RV College of Engineering®

Master of Technology (M.Tech)

COMMUNICATION SYSTEMS

Scheme And Syllabus Of I to IV Semester
(2024 Scheme)

B.E. Programs : AS, BT, CH, CS, CS - AI, CS - CD, CS - CY, CV, EC, EE, ET, IM, IS, ME.
M. Tech (13) MCA, M.Sc. (Engg.)
Ph.D. Programs : All Departments are recognized as Research Centres by VTU Except AI & AS

2024

Edition

99TH
NIRF RANKING IN ENGINEERING (2024)

1501+
Times Higher Education World University Rankings (2024)

601+
Asia University Ranking 2024

EduFuture Excellence Award
Best Private Engineering University (South)
by Zee Digital

1001+
Subject Ranking (Engineering)

801+
Subject Ranking (Computer Science)

IIRF 2024
Indian Institutional Ranking Framework

NATIONAL RANK - 07
STATE RANK - 02
ZONE RANK - 04

AAA
Rating in NPTEL Local Chapter (Jan - Apr 2024)
State Ranking - 1
National Ranking - 16

CURRICULUM STRUCTURE

07 CREDITS PROFESSIONAL CORE COURSE

04 CREDITS BASIC SCIENCE

16 CREDITS INTEGRATED PROFESSIONAL CORE COURSE

24 CREDITS PROJECT WORK

04 CREDITS AEC

19 CREDITS PROFESSIONAL ELECTIVES

06 CREDITS INTERNSHIP

80 CREDITS TOTAL

*ABILITY ENHANCEMENT COURSES (AEC), UNIVERSAL HUMAN VALUES (UHV), INDIAN KNOWLEDGE SYSTEM (IKS), YOGA

17
Centers of Excellence

11
Centers of Competence

1569
Publications On SCI

440
Publications On Web Of Science

2842
Citations
Last 3 Years

70
Patents Filed

40
Patents Granted
Last 3 Years

61
Published Patents

29
Skill Based Laboratories Across Four Semesters

MOUS: 90+WITH INDUSTRIES / ACADEMIC INSTITUTIONS IN INDIA & ABROAD

₹5 crores
Sponsored Projects

₹14 crores
Consultancy Projects

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Glossary of Abbreviations

1.	AS	Aerospace Engineering
2.	BS	Basic Sciences
3.	BT	Biotechnology
4.	CH	Chemical Engineering
5.	CHY	Chemistry
6.	CIE	Continuous Internal Evaluation
7.	CS	Computer Science & Engineering
8.	CV	Civil Engineering
9.	EC	Electronics & Communication Engineering
10.	EE	Electrical & Electronics Engineering
11.	EI	Electronics & Instrumentation Engineering
12.	ET	Electronics & Telecommunication Engineering
13.	GE	Global Elective
14.	HSS	Humanities and Social Sciences
15.	IM	Industrial Engineering & Management
16.	IS	Information Science & Engineering
17.	L	Laboratory
18.	MA	Mathematics
19.	MBT	M. Tech in Biotechnology
20.	MCE	M. Tech. in Computer Science & Engineering
21.	MCN	M. Tech. in Computer Network Engineering
22.	MCS	M. Tech. in Communication Systems
23.	MDC	M. Tech. in Digital Communication
24.	ME	Mechanical Engineering
25.	MHT	M. Tech. in Highway Technology
26.	MIT	M. Tech. in Information Technology
27.	MMD	M. Tech. in Machine Design
28.	MPD	M. Tech in Product Design & Manufacturing
29.	MPE	M. Tech. in Power Electronics
30.	MSE	M. Tech. in Software Engineering
31.	MST	M. Tech. in Structural Engineering
32.	MVE	M. Tech. in VLSI Design & Embedded Systems
33.	N	Internship
34.	P	Projects (Minor / Major)
35.	PHY	Physics
36.	SDA	Skill Development Activity
37.	SEE	Semester End Examination
38.	T	Theory
39.	TL	Theory Integrated with Laboratory
40.	VTU	Visvesvaraya Technological University

POSTGRADUATE PROGRAMS

Sl. No	Core Department	Program	Code
1.	BT	M. Tech in Biotechnology	MBT
2.	CS	M. Tech in Computer Science & Engineering	MCE
3.	CS	M. Tech in Computer Network Engineering	MCN
4.	CV	M. Tech in Structural Engineering	MST
5.	CV	M. Tech in Highway Technology	MHT
6.	EC	M. Tech in VLSI Design & Embedded Systems	MVE
7.	EC	M. Tech in Communication Systems	MCS
8.	EE	M. Tech in Power Electronics	MPE
9.	ET	M. Tech in Digital Communication	MDC
10.	IS	M. Tech in Software Engineering	MSE
11.	IS	M. Tech in Information Technology	MIT
12.	ME	M. Tech in Product Design & Manufacturing	MPD
13.	ME	M. Tech in Machine Design	MMD
14.	MCA	Master of Computer Applications	MCA

ELECTRONICS & COMMUNICATION ENGINEERING

DEPARTMENT VISION

Imparting quality technical education through interdisciplinary research, innovation and teamwork for developing inclusive & sustainable technology in the area of Electronics and Communication Engineering.

DEPARTMENT MISSION

1. To impart quality technical education to produce industry-ready engineers with a research outlook.
2. To train the Electronics & Communication Engineering graduates to meet future global challenges by inculcating a quest for modern technologies in the emerging areas.
3. To create centers of excellence in the field of Electronics & Communication Engineering with industrial and university collaborations.
4. To develop entrepreneurial skills among the graduates to create new employment opportunities.

PROGRAMME OUTCOMES (PO)

M. Tech in **Communication Systems** graduates will be able to:

PO1: Independently carry out research/investigation and development work to solve the practical problems related to Communication Systems.

PO2: Write and present a substantial technical report/document in the field of Communication Systems.

PO3: Demonstrate a degree of mastery over the area of Communication Systems. The mastery should be level higher than the requirements of bachelor's in Electronics & Communication Engineering program.

PO4: Abstract the requirements of modern microelectronics and smart systems to offer innovative solutions with available IPs and interfaces.

PO5: Design and develop wireless and wireline communication system modules with good economics to meet Quality of Service.

PO6: Acquire professional and intellectual integrity, research ethics and execute socio-concern projects related to communication systems.

LEAD SOCIETY

Institute of Electrical and Electronics Engineers (IEEE)

INDEX

I SEMESTER M.Tech Communication Systems												
Sl. No.	**Course Code**	**Course Title**	**Credit Allocation**				**BoS**	**Category**	**CIE Duration (H)**	**Max Marks CIE**	**SEE Duration (H)**	**Max Marks SEE**
			L	**T/ SDA**	**P**	**Total**						
1	MMA211TC	Statistical Signal Processing with Machine Learning	3	1	0	4	MA	Theory	1.5	100	3	100
2	MCS212IA	Advanced Single Carrier Communications	3	0	1	4	EC	Theory+ Lab	1.5	100+50	3	100+50
3	MCS313IA	Advanced Communication Networks and Protocols	3	0	1	4	EC	Theory+ Lab	1.5	100+50	3	100+50
4	MXX214AX	Professional Cluster Elective Courses (Group-A)	3	1	0	4	Resp BoS	Theory	1.5	100	3	100
5	MCS415DL	Design Thinking Lab	0	0	2	2	EC	Lab	1.5	50	2	50
6	HSS116EL	Technical English	0	0	1	1	HSS	Lab	1.5	50	2	50
Total Credits						**19**						

Professional Cluster Elective Courses (Group-A)			
Sl.No	**BoS**	**Course Code**	**Course Title**
1	EC	MCS214A1	Programming, Data Structures and Algorithms
2	ET	MDC214A2	Multimedia Communications
3	EE	MPE214A3	Electric and Hybrid Vehicles
4	EC	MVE214A4	Digital System Design with FPGA

II SEMESTER M.Tech Communication Systems												
Sl. No.	**Course Code**	**Course Title**	**Credit Allocation**				**BoS**	**Category**	**CIE Duration (H)**	**Max Marks CIE**	**SEE Duration (H)**	**Max Marks SEE**
			L	**T/ SDA**	**P**	**Total**						
1	MCS321IA	Advanced Multicarrier Communications	3	0	1	4	EC	Theory+Lab	1.5	100+50	3	100+50
2	MCS322IA	MIMO and Beamforming for Smart Antennas	3	0	1	4	EC	Theory+Lab	1.5	100+50	3	100+50
3	MCS323BX	Program Specific Elective (Group-B)	3	1	0	4	EC	Theory	1.5	100	3	100
4	MXX324CX	Professional Cluster Elective (Group-C)	3	1	0	4	Resp BoS	Theory	1.5	100	3	100
5	MXX325DX	Interdisciplinary Courses (Global Electives) (Group-D)	3	0	0	3	Resp BoS	Theory	1.5	100	3	100
6	MIM426RT	Research Methodology	2	0	0	2	IM	NPTEL	--	--	2	50
7	MCS427SL	Skill Lab	0	0	2	2	EC	Lab	1.5	50	2	50
Total Credits						**23**						

Program Specific Elective (Group-B)			
Sl. No	**BoS**	**Course Code**	**Course Title**
1	EC	MCS323B1	Advanced 5G and Applications
2	EC	MCS323B2	Next Generation wireless LAN
3	EC	MCS323B3	Quantum Communication
4	EC	MVE323B4	Automotive Embedded Systems

Professional Cluster Elective (Group-C)			
Sl. No.	**BoS**	**Course Code**	**Course Title**
1	EC	MCS324C1	Computer Vision with DL
2	ET	MDC324C2	Adhoc Networks
3	EE	MPE324C3	Intelligent control techniques in Electrical Drives
4	EC	MVE324C4	Semiconductor Manufacturing

Interdisciplinary Courses (Global Electives) (Group-D)			
Sl. No.	**BoS**	**Course Code**	**Course Title**
1	BT	MBT325DA	Nature Impelled Engineering
2	BT	MBT325DB	Clinical Data Management
3	CS	MCN325DC	Cyber Forensics and Cyber Laws
4	CV	MCV325DD	Industrial Safety and Health
5	CV	MCV325DE	Advanced Technologies for Transportation Systems
6	EC	MEC325DF	Design & Implementation of Human-Machine Interface
7	EE	MEE325DG	Electric Vehicle technology - II
8	ET	MET325DH	Electronic Navigation Systems
9	ET	MET325DJ	Vehicular Communication Ecosystem
10	IM	MIM325DK	Essentials of Project Management
11	IS	MIS325DM	User Interface & User Experience
12	MA	MMA325DN	Mathematical Methods for Data Science
13	ME	MME325DO	Industry 4.0: The Smart Manufacturing
14	ME	MME325DQ	Industrial Internet of Things (IIoT)

III SEMESTER M.Tech Communication Systems												
Sl. No.	**Course Code**	**Course Title**	**Credit Allocation**				**BoS**	**Category**	**CIE Duration (H)**	**Max Marks CIE**	**SEE Duration (H)**	**Max Marks SEE**
			L	**T/ SDA**	**P**	**Total**						
1	MCS331TA	Error Control Coding for Wireless Communication	3	1	0	4	EC	Theory	1.5	100	3	100
2	MCS232EX	Professional Elective Course (Group-E)	2	0	0	2	EC	NPTEL	--	--	2	50
3	MCS433P	Minor Project	0	0	6	6	EC	Project	1.5	50	3	50
4	MCS434N	Internship	0	0	6	6	EC	Internship	1.5	50	3	50
Total Credits						**18**						

Professional Elective Course (Group-E) NPTEL			
Sl. No	**BoS**	**Course Code**	**Course Title**
1	EC	MCS232E1	Fiber Optic Communication Technology
2	EC	MCS232E2	Simulation of Communication Systems using MATLAB
3	EC	MCS232E3	Modern Digital Communication Techniques
4	EC	MCS232E4	Principles of Modern CDMA/MIMO/OFDM Wireless Communications

IV SEMESTER M.Tech Communication Systems												
Sl. No.	**Course Code**	**Course Title**	**Credit Allocation**				**BoS**	**Category**	**CIE Duration (H)**	**Max Marks CIE**	**SEE Duration (H)**	**Max Marks SEE**
			L	**T/ SDA**	**P**	**Total**						
1	MCS241FX	Program Specific Courses (Group-F)	2	0	0	2	EC	NPTEL	--	--	2	50
2	MCS442P	Major Project	0	0	18	18	EC	Project	--	100	3	100
Total Credits						**20**						

Program Specific Courses (Group-F) NPTEL			
Sl. No	**BoS**	**Course Code**	**Course Title**
1	EC	MCS241F1	Digital Communication using GNU Radio
2	EC	MCS241F2	5G Wireless Standard Design
3	EC	MCS241F3	Satellite Communication
4	EC	MCS241F4	Analysis and Design of Microwave Antennas

SEMESTER: I						
Course Code	**:**	**MMA211TC**	**STATISTICAL SIGNAL PROCESSING WITH MACHINE LEARNING** Professional Core Course (Theory)	**CIE Marks**	**:**	**100**
Credits L-T-P	**:**	**3:1:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**45L+30T+45EL**		**SEE Duration**	**:**	**3 Hours**

UNIT - I	**09 Hours**

Random Vectors: Probability models of N random variables, Vector notation, Marginal probability functions, Joint probability density function, Independence of random variables and random vectors, Expected values of sums, multiplication and division of Random Variables Probability density function of the sum of two random variables. Functions of random vectors, Expected value vector and Correlation matrix, Gaussian random vectors.

UNIT - II	**09 Hours**

Moment Generating Functions (MGF): Introduction, MGF of the sum of independent random variables, Characteristic function and Probability generating function.

Random Processes (RP): Ensemble, Probability density function, Independence, Expectations, Stationarity, Correlation Functions - Autocorrelation Function (ACF), Cross-Correlation Function (CCF), Addition, and Multiplication, Ergodic Random Processes, Addition and Multiplication of RPs.

UNIT - III	**09 Hours**

Feature extraction in signal processing: Extraction of Time domain features like mean, variance, correlation, skewness, energy envelop of signal etc. Extraction of Frequency domain features like dominant frequency, peak value etc, classification of signals based on feature extraction. Overview of Probability Theory, Case studies on feature extraction. Implementation using Python.

UNIT - IV	**09 Hours**

Introduction to Machine Learning: Basic types of data in machine learning, exploring structure of data, Data pre-processing, Model Selection, Stochastic gradient descent algorithms, Boosting and Regularization Paths. Linear Regression, logistic regression, Bayesian Linear Regression. Classification Model - Linear and logistic classifier, k-Nearest Neighbour. Implementation using Python.

UNIT - V	**09 Hours**

Machine Learning Models: Unsupervised vs Supervised Learning, Decision tree, Random Forest model, Application of Supervised Learning, Case studies on supervised machine learning.

Application of Unsupervised Learning - Principal Component Analysis, Case studies on unsupervised machine learning. Implementation using Python.

Course Outcomes:

After going through this course the student will be able to:

CO1	:	Explore fundamental concepts of random vectors, moment generating functions, random process, feature extraction in signal processing and machine learning applied in communication systems. **(PO1, PO4, PO6)**
CO2	:	Apply theoretical concepts of random vectors, moment generating functions, random process, feature extraction in signal processing to model problems of communication system using machine learning. **(PO1, PO2, PO3, PO4, PO6)**
CO3	:	Analyze and solve the problems in communication systems using appropriate techniques of statistical and mathematical learning to the real-world problems arising in many practical situations. **(PO1, PO3, PO5, PO4, PO6)**
CO4	:	Demonstrate professional and ethical integrity in applying statistical signal processing techniques using machine learning to solve real-world problems. **(PO1, PO2, PO4, PO5, PO6)**

Reference Books

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, "Introduction to Algorithms", The MIT Press, 3rd Edition, 2009, ISBN: 978-0262033848
2. Roy D. Yates, David J. Goodman, "Probability and Stochastic Processes", An Indian Adaptation. Wiley, 3rd Edition, 2021, ISBN: 9789354243455.
3. Douglas C. Montgomery and George C. Runger, "Applied Statistics and Probability for Engineers", John Wiley & Sons, 7th Edition, 2019, ISBN: 9781119570615.
4. Shai Shalev-Shwartz and Shai Ben-David "Understanding Machine Learning: From Theory to Algorithms", 1st Edition, Cambridge University Press, 2014, ISBN: 978-1-107-05713-5.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks]**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **THREE quizzes** will be conducted (Two regular quizzes and one optional improvement quiz) & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **THREE** tests will be conducted (Two regular tests and one optional improvement test). Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

Semester: I						
ADVANCED SINGLE CARRIER COMMUNICATIONS Professional Core Course (Theory & Practice)						
Course Code	**:**	**MCS212IA**		**CIE**	**:**	**100+50 Marks**
Credits: L:T:P	**:**	**3:0:1**		**SEE**	**:**	**100+50 Marks**
Total Hours	**:**	**45L+30P+45EL**		**SEE Duration**	**:**	**03 + 03 Hrs**

Unit-I	**09 Hrs**
Signal Representation – Low pass representation of bandpass signals, Low pass representation of bandpass random process. Multiplexing, De-multiplexing and Frame Synchronization of Signals. **Modulation**: Modulation Schemes without memory (Band Limited Schemes - PAM, BPSK, QPSK, MPSK, MQAM, and Power Limited Schemes – FSK, MFSK, DPSK, DQPSK), modulation schemes with memory (PAM – AMI Variants, Manchester and MSK), Transmit PSD for Modulation Schemes.	
Unit – II	**09 Hrs**
Demodulation - Vector Channel, Vector Channel +AWGN, Performance parameters – SER, BER and EVM **Coherent Detection** for power limited and Bandlimited schemes, Optimal Coherent detection for MSK **Non – Coherent detection** for schemes without and with memory (FSK, DPSK, DQPSK, MSK).	
Unit –III	**09 Hrs**
Bandlimited Channels: Bandlimited channel characterization, signalling through band limited linear filter channels, Sinc, RC, Duobinary and Modified Duobinary signaling schemes, Optimum receiver for channel with ISI and AWGN. **Linear Equalizers**: Zero forcing Equalizer, MSE and MMSE, Baseband and Passband Linear Equalizers. Performance of ZFE and MSE.	
Unit –IV	**09 Hrs**
Non-Linear Equalizers: Decision - feedback equalization, Predictive DFE, Performance of DFE. **Adaptive equalization**: Adaptive linear equalizer, adaptive decision feedback equalizer, Adaptive Fractionally spaced Equalizer (Tap Leakage Algorithm).	
Unit –V	**09 Hrs**
Synchronization - Signal Parameter Estimation - The Likelihood Function for Carrier Recovery and Symbol Synchronization in Signal Demodulation. **Carrier Phase Estimation** - ML Carrier Phase Estimation, The PLL, Effect of Additive Noise on the Phase Estimate, Decision-Directed and Non-Decision-Directed Loops. **Symbol Timing Estimation** - ML Timing Estimation, Non-Decision-Directed Estimation	
Practical's: 1. M-PSK transceiver Design using Labview 2. M-QAM transceiver Design using Labview 3. ISI with PAM modulation technique using MATLAB 4. Equalization with QAM Modulation using Labview 5. Symbol Timing Estimation using MATLAB 6. Frequency selective and non-selective fading channel simulation using MATLAB 7. Carrier Phase Estimation: Decision-Directed and Non-Decision-Directed Loops using MATLAB 8. M-PSK transceiver Design using USRP 2920 Software Defined Radio 9. M-QAM transceiver Design using USRP 2920 Software Defined Radio 10. M-FSK transceiver Design using USRP 2920 Software Defined Radio	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explore the concept of low pass and Bandpass signals representations at the Transmitter, the process of Detection and Estimation at the receiver in the presence of AWGN only.

CO2:	Evaluate Receiver performance for various types of single carrier symbol modulations through ideal and AWGN Non-band limited and band limited channels
CO3:	Design single carrier equalizers for various symbol modulation schemes and detection methods for defined channel models, and compute parameters to meet desired rate and performance requirements.
CO4:	Design and develop Carrier recovery , Timing recovery and Frame recovery schemes for specific single carrier application in wireless, wireline domains

Reference Books	
1.	Digital Communications, John G. Proakis, Masoud Salehi, 5th Edition, Pearson Education, 2014, ISBN:9789339204792
2.	Digital Communications: Fundamentals and Applications: Fundamentals &Applications, Bernard Sklar,2nd Edition, Pearson Education, 2009, ISBN:978-8131720929
3.	Signal Detection and Estimation, Mourad Barkat, 2nd Edition, Artech house, 2005, ISBN: 1580530702
4.	Digital Communications Systems, Simon Haykin ,1st Edition ,Wiley, 2014, ISBN:978-8126542314

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	CIE THEORY TOTAL	**100**
RUBRICS FOR CONTINUOUS INTERNAL EVALUATION (CIE-Lab)		
Q.NO.	**CONTENTS**	**MARKS**
1	Conduction of the Experiments & Lab Record	30
2	Open-ended Lab Experiment	10
3	Lab Test	10
CIE LAB TOTAL		**50**
MAXIMUM MARKS FOR THE CIE		**150**
RUBRICS FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20

5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
SEE THEORY TOTAL		**100**
RUBRICS FOR SEMESTER END EXAMINATION (SEE-Lab)		
Q.NO.	**CONTENTS**	**MARKS**
1	Write Up	10
2	Conduction of the Experiments	20
3	Viva	20
SEE LAB TOTAL		**50**
MAXIMUM MARKS FOR THE SEE		**150**

Semester: I						
ADVANCED COMMUNICATION NETWORKS AND PROTOCOLS Professional Core Course (Theory & Practice)						
Course Code	**:**	**MCS313IA**		**CIE**	**:**	**100+50 Marks**
Credits: L:T:P	**:**	**3:0:1**		**SEE**	**:**	**100+50 Marks**
Total Hours	**:**	**45L+30P+45EL**		**SEE Duration**	**:**	**03 + 03 Hrs**

Unit-I	**09 Hrs**
Foundation: Building a Network, Requirements, Perspectives, Scalable Connectivity, - Cost Effective Resource sharing, Internet, Protocol, Network Edge, Network Core, Access Networks and Physical Media, Delay and Loss in Packet-Switched Networks, Protocol Layers and Their Service Models, Internet Backbones, NAPs, and ISPs. Network models, OSI, TCP/IP Protocol layering, Performance, Bandwidth and Latency, Delay X Bandwidth Product, Stop-and-Wait, Sliding Window.	
Unit – II	**09 Hrs**
Internetworking I: Switching and Bridging, Datagram's, Virtual Circuit Switching, Source Routing, Bridges and LAN Switches, Basic Internetworking (IP), Internetwork, Global Addresses, Datagram Forwarding in IP, Subnetting and classless addressing, Address Translation (ARP) Host Configuration (DHCP), Error Reporting(ICMP), Virtual Networks and Tunnels.	
Unit –III	**09 Hrs**
Internetworking- II: Network as a Graph, Distance Vector (RIP), Link State (OSPF), Metrics, The Global Internet, Routing Areas, Routing among Autonomous systems (BGP), IP Version 6(IPv6), Mobility and Mobile IP. **End-to-End Protocols:** Simple Demultiplexer (UDP), Reliable Byte Stream (TCP), End-to-End Issues, Segment Format, Connecting Establishment and Termination	
Unit –IV	**09 Hrs**
Modern day Networking: Network Impasse, Network Ossification. Network Softwarization – Introduction, Network Virtualization, Network Function Virtualization (NFV)-Architecture and Concepts, Separation of control plane and data plane Software Defined Networking (SDN).	
Unit –V	**09 Hrs**
Congestion Control and Resource Allocation: Congestion-Avoidance Mechanisms, DEC bit, Random Early Detection (RED), Source-Based Congestion Avoidance. The Domain Name System (DNS), Electronic Mail (SMTP, POP, IMAP, MIME), World Wide Web (HTTP), Network Management (SNMP)	

Practical:

Part –I: Experiments Using C/C++ programming

1. Bit stuffing & character stuffing.
2. Cyclic Redundancy check.
3. Implement leaky bucket congestion control algorithm
4. Minimum spanning tree.

