVES:

This course aims to:

1. Understand and analyze wireless propagation, fading, and equalization techniques through simulation and measurement of mobile communication channels.
2. Develop and evaluate transmitter, receiver, and modulation techniques used in cellular systems, including GSM, CDMA, and Bluetooth.
3. Implement and assess advanced communication technologies such as MIMO, OFDM, STBC, and cellular coverage models using modern simulation tools such as MATLAB.

COURSE OUTCOMES:

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

1. Analyze wireless propagation models and estimate path loss under indoor and outdoor environments using MATLAB.
2. Simulate and evaluate fading channels and equalization techniques, and assess their impact on BER, SNR, and channel capacity.
3. Demonstrate modulation, transmitter–receiver operations, and GSM/3G AT command applications in mobile communication systems.
4. Implement and analyze advanced communication techniques such as CDMA, MIMO, OFDM, and STBC.
5. Evaluate wireless technologies such as Bluetooth and cellular coverage performance under varying propagation and interference conditions.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	1	3	3	1
CO 2	3	2	3	3	1
CO 3	2	2	3	2	1
CO 4	3	2	3	3	2
CO 5	2	2	3	2	2

List of Experiments:

1. Wireless Path loss Computations - Study of Propagation Path loss Models: Indoor & Outdoor.
2. To demonstrate the concept of RF Propagation taking into account site and terrain visualization, propagation model specification and visualization, path loss & ray tracing using MATLAB.
3. Simulate and study Nakagami-m fading, Rayleigh fading and Racian fading with channel capacity and BER Vs SNR.
4. Wireless Channel Equalizations: ZF, MSME, Adaptive Equalizer, Decision Feedback Equalizer.

5. Develop and simulate the two-ray ground reflection model to study signal propagation in wireless channels. Compare results with free-space models and analyze the impact of antenna height, distance, and reflection.
6. Study Transmitter and Receiver sections in Mobile Handset and also measure GMSK modulated signal.
7. Study various GSM AT Commands such as SMS and HTTP.
8. Study File system by AT commands in 3G network.
9. Study of DSSS technique for CDMA to observe effect of PN codes, Chiprate, Spreading factor and Processing gain.
10. Understand the trade-offs between the spatial diversity and spatial multiplexing in MIMO communication systems.
11. Multi-carrier modulation scheme for frequency selective fading channel.
12. Implement Space-Time Block Coding (STBC) techniques in MIMO systems and perform channel estimation. Analyze improvements in diversity gain, reliability, and error performance under fading conditions.
13. Simulate Bluetooth voice transmission to observe effect of AWGN and of interference of 802.11b on transmission.
14. Simulate and evaluate cellular coverage areas under different propagation conditions to understand quality of service (QoS) constraints.

Note: A minimum of ten experiments should be performed from the list.

SUGGESTED READING:

1. Theodore S. Rappaport, **Wireless Communications: Principles and Practice**, 2nd Edition, Pearson Education.
2. Jochen Schiller, **Mobile Communications**, 2nd Edition, Pearson Education.

26ECC105

ADVANCED COMMUNICATIONS LAB

Instruction	2 P Hours Per Week
Duration of SEE	--
SEE	--
CIE	50 Marks
Credits	1

PREREQUISITES: Basic concepts of GNSS**,** Analog and Digital communications, Signal processing and wireless communication.

COURSE OBJECTIVES:

This course aims :

1. To provide hands-on experience in designing and analyzing communication systems using GNU Radio and SDR platforms.
2. To enable understanding and implementation of modulation techniques, signal sampling, noise analysis, and filtering in practical communication systems.
3. To introduce real-world applications including LTE communication, GNSS-based positioning, and LiDAR data processing.

COURSE OUTCOMES:

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

1. Generate and analyze different signal waveforms and implement modulation techniques using GNU Radio Companion.
2. Evaluate the effects of sampling, noise, and filtering on signal quality in communication systems.
3. Design and implement basic SDR-based communication systems using USRP B200.
4. Analyze LTE and GNSS system performance including positioning, signal strength, and error sources.
5. Process and visualize LiDAR data for 3D point cloud reconstruction and analysis.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	1	3	3	1
CO 2	3	1	3	2	1
CO 3	3	2	3	3	2
CO 4	3	2	3	3	1
CO 5	2	2	3	3	2

List of Experiments:

Experiments using GNU Radio companion, SDR (USRP B200) & LIDAR:

1. Generate sine, cosine, square, triangle, sawtooth wave in Gnu radio with different amplitudes and frequencies, further apply amplitude modulation, Frequency Modulation , ASK, FSK techniques
2. Analyse the oversampling perfect sampling and under sampling of a signal in Gnu radio.

3. Analyse the effects of types of Noises on cosine wave signal in Gnu radio and Estimate Bit Error Rate.
4. Experiment to analyse the effects of low pass and high pass filters on the Audio signals using Gnu radio.
5. Implement the transmission and reception of signals through the audio source & wav file blocks.
6. Design, Implementation, and Spectral Characterization of Audio Signal Transmission using GNU Radio and Spectrum Analyzer
7. Comprehensive Performance Evaluation of a 3GPP LTE Band 7 Link using srsRAN: Throughput, RSRP, MCS, BLER, and Link Adaptation Analysis
8. Extraction and Quantitative Analysis of IQ Samples for RSSI Estimation and Phase Difference Measurement using USRP B200 and GNU Radio
9. Design and Implementation of End-to-End Data Communication between User Equipment (UE) and eNodeB using a USRP B200-Based SDR Platform
10. 3D Point Cloud Reconstruction and Visualization from LiDAR Data using Python-Based Computational Techniques

Experiments using GNSS receiver:

1. Study of GNSS Receiver and Signal Structure.
2. Data Acquisition and RINEX File Generation.
3. Satellite Visibility Analysis and Sky Plot Generation
4. Single Point Positioning (SPP): Determination of receiver position using pseudorange measurements.
5. Multipath error analysis: Study of signal reflection effects on positioning accuracy.
6. Ionospheric Delay Estimation using Dual Frequency Data.

Note: A minimum of ten experiments should be performed from the list.

SUGGESTED READING:

1. Rappaport, T. S., *Wireless Communications: Principles and Practice*, Pearson Education, 2nd Edition, 2002.
2. Kaplan, E. D., and Hegarty, C. J., *Understanding GPS/GNSS: Principles and Applications*, Artech House, 3rd Edition, 2017.
3. Dahlman, E., Parkvall, S., and Sköld, J., *4G LTE/LTE-Advanced for Mobile Broadband*, Academic Press, 2nd Edition, 2018.

26ECC114

AI WORKSHOP FOR COMMUNICATION ENGINEERING

Instruction	2P Hours Per Week
Duration of SEE	--
SEE	--
CIE	50 Marks
Credits	1

PREREQUISITE: Basic Communication Engineering Concepts.

COURSE OBJECTIVES:
This course aims:

1. To introduce AI-assisted tools, open-source platforms, and machine learning techniques for communication engineering applications.
2. To enable analysis, visualization, and intelligent processing of communication signals, including classification, prediction, and noise analysis.
3. To develop the ability to design and implement AI-based solutions for real-world communication systems such as modulation recognition and channel optimization.

COURSE OUTCOMES:
Upon completion of this course, students will be able to:

4. Use AI-assisted tools for signal analysis, visualization, and data processing.
5. Apply machine learning techniques for classification, regression, and noise handling in communication systems.
6. Develop AI-based models for modulation recognition and signal processing.
7. Analyze communication system performance using AI techniques such as channel prediction and optimization.
8. Design and implement a mini-project integrating AI with communication engineering applications.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	3	1	2	2
CO 2	2	3	1	2	2
CO 3	2	3	1	2	2
CO 4	2	3	1	2	2
CO 5	1	3	1	2	2

List of Experiments:

1. Introduction to AI Tools for Communication Engineers
   Tools: Google Colab, ChatGPT
   Experiment:
   Run a basic notebook
   Use AI prompts to explain communication signals dataset
   Outcome: Understand AI-assisted workflow

2. Data Handling for Communication Signals

Tools: Pandas
Experiment:
Load signal datasets (noise, modulation data)
AI-assisted cleaning & summary
Outcome: Data preprocessing basics

3. Visualization of Signals
Tools: Matplotlib
Experiment:
Plot sine, cosine, noisy signals
Compare signal behaviors
Outcome: Signal visualization

4. AI-Based Signal Classification
Tools: Scikit-learn
Experiment:
Classify signals (AM, FM, Noise)
Outcome: ML classification basics

5. Noise Analysis Using AI
Tools: NumPy
Experiment:
Generate noisy signals
AI-based noise identification
Outcome: Noise handling

6. Regression for Channel Prediction
Tools: Scikit-learn
Experiment:
Predict channel attenuation
Outcome: Regression modeling

7. AI-Based Modulation Recognition
Tools: TensorFlow
Experiment:
Identify modulation type using AI
Outcome: Communication + AI integration

8. Spectrum Analysis with AI
Tools: SciPy
Experiment:
FFT-based spectrum analysis
AI interpretation
Outcome: Frequency domain understanding

9. AI for Signal Compression
Tools: TensorFlow
Experiment:
Simple autoencoder for signal compression
Outcome: Efficient transmission concepts

10. AI-Assisted Communication System Simulation
Tools: GNU Radio
Experiment:
Simulate transmitter–receiver chain
Outcome: System-level understanding

11. AI for Error Detection

Tools: Python
Experiment:
Detect bit errors using ML
Outcome: Reliability analysis

12. Edge AI in Communication Systems
Tools: TensorFlow Lite
Experiment:
Simulate low-power communication AI model
Outcome: Edge intelligence

13. AI-Based Channel Optimization
Tools: Scikit-learn
Experiment:
Optimize SNR vs bandwidth
Outcome: System optimization

14. Mini Project (AI in Communication Systems)
Options:
Modulation classifier
Noise reduction system
Channel predictor
Outcome: End-to-end solution using Jetson Nano

Note: A minimum of ten experiments should be performed from the list.

SUGGESTED READING:

1. Simon Haykin, *Communication Systems*, Wiley, 5th Edition.
2. Ian Goodfellow, *Deep Learning*, MIT Press, 1st Edition.
3. Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, O'Reilly Media, 2nd Edition.
4. Theodore S. Rappaport, *Wireless Communications: Principles and Practice*, Pearson, 2nd Edition.

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY(A)

R26 Curriculum (with effect from AY 2026-27)

M.E (Communication Engineering)

SEMESTER – II

S.no	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	26ECC106	Advanced Digital Signal Processing with ML	3	--	--	3	40	60	3
2	26ECC107	Advances in Antennas	3	--	--	3	40	60	3
3	26ECC115	5G and Beyond Communication Systems with AI	2	--	--	3	40	60	2
4		Program Elective-III	3	--	--	3	40	60	3
5		Program Elective-IV	3	--	--	3	40	60	3
6		Audit Course-II	2	--	--	2	--	50	Non-Credit
PRACTICALS									
7	26ECC108	Advanced Digital Signal Processing Lab	--	--	2	--	50	--	1
8	26ECC109	Advanced Antennas Lab	--	--	2	--	50	--	1
9	26ECC110	Mini Project	--	--	2	--	50	--	1
10	26ECC111	Industrial Internship / Training	90 Hours			--	50	--	1
Total			**16**	**--**	**6**	**17**	**400**	**350**	**18**
Clock Hours Per Week: 22									

L: Lecture **D: Drawing** **CIE: Continuous Internal Evaluation**

T: Tutorial **P: Practical/Mini Project/Dissertation** **SEE: Semester End Examination**

26ECC106

ADVANCED DIGITAL SIGNAL PROCESSING WITH ML

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: The knowledge of DSP is required.

COURSE OBJECTIVES:

This course aims to:

1. Analyze digital IIR and FIR filters for the given specifications.
2. Understand the basic concepts of Multirate digital signal processing.
3. Learn the various parametric and non-parametric spectral estimation methods.

COURSE OUTCOMES:

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

1. Design digital filters for the given specifications.
2. Interpret the concepts of Multirate digital signal processing.
3. Understand the concepts of linear prediction filters.
4. Analyze various Power Spectral Estimation methods for random signals
5. Develop feature extraction models for preprocessing signals in ML algorithm.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	--	1	2	1
CO 2	1	--	1	1	1
CO 3	1	--	1	2	2
CO 4	2	--	2	2	2
CO 5	1	--	2	2	2

UNIT-I

Review of Digital Filters: FFT algorithm, Review of digital filter design and structures-Design techniques of linear phase FIR filters, IIR filters by impulse invariance, bilinear transformation. Cascade, parallel and lattice realization of FIR and IIR filters.

UNIT-II

Multirate DSP: Introduction, Decimator and Interpolator, Sampling rate conversion, multistage decimator, polyphase filters, Uniform Digital Filter banks, two channel Quadrature Mirror Filter bank- perfect reconstruction conditions.

UNIT-III

Linear Prediction & Optimum Linear Filters: Introduction to discrete random signals, Power Density spectrum and Ergodic process. Forward and backward linear prediction filters, solution of normal equations- Levinson and Durbin algorithm, AR Lattice and ARMA Lattice-Ladder Filters, FIR Wiener filter.

UNIT-IV

Power Spectrum Estimation: Estimation of Spectra from Finite-Duration Observations of Signals, Nonparametric Methods for Power Spectrum Estimation-Bartlett and Welch methods. Parametric methods for Power Spectrum Estimation-Yule Walker method and Burg method. Minimum-Variance Spectral Estimation, Eigen analysis Algorithms for Spectrum Estimation and MUSIC algorithm.

UNIT-V:

Introduction to Machine Learning in Signal Processing: I**ntroduction to** Machine Learning, Difference between traditional DSP and ML-based approaches, Need for ML in signal processing systems, Basic workflow of ML (Data, Features, Model, Prediction), **Types of Machine Learning- Supervised Learning-**Concept of labeled data, Regression and classification, u**nsupervised Learning-** Clustering and pattern discovery, **Reinforcement Learning** - Interaction-based learning, **Signal Representation for ML-** Time-domain representation, Frequency-domain representation (Spectrogram), Feature extraction techniques: Statistical features (mean, variance), Spectral features (FFT-based).

TEXT BOOKS:

1. J.G.Proakis and D.G.Manolakis, "Digital signal processing: Principles, Algorithm and Applications", 4th Edition, Prentice Hall, 2007.
2. Sanjit. K. Mitra, "Digital signal processing", 3rd edition, McGraw Hill, 2006.
3. M. A. Little, "Machine Learning for Signal Processing: Data Science, Algorithms, and Computational Statistics", Oxford University Press, 2024.

SUGGESTED READING:

1. K. Deergha Rao and M.N.S. Swamy, "Digital Signal Processing: Theory and Practice", Springer, 2018.
2. Emmanuel Ifeachor, Barrie W.Jervis, "Digital signal Processing, A Practical Approach", 2nd edition, Pearson, 2011.
3. Roberto Cristi, "Modern Digital signal Processing", Cengage learning, 2012.
4. P. K. Dutta and S. K. Mitra, "Signal Processing and Machine Learning with Applications", Springer, 2017.
5. S. Theodoridis and K. Koutroumbas, "Machine Learning Algorithms for Signal and Image Processing", Academic Press, 2020.

26ECC107

ADVANCES IN ANTENNAS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Students should have prior knowledge of Electromagnetic waves and basics of Antennas.

COURSE OBJECTIVES:

This course aims:

1. To understand advanced antenna concepts and analysis techniques.
2. To design antennas suitable for modern wireless systems.
3. To expose students to emerging antenna technologies and research trends.

COURSE OUTCOMES:

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

1. Analyze advanced antenna parameters using EM theory.
2. Design broadband and multiband antennas.
3. Apply numerical and simulation techniques in antenna design.
4. Develop smart and array antennas for modern systems.
5. Evaluate emerging antenna technologies and conduct research.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	1	1	-	-	3
CO 2	2	-	3	3	3
CO 3	2	-	3	3	3
CO 4	3	-	3	3	3
CO 5	3	3	3	3	3

UNIT- I

Review of Antenna Fundamentals: Review of Radiation mechanism and Maxwell's equations. Radiation integrals and vector potentials.

Antenna parameters: radiation resistance, input impedance, gain, directivity, efficiency, bandwidth and quality factor. Polarization: linear, circular, elliptical, polarization loss factor. Pattern concepts: isotropic radiator, antenna beamwidth, front-to-back ratio, side lobes.

Aperture antennas: Relationship between gain and aperture size

Introduction to computational electromagnetics: Method of Moments (MoM), Finite Element Method (FEM), Finite Difference Time Domain (FDTD) – fundamentals and comparison.

UNIT- II

Broadband and Multiband Antennas:

Bandwidth definitions and limitations of conventional antennas.

