PG-R23 Curriculum
With effective from 2023-24

ECE - Communication Engineering

Scheme of Instruction and Syllabi of
M.E I to IV Semester of
Two Year Degree Course

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY
(An Autonomous Institute | Affiliated to Osmania University)
Accreditated by NBA & NAAC (A++)
Kokapet Village, Gandipet Mandal, Hyderabad -500075, Telanagana.
E-mail: principal@cbit.ac.in, Website: www.cbit.ac.in
Phone No. : 040-24193276 / 277 / 279

Scheme of Instruction and Syllabi

Master of Engineering

A TWO YEAR (I – IV Semesters) PG Program

in

COMMUNICATION ENGINEERING

(AICTE Model Curriculum with effect from AY 2023-24)

(R–23 Regulation)

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

(Autonomous Institution under UGC, Affiliated to Osmania University)

Department of Electronics and Communication Engineering

Accredited with NAAC- (A++)

Chaitanya Bharathi (Post), Gandipet, Hyderabad–500075

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

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)

(AICTE Model Curriculum with effect from AY 2023-24)

ME (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	23ECC101	Advanced Digital Signal Processing	3	--	--	3	40	60	3
2	23ECC102	Wireless and Mobile Communication	3	--	--	3	40	60	3
3		Program Elective-I	3	--	--	3	40	60	3
4		Program Elective-II	3	--	--	3	40	60	3
5	23MEM103	Research Methodology and IPR	2	--	--	3	40	60	2
6		Audit Course-I	2	--	--	2	--	50	Non-Credit
PRACTICALS									
7	23ECC103	Advanced Digital Signal Processing Lab	--	--	3	--	50	--	1.5
8	23ECC104	Wireless and Mobile Communication Lab	--	--	3	--	50	--	1.5
Total			**16**	**--**	**6**	**17**	**300**	**350**	**17**
Clock Hours per Week: 22									

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

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

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

(AICTE Model Curriculum with effect from AY 2023-24)

ME (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	23ECC105	Advanced Communication Networks	3	--	--	3	40	60	3
2	23ECC106	Industrial IoT and Applications	3	--	--	3	40	60	3
3	23ECC107	5G and Beyond	3	--	--	3	40	60	3
4		Program Elective-III	3	--	--	3	40	60	3
5		Program Elective-IV	3	--	--	3	40	60	3
PRACTICALS									
6	23ECC108	Advanced Communication Networks Lab	--	--	3	--	50	--	1.5
7	23ECC109	Advanced IoT and Applications Lab	--	--	3	--	50	--	1.5
8	23ECC110	Mini Project	--	--	2	--	50	--	1
Total			**15**	**--**	**8**	**15**	**350**	**300**	**19**
Clock Hours per Week: 23									

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

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

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

(AICTE Model Curriculum with effect from AY 2024-25)

ME (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	3	--	--	3	40	60	3
3		Audit Course-II	2	--	--	2	--	50	Non-Credit
DISSERTATION									
4	23ECC111	Industrial Project / Dissertation Phase I	--	--	20	--	100	--	10
Total			**8**	**--**	**20**	**8**	**180**	**170**	**16**
Clock Hours per Week: 28									

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

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

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

(AICTE Model Curriculum with effect from AY 2024-25)

ME (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	23ECC112	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**

List of Courses for the Program ME (CE) with Specialization

COMMUNICATION ENGINEERING

S.No	Course Code	Title of the Course
Program Core Courses		
1.	23ECC101	Advanced Digital Signal Processing
2.	23ECC102	Wireless and Mobile Communication
3.	23ECC105	Advanced Communication Networks
4.	23ECC106	Industrial IoT and Applications
5.	23ECC107	5G and Beyond
Practical Courses / Mini Project / Dissertation		
6.	23ECC103	Advanced Digital Signal Processing Lab
7.	23ECC104	Wireless and Mobile Communication Lab
8.	23ECC108	Advanced Communication Networks Lab
9.	23ECC109	Advanced IoT and Applications Lab
10.	23ECC110	Mini Project
11.	23ECC111	Industrial Project / Dissertation Phase I
12.	23ECC112	Industrial Project / Dissertation Phase II
Program Elective Courses		
Program Elective – I Courses		
1.	23ECE101	Data and Optical Networks
2.	23ECE102	GNSS and Augmentation Systems
3.	23ECE103	Radiating Systems for RF Communication
Program Elective – II Courses		
4.	23ECE104	High Performance Networks
5.	23ECE105	MIMO Wireless Communications
6.	23ECE106	Statistical Decision and Estimation Theory
Program Elective – III Courses		
7.	23ECE107	Information Theory and Coding Techniques
8.	23ECE108	Markov Chain and Queuing Systems
9.	23ECE109	Network Security and Cryptography
Program Elective – IV Courses		
10.	23ECE110	Machine Learning for Next Generation Communication Systems
11.	23ECE111	Signal Intelligence Systems
12.	23ECE112	Wireless Sensor Networks and Protocols
Program Elective – V Courses		
13.	23ECE113	Cognitive Radio
14.	23ECE114	Deep Learning Techniques for Signal Processing
15.	23ECE115	Programmable Networks – SDN, NFV

Mandatory Course		
1.	23MEM103	Research Methodology and IPR

Audit Courses		
1.	23CEA101	Disaster Management
2.	23EGA101	English for Research Paper Writing
3.	23EGA102	Constitution of India
4.	23ADA101	Pedagogy Studies
5.	23EGA104	Personality Development through Life Enlightenment Skills
6.	23EEA101	Sanskrit for Technical Knowledge
7.	23EGA103	Stress Management by Yoga
8.	23ECA101	Value Education
Open Electives Courses		
1.	23CSO101	Business Analytics
2.	23MEO103	Composite Materials
3.	23CEO101	Cost Management of Engineering Projects
4.	23MEO101	Industrial Safety
5.	23MEO102	Introduction To Optimization Techniques
6.	23EEO101	Waste to Energy

23ECC101

ADVANCED DIGITAL SIGNAL PROCESSING

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: After the completion of this course, the student 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 the various applications of Digital signal processing.

CO-PO Articulation Matrix

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

UNIT - I

Review of Digital Filters: FFT Algorithms, 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, 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

Applications of Digital Signal Processing: Dual Tone Multi frequency Signal Detection, sub band coding of speech signals, JPEG-2000, Transmultiplexers, Spectral analysis of sinusoidal signals, Non-stationary signals, Introduction to wavelets.

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.

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.

23ECC102

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 are required.

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. Analyze path loss, shadowing and multipath effects on wireless channels.
3. Interpret the capacity of wireless channels.
4. Appreciate the underlying principles of diversity techniques.
5. Gain an overview of the higher generation Cellular standards 4G & 5G.

CO-PO Articulation Matrix

PO/CO	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

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 - III

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-Invarient and Time-Varying channels.

UNIT - IV

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

UNIT - V

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.

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.

23ECC105

ADVANCED COMMUNICATION NETWORKS

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

Prerequisite: Students should have in depth knowledge of Computer Networks.

COURSE OBJECTIVES: This course aims to

1. Familiarize the student with the basic taxonomy and terminology of the computer networking area.
2. Provide the student with knowledge of advanced networking concepts and techniques.
3. Provide the student with knowledge of Real Time Communications over Internet and Packet Scheduling.