Part-II: Tool Based Simulation

1. Design an Ethernet network comprising of 25 nodes and calculate Packet delivery ratio given the packet size to be 1024 bytes, consider the following application layer protocols a. FTP b. CBR
2. Simulate an IBSS (Independent Basic Service Set) network / Ad-hoc network using 500 sq.km. terrain and plot the output characteristics for a). Packet Delivery Ratio b) Throughput c). Average Jitter d) RTS / CTS and acknowledgement.
3. Simulate a wireless scenario with different two routing protocol distance vector routing protocol (AODV) and Link state routing protocol (OLSR), analyze statistics for two routing protocol.

4. Implement a four node point to point network with links n0-n2, n1-n2and n2-n3. Apply TCP agent between n0-n3 and UDP between n1-n3. Apply relevant applications over TCP and UDP agents by changing the parameters and determine the number of packets sent by TCP/UDP
5. Implementation of Link state routing algorithm.

Open ended experiments:
Programmable Networks- P4 Programming. , SmartNICS and P4 switches.

Course Outcomes: **After completing the course, the students will be able to**	
CO1:	Explore advanced concepts of next generation networks.
CO2:	Analyze TCP/IP variants, network Algorithm's, Protocols and their functionalities.
CO3:	Comprehend features of SDN and its application to next generation systems.
CO4:	Develop different protocols used at application layer.

Reference Books	
1	Computer Networks: A System Approach, Larry Peterson and Bruce S Davis 5th Edition , Elsevier - 2014,ISBN-13:978-0123850591
2	Software defined networks A systems Approach. Larry Peterson, cascone, O'conner,vachnusks and Davie, 4th Edition 2021,ISBN-13:978-1736472101
3	Internetworking with TCP/IP, Principles, Protocols and Architecture, Douglas E Comer, 6th Edition, PTR PHI – 2014, ISBN-0131756052,9780131756052
4	Computer Networks, Protocols, Standards and Interfaces, Uyless Black, 2nd Edition – PHI-2007, ISBN-0131756052,9780131756052
5	TCP /IP Protocol Suite, Behrouz A Forouza n, McGaw-Hill publishing,4th Edition-2009, ISBN-0077414594,9780077414597

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**

3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video-based seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis **(20 Marks)**, lab test **(10 Marks),** and Innovative Experiment/ Concept Design and Implementation (2**0 Marks)** adding up to 50 Marks.	**50**
	MAXIMUM MARKS FOR THE CIE THEORY	**150**

RUBRICS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO Questions of 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

RUBRIC FOR THE SEMESTER END EXAMINATION (LAB)		
Q. NO.	**CONTENTS**	**MARKS**
1	Write Up	10
2	Execution	20
3	Viva	20
	TOTAL	**50**

Semester: I						
PROGRAMMING, DATA STRUCTURES AND ALGORITHMS (Theory) (Professional Cluster Elective- Group A)						
Course Code	**:**	**MCS214A1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+30T+45EL**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Introduction to data structures: Introduction to oops concepts. Introduction to data representation, Linear Lists, Linked Representation **Algorithm Analysis:** Mathematical Background, Model, What to Analyze, Running Time Calculations.	
Unit – II	**09 Hrs**
Stack and queue: Stack and queue implementation using linear list and linked list. Stack application-Parenthesis matching, Queue application-railroad car rearrangement. **Hashing:** Hash table representation- ideal hashing, hashing with linear open addressing, hash tables with chains	
Unit –III	**09 Hrs**
Binary and other Trees: Trees, Binary Trees, Properties and Representation of Binary Trees-Formula Based Representation, Linked Representation, Common Binary Tree Operations. **Binary Search Tree (BST).** Organizing data in a BST. Inserting and deleting items in a BST.	
Unit –IV	**09 Hrs**
Priority Queues (Heaps): Model, Simple Implementations, Binary Heap, Leftist Heaps. **Graph Algorithms:** Definitions, Properties of graphs, Representation of Graphs, Shortest-Path Algorithms, Network Flow Problems, Minimum Spanning Tree, Depth-First Search, Breadth-First Search, Introduction to NP-Completeness	
Unit –V	**09 Hrs**
Searching and Sorting Techniques: Sorting Techniques: Bubble sort, Merge sort, Selection sort', Heap sort, Insertion Sort. Searching Techniques: Sequential Searching, Binary Searching, Search Trees. **Algorithm Design Techniques:** Greedy Algorithms, Divide and Conquer, Dynamic Programming, Randomized Algorithms, Backtracking Algorithms	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Illustrate the fundamental concepts of various technologies in data structures which are used in computer programs
CO2:	Derive the solution by applying the acquired knowledge of classic data structures: array lists, linked lists, stacks, queues, heaps, binary trees, hash tables.
CO3:	Evaluate the solution of the problems using graph algorithms.to the real-world problems arising in many practical situations
CO4:	Design and development of various algorithms built using different data structures knowledge to apply and engage in life – long learning.

Reference Books	
1	Data Structures and Algorithm Analysis in C++ (3rd edition), by M. A. Weiss. Addison-Wesley, ISBN-10: 032144146X & ISBN-13: 9780321441461

2	Sartaj Sahani; "Data structures, Algorithms and applications in c++"; McGraw Hill; 2000;1st Edition; ISBN: 10:007236226X
3	Data Structures and Algorithms in Python, Michael T. Goodrich, Roberto Tamassia, Michael H Goldwasser,1st Edition,ISBN: 978-1-118-29027-9,March 2013
4	Data Structures & Algorithms in Python, John Canning Alan Broder Robert Lafore, 2023 Pearso Education,ISBN-13: 978-0-13-485568-4
5	Data Structures and algorithms Analysis in Java. 3 Editions, Pearson Publication, by Mark Alle Weiss, ISBN-13: 978-0132576277, ISBN-10: 0132576279

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)	
COMPONENTS	**MARKS**
QUIZZES: Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
TESTS: Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
EXPERIENTIAL LEARNING: Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) &** **Phase II (20) ADDING UPTO 40 MARKS**.	**40**
MAXIMUM MARKS FOR THE CIE	**100**
RUBRICS FOR SEMESTER END EXAMINATION (SEE-Theory)	
CONTENTS	**MARKS**
Unit 1: Question 1 or 2	20
Unit 2: Question 3 or 4	20
Unit 3: Question 5 or 6	20
Unit 4: Question 7 or 8	20
Unit 5: Question 9 or 10	20
MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: I						
MULTIMEDIA COMMUNICATIONS (Theory) (Professional Cluster Elective- Group A)						
Course Code	**:**	**MDC214A2**		**CIE Marks**	**:**	**100**
Credits L-T-P	**:**	**3:1:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**45L+30T+45EL**		**SEE Duration**	**:**	**3 Hours**

UNIT - I	**09 Hrs**
Multimedia Communications: Multimedia information representation, multimedia networks, multimedia applications, network QoS and application QoS.	
UNIT - II	**09 Hrs**
Standards and Protocols: JPEG (image compression) ,JPEG 2000 compression standard – development process, features, architecture, bit stream, Audio coding standards for Multimedia: Dolby, AA3, Vorbis. MPEG – 21 multimedia frame work, Protocols - RTP, RTCP, RTSP, RSVP.	
UNIT - III	**09 Hrs**
Video compression: Video compression principles, video compression standards: H.261, H.263, MPEG 1, MPEG 2, and MPEG 4. DivX, Flash Video, Avi, WMV.	
UNIT - IV	**09 Hrs**
Multimedia Entertainment Networks: Introduction, Cable TV networks, Satellite TV networks, Terrestrial TV networks. High speed PSTN access Technologies.	
UNIT - V	**09 Hrs**
Digital Video Broadcasting: DVB Interoperabilities, DVB System, Baseband processing, Digital Television, Services over IP-based networks, Services, Authentication, Authorization. DVB and Internet: IP Multicast, Audio/Video streaming.	

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Explain multimedia information representation, networks and compression techniques
CO2	:	Analyze applications like interpersonal communication, interactive communication over the internet and entertainment networks.
CO3	:	Apply various coding methods and compression techniques.
CO4	:	Analyze and explain the various broadcasting systems.

Reference Books

1. Multimedia Communications, Fred Halsall, 2001, Pearson education, ISBN: 978-81-317-0994-8.

2. Introduction to Multimedia Communications, K. R. Rao, Zoran S. Bojkovic, Dragorad, A. Milovanovic, 2014, Wiley, ISBN 13 978-0-471-46742-7.

3. Multimedia Communication Systems, K. R. Rao, Zoran S. Bojkovic, Dragorad A, Milovanovic,, 2004, Pearson education, ISBN: 013031398X.

4. Data Communications and Networking, Behrouz A Forouzan, 2015, 4th Edition, McGraw Hill publication, ISBN-13:978-0-07-063414-5.

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)	
COMPONENTS	**MARKS**

QUIZZES: Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
TESTS: Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
EXPERIENTIAL LEARNING: Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) &** **Phase II (20) ADDING UPTO 40 MARKS**.	**40**
MAXIMUM MARKS FOR THE CIE	**100**
RUBRICS FOR SEMESTER END EXAMINATION (SEE-Theory)	
CONTENTS	**MARKS**
Unit 1: Question 1 or 2	20
Unit 2: Question 3 or 4	20
Unit 3: Question 5 or 6	20
Unit 4: Question 7 or 8	20
Unit 5: Question 9 or 10	20
MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: I						
ELECTRIC AND HYBRID VEHICLES (Theory) (Professional Cluster Elective- Group A)						
Course Code	**:**	**MPE214A3**		**CIE Marks**	**:**	**100**
Credits L-T-P	**:**	**3:1:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**45L+30T+45EL**		**SEE Duration**	**:**	**3 Hours**

UNIT - I	**09 Hrs**
Introduction to EV & HEV: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive -trains on energy supplies. **Conventional Vehicles:** Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance. **EV & HEV Drive trains:** Basic concepts & components, hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.	
UNIT - II	**09 Hrs**
Electric Traction unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.	
UNIT - III	**09 Hrs**
Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. **Energy Management Strategies:** Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.	
UNIT - IV	**09 Hrs**
Traction Motors: Design, Sizing, Thermal Analysis and Modeling. **Series and Parallel Hybrid Drive Train Design:** Operation Patterns, Control Strategies, Sizing of the Major Components, Power Rating Design of the Traction Motor, Power Rating Design of the Engine/Generator, Design of PPS, Design Example.	
UNIT - V	**09 Hrs**
Design of DC-DC Converters for EV-HEV Applications: Multi-input DC-DC Converters, Multi-input converter Using High/Low Voltage Sources, Flux Additive DC-DC Converter, Bidirectional DC-DC Converters. **Case studies:** Typical converters for EV and HEV Applications.	

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Understand and explain the configuration and propulsion system of EV and HEV.
CO2	:	Analyse the performance EV and HEV drive trains.
CO3	:	Design the structure of EV and HEV.
CO4	:	Evaluate the PE converters performance to EV and HEV applications.

Reference Books
1. Mehrdad Ehsani, Yimin Gao, Sebatien Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel cell vehicles: Fundamentals, Theory and Design", CRC Press, 3rd Edition, 2004, ISBN: 978-1498761772.
2. Iqbal Husain, "Electric and Hybrid Vehicles- Design Fundamentals" CRC Press, 2nd Edition, 2011, ISBN:978-1439811757.
3. Zhang Xi , Mi Chris, "Vehicle Power Management Modeling, Control and Optimization" Springer, 1st Edition, 2011, ISBN: 978-0-85729-735-8.
4. Mi Chris, Masrur A., and Gao D.W.," Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives", Wiley Publisher, 1st Edition, 2011, ISBN:0-824-77653-5.

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)	
COMPONENTS	**MARKS**
QUIZZES: Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
TESTS: Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
EXPERIENTIAL LEARNING: Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) &** **Phase II (20) ADDING UPTO 40 MARKS**.	**40**
MAXIMUM MARKS FOR THE CIE	**100**
RUBRICS FOR SEMESTER END EXAMINATION (SEE-Theory)	
CONTENTS	**MARKS**
Unit 1: Question 1 or 2	20
Unit 2: Question 3 or 4	20
Unit 3: Question 5 or 6	20
Unit 4: Question 7 or 8	20
Unit 5: Question 9 or 10	20
MAXIMUM MARKS FOR THE SEE	**100**

Semester: I						
DIGITAL SYSTEM DESIGN WITH FPGA (Theory) (Professional Cluster Elective- Group A)						
Course Code	**:**	**MVE214A4**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+30T+45EL**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Introduction to Verilog and Design Methodology: Verilog IEEE standards, Verilog Data Types: Net, Register and Constant. Verilog Operators, Number representation and Verilog ports, Simulation and Synthesis, Test-benches. Verilog Primitives. Logic Simulation, Design Verification, and Test Methodology: Four-Value Logic and Signal Resolution in Verilog, Test Methodology Signal Generators for Test benches, Sized Numbers. Introduction to Design Methodology: Digital Systems and Embedded Systems, Real-world circuits. Design Methodology: Design Flow-Architecture.	
Unit – II	**09 Hrs**
Verilog Modelling Styles: Behavioral Modelling: Latches and Level-Sensitive Circuits in Verilog, Cyclic Behavioral Models of Flip-Flops and Latches, Behavioral Models of Multiplexers, Encoders, Decoders and Arithmetic circuits. Dataflow Modelling: Boolean Equation-Based Models of Combinational Logic, Propagation Delay and Continuous Assignments. Linear-Feedback Shift Register. Tasks & Functions. Structural Modelling: Design of Combinational Logic, Verilog Structural Models, Top-Down Design and Nested Modules. (Hands on using Xilinx Vivado tool)	
Unit –III	**09 Hrs**
Synthesis of Digital Sub-systems: Synthesis of Combinational Sub-systems: Introduction to Synthesis, Synthesis of Combinational Logic, Synthesis of Sequential Logic with Latches, Synthesis of Three-state Devices and Bus Interfaces. Synthesis of Sequential Sub-systems: Synthesis of Sequential Logic with Flip-Flops, Synthesis of Explicit State Machines, Registered Logic, State Encoding, Synthesis of Implicit State Machines, Registers and Counters. (Hands on using Xilinx Vivado)	
Unit –IV	**09 Hrs**
System Implementation and Fabrics: CPLD vs FPGA Architecture - Programming Technologies-Chip I/O Programmable Logic Blocks- Fabric and Architecture of FPGA. Xilinx Virtex 5.0 Architecture - Xilinx Virtex VI Architecture – ALTERA Cyclone II Architecture - ALTERA Stratix IV Architecture, Hardcore and Softcore FPGA. (Examples such as counter, sequence detector, sequence generator etc, implementation on FPGA board)	
Unit –V	**09 Hrs**
Processor Design and System Development: Design of Processor Architectures: Functional Units for Addition, Subtraction and Multiplication (overview). Design: Hierarchical Decomposition STG-Based Controller Design, Efficient STG-Based Sequential Binary Multiplier. Case Studies: Algorithms and Architectures for Digital Processors, Digital Filters and Signal Processors	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Identify different modeling styles for various Digital Systems.
CO2:	Verify the behavior of Digital Circuits using Simulation and Validation Techniques.

CO3:	Analyze Digital Systems and build small-scale applications using Interfacing concepts.
CO4:	Demonstrate the skill of cost-effective system designs through proper selection of Implementation Fabric.

Reference Books	
3.	Advanced Digital Design with the Verilog HDL, Michael D. Ciletti, 2nd Edition, 2015, PHI, ISBN: 978–0–07–338054–4.
4.	Digital Systems Design Using Verilog, 1st Edition, 2015, Charles Roth, Lizy K. John, ByeongKil Lee, Cengage Learning, ISBN-10: 1285051076
3.	Digital Design: An Embedded Systems Approach Using VERILOG, Peter J. 1st Edition, 2010, Ashenden, Elsevier, ISBN: 978-0-12-369527-7
4.	IEEE Standard Verilog Hardware Description Language," in IEEE Std 1364-2001, vol., no., pp.1-792, 2001, ISBN: 978-0-7381-4851-9
5.	Fundamentals of Digital Logic with Verilog Design, Stephen Brown and Zvonko Vranesic, 6th Edition, 2014, McGraw Hill publication, ISBN: 978–0–07–338054–4

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO Questions of 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: I						
DESIGN THINKING LAB (Lab)						
Course Code	**:**	**MCS415DL**		**CIE**	**:**	**50 Marks**
Credits: L:T:P	**:**	**0:0:2**		**SEE**	**:**	**50 Marks**
Hours/Week	**:**	**4**		**SEE Duration**	**:**	**2 Hours**

Design thinking is a methodology which provides a solution-based approach to solving problems. It is extremely useful when used to tackle complex problems, as it serves to understand the societal needs involved, reframe the problem in human-centric ways, create numerous ideas in brainstorming sessions and adopt a hands-on approach to prototype and testing.

The 5 Stages in the Design Thinking Process
Stage 1: Empathize—Compile Users' Needs.
Stage 2: Define—State Users' Needs and Problems.
Stage 3: Ideate—Challenge Assumptions and Create Ideas.
Stage 4: Prototype—Start to Create Solutions.
Stage 5: Test—validate the solutions obtained.

The five stages of design thinking will help students to apply the methodology to solve complex problems that occur in product designs. The students are encouraged to apply the 5 stages in the Design Thinking Process to solve the problems in the area identified.

The broad area identified for the M.Tech in specialization is as under:
Theme1: Algorithms for Data Communication
Algorithms for Data Communication Over the Telephone Network: A modem operating at data signalling rates of up to 33 600 bit/s for use on the general switched telephone network and on leased point-to-point 2 wire telephone-type circuits. Simulations in MATLAB.

Theme2: Algorithms for Air Interface
Algorithms for Air Interface Physical Layer of GSM, GPRS, 3G : Modulation, Synchronization , Mapping to Logical Channels, Channel Estimation. Simulations in MATLAB.

Theme3: Emulation in RF-SoC
Introduction and hands on familiarity with RF- SoC Platform – Training Sessions
Emulation of Data Communications Modem functions with Testing routines in RF-SoC Platform.
Emulation of 3G Physical Layer Modem Functions with Testing routines in RF-SoC Platform.

Course Outcomes: After completing the course, the students will be able to	
CO1:	Demonstrate a clear understanding of the principles and stages of the design thinking process, including empathy, ideation, prototyping, and testing.
CO2:	Apply design thinking methodologies to address complex real-world challenges and drive innovation.
CO3:	Analyse and evaluate the success of design solutions and identify areas for improvement.
CO4:	Develop creativity, problem-solving skills and learn iterations, trial and error, and failure that are all part of the creative learning process.

Reference Books	
1	https://onlinecourses.nptel.ac.in/noc22_mg32/preview
2	ITU-T V34 SERIES V: DATA COMMUNICATION OVER THE TELEPHONE NETWORK Interfaces and voiceband modems
3	GSM – Architecture, Protocols and Services: Jörg Eberspächer Technische Universität München, Germany , Hans-Jörg Vögel BMW Group Research & Technology, Germany, Christian Bettstetter University of Klagenfurt, Austria, 2009 John Wiley & Sons Ltd, ISBN 978-0-470-03070-7
4	RF SoC Platform Literature- User Manual

RUBRIC FOR CONTINUOUS INTERNAL EVALUATION (CIE-Lab)
The evaluation of the work will be carried out by the committee appointed by the Head of the department.
Student/team should submit a report on the Case Studies solved under the theme.
Evaluation will be carried out in THREE Phases.

Phase	Activity	MARKS
I	Phase I	10
II	Phase II	15
III	Phase III and Draft report	15
	Final report	10
	MAXIMUM MARKS FOR THE CIE	**50**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Lab)
The evaluation will be done by Internal and External examiners through Exhibition Mode.
The following weightage would be given for the exhibition:

Q.NO.	CONTENTS	MARKS
1	Presentation through posters	15
2	Demonstration of the Prototype	25
3	Vivavoce	10
MAXIMUM MARKS FOR THE SEE		**50**

SEMESTER: I						
TECHNICAL ENGLISH **(Online English Laboratory Course)** **Common to all** **(Humanities and Social Sciences)**						
Course Code	**:**	**HSS116EL**		**CIE Marks**	**:**	**50 Marks**
Credits L:T:P	**:**	**0:0:1**	**Online English Laboratory Course**	**SEE Marks**	**:**	**50 Marks**
Hours	**:**	**30P**	**Humanities and Social Sciences**	**SEE Duration**	**:**	**2 Hours**
Unit – I						**10 Hrs**
The Basics. Business Documents, Questions, and the Technical Pursuit. Engineering Concepts and Complexity; The Future Tense for Technical Work. White Papers; Modifiers and Qualifiers.						
Unit – II						**10 Hrs**
Making Recommendations; Interpreting Data, Ethical Persuasion for Technical Projects; Cause and Effect; Calls for Proposals. Technical Complexity in Communication. Numbers, Plain English, Jargon, and Technical Terms, Active and Passive Structures.						
Unit – III						**10 Hrs**
Organization Needs; Seeing the Big Picture; Negotiating. Audience Needs and Assessment; Standards versus White Papers; Objectivity, Communicating within Expected Genres; Identifying Trustworthy Sources or Bias in. A Review of Major Course Takeaways.						