Techniques for bandwidth enhancement: impedance matching, slotting, stacking and parasitic elements.

Frequency-independent antennas: log-periodic dipole arrays, spiral antennas. Multiband and wideband antenna design approaches.
Reconfigurable antennas: frequency, pattern, and polarization reconfiguration using PIN diodes, Varactors and MEMS. Applications in wireless, WLAN, mobile, and cognitive radio systems.

UNIT-III
Microstrip and Planar Antennas:
Microstrip antenna analysis using transmission-line and cavity models, substrate selection.
Effect of substrate parameters and feeding techniques (inset feed, proximity feed, aperture coupling).
Bandwidth enhancement and size reduction techniques in microstrip antennas.
Planar array antennas and corporate feeding networks.
Defected Ground Structure (DGS) and Electromagnetic Band Gap (EBG) structures.
Compact, miniaturized, and low-profile antenna designs for portable devices.

UNIT-IV
Smart and Adaptive Antennas:
Antenna arrays: linear, planar, and conformal arrays. Beam steering and beam shaping techniques.
Phased array antennas: phase shifters, feeding networks.
Adaptive and Smart antennas: concepts and advantages. Introduction to beamforming algorithms (delay-and-sum, adaptive beamforming).
MIMO antenna systems: diversity techniques, capacity improvement.
Applications in radar, satellite communication, and 5G systems (Qualitative treatment only)

UNIT-V
Emerging Antennas Technologies:
Metamaterial and metasurface antennas: concepts and applications.
Fractal antennas: geometry, self-similarity, and multiband behavior.
Wearable and body-centric antennas: design considerations, SAR issues.
Millimeter-wave and terahertz antennas. Antennas for 5G/6G communication systems and IoT applications. Overview of recent research trends and future challenges in antenna engineering.
Application of Artificial Neural Network (ANN) for pattern optimization

TEXTBOOKS:

1. Constantine. A. Balanis, “Antenna Theory: Analysis and Design,” 4th Edition, 2016, John Wiley.
2. Stutzman & Thiele, “Antenna Theory and Design,” 3rd Edition, 2012, John Wiley.

REFERENCES:

1. Mailloux, “Phased Array Antenna Handbook,” 3rd Edition, 2017, Artech House
2. Girish Kumar, K.P.Ray, “Broadband Microstrip Antennas,” 2003, Artech House.
3. Ramesh Garg, Prakash Bhartia, Inder Bahl, Apisak Ittipiboon, “Microstrip Antenna Design Handbook,”2018, Artech House.

26ECC115

5G AND BEYOND COMMUNICATION SYSTEMS WITH AI

Instruction	2 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	2

PREREQUISITE: Knowledge in Communication systems, Wireless & Mobile Communications

COURSE OBJECTIVES:

This course aims to:

1. Understand the requirements & concepts of 5G.
2. Expose the architecture and radio access technologies of 5G.
3. Learn fundamentals of AI and its role in Next-Gen communications.

COURSE OUTCOMES:

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

1. Recall the requirements and key functionalities of 4G LTEA/5G NR technology.
2. Compare various channel access technologies and modulation techniques used in 5G wireless systems.
3. Illustrate the architecture of 5G and its NextGen core network.
4. Demonstrate the concept of massive MIMO.
5. Explain AI/ML concepts and their relevance to Next-Gen communications.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	2	3	1	2
CO 2	3	2	2	3	2
CO 3	3	1	3	3	2
CO 4	2	1	3	3	2
CO 5	3	1	2	2	1

UNIT- I

Overview of 5G Wireless Communications: Evolution of mobile technologies (1G-5G), 3GPP Releases & its key aspects, Overview of 5G, three high level 5G usage scenarios (eMBB, URLLC, mMTC), Key capabilities & requirements, 5G vs. LTE-A Comparison, 5G frequency bands, 5G Use cases.

UNIT-II

Waveform Design for 5G & Beyond: Introduction - 5G Waveform Design and Waveform Requirements – Flexible OFDM comparison with CP-OFDM, generalized frequency division multiplexing (GFDM), filter bank multi-carriers (FBMC) and universal filtered multi-carrier (UFMC), Multiple Accesses Techniques –non-orthogonal multiple accesses (NOMA), Sparse Code Multiple Access (SCMA) – Comparison of multiple access methods.

UNIT-III

5G Architecture: Introduction: NGMN 5G Architecture framework, Layered functionality, 3GPP 5G architecture, Non-Roaming 5G system architecture, overall RAN architecture, Functional Split Between NG-RAN and 5G Core Network.

5G NextGen Core Network: Modern network requirements, SDN architecture, NFV benefits and requirements, – NFV Reference Architecture, Network Slicing concepts & requirements.

UNIT- IV

Massive Multiple-Input Multiple-Output (MIMO) Systems: Introduction to Multi-Antenna system, Theoretical background: MIMO requirement, MIMO vs. massive MIMO, Massive MIMO benefits, single user and multi-user MIMO, capacity of MIMO for unknown CSIT, massive MIMO capacity, Massive MIMO OFDM transmitter employing digital precoding, analog beamforming and hybrid of digital precoding and analog beamforming.

UNIT - V

AI in Next-Generation Communication Systems: Introduction to AI and ML/DL techniques for beyond 5G/6G networks, AI-enabled Radio Access Networks (AI-RAN), radio resource management, and traffic analysis. AI-driven network optimization, resource allocation, QoS enhancement, and social implications of AI in communication systems.

TEXT BOOKS:

1. Saad Z. Asif, "5G Mobile Communications Concepts and Technologies" CRC Press, 2019. (Unit1, Unit2)
2. Suvra Sekhar Das and Ramjee Prasad, "Evolution of Air Interface Towards 5G: Radio Access Technology and Performance Analysis", Gistrup, Denmark: River Publishers series in Communication, 2018.(Unit 2)

SUGGESTED READING:

1. R. S. Kshetrimayum, "Fundamentals of MIMO Wireless Communications", Cambridge University Press, UK, 2017.(Unit 4)
2. Wei Xiang, Kan Zheng, Xuemin (Sherman) Shen, "5G Mobile Communications", Springer publications-2016.(Unit 1)
3. William Stallings "5G Wireless: A Comprehensive Introduction", Pearson Education, 2021.(Unit 3)
4. Afif Osseiran, Jose F. Monserrat, Patrick Marsch, "5G Mobile and Wireless Communications Technology" Cambridge University Press-2016.(Unit 4)
5. Jonathan Rodriguez, "Fundamentals of 5G Mobile Networks" first edition, John Wiley & Sons, 2015.

26ECE111

MACHINE LEARNING FOR NEXT GENERATION COMMUNICATION SYSTEMS

(Program Elective - III)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Digital Communication concepts.

COURSE OBJECTIVES:

This course aims to:

1. Develop and apply machine learning algorithms to enhance the performance of wireless communication and networks.
2. Use deep learning techniques to improve wireless communication network's coverage and channel capacity.
3. Evaluate the performance of machine learning algorithms and deep learning techniques in wireless communication networks.

COURSE OUTCOMES:

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

1. Develop a comprehensive understanding of machine learning and deep learning techniques for wireless communication networks.
2. Design machine learning algorithms for spectrum access and sharing and reinforcement learning algorithms for resource allocation.
3. Design deep learning algorithms for optimizing coverage and channel capacity.
4. Apply machine learning algorithms for optimizing energy efficiency, modulation, coding, channel equalization, and signal detection.
5. Analyze and evaluate the performance of machine learning and deep learning algorithms in wireless communication networks.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	2	3	2	2
CO 2	3	2	3	2	2
CO 3	3	2	3	2	2
CO 4	3	3	3	3	2
CO 5	1	2	2	2	2

UNIT - I

Machine Learning for Spectrum Access and Sharing: Online Learning Algorithms for Opportunistic Spectrum Access, Performance Measures of the Online Learning Algorithms, Random and Deterministic Approaches, The Adaptive Sequencing Rules Approach, Structure of Transmission Epochs, Learning Algorithms for Channel Allocation, Distributed Learning.

UNIT - II

Machine and Reinforcement Learning for Resource Allocation in Communication Networks: Use of Q-Learning for Cross-layer Resource Allocation, Deep Q-Learning and Resource Allocation, Cooperative Learning and Resource Allocation, Decentralized Resource Minimization, Resource Minimization Approaches, Optimized Allocation.

UNIT - III

Deep Learning–Based Coverage and Capacity Optimization: Related Machine Learning Techniques for Autonomous Network Management, Data-Driven Base-Station Sleeping Operations by Deep Reinforcement Learning, Deep Q-Learning Preliminary and its Applications to BS Sleeping Control, Dynamic Frequency Reuse through a Multi-Agent Neural Network Approach.

UNIT - IV

Machine Learning in Energy Efficiency Optimization: Self-Organizing Wireless Networks, Traffic Prediction and Machine Learning, Cognitive Radio and Machine Learning, Deep Learning, Positioning of Unmanned Aerial Vehicles, Traffic Prediction, Mobility Prediction

UNIT - V

Machine Learning–Based Adaptive Modulation and Coding (AMC) Design: Overview of ML-Assisted AMC, k-NN-Assisted AMC, Algorithm for k-NN-Assisted AMC, Performance Analysis of k-NN-Assisted AMC System, RL-Assisted AMC, Machine Learning for Joint Channel Equalization and Signal Detection.

TEXT BOOKS:

1. Fa-Long Luo," Machine Learning for Future Wireless Communications", John Wiley and Sons, 2020
2. Ruisi He, Z Ding, “Applications of Machine Learning in Wireless Communications”, IET Telecommunication series 81.
3. K. K. Singh, A. Singh, K. Cengiz, Dac-Nhuong Le, “Machine Learning and Cognitive Computing for Mobile Communications and Wireless Networks”, Wiley 2020.

SUGGESTED READING:

1. Shai Shalev-Shwartz and Shai Ben-David, “Understanding Machine Learning: From Theory to Algorithms, “Cambridge University Press”,2014.
2. Athanasios G. Kanatas, Konstantina S. Nikita, Panagiotis Takis Mathiopoulos, “New Directions in Wireless Communications Systems: From Mobile to 5G”, CRC Press, 2017.

26ECE112

MARKOV CHAIN AND QUEUING SYSTEMS

(Program Elective - III)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Probability Theory concepts.

COURSE OBJECTIVES:

This course aims to:

1. Comprehend and analyze probability theory and random variables.
2. Acquire proficiency in modeling systems using stochastic processes.
3. Utilize markov chains, queuing models, and stochastic modeling for real time problem-solving.

COURSE OUTCOMES:

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

1. Compute the characteristics of the random variables with the given probabilities.
2. Solving different cases of stochastic processes along with their properties.
3. Understand Markov Chains and regenerative processes used in modelling a wide variety of systems and phenomena.
4. Model a system as a queuing system with some aspect of the queue governed by a random process.
5. Understand systems modelling using Markov chains with special emphasis on developing queuing models.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	2	2	2	2
CO 2	3	2	2	2	3
CO 3	3	2	2	2	3
CO 4	3	3	2	3	3
CO 5	3	3	2	3	3

UNIT - I

Introduction: Review of basic probability, properties of nonnegative random variables, laws of large numbers and the Central Limit Theorem.

UNIT - II

Renewal Processes: Basic definitions, recurrence times, Rewards and renewal reward theorem, Point processes, Poisson process, Walds equation, Blackwell's theorem.

UNIT - III

Discrete Time Markov Chains: Definitions and properties, Matrix representation, Perron-Frobenius theory.

UNIT - IV

Continuous Time Markov Chains: basic definitions, Q-matrix, Birth-death processes, Quasi Birth Death Processes. Embedded Markov Processes, Semi Markov Processes, Reversible Markov Chains, Random Walks.

UNIT - V

Fundamental Queuing Results: Little's theorem, invariance of the mean delay, Conservation law. Markovian queues: Jackson and BCMP networks, numerical Algorithms. M/G/1 & G/M/1 queues and G/G/1 queues. Advanced queuing models: priority, vacation and retrials in queues.

TEXT BOOKS:

1. R.Gallager, "Discrete Stochastic Processes", Kluwer Academic Press, 1996.
2. Ronald W. Wolff, "Stochastic Modeling and the Theory of Queues", Pearson, 1989.
3. J Medhi, "Stochastic Processes", 3rd edition, New Age International Publishers, 2009.

SUGGESTED READING:

1. Sheldon M. Ross, "Stochastic Processes", Wiley, 2nd edition, 1996.
2. Cliffs, "Stochastic Modelling and the Theory Queues", Prentice Hall, 1989.
3. P.Bremaud, "Markov Chains", Springer-Verlag, 1999.
4. E.Seneta, "Non Negative Matrices and Markov Chains", Springer Series in Statistics, Springer, 1981.
5. L.Kleinrock, "Queuing Systems", vols I and II, John Wiley and Sons 1976.

26ECE113

SMART ANTENNAS

(Professional Elective-III)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Basic concepts of Electromagnetic theory and Antennas.

COURSE OBJECTIVES:

This course aims:

1. To learn the fundamentals of non-uniform, planar antenna arrays and MIMO antenna system.
2. To learn the different types of smart antenna configuration and their importance.
3. To compare the different types of the algorithm used for DOA estimation and beam-forming.

COURSE OUTCOMES:

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

1. Understand the basic principles of Non-Uniform and Planar antenna arrays.
2. Comprehend the necessity of smart antenna and its configuration.
3. Understand the DOA estimation methods and compare different algorithms for DOA estimation.
4. Analyze various beam-forming algorithms used in a smart antenna systems.
5. Describe the fundamentals of the MIMO and RDA antenna systems.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	3	3	2	1
CO 2	3	2	2	1	1
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	2	2	1

UNIT-I

I**ntroduction to Smart Antennas:** Need for Smart Antennas, Architecture of Smart Antenna Systems (SASA), Concept of Spatial Processing, Advantages and Disadvantages over Conventional Antennas, Spatial Channel Modelling and Mobile Communication Systems.

UNIT-II

Antenna Arrays and Beamforming: Array Fundamentals: Uniform Linear Array (ULA), Planar Arrays, Beamforming Techniques: Conventional Beam formers (Delay-and-Sum), Fixed Weight Beam formers, **Adaptive Beamforming Techniques:** Performance Optimization, Constraints.

UNIT-III

Direction of Arrival (DOA) Estimation: Fundamentals of Spectral Estimation, Classical Methods: Bartlett, Capon, and Maximum Likelihood techniques, Subspace Techniques: MUSIC (Multiple Signal Classification), ESPRIT.

UNIT-IV

Adaptive Algorithms: Least Mean Square (LMS) Algorithm, Recursive Least Square (RLS) Algorithm, Algorithm Convergence and Computational Complexity.

UNIT-V

MIMO and Receive Diversity Architecture (RDA): Integration of Smart Antennas into Modern Wireless Standards (e.g., 4G LTE, 5G), Impact of Mutual Coupling and Calibration, Performance Metrics: Signal-to-Interference-plus-Noise Ratio (SINR).

TEXT BOOKS:

1. Balanis CA, Ioannides PI, "Introduction to Smart Antennas", Morgan & Claypool Publishers; 2007.
2. Gross F, "Smart antennas for wireless communications", McGraw-Hill Professional, 2005.
3. Luo Q, Gao SS, Liu W, Gu C. "Low-cost smart antennas", John Wiley & Sons; 2019.
4. Shiban K. Koul, S. Swapna, G. S. Karthikeya, Antenna Systems for Modern Wireless Devices, Springer, Singapore, Vol. (Signals and Communication Technology Series), 1st Edition, 2024.

SUGGESTED READING:

1. Godara LC, "Smart antennas" CRC press; 2004.
2. Mohammad Abdul Matin (Ed.), Wideband, Multiband, and Smart Antenna Systems, Springer, Switzerland, Vol. (Signals and Communication Technology Series), 1st Edition, 2021.
3. Praveen Kumar Malik, Joan Lu, B. T. P. Madhav, Geeta Kalkhambkar (Eds.), Smart Antennas: Latest Trends in Design and Application, Springer, Switzerland, Vol. (EAI/Springer Innovations in Communication and Computing), 1st Edition, 2022.
4. S. Kannadhasan, R. Nagarajan, Alagar Karthick, Aritra Ghosh (Eds.), Smart Antennas, Electromagnetic Interference and Microwave Antennas for Wireless Communications, River Publishers, Denmark, 1st Edition, 2023.
5. Trushit Upadhyaya, Hari Shankar Singh (Eds.), Advanced Antennas for Wireless Communication Systems, MDPI Books, Switzerland, Reprint Volume, 2024.