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

1. Recall the concepts and Issues of Real Time Communications over Internet.
2. Classify protocols and algorithms for Communication Networks.
3. Identify the mechanisms for Quality of Service in networking.
4. Analyze IP addressing challenges and services in Internet.
5. Explain the different versions of IP Protocols, IP switching and MPLS Protocols.

CO-PO Articulation Matrix

PO/CO	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

Overview of Internet Concepts, Challenges and History: Overview of -ATM. TCP/IP Congestion and Flow Control in Internet; Throughput analysis of TCP congestion control, TCP for high bandwidth delay networks and Fairness issues in TCP.

UNIT - II

Issues of Real Time Communications over Internet: Adaptive applications, Latency and throughput, Resource reservation Protocol. Characterization of Traffic by Linearly Bounded Arrival Processes (LBAP), Leaky bucket algorithm and its properties, Token bucket algorithm and its properties.

UNIT - III

Packet Scheduling Algorithms-Requirements and Choices: Scheduling guaranteed service Connections, GPS, WFQ and Rate proportional algorithms, High speed scheduler design; Theory of Latency Rate servers and delay bounds in packet switched networks for LBAP traffic; Active Queue Management - RED, WRED and Virtual clock, Control theoretic analysis of active queue management.

UNIT - IV

IP Address Lookup-Challenges: Packet classification algorithms and Flow Identification, Grid of Tries, Cross producting and controlled prefix expansion algorithm. Admission control in Internet: Concept of Effective bandwidth, Measurement based admission control; Differentiated Services in Internet (DiffServ), DiffServ architecture and framework.

UNIT - V

Protocols and Technologies: IPV4, IPV6, IP tunneling, IP switching and MPLS, Overview of IP over ATM and its Evolution to IP switching; MPLS architecture and framework, MPLS Protocol, Traffic Engineering issues in MPLS.

TEXT BOOKS:

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.

SUGGESTED READING:

1. Anurag Kumar, D. Manjunath and Joy Kuri, "Communication Networking: An Analytical Approach", Morgan Kaufman Publishers, 2004.
2. Jean Wairand and Pravin Varaiya, "High Performance Communications Networks", 2nd Edition, 2000.

23ECC106

INDUSTRIAL IOT AND APPLICATIONS

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

Prerequisite: Embedded Systems and Internet of Things.

COURSE OBJECTIVES: This course aims to

1. Provide an overview of Industrial Internet of Things and Modelling of CPS and CMS.
2. Introduce Architectural Design Patterns for CMS and IIoT, Artificial Intelligence and Data Analytics for manufacturing.
3. Introduction to Advance manufacturing and Innovation Ecosystems.

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

1. Understand the Industrial Internet of Things and Cyber Physical manufacturing.
2. Analyze the Cyber Physical and Cyber Manufacturing systems.
3. Evaluate the Architectural design patterns for industrial Internet of Things.
4. Apply the AI and data Analytics for Industrial Internet of Things.
5. Evaluation of Workforce and Human Machine Interaction and Application of Industrial Internet of Things.

CO-PO Articulation Matrix

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

UNIT - I

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

UNIT - II

Modelling of CPS and CMS: Modelling of Cyber Physical Engineering and manufacturing, Model based engineering of supervisory controllers for cyber physical systems, Evaluation model for assessments of cyber physical production systems.

UNIT - III

Architectural Design Patterns for CMS and IIoT: CPS-based manufacturing and Industry 4.0., Integration of Knowledge base data base and machine vision, Interoperability in Smart Automation, Enhancing Resiliency in Production Facilities through CPS. Communication and Networking of IIoT.

UNIT - IV

Artificial Intelligence and Data Analytics for manufacturing: Application of CPS in Machine tools, Digital production, Cyber Physical system Intelligence, Introduction to big data, machine learning and condition monitoring.

Evaluation of Workforce and Human Machine Interaction: Worker and CPS, Strategies to support user intervention.

UNIT - V

Introduction to Advance manufacturing and Innovation Ecosystems:

Application of IIoT: Smart Metering, e-Health Body Area Networks, City Automation, Automotive Applications, Home Automation, Smart Cards, Plant Automation, Real life examples of IIOT in Manufacturing Sector. Industrial IoT- Application Domains: Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries.

TEXT BOOKS:

1. Sabina Jeschke, Christian Brecher Houbing Song, Danda B. Rawat "Industrial Internet of Things Cyber Manufacturing Systems", springer, 2016.
2. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2017.

SUGGESTED READING:

1. The Internet of Things: Key Applications and Protocols, Olivier Hersent Actility, David Boswarthick ETSI, Omar Elloumi Alcatel-Lucent, 2nd Edition, Wiley Publications. 2012.
2. Internet of Things- From Research and Innovation to Market Deployment; By Ovidiu & Peter; River Publishers Series, 2022.

23ECC107

5G AND BEYOND

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

Prerequisite: The student must prior 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 Massive MIMO, V2X & THz concepts.

COURSE OUTCOMES: After the completion of this course, the student 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. Apply the 5G concepts to D2D communications.
5. Demonstrate the concept of massive MIMO, V2X & THz.

CO-PO Articulation Matrix

PO/CO	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, 5G Architecture framework, 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 - V

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

V2X Communications: Vehicle-to-Vehicle (V2V) Communications, Vehicle-to-Infrastructure (V2I) Communications, Vehicle-to-Pedestrian (V2P) Communication, Self-driving Vehicles & its challenges, Vehicle-to-Network (V2N) Communications.

Novel aspects in Terahertz wireless communications: Overview, potential spectral windows at THz frequencies, Terahertz wave propagation characteristics, opportunities & challenges, applications.

TEXT BOOKS:

1. Saad Z. Asif, "5G Mobile Communications Concepts and Technologies" CRC Press, 2019.
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.
3. Wei Xiang, Kan Zheng, Xuemin (Sherman) Shen, **"**5G Mobile Communications", Springer publications-2016.
4. William Stallings "5G Wireless: A Comprehensive Introduction", Pearson Education, 2021.
5. Afif Osseiran, Jose F. Monserrat, Patrick Marsch, "5G Mobile and Wireless Communications Technology" Cambridge University Press-2016**.**

SUGGESTED READING:

1. R. S. Kshetrimayum, "Fundamentals of MIMO Wireless Communications", Cambridge University Press, UK, 2017.
2. Jonathan Rodriguez, "Fundamentals of 5G Mobile Networks" first edition, John Wiley & Sons, 2015.

23ECC103

ADVANCED DIGITAL SIGNAL PROCESSING LAB

Instruction	3 P Hours per Week
Duration of SEE	--
SEE	--
CIE	50 Marks
Credits	1.5

Prerequisite: The knowledge of signal processing algorithms and MATLAB are required.

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: After the completion of this course, the student will be able to
1. Implement FFT algorithms for linear filtering and correlation using MATLAB.
2. Design and realize of the digital filters using MATLAB.
3. Experiment with multirate techniques using MATLAB.
4. Perform parametric and non-parametric estimation of PSD using MATLAB.
5. Design and Implement the adaptive filters using MATLAB.

CO-PO Articulation Matrix

PO/CO	PO1	PO2	PO3	PO4	PO5
CO 1	2	3	1	2	2
CO 2	2	3	1	2	2
CO 3	1	3	1	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.
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.