Course Outcomes: After completing the course, the students will be able to	
CO1	Demonstrate clarity and precision in technical communication by structuring information effectively, balancing technical terms with plain English, and adapting to diverse audiences.
CO2	Analyze and produce professional documents, such as white papers, business proposals, and reports, while applying ethical persuasion, data interpretation, and evidence-based reasoning.
CO3	Evaluate and refine communication strategies by assessing audience needs, recognizing trustworthy sources, and navigating organizational and technical complexities.
CO4	Apply critical thinking and negotiation skills to align communication with organizational goals, anticipate future challenges, and support informed decision-making.

References	
1	IEEE – EBSCO Technical English for Professionals – Online platform
2	Valerie Lambert, Elaine Murray, English for Work – Everyday Technical English, Pearson Education, 2003, ISBN- 0 582 53963-3
3	David Bonamy, Christpher Jacques, Technical English – First Course Book, Pearson Education, 2008
4	S Sumant. Technical English I, The McGraw Hill, 2011, ISBN -978 81 8209 308 9

Assessment and Evaluation Pattern (Online Mode)		
	CIE (Online Mode)	**SEE (Online Mode)**
Weightage	**50%**	**50%**
Test – I	Each test will be conducted for 50 marks adding to 100 marks. Final test marks will be reduced to 40 marks	**Final assessment will be conducted for 50 marks**
Test – II		
Experiential Learning	10 Marks	
Communication Skills- Activity based test – Script writing, Essay Writing, Role plays. Any other activity that enhances the Communication skills. The students will be assigned with a topic by the faculty handling the batch. The students can either prepare a presentation/write essay/role play etc. for the duration (4-5 minutes per student). **Parameters for evaluation of the Presentation** a. Clarity in the presentation/ Speaking/Presentation skills. b. Concept / Subject on which the drama is enacted/ scripted		
Maximum Marks	50 Marks	**50 Marks**
Total marks for the course	**50**	**50**

Semester: II						
ADVANCED MULTICARRIER COMMUNICATIONS (Theory & Practice) (Professional Core Course)						
Course Code	**:**	**MCS321IA**		**CIE**	**:**	**100+50 Marks**
Credits: L:T:P	**:**	**3:0:1**		**SEE**	**:**	**100+50 Marks**
Total Hours	**:**	**45L+30P+45EL**		**SEE Duration**	**:**	**03 + 03 Hours**

Unit-I	**09 Hrs**
Synthesizers - PLL Synthesizers, fractional PLL synthesizers, Direct Digital synthesizers **Fading** – Large scale, small scale; Statistical characterization of multipath channels – Delay and Doppler spread, classification of multipath channels, scattering function; **Binary signalling** over Fading Channels - Frequency non selective, and Frequency selective Cases.	
Unit – II	**09 Hrs**
Fading and Diversity: - Diversity techniques for performance improvement with binary signaling over FNS, Slow fading channels – power combining and Maximal ratio combining; Channel estimation and synchronization for Single Carrier Channels **Fading over Frequency selective channels** – Rake receivers, Performance, Tap weight Synchronization.	
Unit –III	**09 Hrs**
Capacity of channel: A Review of Entropy. Introduction of Differential Entropy and properties. Mutual Information and Capacity. **Capacity Computations** for Transmission Channel cases – Involving Transmit Power, Bandwidth in the presence of AWGN - Capacity of a Linear time invariant Gaussian channel, Capacity of Colored Noise channels. Derivation of Shannon's Capacity Theorem **Multicarrier Signalling**: Single carrier vs Multicarrier, Multicarrier Concepts, Types of Multicarrier in AWGN channel, OFDM, DMT, MM, FBMC, OTFS Implementation and Spectral Characteristics, Capacity of Multicarrier Channel	
Unit –IV	**09 Hrs**
Support Algorithms for MCM – Constellation Encoding and Decoding, Normalization Factors, Power and bit allocation across sub carriers for Fixed Rate. Adaptive Rate Algorithms for Seamless operation, Dynamic operation. **Training and Synchronization of MCM Modems** – Carrier Recovery and Timing Recovery in MCM links	
Unit –V	**09 Hrs**
Impediments to MCM Transmission - Peak to Average Power Ratio for Multicarrier, ISI and Channel Equalization, ICI with Frequency and Timing Offsets during Synchronization **Coding** Considerations for Multicarrier Performance Improvements	
Lab Component	
1. Performance of AWGN and Rayleigh fading channels for different Binary modulation schemes- BPSK, BFSK and DPSK. 2. (i)Performance improvement through Signal diversity on a frequency non-selective channel. (ii) Performance improvement through RAKE receiver on a frequency selective channel. 3. Computation of the Capacity of a 2 x 2 MIMO System. 4. Computation of the Capacity of SIMO and MISO Channels. Generation of OFDM Signal using 16-point QAM and Effect of Additive Noise on OFDM. 5. Error rate Performance of 2x2 MIMO system in a Rayleigh fading AWGN channel using a. Maximum-Likelihood Detector (MLD) b. Minimum Mean-Square-Error Detector (MMSE) c. Inverse Channel Detector (ICD) 6. Use of Cyclic Prefix and Computation of PAR in OFDM Systems. 7. Ergodic Capacity for a Frequency Nonselective Rayleigh Fading MIMO Channel. 8. Space-Time Codes for MIMO Systems Block Codes	

9. Space-Time Codes for MIMO Systems- Trellis Codes 10. Implementation of 2x2 MIMO with clock synchronization

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explain the concepts of multi-channel signaling scheme and synchronization for carrier and symbol timing recovery at receiver.
CO2:	Evaluate the degradation in performance of various symbol signaling schemes in a multipath fading environment.
CO3:	Develop & analyze schemes to improve performance in a multipath fading environment including diversity, maximal ratio combining and RAKE receivers.
CO4:	Develop and evaluate the performance of a MCM scheme to meet specified rate in a changing Channel environment.

Reference Books	
1.	Digital Communications, John G. Proakis, Masoud Salehi, 5th Edition, Pearson Education, ISBN:9789339204792, 2014
2.	Digital Communications: Fundamentals and Applications, Bernard Sklar,2nd Edition, Pearson Education, ISBN:9788131720929, 2009
3.	Orthogonal Frequency Division Multiplexing for wireless communications, Edited by Ye (geoffrey) Li and Gordon Stuber, 2006 Springer Science+Business Media, ISBN 978-0387-29095-9

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video-based seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis **(20 Marks)**, lab test **(10 Marks),** and Innovative Experiment/ Concept Design and Implementation (2**0 Marks)** adding up to 50 Marks.	**50**
	MAXIMUM MARKS FOR THE CIE THEORY	**150**

RUBRICS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

RUBRIC FOR THE SEMESTER END EXAMINATION (LAB)		
Q. NO.	**CONTENTS**	**MARKS**
1	Write Up	10
2	Execution	20
3	Viva	20
	TOTAL	**50**

Semester: II						
MIMO AND BEAMFORMING FOR SMART ANTENNAS (Theory & Practice) (Professional Core Course)						
Course Code	**:**	**MCS322IA**		**CIE**	**:**	**100+50 Marks**
Credits: L:T:P	**:**	**3:0:1**		**SEE**	**:**	**100+50 Marks**
Total Hours	**:**	**45L+30P+45EL**		**SEE Duration**	**:**	**03 + 03 Hrs**

Unit-I	**09 Hrs**
The wireless channel - Physical modelling for wireless channels, Input /output model of the wireless channel, Time and frequency coherence, Statistical channel models Point-to-point communication: detection, diversity, and channel uncertainty. Time diversity, Frequency diversity, Antenna diversity, Channel estimation. Capacity of wireless channels: AWGN channel capacity, Resources of the AWGN channel, Linear time-invariant Gaussian channels (SIMO, MISO), Capacity of fading channels	
Unit – II	**09 Hrs**
MIMO 1: Spatial multiplexing and channel modelling, , Physical modelling of MIMO channels, Modelling of MIMO fading channels, **MIMO 2**: Capacity and multiplexing architectures: Receiver architectures, V-BLAST and D-BLAST architecture,: an outage-optimal architecture, Slow fading MIMO channel, Fast fading MIMO channel	
Unit –III	**09 Hrs**
Array signal Modelling: Frequency-wavenumber Response, Beam Patterns, Uniform Linear Arrays, Uniformly Weighted Linear Arrays, Beam Pattern Parameters, Array Steering, Array Performance: Directivity Array Gain vs. Spatially White Noise. Characterization of Space-time Processes: Introduction, Frequency-domain Snapshot Models, Narrowband Time-domain Snapshot Models, Orthogonal Expansions	
Unit –IV	**09 Hrs**
Optimum Beamformer: Minimum Variance Distortion less Response (MVDR) Beamformer, Minimum Power Distortion less Response (MPDR) Beamformer, Optimum LCMV and LCMP Beamformer, Generalized Side lobe Cancellers. Adaptive Beamformer: Estimation of Spatial Spectral Matrices -Sample Spectral Matrices: Asymptotic Behaviour, Parametric Spatial Spectral Matrix Estimation, Singular Value Decomposition Sample Matrix Inversion (SMI): Recursive Least Squares (RLS): Least Squares Formulation, Recursive Implementation LMS Beam forming Algorithms	
Unit –V	**09 Hrs**
Direction of Arrival Algorithms: Spectral Estimation Methods, Bartlett Method, Minimum Variance Distortionless Response Estimator, Linear Prediction Method, Maximum Entropy Method, Maximum Likelihood Method, MUSIC Algorithm, ROOT Music, Minimum Norm Method, ESPRIT Method, Weighted Subspace method	
Lab Component	2hrs/ Week
1. Study the performance analysis of Broad side and end fire array using Matlab 2. Analyse the performance for Beamforming algorithms such as MVDR, MPDR, in presence of AWGN using Matlab 3. Analyse the performance (Varying SNR, Snapshot and resolution) for DOA algorithms such as MVDR, MUSIC, Min-Norm in presence of AWGN using Matlab 4. Design a beamforming network for a single channel using ADS 5. Develops a mmWave 5G Development Kit which offers 360° Beam Steering Coverage 6. Measure the radiation characteristics, reflection coefficients of single patch, 2x2 array and 4X4 subarray.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Develop and evaluate the performance of a MIMO scheme to meet specified rate in a given multipath environment.
CO2:	Develop and evaluate the performance like(Snapshot model, Directivity, SNR) of Array antenna system by signalling model
CO3:	Analyse and optimize beamforming techniques in environments with interference, noise, and multipath propagation.
CO4:	Analyse and optimize Direction of arrival algorithm techniques for in noisy environment

Reference Books	
1.	Fundamentals of Wireless Communication, David Tse, Pramod Viswanath, 1st Edition, Cambridge University, Press , ISBN:0521845270, 2005
2.	MIMO-OFDM Wireless Communications With MATLAB, Yong Soo Cho - Chung-Ang University, Republic of Korea, Jaekwon Kim - Yonsei University, Republic of Korea, Won Young Yang - Chung-Ang University, Republic of Korea, Chung G. Kang, John Wiley & Sons (Asia) Pte Ltd, 2010, Print ISBN: 978-0-470-82561-7
3.	Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory, Harry L. Van Trees, John Wiley & Sons, ISBN: 9788126538478, 2002
4.	Array Signal Processing: Concepts and Techniques, Don H. Johnson, Dan E. Dugeon, Prentice Hall Signal Processing Series. ISBN: 0130485136, 1993

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video-based seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis **(20 Marks)**, lab test **(10 Marks),** and Innovative Experiment/ Concept Design and Implementation (2**0 Marks)** adding up to 50 Marks.	**50**
	MAXIMUM MARKS FOR THE CIE THEORY	**150**

RUBRICS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

RUBRIC FOR THE SEMESTER END EXAMINATION (LAB)		
Q. NO.	**CONTENTS**	**MARKS**
1	Write Up	10
2	Execution	20
3	Viva	20
	TOTAL	**50**

Semester: II						
ADVANCED 5G AND APPLICATIONS (Program Specific Elective B) (Theory)						
Course Code	**:**	**MCS323B1**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+30T+45EL**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Introduction of Wireless Communications: Introduction to 3GPP Specs. Introduction to wireless communications; Evolution: 1G, 2G, 3G, 4G and 5G. Fundamentals of mm Wave and cm Wave. List of 3GPP. Road map for 5G. 4th Generations: Basics to Advanced LTE concepts. History and Futures of wireless communications. Multiple access, Duplexing techniques. Functionality of SIM. Access and Non-Access Stratum, LTE Evaluation and network architecture, Interfaces, Basics of eNB, MME, gateway, policy and charging rules, HSS, User plane and Control Plane, LTE protocol stack. LTE mobility, definition of cell, tracking area, cell identifications, NAS procedures, EMM and ESM procedure. EMM and RRC states. UE Identifiers. LTE use cases and features, Carrier aggregation, multiple antenna techniques, support of relay nodes. LTE with MIMO.	
Unit – II	**09 Hrs**
5G Fundamentals Use cases of 5G: Use cases of 5G as per standards, example eMBB, mMTC, URLLC,V2X.Network Architecture; Reference Point System Architecture, Service Based System Architecture and Network Functions. 5G Fundamentals Base Station: Base Station Architecture, CU-DU Split Base Station and CP-UP, Standalone Base Station and Non-Standalone Base Station. Basics of antennas in bases stations and Base station classes; Antenna Architecture basics and Base Station Classes. Network Interfaces: Xn interface, F1 interface, E1 interface, NG interface and X2 interface. Protocol stack: Protocol Stacks, User Plane and Control Plane.	
Unit –III	**09 Hrs**
RRC states: RRC Idle, RRC Connected and RRC Inactive. Call Management in NR & 5G Signalling: Call Management; Registration Management, Connection Management, Access Control. 5G Signalling; Signalling Radio Bearers, PDU Sessions, QoS MIMO & Beam: Introduction to MIMO and Beam forming, ABF, DBF. Beam Types Analog, digital and hybrid beamforming.	
Unit –IV	**09 Hrs**
5G Fixed Wireless Access: Introduction, 5G FWA Market Offers and spectrum challenges,5G FWA End to End Architecture,5G FWA Capacity and Performance,5G CPE and Device Management,5G FWA Mmwave	
Unit –V	**09 Hrs**
5G V2X:5G Core functions and V2X application, server,5G V2X Landscape, 3GPP NR-V2X Architecture,NR-V2X Registration and V2X PDU establishment,NR-V2X PC5 communications,NR-V2X PQI, 5QI and V2X Network Slicing,5G V2X Mobility and Mobile Edge Computing,5G V2X use cases	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Illustrate the fundamental concepts of various technologies in wireless which are used in Communication systems.
CO2:	Derive the solution by applying the acquired knowledge of wireless technologies

CO3:	Evaluate the solution of the problems using wireless techniques to the real-world problems arising in many practical situations
CO4:	Design and development of wireless techniques for 5G communication and gain knowledge to apply and engage in life – long learning.

Reference Books

1	Long Term Evolution IN BULLETS, by Chris Johnson 2nd Edition, July 2012, ISBN-13 : 978-1478166177.
2	5G New Radio IN BULLETS by Chris Johnson, Independently published 2019, ISBN, 1077484356, 9781077484351.
3.	Wireless Communications: From Fundamentals to Beyond 5G,Andreas F. Molisch ,IEEE Press 3rd Edition 2022. ISBN 10: 1119117208, ISBN 13: 9781119117209.
4.	RF Antenna Beam Forming: Focusing and Steering in Near and Far Field. Shun-Ping Chen and Heinz Schmiedel,1st Edition ,2023, ISBN-13:978-3031217647.
5.	Massive MIMO Systems Kazuki Maruta and Francisco Falcone ,Mdpi AG, 3rd July 2020,ISBN-10 : 3039360167, ISBN-13:978-3039360161

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

SEMESTER: II						
NEXT GENERATION WIRELESS LAN (Program Specific Elective B) (Theory)						
Course Code	**:**	**MCS323B2**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+30T+45EL**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Physical layer History of IEEE 802.11, Orthogonal frequency division multiplexing background, MIMO/SDM basics, 802.11n propagation model, Antenna correlation, Doppler model. **PHY interoperability with 11a/g legacy OFDM devices** 11a packet structure review, Mixed format high throughput packet structure. **Robust performance** Receive diversity, Spatial expansion, Space-time block coding, Low density parity check codes encoding process, Effective code rate.	
Unit – II	**09 Hrs**
Medium access control Protocol layering, Management functions, Distributed channel access, Data/ACK frame exchange, Hidden node problem, Enhanced distributed channel access, Block acknowledgement	
Unit –III	**09 Hrs**
MAC throughput enhancements Throughput without MAC changes, MAC throughput enhancements, Throughput with MAC efficiency enhancements and Aggregation. **Advanced channel access techniques** Point coordination function and its limitations, HCCA and its limitations, Reverse direction protocol frame exchange and recovery.	
Unit –IV	**09 Hrs**
Interoperability and coexistence Station and BSS capabilities, Controlling station behavior, Phased coexistence operation (PCO) basic operation, Protection with 802.11b stations present, Protection with 802.11g or 802.11a stations present, Protection for OBSS legacy stations, RIFS burst protection. **MAC frame formats** General frame format, Format of individual frame types, Data frames and Management Frame fields.	
Unit –V	**09 Hrs**
Transmit beamforming Singular value decomposition, Transmit beamforming with SVD, Eigenvalue analysis, Unequal MCS, Receiver design, Channel sounding, Channel state information feedback , Improved performance with transmit beamforming. Introduction to IEEE 802.11ac and ax Technologies.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Illustrate the fundamental concepts of IEEE 802.11a packet structure, propagation model, Doppler model, preamble format and robust performance.
CO2:	Evaluate management functions, distributed channel access techniques and data/ack frame exchange Fragmentation for Duplicate detection.

CO3:	Analyze MAC throughput performance and efficiency enhancements techniques and check the interoperability.
CO4:	Develop and evaluate the transmit beam forming with SVD for different real world scenarios.

Reference Books	
1	Next Generation Wireless LANs: Throughput, Robustness, and Reliability in 802.11n , Eldad Perahia and Robert Stacey, 1st Edition, 2008, Cambridge University Press, ISBN:9781107016767
2	Next-Generation Wireless Networks Meet Advanced Machine Learning Applications, Ioan-Sorin Comşa and Ramona Trestian ,1st edition, 2019,IGI Global Publisher, ISBN: 1522574581.
3.	Digital Communications Paperback, John G. Proakis and Masoud Salehi, 5th edition, 2014, McGraw Hill Education, ISBN: 9789339204792
4.	Transmit Beamforming in Modern Wireless Communications: From Theory to Practice in LTE and WiFi Hardcover, Joonsuk Kim , Pengfei Xia , Yang Tang , 1st edition, 2018, Wiley–Blackwell ISBN:978-1118939475.

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
QUANTUM COMMUNICATION (Program Specific Elective B) (Theory)						
Course Code	**:**	**MCS323B3**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+30T+45EL**		**SEE Duration**	**:**	**3Hours**

Unit-I	**09 Hrs**
Mathematical Tools : Introduction to vector spaces, inner-product spaces, linear independence, basis, Finite dimensional Hilbert spaces, linear operators, projectors, Eigenvalue decomposition, Tensor products; Analysis and probability, limit, infimum, supremum, continuity, compact sets, convexity, dual function, probability distributions.. **Review of Quantum theory:** state vectors, qubits, Paulimatrices, unitary transformations, measurement, composite systems and tensor products, quantum gates and circuits, entanglement and Bell inequalities.	
Unit – II	**09 Hrs**
Introduction to Quantum decision theory: Analysis of a quantum communication system, introduction to the Helstrom decision theory of quantum binary communication systems, decision theory of K-ary Quantum communication systems, Holevo's theorem, constellation of quantum states.	
Unit –III	**09 Hrs**
Introduction to Quantum Information Theory: Notion of density operators, partial trace, reduced density operator, Schmidt rank, purification of mixed states, entanglement, quantum teleportation. **Introduction to classical information theory:** Shannon entropy, classical channels and channel coding. Notion of von-Neumann entropy, quantum channels, accessible information and Holevo bound, transmission through a noisy quantum channel.	
Unit –IV	**09 Hrs**
Introduction to Quantum communication systems: Introduction to Glauber's representation of coherent quantum states, Quantum binary communication systems and different modulation schemes: OOK, BPSK, QAM, PSK, PPM, overview of quantum squeezed states. Introduction to Quantum Cryptography and Quantum Key Distribution. Detailed study of the BB84 protocol,E91 protocol and security analysis. Advanced QKD Protocols: Measurement-device-independent QKD,Device-independent QKD,Practical considerations in QKD	
Unit –V	**09 Hrs**
Classical communication over noisy quantum channels. Holevo information, and classical capacity. Examples of quantum channels. Super additivity of classical capacity. Classical communication over entanglement-assisted quantum channels. Capacity theorem. Coherent communication with noisy resources: entanglement-assisted quantum communication; private classical communication. The quantum capacity theorem. Resource trade-offs and trade-off coding. Non-additivity and other open problems.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Illustrate the fundamental mathematical concepts behind quantum communication and computing.
CO2:	To design various quantum communication systems and modulation schemes.

CO3:	Evaluate the implications of quantum communications on cryptography, including potential vulnerabilities of classical cryptographic systems and the role of quantum-resistant algorithms.
CO4:	Develop critical thinking skills by analysing and discussing the ethical and societal implications of quantum communications.