26ECE114

MM WAVE AND TERA HERTZ

(Professional Elective-III)

Instruction	3 L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Knowledge of Antennas, Microwave Engineering, Analog & Digital Communication,

COURSE OBJECTIVES:

This course aims:

1. To understand the fundamentals of millimeter-wave and terahertz communication systems.
2. To analyze mmWave/THz propagation characteristics and channel behavior.
3. To study semiconductor devices and circuits used in mmWave and THz systems.
4. To explore advanced antenna systems, beamforming, and MIMO techniques.

COURSE OUTCOMES:

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

1. Understand the characteristics of mmWave and THz propagation.
2. Analyze semiconductor devices used in high-frequency communication.
3. Design mmWave/THz components and circuits.
4. Apply beamforming and MIMO techniques in communication systems.
5. Evaluate mmWave and THz communication systems for 5G/6G applications.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	3	3	2	1
CO 2	3	2	2	1	1
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	2	2	1

UNIT - I

Introduction to Millimeter (mm) -Wave and THz Technology: mm-Wave and THz wave Characteristics, Regulation, Propagation at mm-Waves, THz Propagation and Channel Modeling.

UNIT- II

mm-Wave Semiconductor Devices: Transient and ac behaviour of P-N junctions, PIN diode, Varactor diode and its applications; Schottky effect, Schottky barrier diode and its applications; Heterojunctions, high electron mobility transistor.

UNIT- III

mm-Wave and THz Components and Circuits: mm-Wave and THz Integrated Passive Components, Circuits and Interconnects, Millimeter-wave design considerations, mm-Wave and THz component packaging.

UNIT- IV

mm-Wave and THz Communication: Advanced beam steering technology, Advanced beam-forming technology, Advanced antenna Identification (ID) technology, Millimeter- Wave MIMO: Spatial diversity of antenna arrays.

UNIT-- V

Advanced Topics in mm-Wave & THz: THz communication systems, Ultra-high data rate communication, 5G / 6G mmWave systems, Applications: radar, imaging, sensing Introduction to Artificial Intelligence in mmWave systems

TEXT BOOKS:

1. Duixian Liu, Brian Gaucher, Ulrich Pfeier and Janusz Grzyb, Advanced Millimeter-wave Technologies Antennas, Packaging and Circuits, John Wiley Sons Ltd, United Kingdom, 2009.
2. Kao-Cheng Huang, Zhaocheng Wang, Millimeter wave communication systems, John Wiley Sons,Inc., Hoboken, New Jersey 2011.
3. S. Ahmad, Microwave and Millimeter Wave Semiconductor Materials Technology, Tata McGraw Hill.

SUGGESTED READING:

1. D. M. Pozar, Microwave Engineering, 4 e, John Wiley, 2011.
2. Thomas Kurner, Daniel M. Mittleman and Tadao Nagatsuma, THz Communications. Springer Series in Optical Sciences, vol 234. Springer, 1st Edition, 2022.
3. Vasu Babu K., Sudipta Das et al.,Millimeter Wave and Terahertz Devices for 5G and 6G Systems: Modern Design Aspects and Optimization,Springer, 1st Edition, 2025.

26ECE115

CHANNEL CODING TECHNIQUES FOR WIRELESS COMMUNICATIONS

(Professional Elective-III)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES:

This course aims to:

1. Understand the fundamentals of digital communication, channel coding, and modulation techniques over noisy and fading channels.
2. Develop knowledge of algebraic structures and error control coding techniques, including block, cyclic, BCH, and Reed-Solomon codes.
3. Analyze and evaluate modern coding schemes such as convolutional, turbo, LDPC, and polar codes for reliable communication.

COURSE OUTCOMES:

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

1. Explain channel coding, channel capacity, modulation performance over AWGN/fading channels, and apply linear block and cyclic codes for error control.
2. Construct Galois Fields and perform polynomial operations.
3. Design and implement BCH and Reed-Solomon codes using standard decoding algorithms.
4. Analyze convolutional and turbo codes with Viterbi and BCJR decoding.
5. Evaluate LDPC and polar codes, including construction, decoding, and performance.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	3	2	2	2
CO 2	3	3	2	2	2
CO 3	3	3	2	2	2
CO 4	3	3	3	2	2
CO 5	3	3	3	2	2

UNIT- I

Introduction to Channel Coding: Introduction Coding for Reliable Digital Transmission and Storage, Types of codes, channel coding Theorem, Channel coding gain, Wireless communication Channel models, Different Modulations (BPSK, QPSK, 16-QAM) over AWGN and fading channels.

Linear Block code: Linear block codes, Maximum likely hood decoding.

Binary Cyclic Codes: Description, encoder and Syndrome generator implementations. Cyclic Redundancy check codes.

UNIT-II

Galois Fields: Fields, Binary arithmetic, Basic properties of Galois Fields, polynomials over GF (2), Construction of Galois Fields GF(2^m) from GF(2), properties of extension fields, conjugates, Minimal polynomials, Factorization of (X^n+1) over a finite field.

UNIT-III

BCH Codes: Introduction, general description of BCH codes, Encoding, Decoding – Berlekamp's algorithm.
RS Codes: Introduction, general description of Reed-Solomon codes, encoding, decoding of Reed- Solomon codes using Berlekamp-Massey algorithm. BER performance analysis of RS codes for BPSK in AWGN and fading channel.

UNIT- IV

Convolution Codes: Introduction, Encoding, State diagram, Code Tree, Code Trellis diagram, Decoding - Maximum Likelihood (ML) Viterbi decoding - soft decision and hard decision decoding, performance analysis of Convolution codes in AWGN and Rayleigh fading channel.
Turbo codes: Introduction, encoding, decoding-BCJR algorithm.

UNIT-V

LDPC Code: Introduction, Construction of parity check matrix H, encoding, Decoding- Min-Sum algorithm, performance analysis of LDPC code in AWGN channel, Introduction to QC-LDPC codes.
Polar Codes: Introduction, encoding and decoding-Successive Cancellation decoding for N=8, performance analysis of polar code in AWGN channel.

TEXT BOOKS:

1. K. Deergha Rao, "Channel Coding Techniques for Wireless Communications", 2nd edition, springer, 2019.
2. J. Hou, P. H. Siegel, and L. B. Milstein, Channel Coding, New York, NY, USA: Springer, 2022.
3. Shulin and Daniel J. Costello, Jr. "Error Control Coding," 2/e, Pearson, 2011.

SUGGESTED READINGS:

1. K. R. Narayanan and G. L. Stüber, *Channel Coding in 5G New Radio*, CRC Press, 2022.
2. T. K. Moon, *Error Correction Coding: Mathematical Methods and Algorithms*, Wiley, 2005.
3. Simon Haykin, "Communication Systems", 4/e, Wiley, 2000.

26ECE116

DEEP LEARNING TECHNIQUES FOR SIGNAL PROCESSING

(Program Elective - IV)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Concepts of Linear Algebra, Calculus, Probability and Signal Processing.

COURSE OBJECTIVES:

This course aims to:

1. Understand the foundational principles and concepts of Machine Learning and Deep Learning.
2. Apply deep learning methods for evaluating and implementing speech processing.
3. Analyze and apply deep learning methods to image processing tasks, biomedical signal processing and their applications.

COURSE OUTCOMES:

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

1. Understand fundamentals of Machine Learning and Deep Learning.
2. Analyze Various Deep Learning Architectures.
3. Analyze the deep learning methods for speech processing.
4. Analyze the deep learning methods for Image processing.
5. Analyze the deep learning methods for Biomedical signal processing.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	3	3	3	3
CO 2	3	3	2	2	2
CO 3	3	3	2	2	2
CO 4	3	3	3	3	3
CO 5	3	3	2	2	2

UNIT - I

Fundamentals of ML & DL: Basics of Machine Learning (ML), Supervised Learning, Unsupervised Learning, Reinforcement Learning, Introduction to Deep Learning, Perceptron Algorithm, Multilayer Perceptron (Neural Networks), ML vs Deep Neural Networks.

UNIT - II

Deep Learning Algorithms: Basic Building Blocks of CNN, Forward and Back propagation in CNN, Classic CNN Architectures, Modern CNN Architectures, Basic Building Blocks of RNNs, RNNs and Properties, Deep RNN Architectures.

UNIT - III

DL in Speech Processing Applications: A case study approach on Real time Analysis of Speech Processing: Pre-processing, Feature extraction and Implementation of Classification based on Deep learning methods.

UNIT - IV

DL in Image Processing Applications: A case study approach on Real time Analysis of Image Processing: Pre-processing, Feature extraction and Implementation of Classification based on Deep learning methods.

UNIT - V

DL in Bio-medical Signal Analysis: A case study approach on Real time Analysis of any Biomedical signals: Pre-processing, feature extraction and Implementation of Classification based on Deep learning methods.

TEXT BOOKS:

1. Uday Kamath John Liu, James Whitaker, "Deep Learning for NLP and SpeechRecognition", Springer nature, 2019.
2. Deep Learning: Methods and Applications", Li Deng, Microsoft Technical Report.
3. "Automatic Speech Recognition - Deep learning approach" - D. Yu, L. Deng,Springer, 2014.
4. "Machine Learning for Audio, Image and Video Analysis", F. Camastra, Vinciarelli,Springer, 2007.

SUGGESTED READING:

1. Ian J. Goodfellow, Yoshua Bengio and Aaron Courville, "Deep Learning", MIT Press, 2016.
2. B. Yagnarayana, "Artificial Neural Networks", Prentice Hall, New Delhi, 2007.

26ECE117

SIGNAL INTELLIGENCE SYSTEMS

(Program Elective - IV)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Basic knowledge of Radar, Communication and Antenna concepts are required.

COURSE OBJECTIVES:

This course aims to:

1. Elucidate the concepts of electronic intelligence using the fundamentals of radar and localization techniques with necessary mathematical analysis.
2. Explain the operating principles of COMINT Systems based on various localization and position fixing techniques.
3. Provide salient features of EW Systems and Electronic Jamming.

COURSE OUTCOMES:

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

1. Apply the knowledge of Communication and Antenna concepts in understanding the operating principles of Radar and Drones.
2. Analyze the intricacies of ELINT Systems.
3. Discuss the salient features of EW Systems and identify the type of Electronic Jamming.
4. Estimate the DF and position of ELINT/COMINT Systems for simple cases.
5. Interpret the type of modulation of COMINT systems.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	1	2	2	1	1
CO 2	1	2	2	1	1
CO 3	1	2	2	1	1
CO 4	1	2	2	1	1
CO 5	1	2	2	1	1

UNIT - I

Principles of RADAR and DRONES: Radar Range equation, Probability of false alarm, Probability of detection, Radar cross section fluctuations, Blind speed, Pulse Repetition Frequency (PRF), Unambiguous range, Principles and Classification of Drones and their applications.

UNIT - II

Electronic Intelligent (ELINT) Systems: Electronic Intelligence Defined, The Importance of Intercepting and Analyzing Radar Signals, Limitations Due to Noise, Probability of Intercept Problems. Inferring Radar Capabilities from observed Signal Parameters, Receivers for Radar Interception, Major ELINT Signal Parameters, the Impact of LPI Radar on ELINT.

UNIT - III

Communication EW Systems and Techniques for Electronic Jamming: Introduction, Information warfare, Electronic warfare: Electronic support, Electronic attack, Electronic Protect. Typical EW System Configuration. Electronic attack: A General Description of the Basic Elements of Electronic Jamming, Communication jamming, Jammer deployment, Narrow band /partial-band jamming, Barrage jamming, Follower jammer, Jamming LPI targets. Spoofing: Spoofing generation, Detection and anti-spoofing.

UNIT - IV

Direction Finding: Direction Finding, Instantaneous Direction Finding. Amplitude Comparison AOA Measurement, Phase Interferometers.

Position Fixing: Position fixing algorithms: Eliminating Wild Bearings, Stansfield Fix Algorithm, Mean-Squared Distance Algorithm.

Single-site Location Techniques: Fix accuracy, fix coverage. Time of Arrival,

Time Difference of Arrival: Position-Fixing using TDOA Measurements, Differential Doppler.

UNIT - V

Modulation Recognition: Classification of each segment and Classification of a signal frame in Analogue Modulated Signal Recognition Algorithms (AMRAs), Digitally Modulated Signal Recognition Algorithms (DMRAs), Analog and Digitally Modulation Recognition Algorithms (ADMRAs), Structure of ANN Based Modulation Recognisers.

TEXT BOOKS:

1. Richard G. Wiley, "ELINT: The Interception and analysis of Radar Signals", Artech House Inc., 2006.
2. Richard A. Poisel, "Introduction to Communication Electronic Warfare Systems", 2nd edition, Artech house, Inc., 2008.

SUGGESTED READING:

1. Sergei A. Vakin, Lev N. Shustov, Robert H. Dunwell "Fundamentals of Electronic Warfare", Artech House, Inc., 2001.
2. Elsayed Azzouz, Asoke Kumar Nandi, "Automatic Modulation Recognition of Communication Signals", Springer Science+Business Media, B.V, 1996.

26ECE118

WIRELESS SENSOR NETWORKS AND PROTOCOLS

(Program Elective - IV)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Basic knowledge of Digital Communications, Computer Networks, Signals and Systems, Probability Theory, and basic Embedded Systems.

COURSE OBJECTIVES:

This course aims:

1. To make students understand the design issues, architectures, and layered protocol operations in wireless ad hoc, mobile ad hoc, and sensor networks.
2. To provide knowledge of sensor networks, including their architecture, functionalities, and application domains.
3. To familiarize security issues in ad hoc and sensor networks and evaluate appropriate solutions for secure and reliable communication.

COURSE OUTCOMES:

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

1. Identify different issues in wireless ad hoc and sensor networks.
2. To analyze protocols developed for ad hoc and sensor networks.
3. To learn the significance of Transport layer and QoS in wireless sensor networks.
4. To identify and understand security issues in ad hoc and sensor networks.
5. To analyze the tools used for Wireless Sensor Networks

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	3	2	2	1
CO 2	3	3	3	2	2
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	2	2	2

UNIT - I

Wireless Sensor Network Architecture: Introduction to wireless sensor networks, Challenges, Comparison with ad hoc network, Node architecture and Network architecture, design principles, Service interfaces, Gateway, Short range radio communication standards Physical layer and transceiver design considerations.

UNIT-II

MAC & Routing in Wireless Sensor Networks: Introduction, Applications, Challenges, Sensor network architecture, MAC Protocols for wireless sensor networks, Low duty cycle protocols and wakeup concepts, Contention, Based protocols, Schedule, Based protocols – IEEE 802.15.4 Zig bee, Topology Control, Routing Protocols.

UNIT-III

Transport & QoS in Wireless Sensor Networks: Data-Centric and Contention Based Networking, Transport Layer and QoS in Wireless Sensor Networks, Congestion Control, In-network processing, Operating systems for wireless sensor networks - Examples.

UNIT-IV

Security in Ad hoc and Sensor Networks: Security Attacks, Key Distribution and Management , Intrusion Detection, Software based Antitamper techniques, Watermarking techniques, Defense against routing attacks, Secure Ad hoc routing protocols, Broadcast authentication WSN protocols, TESLA, Biba, Sensor Network Security Protocols, SPINS

UNIT-V

Tools for WSN: TinyOS, Introduction, NesC, Interfaces, modules, configuration, Programming in TinyOS using NesC, TOSSIM, Contiki – Structure, Communication Stack, Simulation environment, Cooja simulator, Programming.

TEXT BOOKS:

1. Anna Hac, Wireless Sensor Network Design‖, John Wiley & Sons, 2003.
2. Holger Karl, Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley & Sons, Inc., 2007.
3. Erdal Çayırcı, Chunming Rong, "Security in Wireless Ad Hoc and Sensor Networks", John Wiley and Sons, 2009.
4. C.Siva Ram Murthy and B.S.Manoj, "Ad Hoc Wireless Networks – Architectures and Protocols, 1e", Pearson Education, 2006.
5. Waltenegus Dargie, Christian Poellabauer, *Fundamentals of Wireless Sensor Networks: Theory and Practice*, John Wiley & Sons, 2nd Edition, 2023.

SUGGESTED READINGS:

1. Carlos De Morais Cordeiro, Dharma Prakash Agrawal, "Ad Hoc and Sensor Networks: Theory and Applications (2nd Edition)", World Scientific Publishing, 2011.
2. Waltenegus Dargie, Christian Poellabauer, "Fundamentals of Wireless Sensor Networks Theory and Practice", John Wiley and Sons, 2010
3. Adrian Perrig, J. D. Tygar, "Secure Broadcast Communication: In Wired and Wireless Networks", Springer, 2006.

26ECE119

MICROWAVE CIRCUIT DESIGN

(Program Elective - IV)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Knowledge of electromagnetic field theory, analog and digital electronic circuits.