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.

SUGGESTED READING:

1. Vinay K. Ingle and John G. Proakis, "Digital Signal Processing using MATLAB", 4th edition, Cengage learning, 2011.

23ECC104

WIRELESS AND MOBILE COMMUNICATION LAB

Instruction	3 P Hours per Week
Duration of SEE	--
SEE	--
CIE	50 Marks
Credits	1.5

Prerequisite: Concepts of Electromagnetic theory, Antennas & Wave propagation and Digital Communication.

COURSE OBJECTIVES: This course aims to

1. Facilitate the experimental setup for understanding the Cellular concepts and experiments using GSM and CDMA.
2. Provide the facility to learn AT commands in 3G networks and DSSS technique for CDMA to observe various spread spectrum parameters.
3. Build knowledge on concepts of software radio by studying building blocks such as Baseband and RF section.

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

1. Appraising Cellular concepts, GSM and CDMA networks.
2. Experimenting with GSM handset and fault insertion techniques.
3. Illustrate 3G communication system by means of various AT commands usage in GSM.
4. Testing on DSSS kit for implementing CDMA concept.
5. Develop concepts of Software Radio in real time environment.

CO-PO Articulation Matrix

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

LIST OF EXPERIMENTS:

1. Study of DSSS technique for CDMA to observe effect of PN codes, Chiprate, Spreading factor and Processing gain.
2. Wireless Path loss Computations - Study of Propagation Path loss Models: Indoor & Outdoor
3. Study Transmitter and Receiver sections in Mobile Handset and also measure GMSK modulated signal.
4. Study various GSM AT Commands such as SMS and HTTP.
5. Study File system by AT commands in 3G network.
6. Simulate Bluetooth voice transmission to observe effect of AWGN and of interference of 802.11b on transmission
7. Develop a mobile application for wireless technology using any wizards such as available on www.appypie.com or any other.
8. Develop concepts of Software radio by studying building blocks such as Baseband and RF section.
9. Study and analyze different modulation techniques in time and frequency domains using SDR Kit.
10. Develop Convolutional Encoder, Interleaver and De-Interleaver in Software Radio.
11. Estimation of GPS satellite position using RINEX data.
12. Estimation of key performance parameters of IRNSS L5 and S1 band signals.
13. Estimation of user position using GNSS Single Frequency receiver.
14. Demonstration on generation and estimation of the CW power levels using spectrum analyser.

SUGGESTED READING:

1. T.S.Rappaport, "Wireless Communications Principles and Practice", 2nd edition, PHI, 2002.

23ECC108

ADVANCED COMMUNICATION NETWORKS LAB

Instruction	3 P Hours per Week
Duration of SEE	--
SEE	--
CIE	50 Marks
Credits	1.5

Prerequisite: Students should have in depth knowledge of Computer Networks.

COURSE OBJECTIVES: This course aims to:

1. Provide the student with knowledge sub-netting and routing mechanisms.
2. Provide the student with knowledge of basic routing protocols for Network design and implementation.
3. Provide the student with knowledge configuring User Datagram Protocol.

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

1. Identify the different types of network devices and their functions within a network.
2. Understand and build the skills of sub-netting and routing mechanisms.
3. Understand basic protocols of computer networks, and how they can be used to assist in Network design and implementation.
4. Configure a network using Linux and a mail server for IMAP/POP protocols.
5. Design and configure UDP Client Server.

CO-PO Articulation Matrix

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

LIST OF EXPERIMENTS:

1. Study of Networking Commands (Ping, Tracert, TELNET, nslookup, netstat, ARP, RARP) and Network Configuration Files.
2. Linux Network Configuration.
   a. Configuring NIC's IP Address.
   b. Determining IP Address and MAC Address using if-config command.
   c. Changing IP Address using if-config.
   d. Static IP Address and Configuration by Editing.
   e. Determining IP Address using DHCP.
   f. Configuring Hostname in /etc/hosts file.
3. Design TCP iterative Client and Server application to reverse the given input sentence.
4. Design a TCP concurrent Server to convert a given text into upper case using multiplexing system call "select".
5. Design UDP Client Server to transfer a file.
6. Configure a DHCP Server to serve contiguous IP addresses to a pool of four IP devices with a default gateway and a default DNS address. Integrate the DHCP server with a BOOTP demon to automatically serve Windows and Linux OS Binaries based on client MAC address.
7. Configure DNS: Make a caching DNS client, and a DNS Proxy; implement reverse DNS and forward DNS, using TCP dump/Wire shark characterize traffic when the DNS server is up and when it is down.
8. Configure a mail server for IMAP/POP protocols and write a simple SMTP client in C/C++/Java client to send and receive mails.
9. Configure FTP Server on a Linux/Windows machine using an FTP client/SFTP client Characterize file transfer rate for a cluster of small files 100k each and a video file of700mb.Use a TFTP client and repeat the experiment.
10. Signaling and QoS of labeled paths using RSVP in MPLS.
11. Find shortest paths through provider network for RSVP and BGP.
12. Understand configuration, forwarding tables, and debugging of MPLS.

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.

23ECC109

ADVANCED IOT AND APPLICATIONS LAB

Instruction	3 P Hours per Week
Duration of SEE	--
SEE	--
CIE	50 Marks
Credits	1.5

Prerequisite: Embedded systems.

COURSE OBJECTIVES: This course aims to

1. Implement hardware setup for IoT and interface the components to perform end user applications.
2. Develop basic programming skills for deploying various IoT protocols.
3. Design and develop IoT environment-based solutions.

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

1. Analyze various software and hardware components required for IoT technology.
2. Interface analog and digital sensing & actuating equipment using Raspberry Pi.
3. Apply knowledge of IoT to solve engineering problems.
4. Implement security mechanisms for IoT systems.
5. Evaluate the performance of IoT systems.

CO-PO Articulation Matrix

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

LIST OF EXPERIMENTS:

1. Familiarizing the Raspberry Pi hardware and to perform necessary software installation.
2. To interface LED/Buzzer with Raspberry Pi and write a program to turn On LED for 1 sec after every 2 seconds.
3. To interface Push Button/Digital sensor (IR/LDR) with Raspberry Pi and write a program to turn ON LED when push button is pressed or at sensor detection.
4. To interface DHT11 sensor with Raspberry Pi and write a program to print temperature and humidity readings.
5. To interface motor using relay with Raspberry Pi and write a program to turn ON motor when push button is pressed.
6. To interface OLED with Raspberry Pi and write a program to print temperature and humidity readings on it.
7. To interface Bluetooth with Raspberry Pi and write a program to send sensor data to smart phone using Bluetooth.
8. To interface Bluetooth with Raspberry Pi and write a program to turn ON/OFF when 1/0 is received from smartphone using Bluetooth.
9. Write a program on Raspberry Pi to upload/retrieve temperature and sensor data from Thing speak cloud.
10. Write a program on Raspberry Pi to publish and subscribe sensor data to/from MQTT broker.
11. Write a program to create TCP server on Beaglebone Black and respond with sensor data to TCP client when requested.
12. Write a program to create UDP server on Raspberry Pi/Beaglebone Black and respond with sensor data to UDP client when requested.

SUGGESTED READING:

1. 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.

23ECC110

MINI PROJECT

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

Prerequisite: Knowledge of preparing slides by using power point presentations, capable of searching for suitable literature and presentation skills.