Reference Books	
1	"Quantum Communications", Gianfranco Cariolaro, Springer, Published in 2015, 1st Edition, **ISBN**: 978-3-319-19958-7, 978-3-319-19959-4
2	"Quantum Communication, Quantum Networks, and Quantum Sensing, Academic press, Published in 2022, 1st Edition, **ISBN**: 978-0-12-823530-5 , 978-0-12-823531-2
3.	"Principles of Quantum Communication Theory: A Modern Approach", Sumeet Khatri, and Mark M. Wilde, Published in 2021, 1st Edition, **ISBN**: 978-3-030-71094-6.
4.	"Quantum Computation and Quantum Information", Michael Nielsen and Isaac Chuang, Cambridge University Press, Published in 2010, 10th Anniversary Edition, **ISBN**: 978-0-521-63503-5 (Print), 978-0-521-63535-6 (Online)

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
AUTOMOTIVE EMBEDDED SYSTEM DESIGN (Program Specific Elective B) (Theory)						
Course Code	**:**	**MVE323B4**		**CIE**	**:**	**100 Marks**
Credits: L: T: P	**:**	**3:1:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+30T+45EL**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
Automotive Systems Overview: Automotive Vehicle Technology, Overview of Vehicle Categories, Various Vehicle Sub Systems like Chassis, Body, Driveline, Engine technology, Fuelling technology, vehicle Emission, Brakes, Suspension, Emission, Doors, Dashboard instruments, Wiring Harness, Safety & Security, Comfort &Infotainment, Communication & Lighting, Future Trends in Automotive Embedded Systems: Hybrid Vehicles, Electric Vehicles.	
Unit – II	**09 Hrs**
Automotive Sensors and Actuators: Automotive Control System Applications of Sensors and Actuators. **Sensors:** Air Flow Sensor, Engine Crankshaft Angular Position Sensor, Throttle Angle Sensor, Temperature Sensor, Sensors for Feedback Control, Sensors for Driver Assistance System: Radar, Lidar, Video Technology. **Actuators:** Solenoids, Piezo Electric Force Generators, Fluid mechanical Actuators, Electric Motors and Switches.	
Unit –III	**09 Hrs**
Automotive Control System Design-I: Digital Engine Control, Features, Control Modes for Fuel Control, Discrete Time Idle Speed Control, EGR Control, Variable Valve Timing Control, Electronic Ignition Control, Integrated Engine Control System.	
Unit –IV	**09 Hrs**
Automotive Control System Design-II: Cruise Control System, Cruise Control Electronics, Anti-locking Braking System, Electronic Suspension System, Electronic Steering Control, Four-Wheel Steering, ADAS Systems, Autonomous Vehicles, Application of IoT in automotives	
Unit –V	**09 Hrs**
Automotive Protocols: LIN, CAN, MOST, Flex Ray, Automotive Ethernet, Test, Calibration and Diagnostics tools for networking of electronic systems like ECU Software and Testing Tools, ECU Calibration Tools, Vehicle Network Simulation, Advanced Trends in Automotive Electronics: AUTOSAR Architecture.	

Course Outcomes (CO): **After completing the course, the students will be able to: -**	
CO1	Understand the fundamentals of different Automotive Systems.
CO2	Integrate various sensors and actuators into automotive systems, and understanding their functionalities in vehicle control and monitoring.
CO3	Design control systems specifically applied to automotive engineering, including engine control, transmission control, chassis control, and vehicle dynamics control.
CO4	Provide technical embedded solutions for the development of automotive Systems.

Reference Books	
1.	Understanding Automotive Electronics-An Engineering Perspective, William B. Ribbens, 7th Edition, Butterworth-Heinemann Publications.
2.	Automotive Electronics Handbook, Robert Bosch, 2004, John Wiley and Sons, ISBN-0471288357
3.	Automotive Control Systems for Engine Driveline and Vehicle, Kiencke, Uwe, Nielsen, Lars, 2nd Edition, Springer Publication.

4.	Vehicle Safety Communications: Protocols, Security and Privacy, Tao Zhang, Luca Delgrossi, Wiley Publication.
5.	Automobile Electrical and Electronic Systems, Tom Denton, 4th Edition, Routledge, 2012.

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
COMPUTER VISION WITH DL (Professional Cluster Elective C) (Theory)						
Course Code	**:**	**MCS324C1**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+30T+45EL**		**SEE Duration**	**:**	**3Hours**

Unit-I	**09 Hrs**
Image Formation Models Introduction: Overview and applications. Image formation: Digital images for representing 2D, 3D, and moving objects. Human eye and digital camera models. Photometric information: Colour: Physics of Colour, human perception of Colour, Colour models (RGB, HSI). Geometric-information: Representation of points, lines, planes, surfaces, and shapes in 3D, nature and structure of medical images. Two-dimensional and three-dimensional geometric transformations of images and 3D scenes	
Unit – II	**09 Hrs**
Image Processing Image Processing: Point operators, Linear filtering, Fourier Transform, Geometric transformation. Image filtering: Gray-level transformations, histograms, convolution, noise reduction, spatial and Fourier domain filtering and convolution, Gaussian filtering, and image resolution pyramids. Using Open CV: Smoothing Images, Median Filter, Gaussian Filter, Bilateral Filter, Changing the Shape of Images, Thresholding, Calculating Gradients, Performing Histogram Equalization	
Unit –III	**09 Hrs**
Features Detection and Classification Feature detection and matching: gradient vector, Canny's edge detection, Harris-corner detector. Contours: Model fitting, Total LSE, Least Median Square Error. RANSAC, Hough transform. Image stitching, clustering techniques, K-mean clustering, PCA. Using Open CV: RANSAC Algorithm, SIFT Algorithm.	
Unit –IV	**09 Hrs**
Image-based rendering Image classification using Artificial Neural Networks and CNN, View-dependent texture maps. Application: Photo Tourism. Video-based rendering, Video-based animation, Video textures. Application: Animating pictures .	
Unit –V	**09 Hrs**
Real time use cases Computer Vision Methods for Video Content Analysis: Object detection, Face detection, Pedestrian detection, Face recognition, Eigenfaces, Active appearance and 3D shape models, Application: Personal photo collections. Instance recognition, Geometric alignment, Large databases**,** Application: Location recognition, Recognition databases and test sets.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explore and acquire knowledge on fundamentals of Computer Vision concepts.

CO2:	Analyze and interpret the inherent difficulties encountered in Computer Vision.
CO3:	Apply Computer Vision techniques to solve problems in the visible world around us.
CO4:	Investigate and draw inferences by processing Image in real time applications.

Reference Books	
1	Computer Vision: Algorithms and Applications, Richard Szeliski, Springer Verlag, 2013 Edition, ISBN-13: 978-1848829343, ebook :http://szeliski.org/Book/
	Practical Machine Learning and Image Processing: For Facial Recognition, Object Detection, and Pattern Recognition Using Python, Himanshu Singh, 1st Edition, Apress, ISBN:978-1-4842- 4149-3
2	Computer Vision: A Modern Approach, David Forsyth and Jean Ponce, 2nd edition, 2015, Pearson Education India, ISBN-10: 9332550115, ISBN-13: 978-9332550117
3	Introductory Computer Vision, Imaging Techniques and Solutions, Adrian Low, 2nd Edition, 2010, BS Publications, ISBN-13 9788178001977.

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

SEMESTER: II
ADHOC NETWORKS
(Professional Cluster Elective C)
(Theory)

Course Code	**:**	**MDC324C2**		**CIE Marks**	**:**	**100**
Credits L-T-P	**:**	**3:1:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**45L+30T+45EL**		**SEE Duration**	**:**	**3 Hours**

UNIT - I **09 Hrs**

Introduction: Introduction to Cellular and Ad hoc wireless networks, Applications of ad hoc networks, Issues in ad hoc wireless networks, Medium access scheme, Routing, Multicasting, Transport layer protocols, Pricing scheme, Quality of Service provisioning, Self-organization, Security, Address and security discovery, Energy management, Scalability.

UNIT - II **09 Hrs**

MAC Protocols: Issues in designing a MAC Protocol for ad hoc wireless networks, design goalsof a MAC Protocol for Ad Hoc Wireless Networks, Classification of MAC Protocols, Contention based Protocols, Contention based Protocols with Reservation mechanism, Contention Based MAC Protocols with Scheduling Mechanisms

UNIT - III **09 Hrs**

Routing Protocols: Design issues and classification, Table-driven, On-demand and Hybridrouting protocols, Routing protocols with efficient flooding mechanisms, Hierarchical and Power-aware routing protocol.

UNIT - IV **09 Hrs**

Multicast Routing Protocols : Design issues and operation, Architecture reference model, Classification, Tree-based and Mesh based protocols, Energy-Efficient multicasting, Multicasting with Quality-of-Service guarantee, Application dependent multicast routing.

UNIT - V **09 Hrs**

Quality of Service and Security Issues : Issues and challenges in providing QoS, Classification ofQoS solutions, MAC layer solutions, Network layer solutions, QoS frameworks, Network security issues. Energy Management: Need, Classification of battery management schemes, Transmission powermanagement schemes, System power management schemes.

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Understand the fundamental of ad hoc wireless networks and cellular networks.
CO2	:	Analyze contention-based MAC protocols and routing protocols for ad hoc networks.
CO3	:	Analyze the design aspects and the limitation of the Multicast routing Protocols.
CO4	:	Evaluate the performance of ad hoc networks using quality of service and Energy management.

Reference Books

1. C. Siva Ram Murthy, B. S. Manoj, Ad-Hoc Wireless Networks: Architectures and Protocols, 2012,1st Edition, Prentice Hall, New Jersey. ISBN- 978-81-26547-86-9.

2. C-K. Toh, AdHoc Mobile Wireless Networks: Protocols and Systems, 2011, 1st Edition, PrenticeHall, New Jersey. ISBN- 978-01-30078-17-9

3. Mohammad Ilyas, The Handbook of AdHoc Wireless Networks, 2012, 1st Edition, CRC press,Florida. ISBN - 978-03-67248-26-0

4. Minoru Etoh, Next Generation Mobile Systems 3G and Beyond, 2011, 1st Edition, WileyPublications, NewJersey. ISBN: 978-04-70091-51-7

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

SEMESTER: II

INTELLIGENT CONTROL TECHNIQUES IN ELECTRICAL DRIVES

(Professional Cluster Elective C)

(Theory)

Course Code	**:**	**MPE324C3**		**CIE Marks**	**:**	**100**
Credits L-T-P	**:**	**3:1:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**45L+30T+45EL**		**SEE Duration**	**:**	**3 Hours**

UNIT - I	**09 Hours**

Introduction to Digital control system: Review of difference equations and Z - transforms, sampled data systems: ideal sampler, sample and hold operations, Z- transfer function (Pulse transfer function), pulse transfer functions and different configurations for closed loop discrete-time control systems. Z - Transforms analysis of sampled data systems.

UNIT - II	**09 Hours**

Mapping between the s-plane and the z-plane, stability analysis of closed loop systems in the z-plane Stability analysis (Jury's Stability Test and Bilinear Transformation), State model for continuous time and discrete time systems, Solutions of state equations (for both continuous and discrete systems), discretization of continuous time state equations

UNIT - III	**09 Hours**

Design of Discrete-time Control Systems: Introduction, Stability analysis of closed-loop systems in the z-plane, Transient and steady state response analysis, Design based on the root-locus method, Design based on the frequency response method.

Case Studies: DC-DC Converter design.

UNIT - IV	**09 Hours**

Concepts of controllability and observability (for both continuous and discrete systems): design of state feedback controllers via pole placement, design of full and reduced order state observers and design of servo systems using pole placement technique. (for both continuous and discrete systems), full order and reduced order observers (for both continuous and discrete systems), dead beat control by state feedback

UNIT - V	**09 Hours**

Optimal control problems using state variable approach: state regulator and output regulator, Linear regulator problem: matrix Riccati equation and its solution, concepts of model reference control systems, adaptive control systems and design.

Course Outcomes:

After going through this course the student will be able to:

CO1	:	Understand, formulate and obtain transfer function models, solve discrete control engineering problems, use the techniques, tools and skills related to discrete signals to solve complex control engineering problems.
CO2	:	Analyse the concepts of state space, controllability and observability, pole placement technique, optimal & adaptive control.
CO3	:	Design the digital control system models, state space models, solution of state equation, state feedback controllers and observers.
CO4	:	Evaluate the performance of state feedback controllers and observers, using pole placement for continuous and discrete systems.

Reference Books
1. Digital Control & State Variable Methods, M. Gopal, 4th Edition, 2012, McGraw Hill Education, ISBN: 9780071333276.
2. Modern Control Engineering, Ogata. K., 5th Edition, 2010, PHI, ISBN: 9788120340107.
3. Discrete Time Control Systems, Ogata K, 2nd Edition, 2011, PHI, ISBN: 9788120327603.
4. Control Systems Engineering, Nagarath and Gopal, 7th Edition, 2012, New Age International Publishers, ISBN: 9788122420081.

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
SEMICONDUCTOR MANUFACTURING (Professional Cluster Elective C) (Theory)						
Course Code	**:**	**MVE324C4**		**CIE**	**:**	**100 Marks**
Credits: L: T: P	**:**	**3:1:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+30T+45EL**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
An Introduction to Microelectronic Fabrication: Semiconductor Substrates, Crystallography and Crystal Structure, Crystal Defects, Czochralski Growth, Bridgman Growth of GaAs, Float Zone Growth, Wafer Preparation and Specifications	
Unit – II	**09 Hrs**
Hot Processing and Ion Implantation: Diffusion, Fick's Diffusion Equation in One Dimension, Atomistic Models of Diffusion, Analytic Solutions of Fick's Law, Diffusion Coefficients for Common Dopants, Analysis of Diffused Profiles, Diffusion in SiO2, Simulations of Diffusion Profiles	
Unit –III	**09 Hrs**
Thermal Oxidation: The Deal–Grove Model of Oxidation, The Linear and Parabolic Rate Coefficients, The Initial Oxidation Regime, The Structure of SiO2, Oxide Characterization, The Effects of Dopants During Oxidation and Polysilicon Oxidation, Silicon Oxynitrides, Alternative Gate Insulators, Oxidation Systems, Numeric Oxidations	
Unit –IV	**09 Hrs**
Resistivity: Two-Point Versus Four-Point Probe, Wafer Mapping, Resistivity Profiling, Contactless Methods, Conductivity Type,Contact Resistance and Schottky Barriers, Metal-Semiconductor Contacts, Contact Resistance, Measurement Techniques, Schottky Barrier Height,Comparison of Methods	
Unit –V	**09 Hrs**
Statistical Process Control: Statistics Review: Distributions & Estimation, Hypothesis Tests and Control Chart, Control Charts, Advanced Control Charts, Nested Variance, Experimental Design	

Course Outcomes (CO): **After completing the course, the students will be able to: -**	
CO1	Acquire the concepts of fabrication process and characterization techniques of IC technology.
CO2	Analysis of different process parameters in IC fabrications.
CO3	Define different standard operating procedure in IC fabrication.
CO4	Evaluate different analytic techniques in fabrication process.

Reference Books	
1.	Stephen A. Campbell, "Fabrication Engineering at the Micro and Nanoscale", Third Edition, University of Minnesota, Oxford University Press, 2008.
2.	Dieter K. Schroder, "Semiconductor Material and Device Characterization", Wiley - IEEE, 2006.
3.	Yuan Taur, Tak H. Ning, "Fundamentals of Modern VLSI Devices", 2nd edition , 2013 Cambridge University Press, ISBN: 978-1107635715.
4.	Richard Jaeger, "Introduction to Microelectronic Fabrication": Volume 5, Modular Series on Solid State Deviced, 13 November 2001.
5.	Drain, David. "Variance Components and Process Sampling Design." Chapter 3 in *Statistical Methods for Industrial Process Control.* New York, NY: Chapman and Hall. ISBN: 0412085119.

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
NATURE IMPELLED ENGINEERING Interdisciplinary Courses (Global Electives) (Group-D)						
Course Code	**:**	**MBT325DA**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+45EL**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
Bio-Inspired designs-biomimetics: Termites; Sustainable buildings, Insect foot adaptations for adhesion. Bees and Honeycomb Structure. Namib Desert Beetle; Harvesting desert fog- Nature's water filter. Biopolymers, Bio-steel, Bio-composites, multi-functional biological materials. Antireflection and photo-thermal biomaterials, Invasive and non-invasive thermal detection inspired by skin	
Unit – II	**09 Hrs**
Plant inspired Technologies: Photosynthesis and Photovoltaic cells, Bionic/Artificial leaf. Lotus leaf effect for super hydrophobic surfaces. Flectofin®, a new façade-shading system inspired by flower of the Bird-of-Paradise (Strelitzia reginae). Robotic Solutions Inspired by Plant Root	
Unit –III	**09 Hrs**
Bio-Inspired technologies for medical applications: Organ system- Circulatory- artificial blood, artificial heart, pacemaker. Respiratory- artificial lungs. Excretory- Artificial kidney and skin. Artificial Support and replacement of human organs: artificial liver and pancreas. Total joint replacements- artificial limbs. Visual prosthesis -artificial / bionic eye.	
Unit –IV	**09 Hrs**
Bio-Inspired driven technologies for industrial applications: Biosensors: Artificial tongue and nose. Biomimetic echolation. Insect foot adaptations for adhesion. Thermal insulation and storage materials. Bio-robotics.	
Unit –V	**09 Hrs**
Bio-inspired computing: Cellular automata, neural networks, evolutionary computing, swarm intelligence, artificial life, and complex networks. Genetic Algorithms, Artificial Neural Networks. Artificial intelligence and MEMS.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Contemplate a deep understanding of biological systems, mimetics structures, and functions that inspire engineering innovations for adaptability and sustainability.
CO2	Endeavor biological principles from nature driven techniques to design engineering systems for solving real-world challenges
CO3	Appraise the bioinspired materials for their advanced applications in the domain of health, energy and environmental sustainability.
CO4	Paraphrase biomimicry and ethics in bioinspired engineering designs, ensuring that their solutions are environmentally responsible and socially conscious

Reference Books	
1.	Yoseph Bar-Cohen. Biomimetics: Biologically Inspired Technologies D. Floreano and C. Mattiussi, "Bio-Inspired Artificial Intelligence", CRC Press, 2018. ISBN: 1420037714, 9781420037715.
2.	Guang Yang, Lin Xiao, and Lallepak Lamboni. Bioinspired Materials Science and Engineering. John Wiley, 2018. ISBN: 978-1-119-390336.
3.	M.A. Meyers and P.Y. Chen. Biological Materials, Bioinspired Materials, and Biomaterials Cambridge University Press, 2014 ISBN 978-1-107-01045.
4.	Tao Deng. Bioinspired Engineering of Thermal Materials. Wiley-VCH Press, 2018. ISBN: 978-3-527-33834-4.

RUBRICSS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICSS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
CLINICAL DATA MANAGEMENT Interdisciplinary Courses (Global Electives) (Group-D)						
Course Code	**:**	**MBT325DB**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+45EL**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
Fundamentals of Healthcare Data and Analytics: Overview, importance, and evolution of health informatics in the digital age, Healthcare Data Types: Structured vs. unstructured data, clinical vs. operational data, and sources of healthcare data, Data Conversion and Integration: Data standardization, integration into clinical data warehouses, and data cleaning. Data Analytics: Introduction to descriptive, predictive, and prescriptive analytics in healthcare. Use of AI and machine learning for improved outcomes, Challenges and Future Trends: Data privacy, interoperability issues, the role of informatics in personalized medicine, and the future of digital health.	
Unit – II	**09 Hrs**
Electronic Health Records (EHRs) and Digital Health: Overview of EHRs: Key components, data capture mechanisms, and the shift towards integrated EHR systems. Scope and Adoption: Role of EHRs in enhancing patient care, interoperability, and data sharing between healthcare providers. Implementation Process: Steps for selecting, deploying, and optimizing EHR systems, including vendor selection and compliance with healthcare regulations. Challenges in EHRs: Usability issues, data quality, resistance to adoption, and strategies for overcoming these barriers. Digital Health Innovations: Impact of telemedicine, remote patient monitoring, and digital therapeutics on EHR integration.	
Unit –III	**09 Hrs**
Data Standards, Interoperability, and Medical Coding: Introduction to Standards: Need for data standards in health informatics, and their role in ensuring interoperability. Terminology and Content Standards: Deep dive into ICD, SNOMED CT, LOINC, and HL7 FHIR. Data Exchange and Transport Standards: HL7, DICOM, CDA, and emerging standards for seamless data exchange. Medical Coding Systems: Role of medical coding in billing, clinical documentation, and outcome measurement. Overview of CPT, ICD-10, and DRG codes. Emerging Trends: Role of AI in medical coding and billing, and the shift towards real-time data standardization.	
Unit –IV	**09 Hrs**
Health Informatics Ecosystem: Introduction to the ecosystem, including hospitals, clinics, insurance providers, and regulatory bodies. Key Players and Stakeholders: Role of informatics professionals, data scientists, clinicians, and IT staff in healthcare. Challenges and Barriers: Addressing technical, organizational, and regulatory challenges in health informatics. Career Opportunities: Overview of roles like clinical informatics specialist, health data analyst, and telehealth coordinator. Resources and Professional Development: Important certifications, online resources, and organizations (e.g., HIMSS, AMIA).	
Unit –V	**09 Hrs**
Health Information Privacy, Security, and Ethics: Introduction to Privacy and Security: Core principles of data privacy, HIPAA, and GDPR in healthcare. Security Principles: Confidentiality, integrity, availability, encryption methods, and access control mechanisms. Authentication and Identity Management: Role of biometric authentication, two-factor authentication, and secure access protocols. Data Security in the Cloud: Cloud computing in healthcare, managing risks in cloud-based data storage, and hybrid cloud models. Ethics in the use of AI in healthcare, managing bias in algorithms, and ensuring equitable access to digital health technologies.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the key principles and challenges of health informatics, and apply them to real-world scenarios.
CO2	Effectively manage the process of data capture, conversion, and analysis to generate actionable insights.
CO3	Apply knowledge of medical coding, data standards, and interoperability to improve data sharing and clinical workflows.
CO4	Implement robust security measures to protect patient data, and navigate ethical issues in health informatics.

Reference Books	
1.	Robert E. Hoyt Ann K. Yoshihashi, Health Informatics, Practical guide for Healthcare and Information Technology Professionals, 6th edition , Informatics, 2014, ISBN: 978-0-9887529-2-4
2.	Kathryn J. Hannah Marion J. Ball, Health Informatics, Springer Series edition, Springer, 2005, ISBN: 1-85233-826-1
3.	William R Hersh, Health Informatics, a Practical guide, 8th edition. 2022, ISBN 978-1-387-85475-2
4.	Pentti Nieminen. Medical informatics and data analysis 1st edition, MDPI AG, 2021, ISBN-13: 978-3036500980

RUBRICSS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICSS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II

CYBER FORENSICS AND CYBER LAWS

Interdisciplinary Courses (Global Electives)
(Group-D)

Course Code	**:**	**MCN325DC**	**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:0:0**	**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+45EL**	**SEE Duration**	**:**	**03 Hours**

Unit-I — **09 Hrs**

Computer Forensics in Today's World

Introduction to Computer Forensics and Digital Evidence, the Role of the Forensic Investigator, Understanding Forensic Readiness. Legal Issues and Considerations, Types of Computer Forensic Investigations, Forensic Investigation Process.