COURSE OBJECTIVES:

This course aims:

1. To develop understanding of RF network representation using circuit parameters and S-parameters.
2. To analyze design concepts of RF/microwave amplifiers including stability and matching networks.
3. To gain knowledge of microwave components, generation techniques, and measurement methods.

COURSE OUTCOMES:

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

1. Explain the active & passive microwave devices & components used in Microwave communication systems.
2. Analyze the multi- port RF networks and RF transistor amplifiers.
3. Understand the working of RF transistor amplifier.
4. Generate Microwave signals and design microwave amplifiers.
5. Measure and analyze Microwave signal and S-parameters.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	3	3	2	1
CO 2	3	2	2	1	1
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	2	2	1

UNIT - I

Two Port Network Theory: Review of Low frequency parameters: Impedance, Admittance, Hybrid and ABCD parameters, Different types of interconnection of Two port networks, High Frequency parameters, Formulation of S parameters, Properties of S parameters, Reciprocal and lossless Network, Transmission matrix, RF behavior of Resistors, Capacitors and Inductors.

UNIT - II

RF Amplifiers and Matching Networks: Characteristics of Amplifiers, Amplifier power relations, Stability considerations, Stabilization Methods, Noise Figure, Constant VSWR, Broadband, High power and Multistage Amplifiers, Impedance matching using discrete components, Two component matching Networks, Frequency response and quality factor, T and Pi Matching Networks, Microstrip Line Matching Networks.

UNIT - III

Passive and Active Microwave Devices: Terminations, Attenuators, Phase shifters, Directional couplers, Hybrid Junctions, Power dividers, Circulator, Isolator, Impedance matching devices: Tuning screw, Stub

and quarter wave transformers. Crystal and Schottkey diode detector and mixers, PIN diode switch, Gunn diode oscillator, IMPATT diode oscillator and amplifier, Varactor diode, Introduction to MIC.

UNIT- IV

Microwave Generation: Review of conventional vacuum Triodes, Tetrodes and Pentodes, High frequency effects in vacuum Tubes, Theory and application of Two cavity Klystron Amplifier, Reflex Klystron oscillator, Traveling wave tube amplifier, Magnetron oscillator using Cylindrical, Linear, Coaxial Voltage tunable Magnetrons, Backward wave Crossed field amplifier and oscillator.

UNIT- V

Microwave Measurements: Measuring Instruments : Principle of operation and application of VSWR meter, Power meter, Spectrum analyzer, Network analyzer, Measurement of Impedance, Frequency, Power, VSWR, Q- factor, Dielectric constant, Scattering coefficients, Attenuation, S-parameters.

TEXT BOOKS:

1. Reinhold Ludwig and Gene Bogdanov, "RF Circuit Design: Theory and Applications", Pearson Education Inc., 2011
2. Robert E Colin, "Foundations for Microwave Engineering", John Wiley & Sons Inc, 2005.
3. David M. Pozar, "Microwave Engineering", Wiley India (P) Ltd, New Delhi, 2008.

REFERENCES:

1. Thomas H Lee, "Planar Microwave Engineering: A Practical Guide to Theory, Measurements and Circuits", Cambridge University Press, 2004.
2. Mathew M Radmanesh, "RF and Microwave Electronics", Prentice Hall, 2000.
3. Annapurna Das and Sisir K Das, "Microwave Engineering", Tata Mc Graw Hill Publishing Company Ltd, New Delhi, 2005.

26ECE120

UNDER WATER AND SATELLITE COMMUNICATIONS

(Program Elective-IV)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Knowledge of Antennas, Microwave Engineering, Digital Communications, and Signals & Systems.

COURSE OBJECTIVES:

This course aims to:

1. To provide knowledge of underwater and satellite communication systems, their architectures, and operational principles.
2. To develop the ability to analyze and design communication links for underwater and satellite environments.
3. To expose students to modern applications, security challenges, and emerging trends in underwater and satellite communications.

COURSE OUTCOMES:

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

1. Understand underwater communication principles. and satellite orbital mechanics.
2. Apply communication techniques in AUVs, environmental monitoring for underwater application.
3. Evaluate security, emerging trends, and future communication systems.
4. Design satellite links and orbital mechanics.
5. Analyze satellite subsystems and multiple access techniques.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	3	2	2	1
CO 2	3	2	3	2	2
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	2	2	2

UNIT-I

Underwater Communication Technologies: Overview of underwater communication: importance, applications, challenges, Properties of water: absorption, scattering, propagation, Acoustic vs optical underwater communication, Underwater acoustics: wave propagation, signal processing.

Optical communication in water: light propagation, modulation, Underwater Wireless Sensor Networks (UWSN).

UNIT-II

Underwater Networks and Applications: Underwater network architectures: Routing and multi-hop communication, MAC protocols in underwater communication.

Underwater applications: AUVs, ROVs, Environmental monitoring, Underwater robotics, Military applications.

UNIT-III

Security, Emerging Trends & Advanced Systems: Underwater communication security: Threats and encryption, Underwater IoT and drone communication, Emerging trends in underwater communication.

Future systems: 5G/6G, integrated space–underwater communication.

UNIT-IV

Satellite Subsystems, Orbital Mechanics & Satellite Link Design: Basic satellite communication system (earth segment & space segment), Satellite orbits: Orbital parameters.

Satellite link design: Basic transmission theory, Noise temperature, G/T ratio, Uplink and downlink design.

UNIT-V

Satellite Subsystems & Multiple Access Techniques: Attitude & orbit control, Power system, TT&C, Communication subsystem, Multiple access techniques: FDMA, TDMA, CDMA, DBS-TV: Transponders, receiver systems, VSAT: Architecture, modulation, applications

TEXT BOOKS:

1. Richard P. Hodges and Paul C. Etter, Underwater Acoustics: Analysis, Design, and Performance of Sonar, McGraw Hill Education, United States, 2018.
2. Lufen Xu and Zhengyong Zhang, Underwater Communications: A Practical Guide, Springer, Singapore, 2022.
3. Khalid Qaraqe and Erchin Serpedin, Underwater Wireless Communication Systems: Channel Modeling and Physical Layer Design Considerations, Wiley, United States, 2021.
4. Jun-Hong Cui, Dario Pompili and Tommaso Melodia, Underwater Networks: Algorithms, Protocols, and Applications, CRC Press, United States, 2010.
5. T. Pratt and W. Bostian, Satellite Communications, John Wiley & Sons Ltd, United Kingdom, 2003.

SUGGESTED READINGS:

1. Yi Lou and Niaz Ahmed, Underwater Communications and Networks, Springer Nature Switzerland AG, Switzerland, 2022.
2. Jianping An, Shuai Wang, Pingyue Yue and Gaofeng Pan, Safeguarding Satellite Communications: Issues, Challenges, and Solutions, Wiley, United Kingdom, 2025.
3. Dennis Roddy, Satellite Communications, McGraw Hill Education, United States, 2009

26ECC108

ACN AND IoT LAB

Instruction	2 P Hours per Week
Duration of SEE	--
SEE	--
CIE	50 Marks
Credits	1

PREREQUISITE: Knowledge of Computer Networks and Internet of Things.

COURSE OBJECTIVES:

This course aims to:

1. Apply networking concepts and protocols to design, implement, and analyze wired and wireless communication systems, including routing, error detection, and data transmission techniques.
2. Develop and implement IoT-based applications using Raspberry Pi by interfacing sensors/actuators, and enabling communication through TCP/UDP and MQTT protocols..
3. Demonstrate the ability to analyze real-time data acquisition systems by integrating cloud platforms and network services for efficient monitoring and control.

COURSE OUTCOMES:

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

1. Understand and apply basic networking commands, network configuration, and implementation of various network topologies..
2. Design and analyze data communication using TCP/UDP protocols and implement flow control mechanisms such as Stop & Wait and Sliding Window protocols.
3. Implement data link layer techniques including framing methods (character stuffing and bit stuffing) and error detection/correction techniques.
4. Configure and analyze static and dynamic routing protocols for efficient data transmission in networks.
5. Develop IoT applications using Raspberry Pi by interfacing sensors/actuators and enabling communication through cloud platforms and protocols such as MQTT, TCP, and UDP.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	2	2	3	1
CO 2	3	2	3	3	2
CO 3	3	2	3	2	1
CO 4	3	2	3	3	1
CO 5	3	3	3	3	2

List of Experiments:

1. Study of Networking Commands (Ping, Tracert, TELNET, nslookup, netstat, ARP, RARP) and Network Configuration Files.
2. Implementation of Network Topologies.
3. Creation of wired network with at least four nodes and monitor the data transmission between any two nodes using TCP/UDP using for loop.
4. Implementation of Stop & Wait and Sliding Window Protocols.
5. Implementation of the data link layer framing methods such as character stuffing and bit stuffing. 7. Implementation of Error Detection / Error Correction Techniques.
6. Implementation of Static Routing Protocol.
7. Implementation of Dynamic Routing Protocols.
8. Familiarization with Raspberry Pi hardware and software installation.
9. Interfacing LED/Buzzer with the Raspberry Pi and writing a program to blink LED.
10. Interfacing Push Button / Digital Sensor (IR/LDR) with Raspberry Pi to control an LED based on input detection.
11. Uploading and retrieving temperature and sensor data from ThingSpeak cloud using Raspberry Pi.

12. Publishing and subscribing sensor data using MQTT protocol on Raspberry Pi.
13. Creating a TCP server on Raspberry Pi to send sensor data to a TCP client upon request.
14. Creating a UDP server on Raspberry Pi / BeagleBone Black to respond with sensor data to a UDP client.

Note: A minimum of ten experiments should be performed from the list.

SUGGESTED READING:

1. J.F. Kurose & K.W. Ross, "Computer Networking- A top-down approach featuring the internet", Pearson, 6th Edition, 2013.
2. Nader F. Mir, Computer and Communication Networks, 2nd Edition, 2015.
3. Practical Python Programming for IoT: Build advanced IoT projects using a Raspberry Pi 4, MQTT, RESTful APIs, WebSockets, and Python 3 Paperback – Import, 12 November 2020.

26ECC109

ADVANCED ANTENNAS LAB

Instruction	2 P Hours per Week
Duration of SEE	--
SEE	--
CIE	50 Marks
Credits	1

PREREQUISITE: The knowledge of antennas is essential.

COURSE OBJECTIVES:

This course aims to:

1. Understand the characteristics and radiation pattern of Infinitesimal antenna.
2. Simulate various antennas.
3. Study the effect of change in different parameters on antenna arrays.

COURSE OUTCOMES:

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

1. Determine specifications, design, construct and test antenna.
2. Explore and use tools for designing, analyzing and testing antennas.
3. Apply the concept of current distribution to find the field patterns.
4. Estimate the effect of the height of the monopole antenna on the radiation characteristics.
5. Study the effect of the variation of phase difference 'beta' between the elements of the array and case

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	1	2	1	1	1
CO 2	2	2	1	1	1
CO 3	2	2	2	2	1
CO 4	2	2	3	1	1
CO 5	3	2	3	2	1

List of Experiments:

1. Simulation of half wave dipole antenna.
2. Simulation of change of the radius and length of dipole wire on frequency of resonance of antenna.
3. Simulation of a half wave dipole antenna array.
4. Study the effect of the variation of phase difference 'beta' between the elements of the array on the radiation pattern of the dipole array.
5. Study the effect of change in distance between elements of array on radiation pattern of dipole array.
6. Study the effect of the height of the monopole antenna on the radiation characteristics of the antenna.
7. Simulate Frequency Reconfigurable antenna.
8. Simulate Microstrip patch antenna.
9. Simulate Phased antenna array.
10. Design and simulate any antenna using Artificial Neural Network.

Note: The above experiments are to be carried out by using any appropriate simulation software or any open source.

SUGGESTED READING:

1. Li Ming Yang,"HFSS antenna design", 2nd edition, Electronic Industry Press, 2014.

26ECC110

MINI PROJECT

Instruction	2 P Hours per Week
Duration of SEE	--
SEE	--
CIE	50 Marks
Credits	1

PREREQUISITE: Ability to do literature survey, solve problems, and effectively present technical concepts.

COURSE OBJECTIVES:

This course aims to:

1. The mini-project shall contain a clear statement of the research objectives, background of work, literature review, techniques used, prospective deliverables, and detailed discussion on results, conclusions and references.
2. To expose and practice of searching and referring the required literature.
3. This is expected to provide a good initiation for the student(s) towards R&D.

COURSE OUTCOMES:

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

1. Familiarize in searching the suitable literature in the chosen field.
2. Develop skills to understand and summarize the contents from the literature.
3. Ability to synthesize knowledge/ skills previously gained and applied in execution of a chosen technical problem.
4. Enhance oral presentation skills through power point presentations.
5. Learn and present the findings of their technical solution in a written report.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	1	3	3	1
CO 2	3	1	3	3	1
CO 3	3	1	3	3	2
CO 4	3	2	3	3	1
CO 5	3	3	2	2	2

Guidelines:

1. Each student shall do a mini project, generally comprising about three to four weeks of prior reading, twelve weeks of active research, and finally a presentation of their work for assessment.
2. Each student will be allotted to a faculty supervisor for mentoring.
3. Mini projects should present students with an accessible challenge on which to demonstrate competence in research techniques, plus the opportunity to contribute something more original.
4. Mini projects shall have inter-disciplinary / industry relevance.
5. The students can select a mathematical modelling based / Experimental investigations or Numerical modelling.
6. All the investigations are clearly stated and documented with the reasons/explanations.
7. The mini-project shall contain a clear statement of the research objectives, background of work, literature review, techniques used, prospective deliverables, and detailed discussion on results, conclusions and references.

Departmental Committee:

Supervisor and two faculty coordinators

Guidelines forwarding Marks in CIE:		**Max. Marks: 50**
Evaluation by	**Max. Marks**	**Evaluation Criteria / Parameter**
Supervisor	20	Progress and Review
	05	Report
Departmental Committee	05	Relevance of the Topic
	05	PPT Preparation
	05	Presentation
	05	Question and Answers
	05	Report Preparation

26ECC111

INDUSTRIAL INTERNSHIP / TRAINING

Instruction/Demonstration/Training	90 Hours
Duration of SEE	--
SEE	--
CIE	50 Marks
Credits	1

PREREQUISITE: Candidates should possess fundamental domain knowledge along with practical, hands-on experience in the relevant domain.

COURSE OBJECTIVES:

This Training/Internship aims to:

1. Exposing the students to the industrial environment.
2. Create awareness with the current industrial technological developments relevant to program domain
3. Provide opportunity to understand the social, economic and administrative considerations in organizations/rural areas

COURSE OUTCOMES:

Upon completion of Training/Internship, students will be able to:

1. Understand Engineer's responsibilities and ethics.
2. Use various materials, processes, products and quality control.
3. Provide innovative solutions to solve real world problems.
4. Acquire knowledge in technical reports writing and presentation.
5. Apply technical knowledge to real world industrial/rural situations.

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CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	1	3	3	1
CO 2	3	1	3	3	1
CO 3	3	1	3	3	2
CO 4	3	2	3	3	1
CO 5	3	3	2	2	2

Training / Internship Activities:

1. Three to Four Weeks of Industry Training/Internship or working in Consultancy or Sponsored Research projects with practical relevance in the subject and submission of completion certificate is document evidence.

2. Participation in innovation related competitions for E.g., Hackathons, Ideathons, Intra/Inter Technical Symposiums etc. and submission of certificate is document evidence.

3. Development of a new product, preparation of a business plan, or registration of a start-up shall be optional components of the internship/training. However, additional weightage in awarding credit points will be given upon submission of valid documentary evidence or certification supporting such activities.

Implementation Guidelines: All implementation procedures, documentation processes, and official letter formats shall be updated in accordance with the internship policy guidelines of CBIT. This includes adherence to mandatory internship requirements, defined credit framework, duration norms, institutional approvals, and submission of prescribed documents such as affidavits, reports, and evaluation records. The updated guidelines and formats will be posted on the official CBIT website for reference and compliance.

Evaluation of Internship: The industrial training/internship of the students will be evaluated in three stages:

a) Evaluation by the industry supervisor, with certification provided upon completion; a score or grade awarded by the industry wherever applicable.
b) Evaluation by faculty Mentor on the basis of site visit(s) or periodic communication.
c) Evaluation through seminar presentation/Viva-Voce at the Institute by the constituted committee.

Evaluation through Seminar presentation/Viva-Voce at the institute: Students shall give a presentation before an E*xpert Committee* constituted by college (Director, HoD/Senior faculty, mentor and faculty expert from the same department) based on his/her training/internship carried out
The evaluation will be based on the following criteria:

1. Quality of content presented
2. Proper planning for presentation
3. Effectiveness of presentation
4. Depth of knowledge and skills
5. Attendance record, daily diary, departmental reports shall be analyzed along with the internship Report

Monitoring / Surprise Visits: During the internship program, the faculty mentor makes a surprise visit to the internship site, to check the student's presence physically. If the student is found to be absent without prior intimation to the concerned industry, entire training/internship may be canceled. Students should inform through email to the faculty mentor as well as the industry supervisor at least one day prior to avail leave.