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

PO/CO	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. As part of the curriculum in the II - Semester of the Program 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

23ECC111

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: After the completion of this course, the student 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

PO/CO	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 / Parameter**
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.

23ECC112

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: After the completion of this course, the student 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

PO/CO	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: CIE (Continuous Internal Evaluation)		Max. Marks: 100 Max. Marks: 50
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 reportstandard format
	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 Preparation
	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.

23ECE101

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

Pre requisite: Basic course on principles of Analog and Digital communication systems.

COURSE OBJECTIVES: This course aims to

1. Understand the network design issues and protocols.
2. Analyze data network performance in terms of Quality-of-service parameters and compare SDH and SONET.
3. Design a simple optical network based on WDM.

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

1. Identify performance issues for Data networks.
2. Analyze the Queuing Models of Networks.
3. Understand the performance of end-to-end protocols for Data networks.
4. Explain the architecture of SONET/SDM and measure the performance comparison between SONET and SDM networks.
5. Understand the network survivability with different protection schemes and design simple WDM networks.

CO-PO Articulation Matrix

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

UNIT - I

Network Design Issues: Network Performance Issues, Network Terminology, Centralized and Distributed Approaches for Networks Design, Data Networks and their Design, Link layer design- Link adaptation, Link Layer Protocols, Retransmission. ARQ Mechanisms and their analysis.

UNIT - II

Queuing Models of Networks: Multiplexing of Traffic on a Communication Link Little's Theorem, M/M/1 Queueing System, Inter-networking, Bridging, Global Internet, IP protocol and addressing, Subnetting, Classless Inter Domain Routing (CIDR), IP address lookup, Routing in Internet.

UNIT - III

End to End Protocols: TCP and UDP. Congestion Control, Additive Increase/Multiplicative Decrease, Slow Start, Fast Retransmit/ Fast Recovery**:** Congestion avoidance, RED TCP Throughput Analysis, Quality of Service in Packet Networks. Network Calculus, Packet Scheduling Algorithms.

UNIT - IV

SONET/SDH: Optical transport network, IP, Routing and forwarding, Multiprotocol label switching; WDM network elements: Optical line terminals and amplifiers, Optical add/drop Multiplexers, OADM architectures, reconfigurable OADM, optical cross connects.

UNIT - V

Network Survivability: protection in SONET/SDH & client layer, Optical layer services and Interfacing, Optical layer protection Schemes.

WDM Network Design: LTD and RWA Problems, dimensioning wavelength routing Networks, statistical dimensioning models. Introduction to PON, GPON, AON.

TEXT BOOKS:

1. L. Peterson and B. S. Davie, "Computer Networks: A Systems Approach", 5th Edition, Morgan Kaufman, 2011.
2. Rajiv Rama Swami, Sivarajan, Sasaki, "Optical Networks: A Practical Perspective", MK, Elsevier, 3rd edition, 2010.
3. C. Siva Ram Murthy and Mohan Guruswamy, "WDM Optical Networks: Concepts Design, and Algorithms", PHI, EEE, 2001.

SUGGESTED READING:

1. Aaron Kershenbaum, "Telecommunication Network Design Algorithms", McGraw Hill, 1993.
2. D. Bertsekas and R. Gallager, "Data Networks", 2nd Edition, Prentice Hall, 1992.

23ECE102

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: After the completion of this course, the student 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

PO/CO	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.

23ECE103

RADIATING SYSTEMS FOR RF COMMUNICATION

(Program Elective - I)

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.

COURSE OBJECTIVES: This course aims to

1. The basic principles of an antenna and its parameters for characterizing its performance.
2. The concepts of various types of antennas and arrays for customizing the radiation pattern.
3. The fundamental concept of MIMO antennas.

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

1. Understand the radiation properties of antenna and analyze different type of wire antennas.
2. Analyze the linear arrays for uniform and nonuniform distribution.
3. Learn the concept of different types of planar antenna.
4. Understand the field equivalence principle for aperture antenna.
5. Learn about different type of MIMO and wearable antenna system and measurement techniques.

CO-PO Articulation Matrix

PO/CO	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

UNIT - I

Radiation Mechanism of Antenna: Fundamental Parameters of Antennas, Region separation, Antenna vector effective length, Image Theory, Friis Transmission equation, Field analysis for infinitely small dipole antenna.

UNIT - II

Uniform and Non-Uniform Arrays: N-Element Uniform array, Broadside and End Fire Arrays, Phased antenna array, Non Uniform array: Binomial and Tschebyscheff distribution, Smart Antenna.

UNIT - III

Planar Antennas: Microstrip Antenna: Basic Characteristics, feeding mechanisms, Transmission line model and Cavity Model. Circular polarized Patch antenna. Planer monopole antenna, PIFA Antenna, Vivaldi Antenna.

UNIT - IV

Aperture Antennas: Huygen's Field Equivalence principle, Horn Antennas: E-Plane, H-plane horns, and Pyramidal horn antennas, Reflector Antenna.

UNIT - V

Advanced Antenna System: Introduction to MIMO antenna, MIMO parameter: Envelope Correlation Coefficient, Diversity Gain. Wearable antenna, Specific absorption rate (SAR).

Antenna Measurement and Testing: Measurement by Vector Network Analyzer, Anechoic Chamber and Free space measurement.

TEXT BOOKS:

1. Constantine A. Balanis, "Antenna Theory: Analysis and Design," 4thEdition, John Wiley, 2016.
2. Malviya, L., Panigrahi, R. K., & Kartikeyan, M. V. "MIMO Antennas for Wireless Communication: Theory and Design." CRC Press. 2020.
3. Sabban, Albert. "Novel Wearable Antennas for Communication and Medical Systems", CRC Press, 2017.

SUGGESTED READING:

1. Dennis Roody and John Coolen, “Electronic Communications”, 4th Edition, Prentice Hall, 2008.
2. John D. Krauss, Ronald J. Marhefka & Ahmad S. Khan, “Antennas and Wave Propagation,” 4thEdition, TMH, 2010.
3. I.J.Bhal and P.Bhartia, “Micro-strip antennas”, Artech house, 1980.

23ECE104

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 is essential.

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 the types of networks and apply the services.
2. Distinguish and analyze various VoIP Protocols.
3. Design, implement, and analyze Protocols for the transport of voice media over IP networks.
4. Identify the types of VPN and tunneling protocols for security.
5. Familiarize the various networks by apply the Network security principles.

CO-PO Articulation Matrix

PO/CO	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-P2P 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.

23ECE105

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 basic principles and need of MIMO and OFDM systems.
2. Analyze the MIMO system in terms of space-time coding and various beam forming methodologies.
3. Channel estimation for MIMO-OFDM systems.

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

1. Understand the Concepts of MIMO, OFDM, Diversity, generic MIMO problem.
2. Compare the diversity techniques, Multicarrier techniques.
3. Apply Diversity Techniques and Pre-Coding techniques in MIMO.
4. Analyze MIMO, OFDM, space-time Block and Trellis coding.
5. Understand and Compare Channel Estimation techniques.

CO-PO Articulation Matrix

PO/CO	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 Multi-Antenna Systems: Switched beam, Adaptive Array, Introduction to MIMO systems, MIMO vs. Multi-Antenna Systems. Diversity, Exploiting multipath diversity, receive diversity, Transmit diversity, Delay diversity, The rake receiver, Combining techniques, Spatial Multiplexing, Spectral efficiency and capacity, Transmitting independent streams in parallel.