Unit – II — **09 Hrs**

Investigation Process

Computer Forensics Investigation Methodology, Handling Digital Evidence, Chain of Custody and Documentation, Evidence Preservation: Hashing and Imaging, Investigation Planning and Legal Approval, Searching and Seizing Computers: Search and Seizure Procedures, Obtaining a Search Warrant, Securing the Crime Scene

Unit –III — **09 Hrs**

Digital Evidence

Types of Digital Evidence (Physical, Logical, Latent), Collecting and Preserving Digital Evidence, Writing Reports on Digital Evidence, Identifying Evidence Sources: Hard Drives, Network Logs, Databases, Evidence Recovery Techniques, First Responder Procedures: First Responder Role in Digital Investigations, Protecting and Securing Evidence, Best Practices for Incident Response

Unit –IV — **09 Hrs**

Jurisdiction of Cyberspace:

Information Technology Law Literature and Glossary, Information Technology Law Concepts, Jurisdictional Issues in Cyber Space, scope of I.T. laws,

Law and the Internet:

Domain issues in Internet, Regulatory body, ICANN regulations

Unit –V — **09 Hrs**

Security Governance Objectives –

Security Architecture, Risk Management Objective, Developing A Security Strategy, Sample Strategy Development

Course Outcomes: After completing the course, the students will be able to

CO1	Gain a comprehensive understanding of Cyberfornsic and Investigation
CO2	Apply cyber forensics measures, tools, and techniques to protect systems, networks, and information.
CO3	Analyse the Legal Frameworks governing the internet
CO4	Exploration of Security Frameworks in the Cyber space.

Reference Books	
1.	EC-Council CHFI Course Outline: https://www.eccouncil.org/programs/computer-hacking-forensic-investigator-chfi/.
2.	Guide to Computer Forensics and Investigations" by Bill Nelson, Amelia Phillips, and Christopher Steuart, 6th Edition (latest), Cengage Learning, February 15, 2018, 978-1337568944.
3.	The Basics of Digital Forensics: The Primer for Getting Started in Digital Forensics" by John Sammons, Edition: 2nd Edition (latest) Syngress (an imprint of Elsevier), June 30, 2014, ISBN-10: 0128016353.

RUBRICSS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICSS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
INDUSTRIAL SAFETY AND HEALTH Interdisciplinary Courses (Global Electives) (Group-D)						
Course Code	**:**	**MCV325DD**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+45EL**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure. National Policy and Legislations on EHS in India - Regulations and Codes of Practice - Role of trade union safety representatives. Occupational health and safety: Introduction: Health, Occupational health: definition, Interaction between work and health, Health hazards, workplace, economy and sustainable development. Development of accident prevention programs and development of safety organizations.	
Unit – II	**09 Hrs**
Work as a factor in health promotion. Potential health hazards: Air contaminants, Chemical hazards, Biological hazards, Physical hazards, Ergonomic hazards, Psychosocial factors, Evaluation of health hazards: Exposure measurement techniques, Interpretation of findings, recommended exposure limits. Controlling hazards: Engineering controls, Work practice controls, Administrative controls. Occupational diseases: Definition, Characteristics of occupational diseases, Prevention of occupational diseases.	
Unit –III	**09 Hrs**
Hazardous Materials characteristics and effects on health: Introduction, Chemical Agents, Organic Liquids, Gases, Metals and Metallic Compounds, Particulates and Fibers, Alkalies and Oxidizers, General Manufacturing Materials, Chemical Substitutes, Allergens, Carcinogens, Mutagens, Reproductive Hazards, Sensitizers and Teratogens, Recommended Chemical Exposure Limits. Physical Agents, Noise and Vibration, Temperature and Pressure, Carcinogenicity, Mutagenicity and Teratogenicity. Ergonomic Stresses: Stress-Related Health Incidents, Eyestrain, Repetitive Motion, Lower Back Pain, Video Display Terminals.	
Unit –IV	**09 Hrs**
Occupational safety and Health act. Occupational Safety and Health Administration, right to know Laws, Accident Causation, Correcting Missing Skills, Investigator Tendencies and Characteristics, Theories of accident causation: Domino theory, Human Factors theory, Accident/Incident theory, Epidemiological theory and systems theory of accident causation.GD	
Unit –V	**09 Hrs**
ENVIRONMENTAL HEALTH AND SAFETY MANAGEMENT Concept of Environmental Health and Safety Management – Elements of Environmental Health and Safety Management Policy and implementation and review – ISO 45001-Strucure and Clauses-Case Studies. Occupational Health and Safety Considerations: Water and wastewater treatment plants, Construction material manufacturing industries like cement plants, RMC Plants, precast plants and construction sites, Municipal solid waste management	

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the Industrial and Occupational health and safety and its importance.
CO2	Demonstrate the exposure of different materials, occupational environment to which the employee can expose in the industries.
CO3	Exposure to the onset of regulatory acts and accident causation models.

CO4	Demonstrate the significance of safety policy, models and safety management practices.

Reference Books	
1.	Industrial Health and Safety Acts and Amendments, by Ministry of Labor and Employment, Government of India.
2.	Fundamentals of Industrial Safety and Health by Dr.K.U.Mistry, Siddharth Prakashan, 2012.
3.	Goetsch, D. L. (2011). Occupational Safety and Health for Technologists, Engineers and Managers 3rd edition. Prentice hall.
4.	David. A. Calling - Industrial Safety Management and Technology, Prentice Hall, New Delhi.
5.	5. Environmental and Health and Safety Management by Nicholas P. Cheremisinoff and Madelyn L. Graffia, William Andrew Inc. NY, 1995.
6.	6. ISO 45001:2018 Occupational health and safety management systems – Requirements with guidance for use, International Organisation for Standardisation, 2018.

RUBRICSS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICSS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
ADVANCED TECHNOLOGIES FOR TRANSPORTATION SYSTEMS Interdisciplinary Courses (Global Electives) (Group-D)						
Course Code	**:**	**MCV325DE**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+45EL**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
Introduction to Intelligent Transportation Systems (ITS): Definition, objectives, Historical Background, Benefits of ITS –ITS. ITS User Services. ITS Applications. Strategic Needs Assessment and Deployment. Regional ITS Architecture Development Process. ITS Standards. ITS Evaluation. ITS Challenges and Opportunities.	
Unit – II	**09 Hrs**
Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), video data collection. **Telecommunications in ITS:** Information Management, Traffic Management Centres (TMC). Application of sensors to Traffic management; Traffic flow sensor technologies; Transponders and Communication systems; Data fusion at traffic management centres; Sensor plan and specification requirements; Elements of Vehicle Location and Route Navigation and Guidance concepts.	
Unit –III	**09 Hrs**
Traffic Engineering - Fundamental relations of traffic flow, Traffic Stream models - , Shock wave, Car following models, Lane changing models, Vehicle arrival models, PCU values, Interrupted and Uninterrupted flow. Signalized intersection design and Analysis based on IRC, HCM and Indo –HCM. Numerical Problems. Traffic Simulation. Numerical Problems. Application of IOT, Machine learning in traffic management.	
Unit –IV	**09 Hrs**
Transportation Network Analysis – Basic Introduction to Travel demand modelling, Trip generation, Distribution, Modal Split and Trip Assignment. Transit Capacity, ITS functional areas: Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS).	
Unit –V	**09 Hrs**
ITS applications: Traffic and incident management systems; ITS and sustainable mobility, travel demand management, electronic toll collection, ITS and road-pricing. Parking Management; Transportation network operations; commercial vehicle operations; public transportation applications; Automated Highway Systems-Vehicles in Platoons –ITS in World – Overview of ITS implementations in developed countries, ITS in developing countries. Case Studies	

Course Outcomes: After completing the course, the students will be able to	
CO1	Identify and apply ITS applications at different levels
CO2	Illustrate ITS architecture for planning process
CO3	Examine the significance of ITS for various levels
CO4	Compose the importance of ITS in implementations

Reference Books	
1.	Pradip Kumar Sarkar and Amit Kumar Jain, "Intelligent Transport Systems", PHI Learning Private Limited, Delhi,2018, ISBN-9789387472068
2.	Choudury M A and Sadek A, "Fundamentals of Intelligent Transportation Systems Planning" Artech House publishers (31 March 2003); ISBN-10: 1580531601
3.	Bob Williams, "Intelligent transportation systems standards", Artech House, London, 2008. ISBN-13: 978-1-59693-291-3
4.	Asier Perallos, Unai Hernandez-Jayo, Enrique Onieva, Ignacio Julio García Zuazola "Intelligent Transport Systems: Technologies and Applications" Wiley Publishing ©2015, ISBN:1118894782 9781118894781

RUBRICSS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
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3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICSS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
DESIGN AND IMPLEMENTATION OF HUMAN-MACHINE INTERFACE Interdisciplinary Courses (Global Electives) (Group-D)						
Course Code	**:**	**MEC325DF**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+45EL**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
FOUNDATIONS OF HMI: The Human: History of User Interface Designing, I/O channels, Hardware, Software and Operating environments, The Psychopathology of everyday Things, Psychology of everyday actions, Reasoning and problem solving. The computer: Devices, Memory, processing and networks. Interaction: Models, frameworks, Ergonomics, styles, elements, interactivity, Paradigms. **Introduction to HMI and domains**: Automotive, Industrial, CE, Medical, ECUs within car and their functionalities. Interaction between ECUs. Communication protocols for ECUs(CAN, LIN, Most, FlexRay, Ethernet etc)	
Unit – II	**09 Hrs**
Automotive Human-Machine Interfaces: Automotive infotainment system - Evolution road map, Feature sets, System architecture, Trends, Human factors and ergonomics in automotive design, Automotive User Experience (UX) Design Principles, In-Vehicle Information Systems (IVIS), Driver-Assistance Systems (DAS) Interfaces, HMI design for adaptive cruise control, Voice and Gesture Recognition in Automotive HMIs, Touchscreen Interfaces and Controls, Usability Testing and Evaluation in Automotive HMIs, Safety Considerations and Regulations in Automotive HMIs, Emerging Technologies in Automotive HMIs, Human-Machine Interfaces for Autonomous Vehicles	
Unit –III	**09 Hrs**
UX and Guidelines: Introduction to UX design - stages, theory, Design thinking, UX Study, Interaction concepts, Graphic design tools - Adobe Photoshop, Adobe XD, Blender, GIMP, Asset Design - Overview , Guidelines and norms, 2D/3D rendering, OpenGL, OSG.	
Unit –IV	**09 Hrs**
HMI User Interface: User-centered HMI development process, Basics of Web-Server. Web-based HMI: Basics of TwinCAT and HTML, CSS, JavaScript. **HMI on Mobile**: Four Principles of Mobile UI Design, Benefits of Mobile HMIs, Mobile HMI Development Suites.	
Unit –V	**09 Hrs**
HMI Control Systems: Introduction to Voice-Based HMI, Gesture-Based HMI, Sensor-Based UI controls. **Haptics in Automotive HMI**: Kinesthetic Feedback Systems, Tactile Feedback Systems, Haptics in Multimodal HMI, Automotive Use-Cases **HMI Testing**: Limitations of Traditional Test Solutions, Case - Study: Bosch's HMI validation tool - Graphics Test Systems (GTS). **UI analytics**: Usage patterns, Debugging, Performance Profiling, Use Cases.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understanding the application of HMIs in various domain.
CO2	Comparison of various communication protocols used in HMI development
CO3	Apply and analyse the car multimedia system free software and hardware evolution.
CO4	Design and evaluate the graphic tools and advanced techniques for creating car dashboard multimedia systems.

Reference Books	
1.	Shuo gao, Shuo Yan, Hang Zhao, Arokia Nathan " Touch based HMI; Principles and Applications" Springer Nature Switzerland AG, 1st Edition.
2.	Robert Wells, " Unity 2020 by Example: A Project based guide to building 2D, 3D augumented reality and Virtual reality games from sratch" Packt Publishing ltd , edition 2020.
3.	Ryan Cohen, Tao Wang, "GUI Design and Android Apps" Apress, Berkley, CA,2014.

RUBRICSS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
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3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICSS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
ELECTRIC VEHICLE TECHNOLOGY - II IN ELECTRICAL DRIVES Interdisciplinary Courses (Global Electives) (Group-D)						
Course Code	**:**	**MEE325DG**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+45EL**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
Fuzzy Logic Systems: Introduction to fuzzy logic, fuzzy Vs crisp set, linguistic variables, membership functions, fuzzy sets and operations on crisp sets and fuzzy sets, Fuzzy relations, operations on fuzzy relation, Cartesian Product of Relation. linguistic variables, fuzzy if then rules, compositional rule of inference, Fuzzy Rule Base and Approximate Reasoning	
Unit – II	**09 Hrs**
Fuzzy Logic Control: Basic concept of fuzzy logic control, relationship to PI, PD and PID control, design of FLC: determination of linguistic values, construction of knowledge base, inference engine, tuning, fuzzification, De-fuzzification methods. Fuzzy Inference Systems (FIS), Construction and Working Principle of FIS, Mamdani FIS models, Takagi-Sugeno-Kang (TSK) fuzzy models and concept of Adaptive Fuzzy control, Examples applicable to Drives.	
Unit –III	**09 Hrs**
Neural network: Fundamental Concept, history and development of neural network principles, Biological Neural Network, Comparison Between Biological Neuron and Artificial Neuron, Important Terminologies of ANN. Basic Models and Advantages of Neural Networks. **Learning methods:** types of learning, supervised, unsupervised, reinforced learning, knowledge representation and acquisition **Theory, architecture and learning algorithm of neural network models:** McCulloc model, Hopfield model, Perceptron Network, Back propagation network.	
Unit –IV	**09 Hrs**
Neural Networks for feedback Control: Identification of system models using neural networks, Model predictive control, feedback linearization and model reference control using neural networks, Neural Network Reinforcement Learning Controller, Radial basis function neural networks, Basic learning laws in REF nets, Recurrent back propagation, CMAC networks and ART networks, Kmeans clustering algorithm. Kohnen's feature maps, pattern recognition & mapping, Examples applicable to Drives.	
Unit –V	**09 Hrs**
Hybrid algorithms: Neuro-fuzzy systems, ANFIS and extreme-ANFIS, derivative free optimization methods. **Genetic algorithms:** introduction, principle of natural selection, Flow chart of simple genetic algorithm, GA operators and parameters. Particle swarm optimization, Solution of typical control problems. Case studies on Application to Electrical Drives.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the concepts ANN and Fuzzy Logic.
CO2	Analyze the techniques involved in ANN and fuzzy logic applications.
CO3	Design and model hybrid system with ANN and FL or independent system.
CO4	Apply techniques in modern industrial drives and power electronics system.

Reference Books	
1.	Dr. S. N. Sivanandam and Dr. S. N. Deepa, "Principles of Soft Computing", WILEY publication, 2nd Edition, 2008, ISBN: 9788126527410.
2.	John Yen and Reza Langari, "Fuzzy Logic – Intelligence, Control and Information", Pearson Education Inc, 3rd Edition, 2009, ISBN 978-81-317-0534-6.
3.	Simon Haykin, "Neural Networks – A Comprehensive Foundation", PH Publisher, 2nd Edition, 1998, ISBN:978-81-203-2373-5.
4.	Timothy J. Ross., "Fuzzy Logic with Engineering Applications", John Wiley and Sons, 3rd Edition, 2011, ISBN: 978-0-470-74376-8.

RUBRICSS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
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3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICSS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
ELECTRONIC NAVIGATION SYSTEMS Interdisciplinary Courses (Global Electives) (Group-D)						
Course Code	**:**	**MET325DH**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+45EL**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
An Introduction to Radar: Basic Radar, The simple form of the Radar Equation, Radar Block Diagram, Radar Frequencies, Application of radar, Types of Radars. Detection of signals in Noise, Receiver Noise and the Signal-to Noise Ratio, Probability of Detection and False alarm, Introduction to Doppler, MTI, UWB Radars	
Unit – II	**09 Hrs**
Terrestrial Network based positioning and navigation: General Issues of wireless positions location, Fundamentals, positioning in cellular networks, positioning in WLANs, Positioning in Wireless sensor networks.	
Unit –III	**09 Hrs**
Satellite-based navigation systems: Global Navigation satellite systems (GNSS), GNSS receivers.	
Unit –IV	**09 Hrs**
LiDAR: Introduction to LiDAR, context and conceptual discussion of LiDAR, Types of LiDARS, LiDARS Detection modes, Flash LiDAR versus Scanning LiDAR, Monostatic versus Bistatic LiDAR, Major Devices in a LiDAR, LiDAR remote sensing, Basic components and physical principles of LiDAR, LiDAR accuracy and data formats	
Unit –V	**09 Hrs**
SONAR: Underwater acoustics, applications, comparison with radar, submarine detection and warfare, overcoming the effects of the ocean, sonar and information processing. Transmission of the acoustic signal: Introduction, detection contrast and detection index, transmission equation, equation of passive and active sonar.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the concepts of Radar, LiDAR, Sonar, terrestrial and satellite based navigation system.
CO2	Apply the concepts of radars, LiDAR, Sonar, cellular networks, WLAN, sensor networks and satellites in determining the user position and navigation.
CO3	Analyze the different parameters of satellite and terrestrial networks for navigation systems.
CO4	Evaluate the Radar, LiDAR, Sonar systems and satellite and terrestrial network based navigation and tracking systems.

Reference Books	
1.	Introduction to RADAR Systems, M. L Skolnik, 3rd edition, 2017,TATA Mcgraw-Hill, ISBN: 978-0070445338.
2.	Principles of Modern Radar Basic Principles, Mark A Richards, James A Scheer, William A Holam, 2010, 1st edition,SciTech Publishing Inc, ISBN:978-1891121524 .
3.	Satellite and Terrestrial Radio Positioning techniques- A signal processing perspective, Davide dardari, Emanuela Falletti, Marco Luise, 1st Edition, 2012, Elsevier Academic Press, ISBN: 978-0-12-382084-6.
4.	LiDAR Technologies and Systems, Paul McManamon, SPIE press, 2019.
5.	LiDAR Remote Sensing and Applications, Pinliang Dong and Qi Chen, CRC Press, 2018, ISBN: 978-1-4822-4301-7.
6.	Sonar and Underwater Acoustics, Jean-Paul Marage, Yvon Mori, Wiley, 2013, ISBN: 9781118600658.

RUBRICSS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICSS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
VEHICULAR COMMUNICATION ECOSYSTEM Interdisciplinary Courses (Global Electives) (Group-D)						
Course Code	**:**	**MET325DJ**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+45EL**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
Introduction: Basic Principles and Challenges, Past and Ongoing VANET Activities **Standards and Regulations of DSRC** Introduction, Layered Architecture for VANETs, DSRC Regulations, DSRC Physical Layer Standard, DSRC Data Link Layer Standard (MAC and LLC), DSRC Middle Layers.	
Unit – II	**09 Hrs**
Physical Layer Considerations for Vehicular Communications: Standards Overview, Wireless Propagation Theory, Channel Metrics, Measurement Theory, Empirical Channel Characterization at 5.9 GHz. **MAC Layer and Scalability Aspects of Vehicular Communication Networks:** Challenges and Requirements. MAC Approaches for VANETs, Communication Based on IEEE 802.11p.	
Unit –III	**09 Hrs**
MAC Layer and Scalability Aspects of Vehicular Communication Networks Performance Evaluation and Modeling, Aspects of congestion control. **Data Security in Vehicular Communication Networks**: Challenges of Data Security in Vehicular Networks, Network, Applications, and Adversarial Model, Security Infrastructure, Cryptographic Protocols.	
Unit –IV	**09 Hrs**
Intra-vehicle communication:-In-vehicle networks, Automotive bus systems, In-vehicle Ethernet, Wireless in-vehicle networks **Inter-vehicle communication**: Applications, Requirements and components, Concepts for inter-vehicle communication, Fundamental limits.	
Unit –V	**09 Hrs**
Cooperative Vehicular Safety Applications: Introduction, Enabling technologies, Cooperative system architecture, Mapping for safety applications. **VANET-enabled Active Safety Applications:** Infrastructure-to-vehicle applications, Vehicle-to-vehicle applications, Pedestrian-to-vehicle applications.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Illustrate fundamentals of wireless vehicular networks.
CO2	Design of Physical & MAC layer and routing protocols for vehicular networks.
CO3	Analyse the security issues and energy management in vehicular networks.
CO4	Evaluate the performance of vehicular networks in different use cases.

Reference Books	
1.	VANET Vehicular Applications and Inter-networking Technologies, Hannes Hartenstein and Kenneth Laberteaux (eds.), John Wiley & Sons, 2009
2.	Vehicular Networking, Christophe Sommer and Falko Dressler, Cambridge University Press, 2014.
3.	Vehicular ad hoc Networks: Standards, Solutions, and Research, Claudia Campolo, AntonellaMolinaro and Riccardo Scopigno, Springer, 2015.
4.	Wireless Communications, Andrea Goldsmith, Cambridge University Press, 2005.
5.	VANET Vehicular Applications and Inter-networking Technologies, Hannes Hartenstein and Kenneth Laberteaux (eds.), John Wiley & Sons, 2009.

RUBRICSS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICSS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
ESSENTIALS OF PROJECT MANAGEMENT Interdisciplinary Courses (Global Electives) (Group-D)						
Course Code	**:**	**MIM325DK**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+45EL**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
Introduction: Project Planning, Need of Project Planning, Project Life Cycle, Roles, Responsibility and Team Work, Project Planning Process, Work Breakdown Structure (WBS), Introduction to Agile Methodology.	
Unit – II	**09 Hrs**
Capital Budgeting: Capital Investments: Importance and Difficulties, phases of capital budgeting, levels of decision making, facets of project analysis, feasibility study – a schematic diagram, objectives of capital budgeting	
Unit –III	**09 Hrs**
Project Costing: Cost of Project, Means of Finance, Cost of Production, Working Capital Requirement and its Financing, Profitability Projections, Projected Cash Flow Statement, Projected Balance Sheet, Multi-year Projections, Financial Modeling, Social Cost Benefit Analysis	
Unit –IV	**09 Hrs**
Tools & Techniques of Project Management: Bar (GANTT) chart, bar chart for combined activities, logic diagrams and networks, Project evaluation and review Techniques (PERT) Critical Path Method (CPM), Computerized project management.	
Unit –V	**09 Hrs**
Project Management and Certification: An introduction to SEI, CMMI and project management institute USA – importance of the same for the industry and practitioners. PMBOK 6 - Introduction to Agile Methodology, hemes / Epics / Stories, Implementing Agile. Domain Specific Case Studies on Project Management: Case studies covering project planning, scheduling, use of tools & techniques, performance measurement.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain project planning activities that accurately forecast project costs, timelines, and quality.
CO2	Evaluate the budget and cost analysis of project feasibility.
CO3	Analyze the concepts, tools and techniques for managing projects.
CO4	Illustrate project management practices to meet the needs of Domain specific stakeholders from multiple sectors of the economy (i.e. consulting, government, arts, media, and charity organizations).