SUGGESTED REFERENCES:

1. AICTE Internship Policy: Guidelines and Procedures (AICTE Internship Policy.pdf)

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY(A)

R-26 Curriculum (with effect from AY 2027-28)

M.E (Communication Engineering)

SEMESTER – III

S.no	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1		Program Elective-V	3	--	--	3	40	60	3
2		Open Elective / NPTEL	3	--	--	3	40	60	3
DISSERTATION									
3	26ECC112	Industrial Project / Dissertation Phase I	--	--	20	--	100	--	10
Total			**6**	**--**	**20**	**6**	**180**	**120**	**16**
Clock Hours Per Week: 26									

L: Lecture **D: Drawing** **CIE: Continuous Internal Evaluation**

T: Tutorial **P: Practical/Mini Project / Dissertation** **SEE: Semester End Examination**

26ECE121

SOFTWARE DEFINED AND COGNITIVE RADIO
(Program Elective –V)

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: A prior knowledge of signal processing, Communication and spectral knowledge is required.

COURSE OBJECTIVES:

This course aims to:

1. Make the students understand the difference between Super hetrodyne Radio and Software defined Radio
2. Differentiate between Cognitive Radio (CR) and SDR and study their architectures.
3. Make the students know about the CR signal processing Techniques and applications.

COURSE OUTCOMES:

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

1. The students would learn the difference between the super hetrodyne receiver, Software Defined Radio and Cognitive Radio.
2. The different architectures of SDR and CR would be learnt by the student.
3. The various spectrum sensing methods should be understood.
4. Various signal processing techniques of CR would be known.
5. The facilities available in USRP and WARP boards are known.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	3	3	1	2
CO 2	3	3	3	3	3
CO 3	2	2	3	2	2
CO 4	2	2	3	2	2
CO 5	2	2	2	2	2

UNIT- I

Introduction to SDR: What is Software-Defined Radio, The Requirement for Software-Defined Radio, Legacy Systems, The Benefits of Multi-standard Terminals, Economies of Scale, Global Roaming, Service Upgrading, Adaptive Modulation and Coding, Operational Requirements, Key Requirements, Reconfiguration Mechanisms, Handset Model, New Base-Station and Network, Architectures, Separation of Digital and RF, Tower-Top Mounting, BTS Hoteling, Smart Antenna Systems, Smart Antenna System Architectures.

UNIT- II

Basic Architecture of a Software Defined Radio: Software Defined Radio Architectures, Ideal Software Defined Radio Architecture, Required Hardware Specifications, Digital Aspects of a Software Defined Radio, Digital Hardware, Alternative Digital Processing Options for BTS Applications, Alternative Digital Processing Options for Handset Applications, Current Technology

Limitations, A/D Signal-to-Noise Ratio and Power Consumption, Impact of Superconducting Technologies on Future SDR Systems.

UNIT-III

Signal Processing Devices and Architectures: General Purpose Processors, Digital Signal Processors, Field Programmable Gate Arrays, Specialized Processing Units, Tilera Tile Processor, Application-Specific Integrated Circuits, Hybrid Solutions, Choosing a DSP Solution. GPP-Based SDR, Non real time Radios, High-Throughput GPP-Based SDR, FPGA-Based SDR, Separate Configurations, Multi-Waveform Configuration.

UNIT-IV

Cognitive Radio: Techniques and signal processing History and background, Communication policy and Spectrum Management, Cognitive radio cycle, Cognitive radio architecture, SDR architecture for cognitive radio, Spectrum sensing Single node sensing: energy detection, cyclostationary and wavelet based sensing- problem formulation and performance analysis based on probability of detection versus SNR. Cooperative sensing: different fusion rules, wideband spectrum sensing- problem formulation and performance analysis based on probability of detection vs SNR.

UNIT-V

Cognitive Radio: Hardware and applications: Spectrum allocation models. Spectrum handoff, Cognitive radio performance analysis. Hardware platforms for Cognitive radio (USRP and WARP), details of USRP board, Applications of Cognitive radio.

TEXT BOOKS:

1. Peter B. Kenington "RF and Baseband Techniques for Software Defined Radio", Artech House, Inc @ 2005.
2. Eugene Grayver, "Implementing Software Defined Radio", Springer, New York Heidelberg Dordrecht London, ISBN 978-1-4419-9332-8, 2013.

SUGGESTING READING:

1. Bruce A. Fette, "Cognitive Radio Technology", Elsevier, ISBNA 10: 0-7506-7952-2, 2006.
2. Hüseyin Arslan "Cognitive Radio, Software Defined Radio and Adaptive Wireless Systems", Springer, ISBN 978-1-4020-5541-6 (HB), 2007.

26ECE122

AI FOR COMMUNICATION

(Program Elective –V)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Prior knowledge in Communication systems, Wireless & Mobile Communications.

COURSE OBJECTIVES:

This course aims to:

1. Understand AI-native concepts and requirements of 5G and 6G communication systems.
2. Learn intelligent wireless communication techniques including MIMO and RIS.
3. Study AI-enabled vehicular, aerial, and autonomous communication networks.

COURSE OUTCOMES:

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

1. Explain the architecture and enabling technologies of AI-driven 6G networks.
2. Analyze Massive MIMO, Ultra-Massive MIMO, and RIS communication systems.
3. Illustrate AI-enabled V2X, UAV, and Non-Terrestrial communication frameworks.
4. Evaluate intelligent radar and autonomous robotic communication systems.
5. Discuss emerging AI applications in XR, Digital Twins

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	2	3	1	2
CO 2	3	2	2	3	2
CO 3	3	1	3	3	2
CO 4	2	1	3	3	2
CO 5	3	1	2	2	1

UNIT-I

Introduction to AI-Enabled 6G Communication Networks Evolution from 5G to 6G Networks, AI-Native 6G Architecture Framework, AI-Native vs AI-Standard-Based Networks, Semiconductor and Radio Technologies for 6G, Spectrum Sharing and Seamless Mobility, Millimeter Wave and Terahertz Communications, Joint Communication and Sensing (JCAS), Introduction to Intelligent Wireless Systems.

UNIT-II

AI-Driven MIMO and Intelligent Surface Communications: Introduction - MIMO Fundamentals and Types, Cooperative, Distributed, Network and Virtual MIMO, Massive and Ultra-Massive MIMO Systems, AI/ML/DL Applications in MIMO Systems, Capacity Analysis in MU-MIMO and SU-MIMO, Reconfigurable Intelligent Surface (RIS) Communications, Cooperative Beamforming using RIS, Cell-Free Massive MIMO Systems, Spectral Efficiency and Power Control using AI.

UNIT-III

AI-Based Vehicular and Non-Terrestrial Communication Systems: Vehicle-to-Vehicle (V2V) and Vehicle-to-Everything (V2X) Communications, AI-Enabled V2X Networks, Intelligent Reflecting Surface Assisted V2X, UAV/Satellite Assisted V2X Networks, Terahertz and Hybrid RF-VLC V2X Communications, Peer-to-Peer and Mesh Networking for Vehicles, Relay Selection and Self-

Organizing Vehicular Networks, Non-Terrestrial Networks (NTN), Aerial and Satellite Communication Systems.

UNIT-IV

Intelligent Radar, Robotics and Autonomous Communication Systems: Massive MIMO Radar Fundamentals, AI-Based Target Detection and Tracking, Distributed and Adaptive MIMO Radar Systems, Ultra-Massive MIMO Radar Sensors, Robotics and Autonomous System Communications, Communication-Aware Planning and Algorithms, AI/ML/DL-Based Robotic Communication Mechanisms, UAV Communication Systems, Swarm Robotics and Reinforcement Learning-Based Coordination.

UNIT-V

Emerging AI Applications in Future Communication Networks: Extended Reality (XR), AR, MR and VR Communications, AI for Immersive Media Networks, Digital Twins for 6G Networks, AI Integration in Digital Twin Systems, Holographic MIMO Communications, Electromagnetic Holography and HMIMO, AI-Driven Smart Communication Networks, Challenges, Security, Privacy and Future Research Directions in 6G.

TEXT BOOKS:

1. Kaushik Kumar, Divya Zindani and J. Paulo Davim, "Artificial Intelligence-Based 6G Networking", CRC Press, 2024.
2. Vishal Sharma and Rajesh Kumar, "6G Wireless Systems: Vision, Requirements and Technologies", Wiley Publications, 2022.
3. Fa-Long Luo, "AI and Machine Learning for Future Wireless Networks", Springer Publications, 2021.

SUGGESTING READING:

1. Walid Saad, Mehdi Bennis, and Merouane Debbah, *From 5G to 6G and Beyond: AI-Driven Wireless Networks*, Cambridge University Press, 2022.
2. Tony Q. S. Quek, Matti Latva-aho, and Cicek Cavdar, *Edge Intelligence for 6G Networks*, Elsevier, 2023.

26ECE123

PROGRAMMABLE NETWORKS – SDN, NFV

(Program Elective - V)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Communication Networks.

COURSE OBJECTIVES:

This course aims to:

1. Learn about Common SDN architectures, characteristics.
2. Understand the SDN control plane and application plane.
3. Study the NFV architecture, framework, Management and Orchestration.

COURSE OUTCOMES:

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

1. Differentiate between traditional networks and software defined networks andunderstand the key benefits and use cases of SDN.
2. Interpret the SDN data plane devices and OpenFlow Protocols.
3. Implement the operation of SDN control plane with different controllers.
4. Apply techniques that enable applications to control the underlying network using SDN.
5. Evaluate Network Functions Virtualization components and their roles in SDN.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	1	1	1	2
CO 2	2	3	1	3	2
CO 3	1	2	2	2	3
CO 4	2	2	3	3	2
CO 5	2	3	3	3	3

UNIT - I

Networking Basics: Switching, Addressing, Routing SDN Background and Motivation: Evolving network requirements-The SDN Approach: Requirements,SDN Architecture, and Characteristics of Software-Defined Networking. SDN Data plane and OpenFlow: Data plane Functions, Data plane protocols, OpenFlow: Switch-Controller Interaction, Flow Table, Packet Matching, Actions and Packet Forwarding Flow TableStructure, Flow Table Pipeline, The Use of Multiple Tables, Group Table, Extensions and Limitations, Data plane scalability.

UNIT - II

SDN Control Plane: SDN Control Plane Architecture: Control Plane Functions, Southbound Interface, Northbound Interface, Routing, Cooperation and Coordination among Controllers, Controller placement problem, SDN controllers: Open Daylight, Ryu, ONOS, Floodlight, Control plane scalability, fault tolerance.

UNIT - III

SDN Application Plane: SDN Application Plane Architecture: Northbound Interface, Network Applications, User Interface- Network Services Abstraction Layer: Abstractions in SDN, Frenetic-Traffic Engineering Measurement and Monitoring, Security, Network updates, SDN use cases: Traffic engineering, network management, Network virtualization.

UNIT - IV

Network Functions Virtualization: Background and Motivation for NFV- NFV Principles, High-LevelNFV Framework, NFV Benefits and Requirements- SDN vs. NFV, Network Functions, Service Creation and Chaining, NFV Orchestration, VNF deployment, Service Function Chain Deployment. NFV Reference Architecture: NFV Management and Orchestration.

UNIT - V

Emerging SDN Models: Protocol Models: NETCONF, BGP, MPLS, Controller Models, Application Models: Proactive, Declarative, External, SDN in Datacenters: Multitenancy, Failure Recovery, SDN in Internet eXchange Points (IXPs).

TEXT BOOKS:

1. Paul Goransson Chuck Black Timothy Culver: Software Defined Networks: AComprehensive Approach, Morgan Kaufmann, 2016.
2. Ken Gray Thomas Nadeau: Network Function Virtualization, Morgan Kaufmann, 2016.

SUGGESTED READING:

1. Larry Peterson, Carmelo Cascone , Bruce Davie: Software-Defined Networks: A Systems Approach, Systems Approach, 2021.
2. Paul Burns, “Software Defined Radio for 3G,” Artech House, 2002.

26ECE124

NETWORK SECURITY AND CRYPTOGRAPHY

(Program Elective – V)

Instruction	3L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Concepts of Data Computer and Communication Networks.

COURSE OBJECTIVES:

This course aims to

1. Understand the concepts of public key and private key cryptography techniques.
2. Study about message authentication and digital signature standards.
3. Impart the knowledge of system security.

COURSE OUTCOMES:

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

1. Explain security concepts, attacks, OSI security architecture, and classical cryptographic techniques.
2. Illustrate and compare symmetric key encryption algorithms and their cryptanalysis.
3. Apply public-key cryptography, key exchange, and hashing techniques for secure communication.
4. Analyze authentication protocols and security architectures used in IP and web communication.
5. Examine system security threats and propose suitable defense mechanisms.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	1	1	1	2
CO 2	2	3	1	3	2
CO 3	1	2	2	2	3
CO 4	2	2	3	3	2
CO 5	2	3	3	3	3

UNIT - I

Network Security and Cryptography: Concepts of Network Security, Need, OSI Security Architecture: Security Attacks, Security Services, Security Mechanisms, One-time passwords, Model for Network security, Cryptology and Cryptography, Classical Encryption Techniques like Substitution ciphers, Transposition ciphers and their Cryptanalysis.

UNIT - II

Private-Key (Symmetric) Cryptography: Symmetric Cipher Model, Block Ciphers, Block Cipher Design Principles, Data Encryption Standard (DES), Triple DES, Advanced Encryption Standard (AES), AES Key Expansion, RC5, IDEA, Linear and Differential Cryptanalysis. Stream Ciphers, RC4 Stream cipher.

UNIT - III

Public-Key (Asymmetric) Cryptography: Principles of Public-Key Cryptosystems, RSA, Diffie-Hellman Key Exchange, Elliptic Curve Cryptography, Cryptographic Hash functions, Message digest algorithms: MD4, MD5, Secure Hash algorithm, RIPEMD-160, Message Authentication Code, HMAC. Key Distribution and Management.

UNIT - IV

Authentication: Digital Signatures, Digital Signature Standards, Authentication Protocols, Kerberos Version 4, Kerberos Version 5.

IP and Web Security: IP security Architecture, Encapsulating Security Payload, Web Security Considerations, Secure Socket Layer and Transport Layer Security, Secure Electronic Transaction.

UNIT - V

System Security: Intruders, Intrusion Detection, Password Management

Malwares: Worms, Viruses, Trojans, Virus Countermeasures, Wireless Network Security, Email security, Firewalls, Firewall Design Principles.

TEXT BOOKS:

1. William Stallings, "Cryptography and Network Security, Principles and Practices", Pearson Education, 6th Edition, 2013.
2. Charlie Kaufman, Radia Perlman and Mike Speciner, "Network Security, Private Communicational Public World", Prentice Hall, 2nd Edition, 1995.

SUGGESTED READING:

1. Stephen Northcutt, Leny Zeltser, Scott Winters, Karen Kent, and Ronald W. Ritchey, "Inside Network Perimeter Security", Pearson Education, 2nd Edition, 2005.
2. Richard Bejtlich, "The Practice of Network Security Monitoring: Understanding Incident detection and Response", William Pollock Publisher, 2013.

26ECE125

ENERGY HARVESTING WIRELESS COMMUNICATIONS

(Program Elective - V)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PREREQUISITE: Knowledge on communication systems, Probability theory.

COURSE OBJECTIVES:

This course aims to:

1. To understand the fundamentals of energy harvesting (EH) wireless communication systems, including energy sources, system architecture, and constraints.
2. To analyze and design power allocation strategies and resource management techniques in point-to-point and multi-node EH wireless networks.
3. To apply cross-layer design and optimization techniques for improving energy efficiency, Quality of Service (QoS), and overall system performance in EH-enabled networks.

COURSE OUTCOMES:

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

1. Explain the principles of energy harvesting wireless systems, including energy sources, architecture, and performance metrics.
2. Analyze power allocation strategies in EH communication systems under energy causality and storage constraints.
3. Evaluate the performance of multi-node EH wireless networks with respect to resource allocation, cooperation, and interference management.
4. Apply cross-layer optimization techniques for designing energy-efficient and QoS-aware wireless communication systems.
5. Formulate and solve optimization problems in EH networks using novel techniques

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	1	3	1	3
CO 2	3	2	3	1	3
CO 3	3	3	3	1	3
CO 4	3	3	3	1	3
CO 5	1	1	3	1	3

UNIT – I

Introduction to Energy Harvesting Wireless Systems: Overview of wireless communication systems; Motivation for energy harvesting (EH) in wireless networks; Types of energy sources: solar, RF, thermal, vibration; Basic architecture of EH-enabled communication systems; Energy causality and storage constraints; Performance metrics for EH systems.