UNIT - II

Orthogonal Frequency Division Multiplexing: Introduction, Single-Carrier vs. Multi-Carrier Transmission, Basic Principle of OFDM, OFDM Modulation and Demodulation, BER of OFDM Scheme, Water-Filling Algorithm for Frequency-Domain Link Adaptation, Coded OFDM and OFDMA: Multiple Access Extensions of OFDM.

UNIT - III

The generic MIMO problem: Eigenvalues and eigenvectors, Pre-coding and combining in MIMO systems, Codebooks for MIMO, MIMO in LTE, Pre-coding for spatial multiplexing, Pre-coding for transmit diversity, Beam forming principles, Interference cancellation, Switched beam former, Adaptive beam former, Narrowband beam former, Wideband beam former.

UNIT - IV

Space-Time Codes: Introduction, 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, Space-time turbo encoders, Algebraic space-time codes.

UNIT - V

Channel Estimation: Channel estimation techniques: Training Based channel estimation, Least Squares (LS) and Minimum Mean Square Error (MMSE) channel estimation, Decision-Directed Channel Estimation, Blind and semi-blind channel estimation.

TEXT BOOKS:

1. Yong Soo Cho, Jaekwon Kim, "MIMO-OFDM Wireless Communications With MATLAB" John Wiley & Sons, 2010.
2. Rakhesh Singh Kshetrimayum, "Fundamentals of MIMO Wireless Communications" Cambridge University Press, 2017.
3. Claude Oestges and Bruno Clerckx, "MIMO Wireless Communications: From Real-world Propagation to Space-time Code Design", Academic Press, 2007.

SUGGESTED READING:

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

23ECE106

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 and signals are required.

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: After the completion of this course, the student 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

PO/CO	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.

23ECE107

INFORMATION THEORY AND CODING TECHNIQUES

(Program Elective - III)

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 are to be known.

COURSE OBJECTIVES: This course aims to

1. Study the several source coding techniques.
2. Study the channel coding theorem & various error control codes.
3. Study about 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. Describe 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. Recall the fundamental coding theorem for noisy channels (Shannon's Second Theorem) and relate its implications in coding mechanism.
4. Apply the principles of abstract algebra to design error control codes.
5. Make use of error control coding to achieve error detection and correction in digital transmission systems.

CO-PO Articulation Matrix

PO/CO	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

Turbo 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.

23ECE108

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.

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

PO/CO	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.

23ECE109

NETWORK SECURITY AND CRYPTOGRAPHY

(Program Elective - III)

Instruction	3 L 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. Identify and utilize different forms of cryptography techniques.
2. Analyze solutions for effective key management and distribution and conduct cryptoanalysis.
3. Predict Encrypt and decrypt data using Symmetric key and Asymmetric ciphers.
4. Assess authentication and security in the network applications.
5. Interpret different types of threats to the system and handle the same.

CO-PO Articulation Matrix

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

UNIT - I

Security: Need, security services, Attacks, OSI Security Architecture, one-time passwords, Model for Network security, Classical Encryption Techniques like substitution ciphers, Transposition ciphers, Cryptanalysis of Classical Encryption Techniques.

UNIT - II

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

UNIT - III

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

UNIT - IV

Authentication: IP and Web Security Digital Signatures, Digital Signature Standards, Authentication Protocols, Kerberos, IP security Architecture, Encapsulating Security Payload, Key Management, Web Security Considerations, Secure Socket Layer and Transport Layer Security, Secure Electronic Transaction.

UNIT - V

System Security: Intruders, Intrusion Detection, Password Management, Worms, Viruses, Trojans, Virus Countermeasures, Firewalls, Firewall Design Principles, Trusted Systems.

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, LenyZeltser, 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.

23ECE110

MACHINE LEARNING FOR NEXT GENERATION COMMUNICATION SYSTEMS

(Program Elective - IV)

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

Prerequisite: Digital Communication.

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: After the completion of this course, the student 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

PO/CO	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.

23ECE111

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: After the completion of this course, the student 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

PO/CO	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.

23ECE112

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: The knowledge of Wireless/Mobile communications is essential.

COURSE OBJECTIVES: This course aims to

1. Understanding of Sensor node architecture with hardware and software details for data storage and data dissemination.
2. Familiarization of sensor network protocols such as network based and cluster-based protocols.
3. Analysis of issues pertaining to connectivity, coverage and security in a WSN.

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

1. Recall the Network Architecture, hardware details, programming tools, Protocols and Special features of WSN.
2. Demonstrate hardware and Programming Tools for Performance comparison of wireless sensor networks simulation and experimental platforms.
3. Analyze Sensor Network Protocols and Security Challenges, Sensor deployment mechanisms.
4. Identify open issues for future research, and enabling technologies in wireless sensor network.
5. Design wireless sensor network system for different applications under consideration.

CO-PO Articulation Matrix

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

UNIT - I

Introduction and overview: Sensor network architecture and its applications, Sensor Network comparison with Ad- Hoc Networks, Sensor node architecture with hardware and software details. Sensor deployment mechanisms, Data dissemination and processing; data storage; query processing.

UNIT - II

Hardware: Mica2, Mica-Z: system architecture, logical architecture, processing sub-system, I/O subsystem, secondary storage subsystem, power management subsystem, Performance comparison with other nodes Software (Operating Systems): tiny OS, MANTIS, Contiki, and Ret-OS.

UNIT - III

Programming tools: C, net-C. Performance comparison of wireless sensor networks simulation and experimental platforms like open source (NS-2) and commercial.

UNIT - IV

Overview of Sensor Network Protocols: MAC and routing/ Network layer protocols, node discovery protocols, multi-hop and cluster-based protocols, Fundamentals of 802.15.4, Bluetooth, Bluetooth Low Energy (BLE), UWB.

UNIT - V

Specialized Features of WSN: Energy preservation and efficiency; Security challenges; Fault tolerance, Issues related to Localization, Connectivity and topology, Sensor deployment coverage issues; Sensor Web; Sensor Grid, Open issues for future research, and Enabling technologies in Wireless sensor network.

TEXT BOOKS:

1. F. Zhao and L. Guibas, "Wireless Sensor Networks: An Information Processing Approach", Morgan Kaufmann, 1st Indian reprint, 2013.
2. H. Karl and A. Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley & Sons, India, 2012.
3. C. S. Raghavendra, K. M. Sivalingam, and T. Znati, Editors, "Wireless Sensor Networks", Springer Verlag, 1st Indian reprint, 2010.

SUGGESTED READING:

1. YingshuLi, MyT. Thai, Weili Wu, "Wireless sensor Network and Applications", Springer series on signals and communication technology, 2008.

23ECE113

COGNITIVE RADIO

(Program Elective - V)

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

Prerequisite: Basics of Wireless Communication.

COURSE OBJECTIVES: This course aims to

1. Develop an understanding of the theoretical foundations of Cognitive Radio Networks.
2. Design cognitive radios with effective spectrum detection techniques.
3. Evaluate the efficacy of different technologies for using radio communications, assess their impact on network performance, explore the challenges and optimization techniques.