Reference Books	
1.	Project Planning Analysis Selection Financing Implementation & Review, Prasanna Chandra, Tata McGraw Hill Publication, 9th Edition, 2017, ISBN: 978-9332902572.
2.	Project Management Institute, A Guide to the Project Management Body of Knowledge (PMBOK Guide), 5th Edition, 2013, ISBN: 978-1-935589-67-9
3.	Project Management A System approach to Planning Scheduling & Controlling, Harold Kerzner, John Wiley & Sons Inc., 11th Edition, 2013, ISBN 978-1-118-02227-6.
4.	Project Management – Planning and Controlling Techniques, Rory Burke, John Wiley & Sons, 4th Edition, 2004, ISBN: 978-0470851241

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#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICSS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
USER INTERFACE AND USER EXPERIENCE Interdisciplinary Courses (Global Electives) (Group-D)						
Course Code	**:**	**MIS325DM**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+45EL**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
What's a UI Pattern?: How Users Interact With Design Patterns, Following Universal Design Conventions, Applying Empathy to UI Design Patterns. Why Use UI Patterns?: Why Patterns Work, Expectations Reinforce Themselves, Deadline-Busting Communication, Why not use patterns?. The Importance of Prototyping First: Got a Pattern? Plan it Out, Thinking Through the Process, Patterns Take Guesswork Off of Developers' Plates.	
Unit – II	**09 Hrs**
User Testing: Insights You Can't Ignore. Prototyping UI Patterns: Explaining the Gray Box, Pattern Libraries Are Prototyping Shortcuts, Reusable elements, Patterns and Prototypes Work Together, Applying UI Design Patterns: Building a Pattern Library, Riffing on Design Patterns, Tweaking Pattern Styles, Going forward, Useful UI Pattern Examples, Formatting Data, Getting input, Navigation, Teasers.	
Unit –III	**09 Hrs**
Design for Usefulness: Painkillers & Vitamins, Embracing Goal-Centered Design, Test for Relevancy With an MVP, A Quick MVP Case Study: Buffer. Designing for Usability: Forgiving, Satisfying, The 6-Step Process to Improve Usability. Designing for Desirability: Desirable Products Are More Usable, Desire Is Relative to Users, Elements of Desirable Design.	
Unit –IV	**09 Hrs**
Designing for Findability: Building the Right Information Architecture, 5 IA Layouts for the Web, 5 Navigational Menu Patterns, Testing Findability. Design for Accessibility: Universal Design, What Accessibility Means for UX Design, Benefits of Accessibility, Accessibility Best Practices.	
Unit –V	**09 Hrs**
The Core of Desirable Design: The Habit Loop, A Quick Case Study, Quick Case Study: Apple.com. Designing for Credibility: First Impressions Matter, Quick Case Study: Chase, Building a Credible Product Interface, Selling the Product Through Social Proof, Persuading Through Transparency.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the concept of User Interface and User Experience to increase look and feel various applications.
CO2	Analyse the usability, accesssibility, availability and other factors of User Interface design patterns.
CO3	Design and implement techniques of implementing design patterns.
CO4	Evaluate the design patetrns and elements of user experience.

Reference Books	
1.	Tactical UI Design Patterns, Ben Gremillion, Jerry Cao, Kamil, The Handbook to faster Design, UXPin Inc., 2015.
2.	The Elements of Successful UX Design, Best Practices of Meaningful products, Jerry Cao, Kamil, Matt Ellis, UXPin Inc., 2015.
3.	User Friendly- How the Hidden Rules of Design Are Changing the Way We Live, Work, and Play, Cliff Kuang, Picador Paper; Reprint edition, 2020, ISBN: 1250758203.
4.	Designing Interfaces: Patterns for Effective Interaction Design, Jenifer Tidwel, 3rd Edition, O'Reilly, 2020, ISBN: 1492051969.

RUBRICSS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
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3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICSS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
MATHEMATICAL METHODS FOR DATA SCIENCE Interdisciplinary Courses (Global Electives) (Group-D)						
Course Code	**:**	**MMA325DN**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+45EL**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
Parameter Estimation: Introduction to probability models of univariate random variables, Discrete distribution (Bernoulli, Binomial, Poisson), Continuous distributions (Uniform, Exponential, Normal), Estimation - Criteria for good estimates - unbiasedness, consistency, efficiency and sufficiency, Variance of a point estimator, Parameter estimation via maximum likelihood, Method of moments, Bayesian estimation of parameters.	
Unit – II	**09 Hrs**
Optimization I: Introduction and formulation, Optimality conditions, Review of local maxima, and local minima along with first and second order conditions. Taylor series and local function approximation, automatic differentiation, One dimensional Search Methods - Sequential search method, Fibonacci search method, Golden section search method.	
Unit –III	**09 Hrs**
Optimization II: Constrained and Unconstrained optimization, Gradient vector, Hessian matrix, optimization using Hessian matrix, Gradient descent method, Step size selection and convergence, Newton method, Stochastic gradient descent (SGD), Convex optimization, Duality - weak and strong duality, Optimization using duality.	
Unit –IV	**09 Hrs**
Fuzzy Optimization: Basic concepts of fuzzy sets - Operations on fuzzy sets, Fuzzy relation equations, Fuzzy logic control, Fuzzification, Defuzzification, Decision making logic, Membership functions. **Artificial Neural Networks:** Introduction - Neuron model, Multilayer perceptions - Back propagation algorithm and its variants, Loss functions in artificial neural networks.	
Unit –V	**09 Hrs**
Machine Learning Algorithms: Unsupervised learning, Supervised learning, Linear regression, Multiple Linear Regression, Overfitting, Naïve Bayes classifier. Clustering methods, k-means clustering, Linear support vector machine, Kernel functions and Nonlinear support vector machine.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Explore fundamental concepts of estimation, optimization, and machine learning applied in various branches of engineering.
CO2	Apply theoretical concepts of estimation and optimization to model problems using a machine learning approach on model requirements and to evaluate solutions within given constraints effectively.
CO3	Analyze and solve the modern engineering problems using appropriate techniques of statistical and mathematical learning to the real-world problems arising in many practical situations.
CO4	Develop and implement algorithms for constrained and unconstrained optimization, utilizing estimation techniques to classify, predict, and optimize solutions for practical applications, emphasizing model accuracy and performance and also engage in lifelong learning.

Reference Books	
1.	Numerical Optimization, Springer, Jorge Nocedal Stephen J. Wright, 2nd Edition, 2006, ISBN-10: 0-387-30303-0 ISBN-13: 978-0387-30303-1.
2.	Algorithms for Optimization, Mykel J. Kochenderfer, Tim A. Wheeler, MIT Press, Illustrated Edition, 2019, ISBN-13 978-0262039420.
3.	Pattern Recognition and Machine Learning, Christopher M. Bishop, Springer, 1st Edition, 2006, ISBN-10: 0-387-31073-8 ISBN-13: 978-0387-31073-2.
4.	Understanding Machine Learning: From Theory to Algorithms, Shai Shalev-Shwartz and Shai Ben-David, 1st Edition, Cambridge University Press, 2014, ISBN: 978-1-107-05713-5.
5.	Fuzzy Sets and Fuzzy Logic: Theory and Applications**,** George J. Klir and Bo Yuan, 1st Edition, Prentice Hall PTR, 1995, ISBN 0-13-101171-5.

RUBRICSS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
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3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICSS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
INDUSTRY 4.0: THE SMART MANUFACTURING Interdisciplinary Courses (Global Electives) (Group-D)						
Course Code	**:**	**MME325DO**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+45EL**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
Fundamentals of Industry 4.0-Introduction, Key Components of Industry 4.0, RAMI 4.0, Cyber-Physical Systems. **Servitization and Product-Service Systems** - Integrated Overview, Examples Across Sectors. Industry 4.0 Across Sectors- Introduction, Smart Manufacturing, Transportation 4.0, Multimodal Transportation Systems, Rail 4.0, Logistics 4.0 and Implications. **Future Trends and Challenges**- Emerging Applications, Risks and Barriers to Implementation	
Unit – II	**09 Hrs**
The Concept of IIoT- Introduction to IIoT, Key Features and Applications. **Modern Communication Protocols**- Overview, TCP/IP, Wireless Communication, Technologies. **API**- A Technical Perspective, Importance in IIoT, Examples Applications, **Middleware Architecture**- Role in IIoT, Integration and Data Flow Management. **Emerging Trends in IIoT**- Industrial IoT Standards and Frameworks, Edge Computing in IIoT.	
Unit –III	**09 Hrs**
Data Analytics in Manufacturing: Energy Efficiency in Manufacturing, Anomaly Detection in Air Conditioning Systems, Smart Remote Machinery Maintenance Systems with Komatsu, Quality Prediction in Steel Manufacturing, Predictive Maintenance with Data Analytics **Internet of Things and New Value Proposition**: IoT in Manufacturing, Value Creation Barriers: Standards, security, and privacy concerns. **Advances in Robotics in the Era of Industry 4.0**: Recent Technological Components of Robots, Advanced Sensor Technologies, Artificial Intelligence in Robotics, Collaborative Robots, Internet of Robotic Things, Cloud Robotics, Digital Twin Technology.	
Unit –IV	**09 Hrs**
Additive Manufacturing Technologies and Applications: Additive Manufacturing Technologies Overview, Stereo lithography, 3D Printing, Fused Deposition Modeling, Selective Laser Sintering, Laser Engineered Net Shaping, Manufacturing in Industry 4.0, Hybrid Manufacturing Processes. **Advances in Virtual Factory Research and Applications**: The State of Art, The Virtual Factory Software.	
Unit –V	**09 Hrs**
Cybersecurity and Resilience in Industry 4.0: Introduction to Cybersecurity in Industry 4.0, Industrial IoT security, Edge and Cloud Security, Digital Twin Security, AI and Machine Learning for Cybersecurity, Standards and Frameworks for Industry 4.0 Cybersecurity, Resilience Strategies for Industry 4.0, Future Trends in Cybersecurity for Industry 4.0.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the opportunities, challenges brought about by Industry 4.0 for benefits of organizations and individuals
CO2	Analyze the effectiveness of Smart Factories, Smart cities, Smart products and Smart services
CO3	Apply the Industrial 4.0 concepts in a manufacturing plant to improve productivity and profits
CO4	Evaluate the effectiveness of Cloud Computing in a networked economy

Reference Books	
1.	Industry 4.0 The Industrial Internet Of Things, Alasdair Gilchrist, Apress Publisher, ISBN-13 (pbk): 978-1-4842-2046-7.
2.	Industry 4.0: Managing The Digital Transformation, Alp Ustundag, Emre Cevikcan, Springer, 2018 ISBN 978-3-319-57869-9.
3.	Designing the industry - Internet of things connecting the physical, digital and virtual worlds, Ovidiu Vermesan and Peer Friess, Rivers Publishers, 2016 ISBN 978-87-93379-81-7.
4.	The concept Industry 4.0- An Empirical Analysis of Technologies and Applications in Production Logistics, Christoph Jan Bartodziej, Springer Gabler, 2017 ISBN 978-3-6581-6502-4 .

RUBRICSS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
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3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICSS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

Semester: II						
INDUSTRIAL INTERNET OF THINGS (IIOT) Interdisciplinary Courses (Global Electives) (Group-D)						
Course Code	**:**	**MME325DQ**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+45EL**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**09 Hrs**
Introduction: IoT vs IIoT, challenges in deployment, building blocks of business model and architecture, layers, sensing for manufacturing process, processing, communication and networking. Applications – Factories and assembly lines, inventory management and quality control, facility management. **Industrial Control Systems** Process Industries versus Discrete Manufacturing Industries – Levels, variables and parameters, Continuous Control Systems, Discrete Control Systems, Computer Process Control - Control Requirements, Capabilities of Computer Control, Forms of Computer Process Control.	
Unit – II	**09 Hrs**
Sensors in IIoT applications Temperature sensor interfacing, accelerometer sensor interfacing, MoS Gas sensor, magneto strictive sensors, speed sensor, ultrasonic sensor, smart sensors. **Automatic identification and data Capture** Overview Of Automatic Identification Methods, Linear (One-Dimensional) Bar Code, Two-Dimensional Bar Codes, Radio Frequency Identification, Magnetic Stripes, Optical Character Recognition, Machine Vision	
Unit –III	**09 Hrs**
Group Technology and Cellular Manufacturing Part Family, Intuitive Grouping, Parts Classification and Coding, Production Flow Analysis, cellular manufacturing - Composite Part Concept, Machine Cell Design, applications of group technology, Opitz Part Coding System, Machine Cell Organization and Design Rank-Order Clustering - Numericals	
Unit –IV	**09 Hrs**
Industrial Networking Introduction, Hierarchy of Industrial Networks, Network Topologies, Data Flow Management, Transmission Hardware, Network Backbones, Network Communication Standards, Fieldbus Networks **Simulating Industrial Processes** Queues and Queueing – waiting time, service time, machine utilisation, Modelling an Industrial Process Designing a Process Simulation, managing resource utilisation, product mixes, Queuing network models.	
Unit –V	**09 Hrs**
Clustering Similarity measures, hierarchical clustering – single linkage, complete linkage, average linkage Non heirerchial clustering – Numericals, multidimensional scaling correspondence analysis - Numericals **Prediction Models** K- Nearest neighbour, RMS Error and Mean Absolute Error, Mean Absolute Percentage Error, Coefficient of Determination, Underfitting and Overfitting, Cross-Validation, multiple regression – Numericals.	

Course Outcomes: After completing the course, the students will be able to	
CO1	***Analyze*** the differences between IoT and IIoT, and evaluate the challenges, architectures, and sensing layers involved in the deployment of IIoT for manufacturing and industrial applications.
CO2	***Demonstrate*** the ability to interface sensors in IIoT systems, and apply automatic identification techniques for process automation.

CO3	***Design*** machine cells using group technology principles, and implement cellular manufacturing systems for optimized production workflows.
CO4	***Develop*** simulation models for industrial processes, and predict outcomes to optimize industrial system performance.

Reference Books	
1.	Industrial Internet of Things: Cyber manufacturing Systems, Jeschke, S., Brecher, C., Song, H., & Rawat, D. B. (Eds.). (2017). Springer. ISBN: 978-3-319-42559-7.
2.	Automation, Production Systems, and Computer-Integrated Manufacturing (5th ed.), Groover, M. P. (2018), Pearson. ISBN: 978-0134605463.
3.	Applied Multivariate Statistical Analysis (6th ed.), Johnson, R. A., & Wichern, D. W. (2007). Pearson Prentice Hall. ISBN: 978-0131877153.
4.	Guide to Industrial Analytics: Solving Data Science Problems for Manufacturing and the Internet of Things, Hill, R., & Berry, S. (2021), Springer, ISBN: 978-3-030-79103-2.

RUBRICSS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICSS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

SEMESTER: II						
Course Code	**:**	**MIM416RT**	**RESEARCH METHODOLOGY**	**CIE Marks**	**:**	**NA**
Credits L-T-P	**:**	**2:0:0**	*(Theory - NPTEL Online Course)*	**SEE Marks**	**:**	**50**
Hours	**:**	**16L**	*(Common Course to all M.Tech Programs)*	**SEE Duration**	**:**	**2 Hours**

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 8 Weeks

Week 1: A group discussion on what is research; Overview of research
Week 2: Literature survey, Experimental skills
Week 3: Data analysis, Modelling skills
Week 4: Technical writing; Technical Presentations; Creativity in Research
Week 5: Creativity in Research; Group discussion on Ethics in Research
Week 6: Design of Experiments
Week 7: Intellectual Property
Week 8: Department specific research discussions

Reference Books:

1. Krishnaswami, K.N., Sivakumar, A. I. and Mathirajan, M., Management Research Methodology, Integration of Principles, Methods and Techniques, 17th Impression, Pearson India Education Services Pvt. Ltd, 2018. ISBN: 978-81-7758-563-6
2. William M. K. Trochim, James P. Donnelly, The Research Methods Knowledge Base, 3rd Edition, Atomic Dog Publishing, 2006, ISBN: 978-1592602919
3. Kothari C.R., Research Methodology Methods and Techniques, 4th Edition, New Age International Publishers, 2019, ISBN: 978-93-86649-22-5.
4. Levin, R.I. and Rubin, D.S., Statistics for Management, 8th Edition, Pearson Education: New Delhi, 2017, ISBN-13- 978-8184957495.

GENERAL GUIDELINES

1. NPTEL is an acronym for National Programme on Technology Enhanced Learning which is an initiative by seven Indian Institutes of Technology (IIT Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and Indian Institute of Science (IISc) for creating course contents in engineering and science.
2. NPTEL is offering online certification courses through its portal -https://swayam.gov.in/nc_details/NPTEL
3. Enrollment to courses and exam registration can be done in ONLINE mode only. The link is available on NPTEL website http://nptel.ac.in/
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5. In case students fail to get the certificate, they need to enroll for the same course once again, in the subsequent NPTEL semester and clear the exam.
6. If the same course is not offered by NPTEL (i.e. if the same course is not re-run) in the subsequent semester by NPTEL, the students need to write letter seeking permission from the Counsellor, HoD and Dean Academics with further approval from BoS Committee to take alternative course from the list announced by NPTEL.
7. Exam is conducted by NPTEL.

Semester: II						
SKILL LAB (MULTICARRIER MODEM FUNCTIONS)						
Course Code	**:**	**MCS427SL**		**CIE**	**:**	**50**
Credits: L:T:P	**:**	**0:0:2**		**SEE**	**:**	**50**
Hours/Week	**:**	**4**		**SEE Duration**	**:**	**02 Hours**

- **Module 1:** Design and development of algorithms for DSL modem functions: Develop DSL constellation encoding/decoding, normalization, and bit/power allocation algorithms, implement adaptive-rate control for seamless operation using MATLAB.
- **Module 2:** Design and development of algorithm for LTE modem functions: Implement LTE constellation encoding/decoding and normalization techniques, develop power/bit allocation algorithms for fixed and adaptive-rate scenarios using MATLAB.
- **Module 3:** Design and development of algorithm for DSL and LTE Synchronization: Design frame detection, symbol timing, and frequency offset correction algorithms, implement synchronization mechanisms and validate in MATLAB.
- **Module 4:** Emulation of DSL Modem Functions in RF-SoC with Test Routines: Implement DSL modem functions on RF-SoC, develop test routines for real-time validation.

Course Outcomes: After completing the course, the students will be able to	
CO1:	Illustrate the fundamental concepts of various technologies in wireless which are used in Communication systems.
CO2:	Derive the solution by applying the acquired knowledge of wireless technologies
CO3:	Evaluate the solution of the problems using wireless techniques to the real-world problems arising in many practical situations
CO4:	Design and development of wireless techniques for 5G communication and gain knowledge to apply and engage in life – long learning.

Reference Books	
1	ITU-T G.992.3: SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS, Digital sections and digital line system – Access networks, Asymmetric digital subscriber line transceivers 2 (ADSL2).
2	IEEE Communications Magazine, 5G Special Issue
3	RF SoC Literature

RUBRIC FOR CONTINUOUS INTERNAL EVALUATION (CIE-Lab)		
1	Conduction of the experiments relevant to the modules & Report	15
2	Design and testing of the Prototype / Projects / Modules	20
3	Final presentation and report	15
MAXIMUM MARKS FOR THE SEE		**50**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Lab)
The evaluation will be carried out by Internal and External examiners through Exhibition Mode.
The following weightage would be given for the exhibition.

Q.NO.	CONTENTS	MARKS
1	Presentation through posters	15
2	Demonstration of the Prototype / Projects / Modules	25
3	Vivavoce	10
MAXIMUM MARKS FOR THE SEE		**50**

SEMESTER: III						
ERROR CONTROL CODING FOR WIRELESS COMMUNICATION (Theory) (Professional Core Course)						
Course Code	**:**	**MCS331TA**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L+30T+45EL**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Introduction to algebra: Groups, Fields, binary field arithmetic, Construction of Galois Field GF (2m) and its properties, Computation using Galois filed GF (2m) arithmetic, Vectors and Matrices.	
Unit – II	**09 Hrs**
BCH codes: Binary primitive BCH codes, Decoding procedures, Implementation of Galois field arithmetic, Implementation of error correction. Non-binary BCH codes: Primitive BCH codes over GF(q).	
Unit –III	**09 Hrs**
Majority Logic decodable codes: One -step majority logic decoding, Class of One-step majority logic decodable codes. Convolution codes: Encoding of convolutional codes, Transfer Function of convolution codes, Structural properties, Distance properties, Viterbi search decoding algorithm – soft decision and hard decision based.	
Unit –IV	**09 Hrs**
Concatenated Codes: Single level Concatenated Codes, Multilevel Concatenated Codes (Formulation only), PCBC and one PCCC, Performance Analysis Formulation and one example only. Low Density parity-Check Codes: Tanner Graphs, Geometric Construction of LDPC Codes, Decoding of LDPC Codes – Majority Logic, Bit Flipping.	
Unit –V	**09 Hrs**
Polar Codes: Primary Concepts and Practical Decoding Algorithms-successive cancellation (SC) list and fast SC	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explain the principles and theory of Linear Algebra, and apply the same for BCH Codes in Communication systems.
CO2:	Perform a decoding procedure for Majority logic decodable and Convolution codes
CO3:	Test and evaluate the Convolution Codes schemes for performance.
CO4:	Construct and Decode Concatenated codes and polar codes to perform close to Shannon Limit in a data Transmission system.

Reference Books	
1	Error control coding, Shu Lin and Daniel J. Costello. Jr, Pearson, 2nd edition, 2011, ISBN 978-81-317-3440-7
2	Introduction to Error control coding, Salvatore Gravano, Oxford university press, , ISBN:019923678X , 2007

3.	Theory and practice of error control codes, Blahut. R. E, Addison Wesley, ISBN: 0201101025, 1984 4. Coding theory A first course, Cambridge university press, SAN ling, chaoping xing,ISBN: 0521821916, 2004
4.	Polar codes are referred from IEEE transaction papers and Journal papers. Error Control Coding for Wireless Communication

RUBRICSS FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO tests will be conducted**. Each test will be evaluated for **50 Marks**, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program-specific requirements (10), Video- seminar/presentation/demonstration (10**)** Real-time problem solving (10) **ADDING UP TO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRICSS FOR SEMESTER END EXAMINATION (THEORY)		
Q.NO.	**CONTENTS**	**MARKS**
Each unit consists of TWO questions with 20 marks each. Answer FIVE full questions selecting ONE from each unit [1 to 5]		
1 & 2	Unit 1: Question 1 or 2	**20**
3 & 4	Unit 2: Question 3 or 4	**20**
5 & 6	Unit 3: Question 5 or 6	**20**
7 & 8	Unit 4: Question 7 or 8	**20**
9 &10	Unit 5: Question 9 or 10	**20**
	TOTAL	**100**

SEMESTER: III						
Course Code	**:**	**MCS232E1**	**FIBER OPTIC COMMUNICATION TECHNOLOGY** (Theory) (Professional Elective E (NPTEL))	**CIE Marks**	**:**	**NA**
Credits L-T-P	**:**	**2:0:0**		**SEE Marks**	**:**	**50**
Hours	**:**	**24L**		**SEE Duration**	**:**	**2 Hours**

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 12 Weeks

Week 1: Motivation for fiber optic communication, Introduction to digital modulation, Overview of Optical Communication System.