UNIT – II

Power Allocation in Energy Harvesting Communication Systems: Fundamentals of power allocation strategies; Point-to-Point EH Channels: Offline vs. online power allocation, Energy causality constraints, Throughput maximization, Delay minimization; Optimal transmission policies; Water-filling algorithms for EH systems.

UNIT – III

Multi-Node Energy Harvesting Wireless Networks: Extension from single-user to multi-user systems; Multi-node EH Channels: Multiple access channels (MAC), Broadcast channels (BC), Relay channels; Resource allocation in multi-user EH systems; Cooperative communication in EH networks; Interference management.

UNIT – IV

Cross-Layer Design for Energy Harvesting Systems: Need for cross-layer optimization; Joint design of: Physical layer (power control, modulation), MAC layer (scheduling, access protocols), Network layer (routing); Queue stability and delay analysis; Trade-offs between energy efficiency and QoS;

UNIT – V

Energy Harvesting Network Optimization and Advanced Topics: Energy Harvesting Ad Hoc Networks: Distributed protocols; Energy-aware routing; EH in Cellular Networks: Cost-aware design, Base station energy management; Next-Generation EH Networks: Integration with 5G/6G systems, Smart grid interaction, IoT and ultra-low power devices.

TEXT BOOKS:

1 Chuan Huang, Sheng Zhou, Jie Xu, Zhisheng Niu, Rui Zhang, Shuguang Cui, "Energy Harvesting Wireless Communications" Wiley-IEEE Press, Dec 2018.
2 Yunfei Chen, "Energy Harvesting Communications: Principles and Theories" Wiley-IEEE Press,

SUGGESTED READING:

1. Shaikh, F. K., & Zeadally, S. (Eds.). (2021). *Energy harvesting in wireless sensor networks and internet of things*. Institution of Engineering and Technology.

26ECC112

INDUSTRIAL PROJECT / DISSERTATION PHASE I

Instruction	20 P Hours per Week
Duration of SEE	
SEE	--
CIE	100 Marks
Credits	10

PREREQUISITE: Capable of carrying out suitable literature survey and accomplish / execute a software / hardware based project in the Communications and allied areas.

COURSE OBJECTIVES:

This course aims to:

1. Orient the students to carry out literature survey and identify the problem statement.
2. Make the student devise a methodology on his own.
3. Facilitate the student to explore different software/hardware techniques.

COURSE OUTCOMES:

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

1. Review the literature from standard books, refereed journals, reputed conference proceedings etc., in the area of interest.
2. Identify the problem statement based on existing gaps.
3. Able to define the aim of the project and derive the objectives to fulfill the aim.
4. Formulate an innovative methodology and identify the resources to carry out the objectives.
5. Present the details of the problem statement, thorough literature survey and methodology in the form of a detailed technical report.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	3	3	3	1
CO 2	3	3	3	3	2
CO 3	3	3	3	3	2
CO 4	3	3	2	3	1
CO 5	2	2	2	3	2

The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have the following.

- Relevance to social needs of society.
- Relevance to value addition to existing facilities in the institute.
- Relevance to industry need.
- Problems of national importance.
- Research and development in various domain.

The student should complete the following:

- Literature survey Problem Definition.
- Motivation for study and Objectives.
- Preliminary design / feasibility / modular approaches.

- Implementation and Verification.
- Report and presentation.

As per the AICTE and Institute directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e., Phase – I and Phase – II.

Guidelines for Dissertation Phase – I:

- The dissertation may be carried out preferably in-house i.e., departments laboratories and centers OR in industry allotted through departments T & P coordinator.

- After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include IEEE/IET/IETE/Springer/Science Direct/ACM journals in the areas of Signal processing, Communications and allied areas. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.

- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.

- Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and / or computer aided design, proof of concept / functionality, part results, A record of continuous progress.

- Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend repeating the Phase-I work.

Guidelines for awarding Marks in CIE:		Max. Marks: 100
Evaluation by	**Max. Marks**	**Evaluation Criteria /**
Supervisor	30	Project Status / Review(s)
	20	Report
Departmental Review Committee	10	Relevance of the Topic
	10	PPT Preparation(s)
	10	Presentation(s)
	10	Question and Answers
	10	Report Preparation

Note: Departmental Review Committee has to assess the progress of the student for every two weeks.

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY(A)

R-26 Curriculum (with effect from AY 2027-28)

M.E (Communication Engineering)

SEMESTER – IV

S.no	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
DISSERTATION									
1	26ECC113	Industrial Project / Dissertation Phase II	--	--	32	Viva-Voce	100	100	16
Total			**--**	**--**	**32**	**--**	**100**	**100**	**16**
Clock Hours Per Week: 32									

L: Lecture **D: Drawing** **CIE: Continuous Internal Evaluation**

T: Tutorial **P: Practical/Mini Project /Dissertation** **SEE: Semester End Examination**

26ECC113

INDUSTRIAL PROJECT / DISSERTATION PHASE II

Instruction	32 P Hours per Week
Duration of SEE	Viva - Voce
SEE	100 Marks
CIE	100 Marks
Credits	16

PREREQUISITE: Should have completed literature survey and defined problem statement with a brief idea of the methodology, as a part of Industrial Project/ Dissertation Phase-I.

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COURSE OBJECTIVES:

This course aims to:

1. Orient the students towards scientific research, problem solving, design, generation/collection and analysis of data.
2. Make the student to realize the objectives and fulfil the aim of the project.
3. Enhance the technical writing skills and encourage to publish the findings.

COURSE OUTCOMES:

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

1. Plan the experimental set-up, initiate the design process, devise the algorithms required to fulfill the objectives.
2. Realize the objectives by carrying out suitable experiments and implementing modern techniques through the usage of relevant hardware/software tools.
3. Validate the results and draw the inferences.
4. Present the findings in the form of a good technical report / thesis and publish the findings in a reputed journal / conference proceedings.
5. Develop skills to independently carry out research / investigation and development for problem solving while being committed to ethical and social responsibilities.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	3	2	3	2
CO 2	3	3	3	3	2
CO 3	3	3	3	3	2
CO 4	3	3	3	3	2
CO 5	3	2	2	2	2

As per the AICTE and Institute directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e. Phase – I and Phase – II.

- The dissertation may be carried out preferably in-house i.e. departments laboratories and centers OR in industry allotted through departments T & P coordinator.
- After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include IEEE/IET/IETE/Springer/Science Direct/ACM journals in the areas of Signal processing, Communications and allied areas.
- In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.

Guidelines for Dissertation Phase – II:

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them. It may be based on:

- Experimental verification / Proof of concept.
- Design, Fabrication, Testing of Communication System.
- The viva-voce examination will be based on the above report and work.

During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.

- Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, A record of continuous progress.
- Phase – II evaluation: Guide along with appointed external examiner shall assess the progress / performance of the student based on report, presentation and Q & A.
- In case of unsatisfactory performance, committee may recommend for extension or repeating the work.

Guidelines for awarding marks in CIE:		Max. Marks: 100
Evaluation by	**Max. Marks**	**Evaluation Criteria / Parameter**
Departmental Review Committee	05	Review 1
	10	Review 2
	10	Review 3
	15	Final presentation with the draft copy of the report
	10	Submission of the report in a standard format
Supervisor	10	Regularity and Punctuality
	10	Work Progress
	10	Quality of the work which may lead to publications
	10	Analytical / Programming / Experimental Skills
	10	Report preparation in a standard format

Guidelines for awarding marks in SEE:		Max. Marks: 100
Evaluation by	**Max. Marks**	**Evaluation Criteria / Parameter**
External and Internal Examiner(s) together	20	Power Point Presentation
	40	Quality of thesis and evaluation
	20	Quality of the project • Innovations • Applications • Live Research Projects • Scope for future study • Application to society
	20	Viva-Voce

Note: Departmental Review Committee has to assess the progress of the student for every two weeks.

26CEA101

DISASTER MITIGATION AND MANAGEMENT
(Audit Course)

Instruction	2L Hours per week
Duration	2 Hours
SEE	50 Marks
CIE	--
Credits	--

COURSE OBJECTIVES:

To enable the student:

1. To equip the students with the basic knowledge of hazards, disasters, risks and vulnerabilities, including natural, climatic and human-induced factors and associated impacts
2. To impart knowledge in students about the nature, causes, consequences and mitigation measures of the various natural disasters
3. To enable the students to understand risks, vulnerabilities and human errors associated with human-induced disasters
4. To enable the students to understand and assimilate the impacts of any disaster on the affected area, depending on its position/ location, environmental conditions, demographic, etc.
5. To equip the students with the knowledge of the chronological phases in a disaster management cycle and to create awareness about the disaster management framework and legislations in the context of national and global conventions

COURSE OUTCOMES:

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

1. Ability to analyse and critically examine existing programs in disaster management regarding vulnerability, risk and capacity at different levels
2. Ability to understand and choose the appropriate activities and tools, and set up priorities to build a coherent and adapted disaster management plan
3. Ability to understand various mechanisms and consequences of human-induced disasters for the participatory role of engineers in disaster management
4. To understand the impact on various elements affected by the disaster and to suggest and apply appropriate measures for the same
5. Develop an awareness of the chronological phases of disaster preparedness, response and relief operations for formulating effective disaster management plans and the ability to understand various participatory approaches/strategies and their application in disaster management

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	3	2	1	1
CO 2	3	3	2	2	1
CO 3	2	3	3	2	1
CO 4	3	3	2	3	1
CO 5	3	2	2	3	1

UNIT- I

Introduction: Basic definitions- Hazard, Disaster, Vulnerability, Risk, Resilience, Mitigation, Management; classification of types of disaster-Natural and manmade; International Decade for natural disaster reduction (IDNDR); International strategy for disaster reduction (ISDR), National disaster management authority (NDMA).

UNIT- II

Natural Disasters: Hydro meteorological disasters: Causes, Early warning systems- monitoring and management, structural and non-structural measures for floods, drought and Tropical cyclones; Geographical based disasters: Tsunami generation, causes, zoning, Early warning systems- monitoring and management, structural and non-structural mitigation measures for earthquakes, tsunami, landslides, avalanches and forest fires. Case studies related to various hydro-meteorological and geographical based disasters.

UNIT- III

Human Induced Hazards: Chemical disaster- Causes, impacts and mitigation measures for chemical accidents, Risks and control measures in a chemical industry, chemical disaster management; Case studies related to various chemical industrial hazards eg.: Bhopal gas tragedy; Management of chemical terrorism disasters and biological disasters; Radiological Emergencies and case studies; Case studies related to major power break downs, fire accidents, traffic accidents, oil spills and stampedes, disasters due to double cellar construction in multistoried buildings.

UNIT- IV

Disaster Impacts: Disaster impacts- environmental, physical, social, ecological, economic, political, etc.; health, psycho-social issues; demographic aspects- gender, age, special needs; hazard locations; global and national disaster trends; climate change and urban disasters.

UNIT- V

Concept of Disaster Policies and legislation for disaster risk reduction

Management: Disaster management cycle – its phases; prevention, mitigation, preparedness, relief and recovery; risk analysis, vulnerability and capacity assessment; post-disaster environmental response water, sanitation, food safety, waste management, disease control; Roles and responsibilities of government, community, local in situations, NGOs and other stakeholders;, DRR programmers in India and the activities of National Disaster Management Authority.

TEXT BOOKS:

1. Pradeep Sahni*," Disaster Risk Reduction in South Asia*", Prentice Hall, 2003.
2. B. K. Singh,*" Handbook of Disaster Management*: *techniques &Guidelines*", Rajat Publication, 2008.
3. Ministry of Home Affairs". *Government of India, "National disaster management plan, Part I and II",*
4. K. K. Ghosh," *Disaster Management",*APH Publishing Corporation, 2006.

SUGGESTED READING:

1. http://www.indiaenvironmentportal.org.in/files/file/disaster_management_india1.pdf
2. http://www.ndmindia.nic.in/ (National Disaster management in India, Ministry of Home Affairs)
3. Hazards, Disasters and your community: A booklet for students and the community, Ministry of home affairs.

26EGA101

ENGLISH FOR RESEARCH PAPER WRITING

(Audit Course)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	-

PREREQUISITE: Writing to express on science and technological concepts with good taste for research and development.

COURSE OBJECTIVES:

This course aims to:

1. Motivate learners for academic writing and thus encourage them for continuous professional updating and up-gradation.
2. Facilitate a practical understanding of the multiple purposes of Writing Research Papers and help them infer the benefits and limitations of research in science and technology.
3. Brainstorm and develop the content, formulating a structure and illustrating the format of writing a research paper.
4. Survey and select a theme/topic for a thorough reading and to writing a research paper.
5. Understand to implement the intricacies of writing and publishing a research paper.

COURSE OUTCOMES:

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

1. Improve work performance and efficiency. Illustrate the nuances of research paper writing and draw conclusions on professional usefulness.
2. Classify different types of research papers and organize the format and citation of sources.
3. Explore various formats of APA, MLA and IEEE and set up for writing a research paper.
4. Draft paragraphs and write theme based thesis statements in a scientific manner.
5. Develop an original research paper while acquiring the knowledge of how and where to publish their papers.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	1	2	1	1	1
CO 2	1	1	1	1	1
CO 3	1	2	2	1	1
CO 4	1	2	1	1	1
CO 5	2	3	1	1	1

UNIT - I

Academic Writing: Meaning & Definition of a research paper; Purpose of a research paper - Scope, Benefits, Limitations and outcomes for professional development, An introduction to methods and Approaches of Research.

UNIT - II

Research Paper Format: Title - Abstract - Introduction - Discussion - Findings - Conclusion - Style of Indentation - Font size/Font types - Indexing - Citation of sources.

UNIT - III

Process of Writing a research paper, Writing to Draft a Format, Develop content, Adapting, Reviewing, Paraphrasing& Plagiarism Checks.

UNIT - IV

Choosing a topic - Thesis Statement - Outline - Organizing notes - Language of Research - Word order, Paragraphs - Writing first draft-Revising/Editing - The final draft and proof reading. Understanding APA, MLA, IEEE formats.

UNIT - V

Research Paper Publication Reputed Journals –Paid, Free and peer reviewed journals, National/International - ISSN No, No. of volumes, Scopus Index/UGC Journals. Getting Papers Published.

TEXT BOOKS:

1. Kothari, C. R. and Gaurav, Garg, Research Methodology Methods and Techniques", 4thEdition, New Age International Publishers, New Delhi, 2019.
2. Ellison, Carroll. "Writing Research Papers", McGraw Hill's Concise Guide, 2010.
3. Lipson, Charles. "Cite Right: A Quick Guide to Citation Styles-- MLA, APA, Chicago, the Sciences, Professions, and More", 2nd Edition,. University of Chicago Press. Chicago, 2018.

SUGGESTED READING:

1. Day, Robert A. "How to Write and Publish a Scientific Paper", Cambridge University Press, 2006.
2. Girden, E. R. "MLA Hand book for writers of Research Papers", 7th Edition, East West Press Pvt. Ltd, New Delhi, 2009
3. Bailey, Stephen. "Academic Writing: A Handbook for International Students", Routledge, 2018.

ONLINE RESOURCES:

1. https://onlin://onlinecourses.nptel.ac.in/noc 18_mg13/preview.
2. https://nptel.ac.in/courses/121/106/121106007/.
3. https://www.classcentral.com/course/swayam-introduction-to-research-5221.

WRITING TOOLS:

1. https://owl.purdue.edu/owl_exercises/index.html - The Owl writing lab.
2. https://www.turnitin.com/login_page.asp?lang=en_us – Turn tin software.

26EGA102

CONSTITUTION OF INDIA

(Audit Course)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	-

PREREQUISITE: Knowledge on basics of the Constitution and the Government.

COURSE OBJECTIVES:

This course aims to:

1. The history of Indian Constitution and its role in the Indian democracy.
2. Address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. Have knowledge of the various Organs of Governance and Local Administration.

COURSE OUTCOMES:

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

1. Understand the making of the Indian Constitution and its features.
2. Understand the Rights of equality, the Right of freedom and the Right to constitutional remedies.
3. Have an insight into various Organs of Governance - composition and functions.
4. Understand powers and functions of Municipalities, Panchayats and Co-operative Societies.
5. Understand Electoral Process, special provisions.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	1	1	-	1	1
CO 2	1	1	-	1	1
CO 3	1	1	-	1	1
CO 4	1	1	-	1	1
CO 5	1	1	-	1	1

UNIT-I

History of making of the Indian constitutions - History, Drafting Committee (Composition & Working). **Philosophy of the Indian Constitution**: Preamble, Salient Features.