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

1. Understand the fundamental concepts of cognitive radio networks.
2. Develop the cognitive radio, as well as techniques for spectrum holes detection that cognitive radio takes advantages in order to exploit it.
3. Understand technologies to allow an efficient use of radio communications based on two spectrum sharing business models/policies.
4. Understand fundamental issues regarding dynamic spectrum access, radio-resource management and trading, as well as a number of optimization techniques for better.
5. Explore the challenges of dynamic spectrum sensing and optimization techniques.

CO-PO Articulation Matrix

PO/CO	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 Cognitive Radios: Digital Dividend, Software Defined Radio (SDR), Cognitive Radio (CR) architecture, Functions of cognitive radio, Dynamic Spectrum Access (DSA), Components of cognitive radio, Spectrum Sensing, Spectrum Analysis and Decision, Potential Applications of Cognitive Radio.

UNIT - II

Spectrum Sensing: Introduction, Challenges, Spectrum Sensing Methods for Cognitive Radio - Matched Filtering, Waveform-Based Sensing, Cyclostationarity - Based Sensing, Energy Detector-Based Sensing, Radio Identification, Other Sensing Methods, Cooperative Sensing, Statistical Approaches and Prediction, Spectrum Sensing in Current Wireless Standards.

UNIT - III

Optimization Techniques of Dynamic Spectrum Allocation: Linear programming, convex programming, non-linear programming, integer programming, dynamic programming, stochastic programming.

UNIT - IV

Dynamic Spectrum Access and Management: Spectrum broker, cognitive radio architectures, centralized dynamic spectrum access, distributed dynamic spectrum access, learning algorithms and protocols.

UNIT - V

Spectrum Trading: Introduction to spectrum trading, classification to spectrum trading, radio resource pricing, brief discussion on economics theories in DSA (utility, auction theory), classification of auctions (single auctions, double auctions, concurrent, sequential). Research Challenges in Cognitive Radio: Network layer and transport layer issues, crosslayer design for cognitive radio networks.

TEXT BOOKS:

1. Ekram Hossain, Dusit Niyato, Zhu Han, "Dynamic Spectrum Access and Management in Cognitive Radio Networks", Cambridge University Press, 2009.
2. Huseyin Arslan, "Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems", Springer, 2007.

SUGGESTED READING:

1. Francisco Rodrigo Porto Cavalcanti, Soren Andersson, "Optimizing Wireless Communication Systems" Springer, 2009.
2. Linda Doyle, "Essentials of Cognitive Radio", Cambridge University Press, 2009.
3. Kwang-Cheng Chen, Ramjee Prasad, "Cognitive radio networks", John Wiley & Sons Ltd., 2009.
4. Bruce Fette, "Cognitive radio technology", Elsevier, 2nd edition, 2009.
5. Peter B. Kenington, "RF and Baseband Techniques for Software Defined Radio", Artech House, 2005.

23ECE114

DEEP LEARNING TECHNIQUES FOR SIGNAL PROCESSING

(Program Elective - V)

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: After the completion of this course, the student 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

PO/CO	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 Speech Recognition", 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.

23ECE115

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

1. Differentiate between traditional networks and software defined networks and understand 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

PO/CO	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 Table Structure, 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-Level NFV 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: A Comprehensive 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.

23CEA101

DISASTER MANAGEMENT

(Audit Course)

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

Prerequisite:

COURSE OBJECTIVES: This course aims to

1. Equip the students with the basic knowledge of hazards, disasters, risks and vulnerabilities including natural, climatic and human induced factors and associated impacts.
2. Impart knowledge in students about the nature, causes, consequences and mitigation measures of the various natural disasters.
3. Enable the students to understand risks, vulnerabilities and human errors associated with human induced disasters.
4. 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. 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: After the completion of this course, the student 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. 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 ability to understand various participatory approaches/strategies and their application in disaster management.

CO-PO Articulation Matrix

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

UNIT - I

Introduction: Basic definitions- Hazard, Disaster, Vulnerability, Risk, Resilience, Mitigation, Management; classification of types of disaster- Natural and man-made; 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 multi-storied buildings.

UNIT - IV

Disaster Impacts: Disaster impacts- environmental, physical, social, ecological, economical, 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 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 institutions, NGOs and other stakeholders; Policies and legislation for disaster risk reduction, DRR Programs 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.

SUGGESTED READING:

1. Ministry of Home Affairs". Government of India, "National disaster management plan, Part I and II",
2. K. K. Ghosh," Disaster Management", APH Publishing Corporation, 2006.
3. Hazards, Disasters and your community: A booklet for students and the community, Ministry of home affairs.
4. http://www.indiaenvironmentportal.org.in/files/file/disaster_management_india1.pdf
5. http://www.ndmindia.nic.in/ (National Disaster management in India, Ministry of Home Affairs)

23EGA101

ENGLISH FOR RESEARCH PAPER WRITING

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	0

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: After the completion of this course, the student 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

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

23EGA102

CONSTITUTION OF INDIA

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	0

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: After the completion of this course, the student 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

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

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: Zilla Panchayat, Elected Officials and their roles, CEO Zilla Panchayat: 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: 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:

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

23ADA101

PEDAGOGY STUDIES

(Audit Course)

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

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: After the completion of this course, the student 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

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

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.

23EGA104
PERSONALITY DEVELOPMENT THROUGH LIFE'S ENLIGHTENMENT SKILLS

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	0

Prerequisite: Awareness on Personality Development.

COURSE OBJECTIVES: This course aims to

4. Learn to achieve the highest goal happily.
5. Become a person with stable mind, pleasing personality and determination.
6. Awake wisdom among themselves.

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

6. Develop their personality and achieve their highest goal of life.
7. Lead the nation and mankind to peace and prosperity.
8. Practice emotional self regulation.
9. Develop a positive approach to work and duties.
10. Develop a versatile personality.

CO-PO Articulation Matrix

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

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 BhagawadGeeta: 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 BhagawadGeeta: Chapter 2- Verses 56, 62,68 - Chapter 12 – Verses 13, 14, 15, 16, 17, 18 - Personality of Role model from Shrimad BhagawatGeeta.

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/

23EEA101

SANSKRIT FOR TECHNICAL KNOWLEDGE

(Audit Course)

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

Course Outcomes Prerequisite:

COURSE OBJECTIVES: This course aims to

1. Get a working knowledge in illustrious Sanskrit, the scientific language in the world.
2. Make the novice Learn the Sanskrit to develop the logic in mathematics, science & other subjects.
3. Explore the huge knowledge from ancient Indian literature.

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

1. Develop passion towards Sanskrit language.
2. Decipher the latent engineering principles from Sanskrit literature.
3. Correlates the technological concepts with the ancient Sanskrit history.
4. Develop knowledge for the technological progress.
5. Explore the avenue for research in engineering with aid of Sanskrit.

CO-PO Articulation Matrix

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

UNIT - I

Introduction to Sanskrit Language: Sanskrit Alphabets-vowels-consonants- significance of Amarakosa-parts of speech-Morphology-creation of new words-significance of synonyms-sandhi-samasa-sutras-active and passive voice-Past/Present/Future Tense-syntax-Simple Sentences (elementary treatment only).