Week 2: Optical Sources: LED - Working principle, Efficiency, Modulation bandwidth, Emission Pattern, Need for Laser Diodes, Resonator Concepts.

Week 3: Optical Sources : Laser Diodes - Resonator, FSR, Q, Single Longitudinal Mode Lasers, Photon Lifetime, Semiconductor, Laser Rate equation, steady state solution, LI characteristics, Output power from laser, Modulation response of LD, Chirp.

Week 4: Optical Sources- Noise in Lasers- Relative Intensity Noise, Phase noise, Effect of noise on different modulation schemes, External Modulation- generation of OOK, BPSK, QPSK and 16QAM.

Week 5: Optical Fibers - Attenuation in fibers, Modes of a step index fiber, b-V curves, Modal profiles.

Week 6: Optical Fibers- Dispersion in fibers, intermodal dispersion, material dispersion, waveguide dispersion, polarisation mode dispersion.

Week 7: Photo detectors- PIN and APD Detectors, Sources of Noise- shot noise, thermal noise, NEP, SNR, Heterodyne detectors, SNR in heterodyne detection.

Week 8: Optical Link Design - Performance Evaluation of an OOK link- BER, Q, Receiver Sensitivity, Optical Amplifiers- EDFA.

Week 9: Optical Link Design Link Budget, Case Studies, Dispersion COmpensation, Nonlinear Effects-Self Phase Modulation.

Week 10: Nonlinear effects - Cross Phase Modulation, Four Wave Mixing, Stimulated Raman and Brillouin Scattering, Commonly used components in Optical Networks.

Week 11: Coherent Detection and DSP : Balanced Detection, Phase and Polarisation Diverse Coherent Detection, Digital Signal Processing for compensation of phase noise, frequency offset, chromatic dispersion, polarisation mode dispersion.

Week 12: Optical Networks : SDH/SONET Layering, Frame Structure , Physical network topologies, Access Networks- PON ,Optical Interconnects, Data Centers ,Optical communication for Wireless Fronthauling.

Course duration: 12 Weeks
Course start Date: Jan 20,2025
Course end date: March 14,2025
Probable Exam date: March 22,2025

Course Instructors:
Prof. Deepa Venkitesh

GENERAL GUIDELINES

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Reference Books	
1	Fiber-Optic Communications Systems, Govind P. Agrawal, John Wiley & Sons, Inc., 3rd edition, 2012, ISBN 0-471-22114-7.
2	Introduction to Fiber Optics, Ajoy Ghatak and K. Thyagarajan, Cambridge university press, ISBN:0-521-57120, 2000.
3.	Optical Fiber Communication: Principles and Practice, Senior John M., Third edition, Pearson, ISBN: 978-81-317-3266-3

SEMESTER: III						
Course Code	**:**	**MCS232E2**	**SIMULATION OF COMMUNICATION SYSTEMS USING MATLAB** (Theory) (Professional Elective E (NPTEL))	**CIE Marks**	**:**	**NA**
Credits L-T-P	**:**	**2:0:0**		**SEE Marks**	**:**	**50**
Hours	**:**	**24L**		**SEE Duration**	**:**	**2 Hours**

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 12 Weeks

Week 1: Introduction
Week 2: MATLAB Programming
Week 3: Monte Carlo Methods
Week 4: Random Processes
Week 5: Information Sources and Quantization
Week 6: Modelling and Simulation of AWGN Communication Systems
Week 7: Fading Channels
Week 8: MIMO
Week 9: Markov Chains and the Viterbi Algorithm
Week 10: Queueing I
Week 11: Queueing II
Week 12: Optimal Filtering and Stochastic Gradient Descent

Course duration: 12 Weeks
Course start Date: Jan 20,2025
Course end date: March 14,2025
Probable Exam date: March 22,2025

Course Instructors:
Prof. Ribhu

GENERAL GUIDELINES

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6. If the same course is not offered by NPTEL (i.e. if the same course is not re-run) in the subsequent semester by NPTEL, the students need to write letter seeking permission from the Counsellor, HoD and Dean Academics with further approval from BoS Committee to take alternative course from the list announced by NPTEL.
7. Exam is conducted by NPTEL.

Reference Books

1	Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers, Rudra Pratap, Oxford University Press, Inc., USA, 2009.

2	Introduction to Probability Models, Sheldon M. Ross, Twelfth Edition, Academic Press, 2019.
3.	Contemporary Communication Systems Using MATLAB, Proakis, J.G., Salehi, M., Bauch, G., Third edition, Cengage Learning, 2012.
4.	Adaptive Filter Theory, Haykin, Simon S, Fifth Edition, Pearson, 2014.

SEMESTER: III						
Course Code	**:**	**MCS232E3**	**MODERN DIGITAL COMMUNICATION TECHNIQUES** (Theory) (Professional Elective E (NPTEL))	**CIE Marks**	**:**	**NA**
Credits L-T-P	**:**	**2:0:0**		**SEE Marks**	**:**	**50**
Hours	**:**	**24L**		**SEE Duration**	**:**	**2 Hours**

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 12 Weeks

Week 1: Introduction to digital communication systems
Week 2: Source Coding
Week 3: Characterization of Communication Signals & Systems
Week 4: Signal space Representation
Week 5: Representation of Memory less Modulation Methods
Week 6: Nonlinear modulation methods
Week 7: Optimal receivers of AWGN
Week 8: Receiver for non-ideal channel
Week 9: Probability of error of different modulation schemes
Week 10: Fundamentals of estimation and detection theory used in digital communication
Week 11: Carrier phase and symbol timing synchronization techniques
Week 12: Channel estimation and equalization techniques, Power Adaptation methods for colored noise channel

Course duration: 12 Weeks
Course start Date: Jan 20,2025
Course end date: March 14,2025
Probable Exam date: March 22,2025

Course Instructors:
Prof. Suvra Sekhar Das

GENERAL GUIDELINES

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4. Students need to enroll for the NPTEL course and clear the exam.
5. In case students fail to get the certificate, they need to enroll for the same course once again, in the subsequent NPTEL semester and clear the exam.
6. If the same course is not offered by NPTEL (i.e. if the same course is not re-run) in the subsequent semester by NPTEL, the students need to write letter seeking permission from the Counsellor, HoD and Dean Academics with further approval from BoS Committee to take alternative course from the list announced by NPTEL.
7. Exam is conducted by NPTEL.

Reference Books

1	Digital Communications, John G. Proakis, Masoud Salehi, 5th edition, McGraw-Hill Education, 2007, ISBN-13, 978-0072957167.
2	Digital communications: fundamentals and applications, Sklar B., Pearson, 2021, ISBN: 9780137569076.
3.	Digital Communications, Robert Gallager, Vol. 1., Cambridge, UK: Cambridge University Press, 2008, ISBN: 9780521879071.
4.	Digital communications, Haykin, Simon S., Vol. 5. New York: Wiley, 1988, ISBN: 9788126508242

SEMESTER: III						
Course Code	**:**	**MCS232E4**	**PRINCIPLES OF MODERN CDMA/MIMO OFDM WIRELESS COMMUNICATIONS** (Theory) (Professional Elective E (NPTEL))	**CIE Marks**	**:**	**NA**
Credits L-T-P	**:**	**2:0:0**		**SEE Marks**	**:**	**50**
Hours	**:**	**16L**		**SEE Duration**	**:**	**2 Hours**

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 8 Weeks

Week 1: Introduction to Wireless Systems
Week 2: Performance in Fading wireless channels
Week 3: Multiple Antenna Wireless Systems and Diversity
Week 4: Wireless Channel Characterization - Delay Spread and Doppler
Week 5: Principles of CDMA Wireless Communication
Week 6: Principles of MIMO Wireless Communication
Week 7: Principles of MIMO Wireless Communication (Continued)
Week 8: Principles of OFDM Wireless Communication

Course duration: 8 Weeks
Course start Date: Jan 20,2025
Course end date: March 14,2025
Probable Exam date: March 22,2025

Course Instructors:
Prof. Aditya K. Jagannatham

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7. Exam is conducted by NPTEL.

Reference Books

1	Fundamentals of wireless communication, Tse, David, and Pramod Viswanath, Cambridge university press, 2005, ISBN-13: 978-0521845274.
2	Wireless communications, Goldsmith, Andrea, Cambridge university press, 2005, ISBN: 9780521837163

3.	Jagannatham, Aditya K. Principles of modern wireless communication systems. McGraw-Hill Education, 2015, ISBN-10. 9781259029578.

SEMESTER: III					
MINOR PROJECT					
Course Code	**:**	**MCS443P**		**CIE Marks**	**50**
Credits L:T:P	**:**	**0:0:6**		**SEE Marks**	**50**
Hours/Week	**:**	**180P**		**SEE Duration**	**03 Hrs**

Guidelines

1. Students can form group of two to execute the Minor Project.
2. Students are required to select topics related to their PG Program Specialization after extensive Literature Survey and analyzing the Research gaps.
3. Students will be assigned to guides in accordance with the expertise of the faculty.
4. Minor project topics could also be aligned to be implemented/executed based on any of the 16 Centre of Excellence (CoE)/ 06 Center of Competence (CoC) domain. The details of these could be obtained by visiting the website https://rvce.edu.in/rvce-center-excellence
5. Minor project has to be implemented/executed in-house, using the resources available in the department/college/CoE/CoC.
6. Students have to note the periodic progress in the Minor Project Diary and report the work carried to their respective guides.
7. Students have to present the Minor project work to the departmental committee and only upon approval by the committee, the student can proceed to prepare and submit the hard copy of the final Minor project report.
8. The reports shall be printed on A4 size with 1.5 spacing and Times New Roman with font size 12, outer cover of the report (wrapper) has to be softbound in Ivory/White color for PG circuit Programs and Light Blue for Non-Circuit Programs.

Course Outcomes: After completing the course, the students will be able to

CO1	:	Analyze the research gaps, formulate the problem definition, conceptualize the objectives and design solution to cater to specific problems.
CO2	:	Apply higher order thinking skills and develop skill competencies specific to program specialization to implement real world problems with professional ethical standards.
CO3	:	Demonstrate the skill and knowledge by applying appropriate tools and techniques specific to their domain.
CO4	:	Communicate, work in teams and demonstrate the learning through oral presentations and report writing.

Scheme of Continuous Internal Evaluation (CIE):

The evaluation committee shall consist of Guide, Professor, Associate Professor/Assistant Professor. The committee shall assess and evaluate the presentation and the progress reports.

The evaluation criteria shall be as per the rubrics given below:

Reviews	**Activity**	**Weightage**
I	Approval of the selected topic, formulation of Problem Statement and Objectives along with Synopsis submission	10%
II	Demonstrate the skill and knowledge by applying appropriate tools/techniques to design solution specific to the problem.	30%
III	Demonstrates the work carried out through experimental results, analysis and	60%

	testing. Exhibits writing and communication skills through presentations and report writing.	

Scheme for Semester End Evaluation (SEE):

The SEE examination shall be conducted by an external examiner (domain expert) and an internal examiner. Evaluation shall be done in batches, not exceeding 6 students per batch.

RUBRICS FOR SEMESTER END EXAMINATION

The SEE examination shall be conducted by an external examiner (domain expert) and an internal examiner.

Q.NO.	**CONTENTS**	Marks
1	Write Up	20%
2	Demonstration of Minor Project Work	60%
3	Viva voce	20%

SEMESTER: III					
INTERNSHIP					
Course Code	**:**	**MCS434N**		**CIE Marks**	**50**
Credits L:T:P	**:**	**0:0:6**		**SEE Marks**	**50**
Hours/Week	**:**	**23**		**SEE Duration**	**03 Hrs**

Guidelines

1. Students can opt for undergoing internship at the industry or research organizations like BEL, DRDO, ISRO, NAL, etc.
2. Students must submit letter from the industry/research organizations clearly specifying the candidate's name and the duration of the internship on the company letter head with authorized signature.
3. The duration of the internship shall be for a period of 6 weeks on full time basis after II semester final exams and before the commencement of III semester.
4. RVCE hosts around 16 Centre of Excellence (CoE) in various domains and around 06 Center of Competence (CoC). The details of these could be obtained by visiting the website https://rvce.edu.in/rvce-center-excellence
5. Students can approach the CoE/CoC for registering and working on relevant domain for training/internship at the CoE/CoC.
6. Internship must be related to the field of specialization of the respective PG program in which the student has enrolled.
7. Students undergoing internship training are advised to report their progress and submit periodic progress reports/diary to their respective guides.
8. Students have to present the internship activities carried out to the departmental committee and only upon approval by the committee, the student can proceed to prepare and submit the hard copy of the final internship report.
9. The reports shall be printed on A4 size with 1.5 spacing and Times New Roman with font size 12, outer cover of the report (wrapper) has to be softbound in Ivory/White color for PG circuit Programs and Light Blue for Non-Circuit Programs.

Course Outcomes: After completing the course, the students will be able to

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Explore the workplace, operating procedures of the department/company and its products, and other organizational concepts.
CO2	:	Learn and improve writing and communication skills, research and technology, work in a team, and develop leadership skills.
CO3	:	Apply higher order thinking skills - critical thinking, analysis, synthesis and evaluate complex problems to solve real world problems with professional ethical standards.
CO4	:	Develop and demonstrate skill competencies and knowledge specific to program specialization by applying appropriate tools and techniques.

Scheme of Continuous Internal Evaluation (CIE):

The evaluation committee shall consist of Guide, Professor, Associate Professor/Assistant Professor. The committee shall assess and evaluate the presentation and the progress reports.

The evaluation criteria shall be as per the rubrics given below:

Reviews	Activity	Weightage
I	Ability to comprehend the functioning/operating procedures of the Organization/Departments. Application of Engineering knowledge, Critical thinking and analysis to solve problems.	40%

II	Demonstrates skill competencies, Resource Management and Sustainability. Exhibits writing and communication skills through presentations and report writing.	60%

Scheme for Semester End Evaluation (SEE):

The SEE examination shall be conducted by an external examiner (domain expert) and an internal examiner. Evaluation shall be done in batches, not exceeding 6 students per batch.

RUBRICS FOR SEMESTER END EXAMINATION

The SEE examination shall be conducted by an external examiner (domain expert) and an internal examiner.

Q.NO.	**CONTENTS**	**MARKS**
1	Write Up	**20%**
2	Demonstration of Internship Work	**60%**
3	Viva	**20%**

SEMESTER: IV						
Course Code	**:**	**MCS241F1**	**DIGITAL COMMUNICATION USING GNU RADIO** (Theory) (Program Specific Elective F (NPTEL))	**CIE Marks**	**:**	**NA**
Credits L-T-P	**:**	**2:0:0**		**SEE Marks**	**:**	**50**
Hours	**:**	**24L**		**SEE Duration**	**:**	**2 Hours**

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 12 Weeks

Week 1: The GNU Radio Signal Model
Week 2: Complex baseband model and Analog modulation
Week 3: Transmission spectrum, bandwidth and pulse design
Week 4: Digital modulation, detection and noise
Week 5: Digital modulation, detection and noise (contd.)
Week 6: Symbol errors and bit errors
Week 7: Matched filtering, synchronization and channel estimation
Week 8: Matched filtering, synchronization and channel estimation (contd.)
Week 9: Digital Equalization
Week 10: Channels with inter-symbol interference and OFDM
Week 11: Introduction to binary error control coding
Week 12: Miscellaneous topics on GNU Radio and Digital Communication

Course duration: 12 Weeks
Course start Date: Jan 20,2025
Course end date: March 14,2025
Probable Exam date: March 22,2025

Course Instructors:
Prof. Kumar Appaiah

GENERAL GUIDELINES

1. NPTEL is an acronym for National Programme on Technology Enhanced Learning which is an initiative by seven Indian Institutes of Technology (IIT Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and Indian Institute of Science (IISc) for creating course contents in engineering and science.
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7. Exam is conducted by NPTEL.

Reference Books	
1	Fundamentals of digital communication, Madhow, Upamanyu, Cambridge university press, 2008, ISBN-13. 978-0521874144.

2	Digital Communications, Robert Gallager, Vol. 1., Cambridge, UK: Cambridge University Press, 2008, ISBN: 9780521879071.
3.	Digital Communications, John G. Proakis, Masoud Salehi, 5th edition, McGraw-Hill Education, 2007, ISBN-13, 978-0072957167.

SEMESTER: IV						
Course Code	**:**	**MCS241F2**	**5G WIRELESS STANDARD DESIGN** (Theory) (Program Specific Elective F (NPTEL))	**CIE Marks**	**:**	**NA**
Credits L-T-P	**:**	**2:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**24L**		**SEE Duration**	**:**	**2 Hours**

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 12 Weeks

Week 1:
Module 1: Course Introduction
Module 2: Key 5G Technologies - Adaptive Modulation and Coding (AMC)
Module 3: Key 5G Technologies - Hybrid automatic repeat request (HARQ)
Module 4: Key 5G Technologies - Orthogonal frequency division multiplexing (OFDM)
Module 5: 5G Numerology
Week 2:
Module 6: 5G frame structure
Module 7: 5G physical downlink shared channel (PDSCH) transmit chain– CRC generation
Module 8: 5G PDSCH transmit chain – code block segmentation – part I
Module 9: 5G PDSCH transmit chain – LDPC coding
Module 10: 5G PDSCH transmit chain – code block segmentation – part II
Week 3:
Module 11: 5G PDSCH transmit chain – rate matching – part I
Module 12: 5G PDSCH transmit chain – rate matching – part II
Module 13: 5G PDSCH transmit chain – interleaving and concatenation
Module 14: 5G PDSCH transmit chain – scrambling and modulation
Module 15: 5G PDSCH transmit chain – recap
Week 4:
Module 16: 5G PDSCH receive chain – part I
Module 17: 5G PDSCH receive chain – part II
Module 18: 5G PDSCH – map receiver design part I
Module 19: 5G PDSCH – map receiver design part II
Module 20: 5G baseband – RF conversion
Week 5:
Module 21: Indigenous 5G network architecture
Module 22: 5G physical downlink control channel (PDCCH) transmit chain- introduction
Module 23: 5G PDCCH transmit chain – CRC and segmentation
Module 24: 5G PDCCH transmit chain – Polar encoding
Module 25: 5G PDCCH transmit chain – CRC interleaver
Week 6:
Module 26: 5G PDCCH transmit chain – sub-block interleaver
Module 27: 5G PDCCH transmit chain – rate matching
Module 28: 5G PDCCH transmit chain – control resource set (CORESET) design – part I
Module 29: 5G PDCCH transmit chain –CORESET design – part II
Module 30: 5G PDCCH transmit chain –CORESET design – part III
Week 7:
Module 31: 5G PDCCH transmit chain –CORESET design – part IV
Module 32: 5G physical uplink control channel (PUCCH) - part I

Module 33: 5G physical uplink control channel (PUCCH) - part II
Module 34: Multiple input multiple output (MIMO) transceiver chain – part I
Module 35: MIMO transceiver chain – part II
Week 8:
Module 36: MIMO transceiver chain – part III
Module 37: MIMO transceiver chain – part IV
Module 38: MIMO transceiver chain – part V
Module 39: MIMO transceiver chain – part VI
Module 40: MIMO transceiver chain – part VII
Week 9:
Module 41: 5G demodulation reference signal (DM-RS) design – part I
Module 42: 5G DM-RS design – part II
Module 43: 5G DM-RS design – part III
Module 44: 5G DM-RS design – part IV
Module 45: 5G sounding reference signal (SRS) design – part I
Week 10:
Module 46: 5G SRS design – part II
Module 47: 5G SRS design – part III
Module 48: 5G SRS design – part IV
Module 49: 5G SRS design – part V
Module 50: 5G channel state estimation reference signal (CSI-RS) – part I
Week 11:
Module 51: 5G CSI-RS – part II
Module 52: 5G MIMO transceiver chain – part I
Module 53: 5G MIMO transceiver chain – part II
Module 54: 5G MIMO codebook design – part I
Module 55: 5G MIMO codebook design – part II
Week 12:
Module 56: 5G FR1/FR2 design– part I
Module 57: 5G FR1/FR2 design– part II
Module 58: 5G FR1/FR2 design– part III
Module 59: 5G initial access - part I
Module 60: 5G initial access - part II

Course duration: 12 Weeks
Course start Date: Jan 20,2025
Course end date: March 14,2025
Probable Exam date: March 22,2025

Course Instructors:
Prof. Rohit Budhiraja

GENERAL GUIDELINES

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Reference Books	
1	Design and optimization for 5G wireless communications, Kim, Haesik, John Wiley & Sons, 2020, ISBN-13. 978-1119494553
2	5G mobile and wireless communications technology, Dohler, Mischa, and Takehiro Nakamura, Cambridge University Press, 2016.
3.	An introduction to 5G wireless networks: technology, concepts and use-cases, Saravanan Velrajan, 2020.

SEMESTER: IV						
Course Code	:	**MCS241F3**	**SATELLITE COMMUNICATION** (Theory) (Program Specific Elective F (NPTEL))	**CIE Marks**	:	**NA**
Credits L-T-P	:	**2:0:0**		**SEE Marks**	:	**50**
Hours	:	**16L**		**SEE Duration**	:	**2 Hours**

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 8 Weeks

Week 1: Orbit
Week 2: Space segment
Week 3: Link Budget
Week 4: Link Budget and Propagation
Week 5: Ground segment
Week 6: Multiple access
Week 7: Non-linearity and synchronization
Week 8: Effect on higher layer, Satellite navigation

Course duration: 8 Weeks
Course start Date: Jan 20,2025
Course end date: March 14,2025
Probable Exam date: March 22,2025

Course Instructors:
Prof. KK Bandyopadhyay

GENERAL GUIDELINES

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7. Exam is conducted by NPTEL.

Reference Books	
1	Satellite communications, 2nd edition, by T. Pratt, C. W. Bostian, J. E. Allnut, Publisher: John Willey and sons.
2	Satellite Communications Systems: systems, techniques and technology, 5th edition, by G. Maral, M. Bousquet, Z. Sun, John Willy and sons.