UNIT-II

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

UNIT-III

Organs of Governance - Parliament : Composition, Qualifications, Powers and Functions.
Union executives : President, Governor, Council of Ministers, Judiciary, appointment and transfer of judges, qualifications, powers and functions.

UNIT-IV

Local Administration - District's Administration head: Role and importance.
Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Panchayati Raj: Introduction, PRI: ZillaPanchayat, Elected Officials and their roles, CEO ZillaPanchayat: positions and role.
Block level: Organizational Hierarchy(Different departments) Village level: role of elected and appointed officials. Importance of grass root democracy.

UNIT-V

Election commission: Role and functioning, Chief Election Commissioner and Election Commissioners.
State Election Commission : Role and functioning. Institute and Bodies for the welfare of SC/ST/OBC and women**.**

TEXT BOOKS:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Busi, S. N., Dr. B. R. Ambedkar, Framing of Indian Constitution'', 1st Edition, Ava Publishers, New Delhi, 2015.
3. Jain, M. P., "Indian Constitution Law", 7th Edition, Lexis Nexis, New Delhi, 2014.
4. Basu, D.D. "Introduction to the Constitution of India", Lexis Nexis, New Delhi., 2015.

SUGGESTED READING:

1. Bhargava, Rajeev. (ed), "Politics and Ethics of the Indian Constitution", OUP, 2008.
2. NCERT, Indian Constitution at Work, 1st Edition, Government of India, New Delhi 2006, reprinted in 2022.
3. Ravindra Sastry, V. (ed.), Indian Government & Politics, 2nd edition, Telugu Akademy, 2018.

ONLINE RESOURCES:

1. http://www.nptel.ac.in/courses/103107084/Script.pdf

26ADA101

PEDAGOGY STUDIES

(Audit Course)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	--
Credits	--

PREREQUISITE:

COURSE OBJECTIVES:

This course aims to:

1. Present the basic concepts of design and policies of pedagogy studies.
2. Provide understanding of the abilities and dispositions with regard to teaching techniques, curriculum design and assessment practices.
3. Familiarize various theories of learning and their connection to teaching practice.
4. Create awareness about the practices followed by DFID, other agencies and other researchers.
5. Provide understanding of critical evidence gaps that guides the professional development.

COURSE OUTCOMES:

Upon completing this course, students will be able to:

1. Illustrate the pedagogical practices followed by teachers in developing countries both in formal and informal classrooms.
2. Examine the effectiveness of pedagogical practices.
3. Understand the concept, characteristics and types of educational research and perspectives of research.
4. Describe the role of classroom practices, curriculum and barriers to learning.
5. Understand Research gaps and learn the future directions.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	1	1	1	2	2
CO 2	1	1	1	2	2
CO 3	2	2	2	2	2
CO 4	1	1	1	2	2
CO 5	2	2	2	2	2

UNIT - I

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

UNIT - II

Thematic Overview: Pedagogical practices followed by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT - III

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

UNIT - IV

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

UNIT - V

Research Gaps and Future Directions: Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment – Dissemination and research impact.

TEXT BOOKS:

1. Ackers J, Hardman F, "Classroom Interaction in Kenyan Primary Schools, Compare", 31 (2): 245 – 261, 2001.
2. Agarwal M, "Curricular Reform in Schools: The importance of evaluation", Journal of Curriculum Studies, 36 (3): 361 – 379, 2004.

SUGGESTED READING:

1. Akyeampong K, "Teacher Training in Ghana – does it count? Multisite teacher education research project (MUSTER)", Country Report 1.London: DFID, 2003.
2. Akyeampong K, Lussier K, Pryor J, Westbrook J, "Improving teaching and learning of Basic Maths and Reading in Africa: Does teacher Preparation count?, International Journal Educational Development, 33 (3): 272- 282, 2013.
3. Alexander R J, "Culture and Pedagogy: International Comparisons in Primary Education", Oxford and Boston: Blackwell, 2001.
4. Chavan M, "Read India: A mass scale, rapid, 'learning to read' campaign", 2003.

WEB RESOURCES:

1. https://onlinecourses.nptel.ac.in/noc17_ge03/preview
2. www.pratham.org/images/resources%20working%20paper%202.pdf.

26EGA104

PERSONALITY DEVELOPMENT THROUGH LIFE'S ENLIGHTENMENT SKILLS

(Audit Course)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	--
Credits	--

PREREQUISITE: Awareness on Personality Development.

COURSE OBJECTIVES:

This course aims to:

1. Learn to achieve the highest goal happily.
2. Become a person with stable mind, pleasing personality and determination.
3. Awake wisdom among themselves.

COURSE OUTCOMES:

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

1. Develop their personality and achieve their highest goal of life.
2. Lead the nation and mankind to peace and prosperity.
3. Practice emotional self regulation.
4. Develop a positive approach to work and duties.
5. Develop a versatile personality.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	1	1	-	1	1
CO 2	1	1	-	1	1
CO 3	1	1	-	1	1
CO 4	1	1	-	1	1
CO 5	1	1	-	1	1

UNIT - I

Neetisatakam – Holistic development of personality - Verses 19, 20, 21, 22 (Wisdom) - Verses 29, 31, 32 (Pride and Heroism) - Verses 26,28,63,65 (Virtue)

UNIT - II

Neetisatakam – Holistic development of personality (cont'd) - Verses 52, 53, 59 (dont's) - Verses 71,73,75& 78 (do's) - Approach to day to day works and duties.

UNIT - III

Introduction to Bhagavadgeetha for Personality Development – Shrimad Bhagawad Geeta: Chapter 2–Verses 41, 47, 48 - Chapter 3 – Verses 13,21,27,35 - Chapter 6 – Verses 5,13,17,23,35 - Chapter 18 –Verses 45, 46, 48 Chapter – 6: Verses 5, 13, 17, 23, 35; Chapter – 18: Verses 45, 46, 48

UNIT - IV

Statements of basic knowledge – Shrimad Bhagawad Geeta: Chapter 2- Verses 56, 62,68 - Chapter 12 – Verses 13, 14, 15, 16, 17, 18 - Personality of Role model from Shrimad Bhagawat Geeta.

UNIT - V

Role of Bahgavadgeeta in the present scenario - Chapter 2 – Verses 17 - Chapter 3 – Verses 36, 37, 42 - Chapter 4 – Verses 18, 38, 39 - Chapter 18 – Verses 37, 38, 63.

TEXT BOOKS:

1. Gopinath, P., "Bhartrihari's Three Satakam (Niti-sringar-vairagya)", Rashtriya Sanskrit Sansthanam, New Delhi, 2018.
2. Swarupananda, Swami, "Srimad Bhagavad Geeta", Advaita Ashram (Publication Dept), Kolkata, 2017.

ONLINE RESOURCES:

1. http://nptel.ac.in/downloads/109104115/

26EEA101

SANSKRIT FOR COMPUTATIONAL THINKING & ENGINEERING APPLICATIONS

(Audit Course)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	-

COURSE OBJECTIVES:

This course aims to:

1. To introduce Sanskrit as a structured language useful for logical thinking and algorithm design
2. To connect Sanskrit concepts with modern engineering domains (AI, circuits, structures, systems)
3. To develop computational and analytical skills using Sanskrit-based principles
4. To enable students to explore interdisciplinary applications for research and innovation

COURSE OUTCOMES:

After completion, students will be able to:

1. Apply structured Sanskrit rules to improve logical and algorithmic thinking
2. Relate concepts from Sanskrit texts to modern Engineering principles
3. Develop simple computational models inspired by Sanskrit grammar/logics
4. Use Sanskrit-based frameworks in AI, coding logic, or system design
5. Identify interdisciplinary research opportunities combining Sanskrit & Engineering

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	1	2	1	1
CO 2	2	1	2	2	1
CO 3	3	1	2	3	1
CO 4	2	2	2	2	1
CO 5	3	2	2	2	1

UNIT–I

Sanskrit as a Structured Language: Sanskrit as rule-based system -Basics: alphabets, word formation (only essentials) -Sandhi as **data compression analogy** -Samasa as **modular design / block abstraction**-Simple sentence formation (very minimal grammar)

UNIT–II

Sanskrit & Computational Thinking: Paninian grammar → rule engine / compiler design -Shiva Sutras → encoding system- Binary concepts in Pingala (Chandas → digital logic) -Recursion & patterns in Sanskrit structures.

UNIT–III

Sanskrit in Core Engineering Domains:Civil / Mechanical:

Sulba Sutras → geometry, measurements -Ancient construction logic → modular design

Electrical / ECE: Concept of energy (Agni, Surya) → symbolic + physical mapping -Wave & sound (Nada → signal analogy)

Systems Thinking: Interconnectedness → system design philosophy

UNIT–IV

Sanskrit & Modern Technology: Sanskrit & Artificial Intelligence (knowledge representation) -Natural Language Processing (NLP) -Formal languages & syntax -Command-based structures → programming analogy

UNIT–V

Mini Applications & Case Studies: Case study: Sanskrit → Algorithm (simple flowchart) -Chandas → binary pattern generation-Design a simple rule-based system using Sanskrit logic -Mini presentation / activity

TEXT BOOKS:

1. **Kapil Kapoor** – Language, Linguistics and Literature- Indian Perspective ; Academic Foundation, New Delhi; 1994 (1st Edition); **ISBN:** 978-8171880577
2. **Frits Staal** : *A Reader on the Sanskrit Grammarians;* MIT Press / Motilal Banarsidass ; 1972 (Original); **ISBN:** 978-0262191340
3. **George Gheverghese Joseph:** The Crest of the Peacock"; Princeton University Press; 2000 (2nd Edition; widely used); **ISBN:** 978-0691135267
4. B.V. Subbarayappa: "Indian Scientific Heritage" – National Institute of Advanced Studies (NIAS), Bangalore; 2006 **ISBN:** 978-8185015026
5. – M. Krishnamachariar : "History of Sanskrit Literature"; Motilal Banarsidass Publishers; Reprint 1993 (Original: 1937, TTD Press); **ISBN:** 978-8120802841

SUGGESTED READING:

1. Pingala. *Chandah Shastra* (various editions, Nirnaya Sagar Press / Chowkhamba)
2. Bharati, A., et al. *Natural Language Processing: A Paninian Perspective*, PHI, 1995
3. Selected IEEE / Springer Papers on Sanskrit & AI

26EGA103

STRESS MANAGEMENT BY YOGA

(Audit Course)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	--
Credits	--

PREREQUISITE: Knowledge on Yoga Practices.

COURSE OBJECTIVES:

This course aims to:

1. Create awareness about different types of stress and the role of yoga in the management of stress.
2. Promote positive health and overall well-being (Physical, mental, emotional, social and spiritual).
3. Prevent stress related health problems by yoga practice.

COURSE OUTCOMES:

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

1. Understand yoga and its benefits.
2. Enhance Physical strength and flexibility.
3. Learn to relax and focus.
4. Relieve physical and mental tension through asanas
5. Improve work performance and efficiency

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	1	1	-	-	1
CO 2	1	1	-	-	1
CO 3	1	1	-	-	1
CO 4	1	1	-	-	1
CO 5	1	1	-	-	1

UNIT - I

Meaning and definition of Yoga - Historical perspective of Yoga - Principles of Astanga Yoga by Patanjali).

UNIT - II

Meaning and definition of Stress - Types of stress - Eustress and Distress. Anticipatory Anxiety and Intense Anxiety and depression. Meaning of Management- Stress Management.

UNIT - III

Concept of Stress according to Yoga - Stress assessment methods - Role of Asana, Pranayama and Meditation in the management of stress.

UNIT - IV

Asanas- (5 Asanas in each posture) - Warm up - Standing Asanas - Sitting Asanas - Prone Asanas - Supine asanas - Surya Namaskar

UNIT – V

Pranayama- Anulom and Vilom Pranayama - Nadishudhi Pranayama - Kapalabhati Pranayama - Bhramari Pranayama - Nadanusandhana Pranayama.

Meditation techniques: Om Meditation - Cyclic meditation: Instant Relaxation technique (QRT), Quick Relaxation Technique (QRT), Deep Relaxation Technique (DRT)

TEXT BOOKS:

1. Janardhan, Swami, "Yogic Asanas for Group Training - Part-I": Yogabhyasi Mandal, Nagpur.
2. Vivikananda, Swami**.** "Rajayoga or Conquering the Internal Nature", Advaita Ashrama (Publication Department), Kolkata.
3. Nagendra H.R and R. Nagaratna, "Yoga Perspective in Stress Management", Swami Vivekananda Yoga Prakashan, Bangalore.

ONLINE RESOURCES:

1. https://onlinecourses.nptel.ac.in/noc16_ge04/preview
2. https://freevideolectures.com/course/3539/indian-philosophy/11

26ECA101

VALUE EDUCATION

(Audit Course)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	--
Credits	--

PREREQUISITE:

COURSE OBJECTIVES:

This course aims to:

1. Understand Value Education, Self-development and National development.
2. Imbibe good human values and Morals in students.
3. Cultivate individual and National character.

COURSE OUTCOMES:

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

1. Summarize classification of values and values for self-development.
2. Identify the importance of values in personal and professional life.
3. Apply the importance of social values for better career and relationships.
4. Analyze ethical issues in modern technology
5. Discuss concept of soul and reincarnation and promote responsible citizenship

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	2	2	2	2	3
CO 2	2	2	2	2	3
CO 3	2	2	2	2	3
CO 4	2	2	2	2	3
CO 5	2	2	2	2	3

UNIT-I

Human Values, Ethics and Morals: Concept of Values, Human Values, Indian concept of humanism, Values for self-development, Social values, Individual attitudes, Work ethics, Moral and non- moral behavior, Standards and Principles based on religion, Culture and Tradition.

UNIT-II

Value Cultivation, and Self-Management: Need and Importance of cultivation of values such as Sense-of Duty, Devotion to work, Self-reliance, Confidence, Concentration, Integrity & discipline, and Truthfulness.

UNIT-III

Spiritual Outlook and Social Values: Personality and Behaviour Development, Scientific attitude and Spiritual (soul) outlook, Cultivation of Social Values Such as Positive Thinking, Punctuality, Love & Kindness, Avoiding fault finding in others, Reduction of anger, Forgiveness, Dignity of labour, True friendship, Universal brotherhood and religious tolerance., Happiness Vs Suffering, Love for truth, Aware of self-destructive habits, Appreciation and co-operation.

UNIT-IV

Technology, Society, and Sustainability: Ethics in emerging technologies (AI, Data, 5G, IoT); Privacy and cybersecurity, Environmental ethics and sustainable development; Social responsibility of engineers, Policy and governance.

UNIT-V

Universal Values and Global Perspectives: Mind your mind, Self-control**,** Concept of soul, Scienceof Reincarnation, Concepts of Dharma and Karma, The qualities of Devine and Devilish, Satwic, Rajasic and Tamasicgunas. Global citizenship, Happiness and meaningful life.

TEXT BOOKS:

1. Chakroborty, S.K. "Values & Ethics for organizations Theory and practice", Oxford University Press, New Delhi, 1998.
2. Jaya Dayal Goyandaka, "Srimad Bhagavad Gita", with Sanskrit Text, Word meaning and Prose meaning, Gita Press, Gorakhpur, 2017.

REFERENCE BOOKS:

1. George Reynolds, Ethics in Information Technology, 6th Edition, Cengage Learning, 2018
2. Melanie Mitchell, Artificial Intelligence: A Guide for Thinking Humans, 1st Edition, Farrar, Straus and Giroux, 2019.

26CSO101

BUSINESS ANALYTICS
(Open Elective)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

PRE-REQUISITES: Basic of programming, basic mathematics.

COURSE OBJECTIVES:

This course aims to:

1. Understanding the basic concepts of business analytics and applications.
2. Study various business analytics methods including predictive, prescriptive and descriptive analytics.
3. Prepare the students to model business data using various data mining, decision making methods.

COURSE OUTCOMES:

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

1. Identify and describe complex business problems in terms of analytical models.
2. Apply appropriate analytical methods to solve business problems and interpret the resulting metrics and measures to achieve stated objectives.
3. Illustrate descriptive, predictive and prescriptive analytics methods and techniques.
4. Model business data using data mining, forecasting, decision tree, and clustering techniques.
5. Design and evaluate viable data-driven solutions to complex business decision-making problems.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	1	2	2	1
CO 2	3	2	3	2	2
CO 3	2	2	3	2	2
CO 4	3	2	3	3	2
CO 5	3	3	3	3	3

UNIT - I

Introduction to Business Analytics: Introduction to Business Analytics, need and science of data driven decision making, Descriptive, predictive, prescriptive analytics and techniques, Big data analytics, Web and Social media analytics, Machine Learning algorithms, Generative AI , LLMs and Explainable AI (XAI) in business analytics, framework for decision making, challenges in data driven decision making and future.