UNIT - II

Role of Sanskrit in Basic Sciences: Brahmagupthas lemmas (second degree indeterminate equations), sum of squares of n-terms of AP- sulba_sutram or baudhayana theorem (origination of pythogorous theorem)-value of pie-Madhava's sine and cosine theory (origination of Taylor's series). The measurement system-time-mass-length-temp, Matter elasticity-optics-speed of light (origination of michealson and morley theory).

UNIT - III

Role of Sanskrit in Engineering-I (Civil, Mechanical, Electrical and Electronics Engineering):

Building construction-soil testing-mortar-town planning-Machine definition-crucible-furnace-air blower-Generation of electricity in a cell-magnetism-Solar system-Sun: The source of energy, the earth-Pingala chandasutram (origination of digital logic system).

UNIT - IV

Role of Sanskrit in Engineering-II (Computer Science Engineering & Information Technology): Computer languages and the Sanskrit languages-computer command words and the vedic command words-analogy of pramana in memamsa with operators in computer language-sanskrit analogy of physical sequence and logical sequence, programming.

UNIT - V

Role of Sanskrit in Engineering-III (Bio-technology and Chemical Engineering): Classification of plants-plants, the living-plants have senses-classification of living creatures. Chemical laboratory location and layout-equipment-distillation vessel-kosthi yanthram.

TEXT BOOKS:

1. M Krishnamachariar, History of Classical Sanskrit Literature, TTD Press, 1937.
2. M.R. Kale, A Higher Sanskrit Grammar: For the Use of School and College Students, Motilal Banarsidass. Publishers, ISBN-13: 978-8120801783, 2015.
3. Kapail Kapoor, Language, Linguistics and Literature: The Indian Perspective, ISBN-10: 8171880649, 1994.
4. Pride of India, Samskrita Bharati Publisher, ISBN: 81-87276-27-4, 2007.
5. Shri RamaVerma, Vedas the source of ultimate science, Nag publishers, ISBN:81-7081-618-1, 2005.

23EGA103

STRESS MANAGEMENT BY YOGA

(Audit Course)

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

Prerequisite:

COURSE OBJECTIVES: This course aims to

1. Creating awareness about different types of stress and the role of yoga in the management of stress.
2. Promotion of positive health and overall wellbeing (Physical, mental, emotional, social and spiritual).
3. Prevention of stress related health problems by yoga practice.

COURSE OUTCOMES: After the completion of this course, the student 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

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

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.

SUGGESTED READING:

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

23ECA101

VALUE EDUCATION

(Audit Course)

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

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. Compile the values from holy books for personal and social responsibility.
5. Discuss concept of soul and reincarnation, values Dharma, Karma and Guna.

CO-PO Articulation Matrix

PO/CO	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

Values in Holy Books : Self-management, Good health and internal & external cleanliness**,** Holy books versus Blind faith, Character and Competence, Equality, Nonviolence, Humility, Role of Women.

UNIT - V

All religions and same message: Mind your mind, Self-control**,** Concept of soul, Science of Reincarnation, Character and Conduct, Concept of Dharma, Cause and Effect based Karma Theory, The qualities of Devine and Devilish, Satwic, Rajasic and Tamasicgunas.

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.

23CSO101

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: The objectives of this course are

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

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

1. Identify and describe complex business problems in terms of analytical models.
2. Apply appropriate analytical methods to find solutions to business problems that achieve stated objectives.
3. Interpret various metrics, measures used in business analytics
4. Illustrate various descriptive, predictive and prescriptive methods and techniques.
5. Model the business data using various business analytical methods and techniques.
6. Create viable solutions to decision making problems.

CO-PO Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PEO1	PEO2	PEO3
CO1	3	2	2	1	1	-	-
CO2	3	3	2	1	-	3	3
CO3	3	3	3	1	-	-	-
CO4	3	3	3	1	-	-	-
CO5	3	3	3	1	-	-	-
CO6	3	3	3	1	-	-	-

UNIT - I

Introduction to Business Analytics: Introduction to Business Analytics, need and science of data driven (DD) decision making, Descriptive, predictive, prescriptive analytics and techniques, Big data analytics, Web and Social media analytics, Machine Learning algorithms, framework for decision making, challenges in DDdecision 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 and method and random forest. Clustering: Distance and similarity measures used in clustering, Clustering algorithms, K-Means and Hierarchical algorithms, Prescriptive Analytics- Linear Programming (LP) and LP model building,

UNIT-V

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

TEXT BOOKS:

1. U Dinesh Kumar, "Business Analytics", Wiley Publications, 1st Edition, 2017
2. Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, "Business analytics Principles, Concepts, and Applications with SAS", Associate Publishers, 2015

Suggested Readings:

1. S. Christian Albright, Wayne L. Winston, "Business Analytics - Data Analysis and Decision Making", 5th Edition, Cengage, 2015.

23MEO103

COMPOSITE MATERIALS

(Open Elective)

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

Prerequisite: Basic knowledge of Engineering Materials and Mechanics.

COURSE OBJECTIVES: This course aims to

1. Composite materials and their constituents.
2. Classification of the reinforcements and evaluate the behaviour of composites.
3. Fabrication methods of metal matrix composites.
4. Manufacturing of Polymer matrix composites.
5. Failure mechanisms in composite materials.

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

1. Classify and characterize the composite materials.
2. Describe types of reinforcements and their properties.
3. Understand different fabrication methods of metal matrix composites.
4. Understand different fabrication methods of polymer matrix composites.
5. Decide the failure of composite materials.

CO-PO Articulation Matrix

PO/CO	PO1	PO2	PO3	PO4	PO5
CO 1	3	1	3	1	1
CO 2	3	1	3	1	1
CO 3	3	2	3	1	1
CO 4	3	2	3	1	1
CO 5	3	1	3	1	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 Behavior of Composites: Rule of Mixtures, Inverse Rule of Mixtures. Isostrain and Isostress Conditions.

UNIT – II

Manufacturing of Metal Matrix Composites: Casting – Solid State Diffusion Technique, Cladding – Hot Isostatic Pressing. Properties and Applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid Phase Sintering. Manufacturing of Carbon – Carbon Composites: Knitting, Braiding, Weaving. Properties and Applications.

UNIT – IV

Manufacturing of Polymer Matrix Composites: Preparation of Moulding Compounds and Prepegs – 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, Interacting Failure Criteria, Hygrothermal Failure. Laminate First Play Failure - Insight Strength.

TEXT BOOKS:

1. K.K.Chawla, "Composite Materials- Science and Engineering", 4th edition, Springer Verlag, 2019.
2. WD Callister, Jr., Adapted by R. Balasubramaniam , "Materials Science and Engineering, An Introduction"., John Wiley & Sons, NY, Indian edition, 2007.

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.

23CEO101

COST MANAGEMENT OF ENGINEERING PROJECTS

(Open Elective)

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

Prerequisite:

COURSE OBJECTIVES: This course aims to

1. Enable the students to understand the concepts of Project management.
2. Provide knowledge on concepts of Project Planning and scheduling.
3. Create an awareness on Project Monitoring and Cost Analysis.
4. Provide adequate knowledge to the students on Recourse Management Costing-Variance Analysis.
5. 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

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

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, 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 tradeoff- 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

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; 14th edition 2012.
2. Charles T. Horngren and George Foster, "Advanced Management Accounting" Prentice-Hall; 6th Revised edition, 1987.
3. Robert S Kaplan Anthony A. Atkinson, "Management & Cost Accounting", Pearson; 2nd edition, 1996.
4. K. K Chitkara, "Construction Project Management: Planning, scheduling and controlling", Tata McGraw-Hill Education. 2004 .
5. Kumar Neeraj Jha "Construction Project Management Theory and Practice", Pearson Education India; 2nd edition, 2015.