UNIT - II

Descriptive Analytics: Introduction, data types and scales, types of measurement scales, population and samples, measures of central tendency, percentile, decile and quadrille, measures of variation, measures of shape-skewness, data visualization.

UNIT - III

Forecasting Techniques: Introduction, time-series data and components, forecasting accuracy, moving average method, single exponential smoothing, Holt's method, Holt-Winter model, Croston's forecasting method, regression model for forecasting, Auto regression models, auto-regressive moving process, ARIMA, Theil's coefficient

UNIT - IV

Decision Trees: CHAID, Classification and Regression tree, splitting criteria, Ensemble methods, Random Forest, XGBoost. Clustering: Distance and similarity measures used in clustering, Clustering algorithms, K-Means, Prescriptive Analytics- Linear Programming (LP) and LP model building.

UNIT-V

Six Sigma: Introduction, origin, 3-Sigma Vs Six-Sigma process,cost of poor quality, industry applications, six sigma measures, DPMO, yield, sigma score, DMAIC methodology, Six Sigma toolbox.

TEXTBOOKS:

1. U Dinesh Kumar, "Business Analytics", Wiley Publications, 2nd Edition, 2022
2. Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, "Business analytics Principles,Concepts, and Applications with SAS", Associate Publishers, 2015

SUGGESTED READING:

1. S. Christian Albright, Wayne L. Winston, "Business Analytics - Data Analysis and Decision Making",6th Edition, Cengage, 2020.

ONLINE RESOURCES:

1. Coursera – Business Analytics Specialization (University of Pennsylvania, Wharton): https://www.coursera.org/specializations/business-analytics
2. NPTEL – Business Analytics and Data Mining (IIT Roorkee): https://nptel.ac.in/courses/110107106
3. edX – Data Science and Analytics MicroMasters (MIT): https://www.edx.org/micromasters/mitx-statistics-and-data-science

26MEO103

COMPOSITE MATERIALS
(Open Elective)

Instruction	3L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES:
This course aims to:
1. Provide concepts of Composite materials and their constituents.
2. Explain the Classification of the reinforcements and matrix materials.
3. Provide Fabrication methods of metal matrix composites.
4. Explain manufacturing of Polymer matrix composites.
5. Elucidate Failure mechanisms in composite materials.

COURSE OUTCOMES:
Upon completion of this course, students will be able to:
1. Understand composite materials and their reinforcements.
2. Summarize micro-mechanics approach as applied to UD lamina.
3. Apply fabrication methods of metal, ceramic and carbon matrix composites.
4. Apply fabrication methods of polymer matrix composites..
5. Analyze the lamina and laminate from failure perspective.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	1	3	1	-
CO 2	3	1	3	1	-
CO 3	3	1	3	1	-
CO 4	3	1	3	1	-
CO 5	3	1	3	1	-

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

UNIT - II
Reinforcements: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements.
Mechanical Behaviour of composites: Rule of mixtures, Inverse rule of mixtures. Iso-strain and Iso-stress conditions.

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

UNIT - IV

Processing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs - hand layup method - Autoclave method - Filament winding method - Compression moulding - Reaction injection moulding. Properties and applications.

UNIT - V

Strength: Lamina Failure Criteria, strength ratio, maximum stress criteria, maximum strain criteria, interactive failure criteria and hygrothermal failure. Laminate first ply failure -insight strength**.**

TEXT BOOKS:

1. K.K.Chawla, "Composite Materials- Science and Engineering", 4th edition, Springer Verlag, 2019.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007..
3. R.M. Jones. Mechanics of Composite Materials. 2 nd ed. CRC press. 2018.

SUGGESTED READING:

1. Deborah D.L. Chung, "Composite Materials Science and Applications" 2nd edition, Springer Verlag, 2010.
2. Sanjay K. Mazumdar, "Composites Manufacturing- materials, product and process engineering", 1st edition, CRC press, 2002.
3. Daniel Gay, "Composite Materials Design and Applications" 3rd edition, CRC press, 2015.

26CEO101

COST MANAGEMENT OF ENGINEERING PROJECTS

(Open Elective)

Instruction	3 Hours per week
Duration	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES:

This course aims to:

1. To enable the students to understand the concepts of Project management.
2. To provide knowledge on concepts of Project Planning and scheduling.
3. To create an awareness on Project Monitoring and Cost Analysis
4. To provide adequate knowledge to the students on Recourse Management Costing-Variance Analysis
5. To train the students with the concepts of Budgetary Control for cost management and to provide basic platform on Quantitative techniques for cost management.

COURSE OUTCOMES:

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

1. Acquire in-depth knowledge about the concepts of project management and understand the principles of project management
2. Determine the critical path of a typical project using CPM and PERT techniques.
3. Prepare a work break down plan and perform linear scheduling using various methods.
4. Solve problems of resource scheduling and levelling using network diagrams.
5. Learn the concepts of budgetary control and apply quantitative techniques for optimizing project cost.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	1	1	-	1	-
CO 2	1	2	1	1	-
CO 3	1	1	1	1	-
CO 4	2	2	1	1	-
CO 5	-	1	1	1	-

UNIT- I

Project Management: Introduction to project managements, stakeholders, roles, responsibilities and functional relationships. Principles of project management, objectives and project management system. Project team, organization, roles, and responsibilities. Concepts of project planning, monitoring, staffing, scheduling and controlling.

UNIT- II

Project Planning and Scheduling: Introduction for project planning, defining activities and their interdependency, time and resource estimation. Work break down structure. Linear scheduling methods-bar charts, Line of Balance (LOB), their limitations. Principles, definitions of network-based scheduling methods: CPM, PERT. Network representation, network analysis-forward and backward passes.

UNIT- III

Project Monitoring and Cost Analysis: introduction-Cost concepts in decision making; relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision- Making, Time cost trade off Crashing project schedules, its impact on time on time, cost. Project direct and indirect costs.

UNIT- IV

Resources Management and Costing-Variance Analysis: Planning, Enterprise Resource Planning, Resource scheduling and levelling. Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis

Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement

UNIT- V

Boundary Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

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

TEXT BOOKS:

1. Charles T Horngren "Cost Accounting A Managerial Emphasis", Pearson Education; 14 edition (2012),
2. Charles T. Horngren and George Foster, "Advanced Management Accounting" Prentice-Hall; 6th Revised edition (1 February1987)
3. Robert S Kaplan Anthony A. Atkinson, "Management & Cost Accounting", Pearson; 2 edition (18 October1996)

SUGGESTED READING:

1. *K. K Chitkara, "Construction Project Management: Planning, scheduling and controlling", Tata McGrawHill Education. (2004).*
2. *Kumar Neeraj Jha "Construction Project Management Theory and Practice", Pearson Education India; 2 edition (2015).*

26MEO101

INDUSTRIAL SAFETY

(Open Elective)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES:

This course aims to cover:

1. Causes for industrial accidents, preventive steps to be taken, Factories act 1948 and 5S Techniques.
2. Fundamental concepts of Maintenance Engineering.
3. About Safety in advanced manufacturing systems.
4. The basic concepts and importance of fault tracing.
5. The steps involved in periodic and preventive maintenance of various industrial equipments.

COURSE OUTCOMES:

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

1. Identify causes of industrial accidents and recommend preventive measures.
2. Select appropriate tools and practices for various maintenance procedures.
3. Apply different Safety measures in advanced manufacturing systems.
4. Diagnose faults in equipment such as machine tools, IC engines, and boilers.
5. Implement periodic and preventive maintenance for industrial equipment including motors, pumps, air compressors, and machine tools.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	3	2	2	1
CO 2	3	3	2	2	1
CO 3	3	3	2	2	1
CO 4	3	3	2	2	1
CO 5	3	3	3	2	1

UNIT - I

SAFETY MANAGEMENT CONCEPTS AND INDUSTRIAL SAFETY PRACTICES

Industrial Safety & Legal Aspects: Industrial accidents – causes, types, consequences, and preventive measures. Mechanical and electrical hazards and their control. Fire hazards, prevention and firefighting methods. Safety color codes and safety signage. Salient provisions of the Factories Act 1948 related to health, safety, and welfare.

Safety Audit: Types of safety audits – audit methodology, preparation of audit checklists, Non-Conformity Reporting (NCR). Analysis and interpretation of accident records and safety reports.

5S Techniques: Introduction, objectives, and elements of 5S (Sort, Set in order, Shine, Standardize, Sustain). Benefits of 5S in enhancing workplace safety, productivity, and efficiency.

UNIT - II

Fundamentals of Maintenance Engineering: Definition and objectives of maintenance engineering. Primary and secondary functions and responsibilities of the maintenance department. Types of maintenance (preventive, predictive, breakdown, corrective) and their applications. Tools and equipment used in maintenance activities. Maintenance cost and its relationship with replacement decisions and economy. Concept of service life and factors affecting the lifespan of equipment.

UNIT- III

Safety in advanced manufacturing systems: Machine safety in CNC, robotics, and Flexible Manufacturing Systems (FMS). Human–machine interaction safety. Safety in Industry 4.0 environments including cyber-physical systems, smart factories, and digital twins. Safety in additive manufacturing (powder handling and laser safety). Safety in material handling systems (conveyors, cranes, AGVs) and manufacturing processes (welding, casting, forging, machining). Electrical safety in automation and Lockout/Tagout (LOTO) procedures.

UNIT - IV

Fault Tracing: Concept and importance of fault tracing. Decision tree approach – need, structure, and applications. Sequence of fault-finding activities and systematic troubleshooting procedures. Development and representation of fault diagnosis using decision trees. Fault tracing in industrial equipment including machine tools, pumps, air compressors, internal combustion engines, boilers, and electrical motors. Types of faults in machine tools and their general causes.

UNIT - V

Maintenance and Condition Monitoring

Periodic and Preventive Maintenance: Periodic inspection, concept and need. Cleaning, servicing, and overhauling of mechanical components and electrical motors. Common motor faults and remedies. Preventive maintenance definition, steps, and advantages. Maintenance procedures for machine tools, pumps, air compressors, and DG sets.

Condition monitoring and basic concepts of Proactive maintenance for Industry 4.0.

TEXT BOOKS:

1. L. M. Deshmukh, Industrial Safety Management, McGraw Hill Education, New Delhi, 1st Edition, 2010.
2. M.R. Sahoo, Industrial Safety Engineering, RK Publications, New Delhi, 1st Edition, 2015.
3. H. P. Garg, "Industrial Maintenance", S. Chand and Company, may 1987.
4. Das Akhil Kumar, Principles of Industrial Safety Management Understanding the Ws of Safety at Work, Second edition, PHI Learning Pvt Ltd, Jan 2020

SUGGESTED READING:

1. Parth B. Shah, Industrial Safety and Maintenance Engineering, Technical publications, 2021.
2. Higgins & Morrow, "Maintenance Engineering Handbook", McGraw-Hill Education Eighth Edition, February 2014.
3. M.P. Poonia, S.C. Sharma, Khanna Publishing House - Technology & Engineering, year 2019.

26MEO102

INTRODUCTION TO OPTIMIZATION TECHNIQUES

(Open Elective)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES:

This course aims to:

1. Understand the LPP models.
2. Understand the Transportation and Assignment techniques.
3. Understand the procedure of Project Management along with CPM and PERT techniques.
4. Understand the concepts of queuing theory and inventory models.
5. Understand sequencing techniques.

COURSE OUTCOMES:

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

1. Formulate a linear programming problems (LPP).
2. Build and solve Transportation Models and Assignment Models.
3. Apply project management techniques like CPM and PERT to plan and execute project successfully.
4. Apply queuing and inventory concepts in industrial applications.
5. Apply sequencing models in industries.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	3	1	3	1	2
CO 2	3	1	3	1	2
CO 3	1	1	3	2	3
CO 4	2	1	3	2	2
CO 5	2	1	3	2	2

UNIT - I

Operations Research: Definition, Scope, Models, Linear programming problems (LPP), Formulation, Graphical Method, and Simplex Method.

UNIT - II

Transportation Models: Finding an initial feasible solution, North West corner method, Least cost method, Vogel's approximation method, Finding the optimal solution, Special cases in transportation problems, Unbalanced transportation problem, Degeneracy in transportation, Profit maximization in transportation.

UNIT- III

Project Management: Definition, Procedure and objectives of project management, Differences between PERT and CPM, Rules for drawing network diagram, Scheduling the activities, Fulkerson's rule, Earliest and latest times, Determination of ES and EF times in forward path, LS & LF times in backward path, Determination of critical path, Duration of the project, Free float, Independent float and total float.

UNIT - IV

Queuing Theory and Inventory: Kendols notation, Single server models, Inventory control, Deterministic inventory models, Probabilistic inventory control models.

UNIT - V

Sequencing Models: Introduction, Objectives, General assumptions, Processing 'n' jobs through two machines, Processing 'n' jobs through three machines**.**

TEXT BOOKS:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008.
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008.

SUGGESTED READING:

1. Hitler Libermann, Operations Research, McGraw Hill Pub, 2009.
2. Harvey M Wagner, Principles of Operations Research, Prentice Hall of India, 2010.

26EEO102

ELECTRIC VEHICLES & FUTURE MOBILITY

(Open Elective)

Instruction:	3L Hours per Week
Duration of SEE:	3 Hours
SEE:	60 Marks
CIE:	40 Marks
Credits:	3

PREREQUISITE:
No prior knowledge required. Basic understanding of science is sufficient.

COURSE OBJECTIVES:
This course aims to:

1. Introduce the fundamentals of electric vehicles and their importance in modern transportation.
2. Explain the basic components and working of electric vehicles.
3. Familiarize students with battery technologies and charging infrastructure.
4. Create awareness about environmental benefits and challenges of EV adoption.
5. Provide insights into future mobility trends including smart transportation systems.

COURSE OUTCOMES:
Upon completion of this course, students will be able to:

1. Understand the basic concepts and need for electric vehicles.
2. Explain the components and working principles of EV systems.
3. Analyze battery technologies and charging methods.
4. Evaluate the environmental and economic impact of EVs.
5. Appreciate future mobility trends and emerging transportation technologies.

CO-PO ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5
CO 1	1	1	1	1	
CO 2	2	1	1	1	
CO 3	2	2	1	2	
CO 4	1	-	-	2	
CO 5	2	2	1	1	

UNIT – I
Introduction to Electric Vehicles: History and evolution of transportation.-Need for electric mobility – energy crisis and environmental concerns.-Types of vehicles: Conventional, Hybrid, Plug-in Hybrid, Battery Electric Vehicles (BEV).-Basic comparison between IC engine vehicles and electric vehicles. Overview of EV ecosystem.

UNIT – II
Components and Working of Electric Vehicles: Main components: Electric motor -Battery pack -Controller and power electronics -Transmission system -Working principle of EVs.-Types of motors used in EVs (overview).-Regenerative braking concept.

UNIT – III

Batteries and Charging Infrastructure: Battery basics – types (Lead-acid, Lithium-ion, emerging technologies).-Battery parameters – capacity, energy density, charging cycles.-Charging methods: Slow charging; Fast charging; Wireless charging (intro) -Charging infrastructure – public and private charging stations.

Battery management system (BMS) – basic concept**.**

UNIT – IV

Environmental and Economic Aspects: Environmental impact of EVs – emissions comparison.-Lifecycle analysis (production to disposal).-Cost comparison – EV vs conventional vehicles.-Government policies and incentives (India focus).-Challenges in EV adoption – range anxiety, infrastructure, cost.

UNIT – V

Future Mobility and Emerging Trends: Smart mobility and intelligent transportation systems.-Electric public transport – buses, metros. Autonomous and connected vehicles (intro).-Vehicle-to-Grid (V2G) concept.-Future trends: Sustainable mobility, shared mobility, green transportation.

TEXTBOOKS:

1. James Larminie & John Lowry, *Electric Vehicle Technology Explained*, Wiley.
2. Mehrdad Ehsani et al., *Modern Electric, Hybrid Electric and Fuel Cell Vehicles*, CRC Press.
3. Government of India, *EV Policy Reports and Mobility Guidelines*.

SUGGESTED READING:

1. NITI Aayog, *India Electric Mobility Reports*.
2. International Energy Agency (IEA), *Global EV Outlook*.
3. Bureau of Energy Efficiency (BEE), EV awareness materials.
4. IEEE Journals on Electric Mobility.

NPTEL / Online Resources:

S.No	Course Name	Instructor	Institute
1	Electric Vehicles	Prof. S. Banerjee	IIT Kharagpur
Other Online Resources:			
1	https://nptel.ac.in		
2	https://niti.gov.in		
3	https://iea.org		