23MEO101

INDUSTRIAL SAFETY

(Open Elective)

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

Prerequisite: Awareness about Mechanical and Electrical hazards.

COURSE OBJECTIVES: This course aims to

1. Familiarize causes for industrial accidents and preventive steps to be taken.
2. Elucidate fundamental concepts of Maintenance Engineering.
3. Explain about wear and corrosion along with preventive steps to be taken
4. Provide basic concepts and importance of fault tracing.
5. Provide steps involved in carrying out periodic and preventive maintenance of various equipment used in industry

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

1. Identify the causes for industrial accidents and suggest preventive measures.
2. Identify the basic tools and requirements of different maintenance procedures.
3. Apply different techniques to reduce and prevent Wear and corrosion in Industry.
4. Identify different types of faults present in various equipments like machine tools, IC Engines, boilers etc.
5. Apply periodic and preventive maintenance techniques as required for industrial equipment like motors, pumps and air compressors and machine tools etc

CO-PO Articulation Matrix

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

UNIT - I

Industrial Safety: Accident, Causes, Types, Results and control, Mechanical and electrical hazards, Types, Causes and preventive steps/procedure, Describe salient points of factories act 1948 for health and safety, Wash rooms, Drinking water layouts, Light, Cleanliness, Fire, Guarding, Pressure vessels, Safety color codes, Fire prevention and fire fighting, Equipment and methods.

UNIT - II

Fundamentals of Maintenance Engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT - III

Wear and Corrosion and their Prevention: Wear, Types, Causes, Effects, Wear reduction methods, Lubricants, Types and applications, Lubrication methods, General sketch, Working and applications of Screw down grease cup, Pressure grease gun, Splash lubrication, Gravity lubrication, Wick feed lubrication, Side feed lubrication, Ring lubrication, Definition of corrosion, principle and factors affecting the corrosion, Types of corrosion, Corrosion prevention methods.

UNIT - IV

Fault Tracing: Fault tracing, Concept and importance, Decision tree concept, Need and applications, Sequence of fault finding activities, Show as decision tree, Draw decision tree for problems in machine tools, Hydraulic, Pneumatic, Automotive, Thermal and electrical equipment's like any one machine tool, Pump, Air compressor, Internal combustion engine, Boiler, Electrical motors, Types of faults in machine tools and their general causes.

UNIT - V

Periodic and Preventive Maintenance: Periodic inspection, Concept and need, Degreasing, Cleaning and repairing schemes, Overhauling of mechanical components, Overhauling of electrical motor, Common troubles and remedies of electric motor, Repair complexities and its use, Definition, Need, Steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of Machine tools, Pumps, Air compressors, Diesel generating sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, Advantages of preventive maintenance, Repair cycle concept and importance

TEXT BOOKS:

1. H. P. Garg, "Maintenance Engineering", S. Chand and Company.
2. Audels, "Pump-hydraulic Compressors", Mcgraw Hill Publication.

SUGGESTED READING:

1. Higgins & Morrow, "Maintenance Engineering Handbook", Da Information Services.
2. Winterkorn, Hans, "Foundation Engineering Handbook", Chapman & Hall London.

23MEO102

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

Prerequisite: Basic knowledge of Mathematics.

COURSE OBJECTIVES: This course aims to

1. Come to know the formulation of LPP models.
2. Understand the Transportation and Assignment techniques.
3. Come to know 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: After the completion of this course, the student 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 queing and inventory concepts in industrial applications.
5. Apply sequencing models in industries.

CO-PO Articulation Matrix

PO/CO	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	3	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.

23EEO101

WASTE TO ENERGY

(Open Elective)

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

Prerequisite: Prior knowledge of Energy Conversions.

COURSE OBJECTIVES: This course aims to

1. Know the various forms of waste
2. The extraction of Energy from Waste.
3. Infer the Global and national scenario.

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

1. Understand the concept of waste to energy.
2. Explore the various Energy extraction options.
3. Describe the Energy Production methodology.
4. Explicate the Environmental implications.
5. Compare and contrast waste to energy productions by case studies.

CO-PO Articulation Matrix

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

UNIT - I

Introduction: The Principles of Waste Management and Waste Utilization. Waste Management Hierarchy and 3R Principle of Reduce, Reuse and Recycle. Waste as a Resource and Alternate Energy source. Waste Sources & Characterization Waste production in different sectors such as domestic, industrial, agriculture, postconsumer, waste etc. Classification of waste – agro based, forest residues, domestic waste, industrial waste (hazardous and non-hazardous). Characterization of waste for energy utilization. Waste Selection criteria.

UNIT - II

Energy Extraction Options: Landfill gas, collection and recovery. Refuse Derived Fuel (RDF) – fluff, briquettes, pellets. Alternate Fuel Resource (AFR) – production and use in Cement plants, Thermal power plants and Industrial boilers. Conversion of wastes to fuel resources for other useful energy applications Energy from Plastic Wastes: Non-recyclable plastic wastes for energy recovery. Energy Recovery from waste and optimization of its use, benchmarking and standardization. Energy Analysis

UNIT - III

Energy production Methodologies: Collection, segregation, transportation and storage requirements. Location and Siting of 'Waste to Energy' plants. Industry Specific Applications: In-house use: sugar, distillery, pharmaceuticals, Pulp and paper, refinery and petrochemical industry and any other industry. Centralized and Decentralized Energy production, distribution and use. Comparison of Centralized and decentralized systems and its operations

UNIT - IV

Environmental Implications: Environmental standards for Waste to Energy Plant operations and gas clean-up. Savings on non-renewable fuel resources. Carbon Credits: Carbon foot calculations and carbon credits transfer mechanisms

UNIT - V

Case Studies: Success/failures of waste to energy Global Best Practices in Waste to energy production distribution and use. Indian Scenario on Waste to Energy production distribution and use in India. Success and Failures of Indian Waste to Energy plants. Role of the Government in promoting 'Waste to Energy'

TEXT BOOKS:

1. "Industrial and Urban Waste Management in India", TERI Press.
2. Banwari Lal and Patwardhan, "Wealth from Waste: Trends and Technologies" TERI Press.
3. S.N Mukhopadhyay, "Fundamentals of waste and Environmental Engineering", TERIPress.
4. "Waste-to-Energy in Austria – White Book – Figures, Data Facts", May 2010, 2nd edition.

SUGGESTED READING:

1. CPCB Guidelines for Co-processing in Cement/Power/Steel Industry
2. Report of the task Force on Waste to Energy, Niti Ayog (Formerly Planning Commission) 2014.
3. Municipal Solid Waste Management Manual, CPHEEO, 2016
4. Gazette Notification on Waste Management Rules 2016.

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(An Autonomous Institute | Affiliated to Osmania University)

Accreditated by NBA & NAAC (A++)

Kokapet Village, Gandipet Mandal, Hyderabad -500075, Telanagana.

E-mail: principal@cbit.ac.in, Website: www.cbit.ac.in

Phone No. : 040-24193276 / 277 / 279