SEMESTER: IV						
Course Code	**:**	**MCS241F4**	**ANALYSIS AND DESIGN OF MICROWAVE ANTENNAS** (Theory) (Program Specific Elective F (NPTEL))	**CIE Marks**	**:**	**NA**
Credits L-T-P	**:**	**2:0:0**		**SEE Marks**	**:**	**50**
Hours	**:**	**16L**		**SEE Duration**	**:**	**2 Hours**

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 8 Weeks

Week 1: Microwave Radiation Fundamentals
Week 2: Basic Antenna Parameters
Week 3: Wire Antennas
Week 4: Aperture Antennas
Week 5: Array of Radiating Elements
Week 6: Reflector Antenna
Week 7: Generalized Antenna Analysis by Potential Concept
Week 8: Selected Advanced Topics of Modern Antenna

Course duration: 8 Weeks
Course start Date: Jan 20,2025
Course end date: March 14,2025
Probable Exam date: March 22,2025

Course Instructors:
Prof. Amitabha Bhattacharya

GENERAL GUIDELINES

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7. Exam is conducted by NPTEL.

Reference Books

1	Antenna Theory Analysis and Design, Balanis, C. A., Third Edition, John Wiley and Sons, 2005
2	Microwave RF Antennas and Circuits, Aluf, Ofer, Springer International Pu, 2017.

SEMESTER: IV					
MAJOR PROJECT					
Course Code	**:**	**MCS442P**		**CIE Marks**	**100**
Credits L:T:P	**:**	**0:0:18**		**SEE Marks**	**100**
Hours/Week	**:**	**42**		**SEE Duration**	**03 Hrs**

Guidelines

1. Major Project is to be carried out for a duration of 18 weeks
2. Students have to implement the Major Project individually.
3. Students are required to select topics related to their PG Program Specialization after extensive Literature Survey and analyzing the Research gaps.
4. Students will be assigned to guides in accordance with the expertise of the faculty.
5. Major project topics could also be chosen to be implemented/executed based on any of the 16 Centre of Excellence (CoE)/ 06 Center of Competence (CoC) domain. The details of these could be obtained by visiting the website https://rvce.edu.in/rvce-center-excellence
6. Major Project could be implemented in Industry/Research organizations after providing the letter of approval. Students can also implement Major Project, in-house using the resources available in the department/college/CoE/CoC.
7. Students have to adhere to the Project Presentation Schedule note the periodic progress in the Major Project Diary and report the work carried to their respective guides.
8. It is mandatory for the students to present/publish their project work in National/International Conferences/Journals
9. Students have to present the Major Project work to the departmental committee and only upon approval by the committee, the student can proceed to prepare and submit the hard copy of the final Major Project report.
10. Major Project report has to be printed on A4 size with 1.5 spacing and Times New Roman with font size 12, outer cover of the report (wrapper) has to be softbound in Ivory/White color for PG circuit Programs and Light Blue for Non-Circuit Programs.

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Analyze the research gaps, formulate the problem definition, conceptualize the objectives and design solution to cater to specific problems.
CO2	:	Apply higher order thinking skills and develop skill competencies specific to program specialization to implement real world problems with professional ethical standards.
CO3	:	Demonstrate the skill and knowledge by applying appropriate tools and techniques specific to their domain.
CO4	:	Communicate, work in teams and demonstrate the learning through oral presentations and report writing.

Scheme of Continuous Internal Evaluation (CIE):
The evaluation committee shall consist of Guide, Professor, Associate Professor/Assistant Professor. The committee shall assess and evaluate the presentation and the progress reports.

The evaluation criteria shall be as per the rubrics given below:

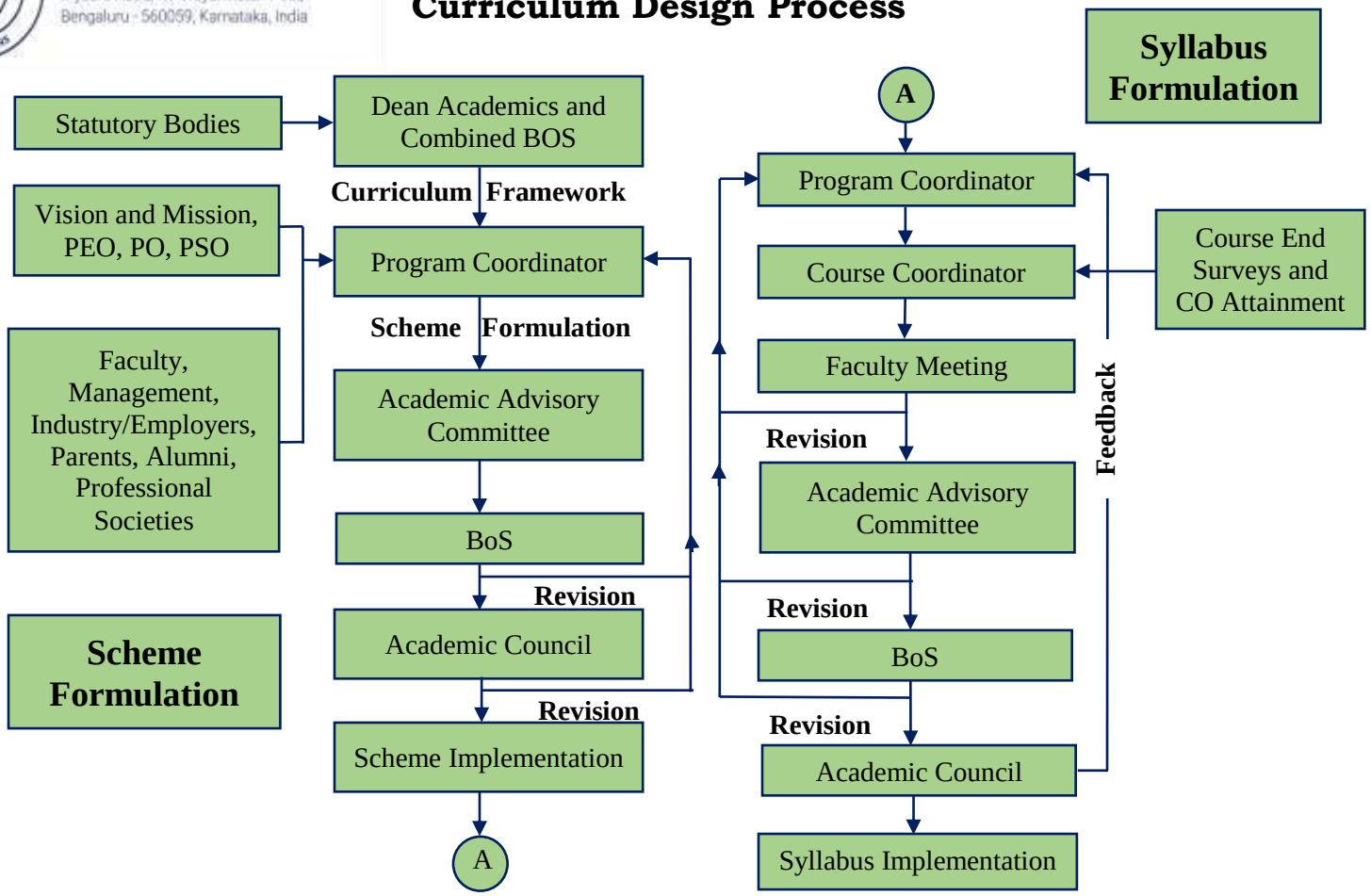
Reviews	Activity	Weightage
I	Approval of the selected topic, formulation of Problem Statement and Objectives along with Synopsis submission	**10%**
II	Demonstrate the skill and knowledge by applying appropriate tools/techniques to design solution specific to the problem.	**30%**
III	Demonstrates the work carried out through experimental results, analysis and testing. Exhibits writing and communication skills through presentations, report writing and paper publication.	**60%**

Scheme for Semester End Evaluation (SEE):

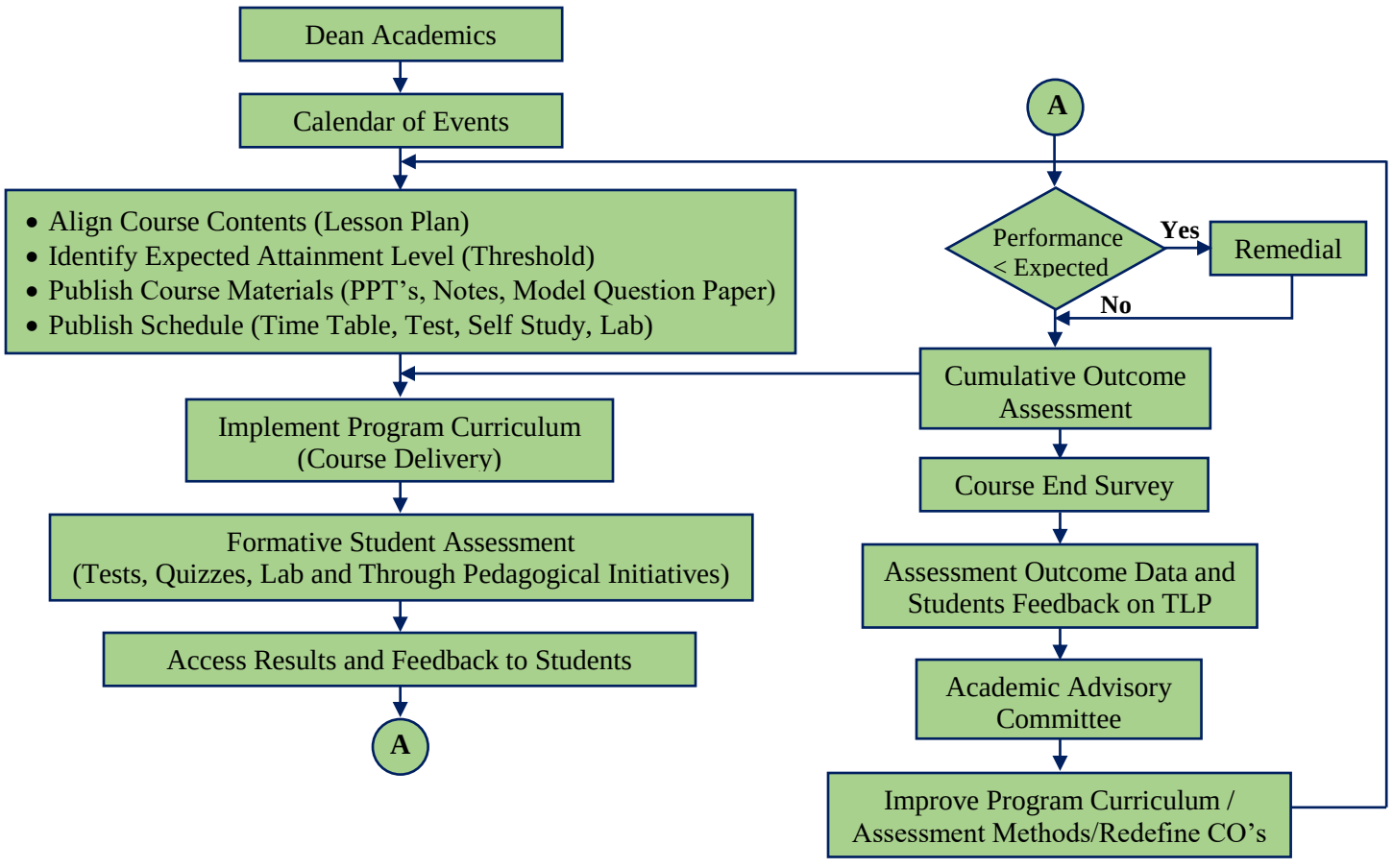
Major Project SEE evaluation shall be conducted in two stages. This is initiated after fulfilment of submission of Project Report and CIE marks. **Stage-1 Report Evaluation:** Evaluation of Project Report shall be done by the Guide and an External examiner. **Stage-2 Project Viva-voce:** Major Project Viva-voce examination is conducted after receipt of evaluation reports from Guide and External examiner.
RUBRICS FOR SEMESTER END EXAMINATION
SEE procedure is as follows:

Report Evaluation	Internal Examiner: 100 Marks **(A)**	**Report Evaluation (A) + (B) = 200/2 = 100 (C)**
	External Examiner: 100 Marks **(B)**	
Viva-Voce	Jointly evaluated by Internal Guide & External Examiner	**100 (D)**
Total Marks = **(C+D)/2** = 200/2 =100		**100 Marks**

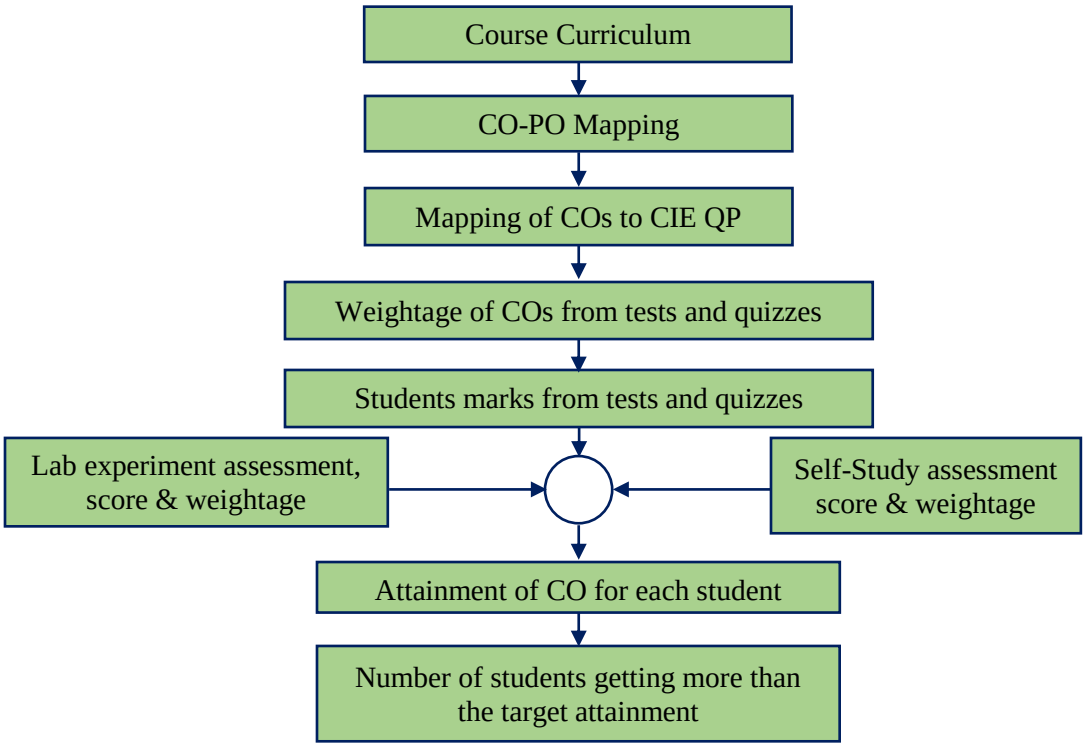
Curriculum Design Process



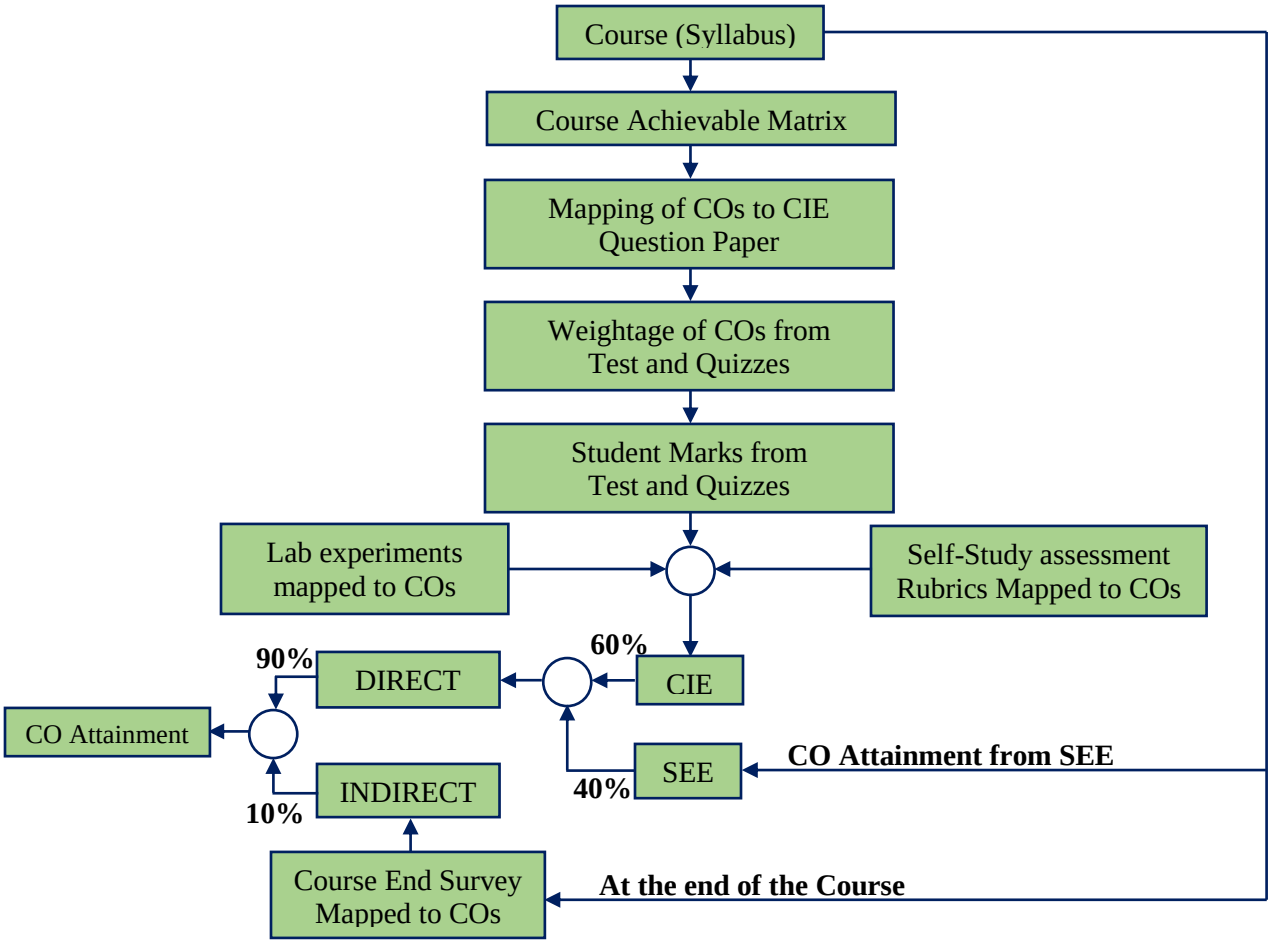
Academic Planning and Implementation



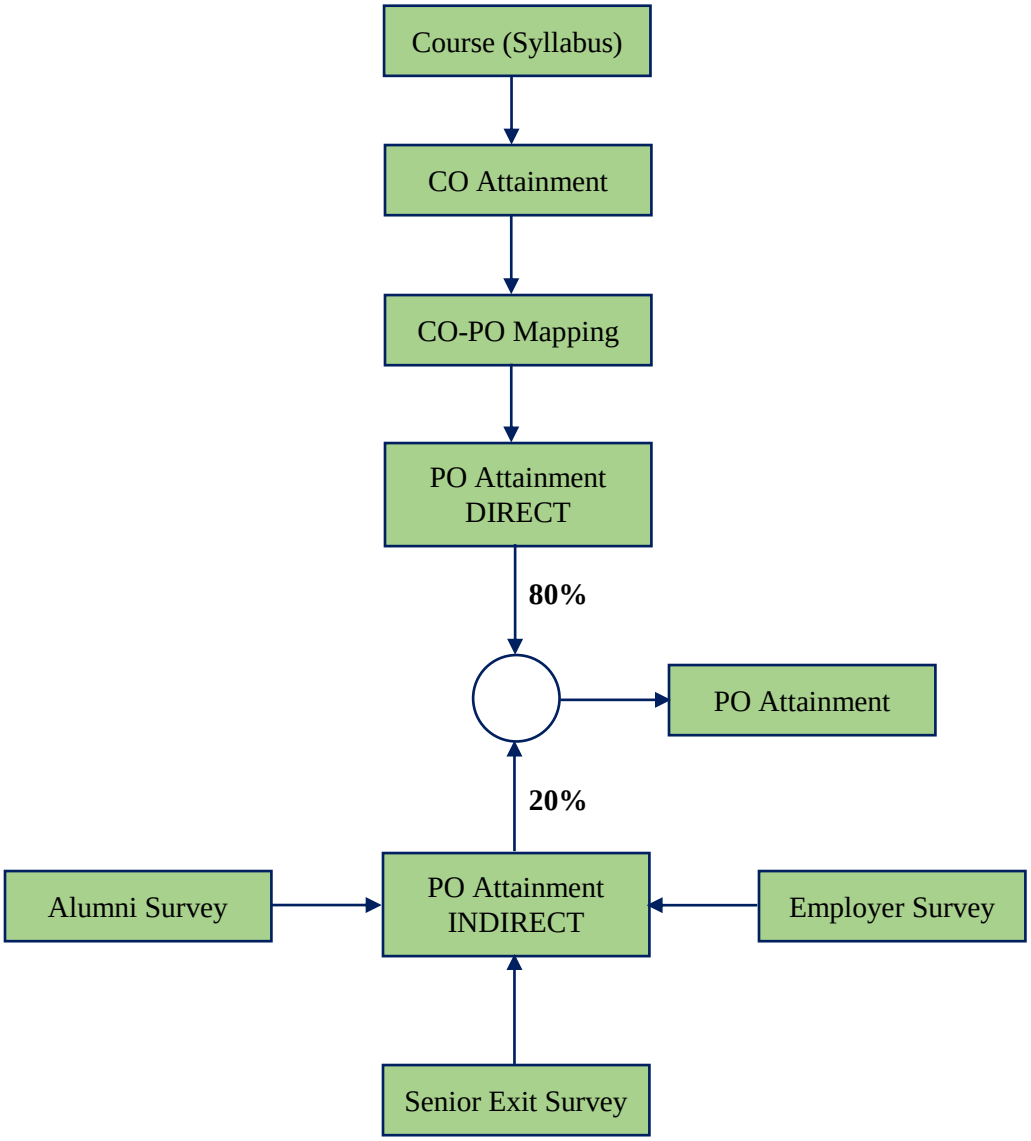
Process For Course Outcome Attainment



Final CO Attainment Process



Program Outcome Attainment Process



RV College of Engineering®
Mysore Road, RV Vidyaniketan Post,
Bengaluru - 560059, Karnataka, India

KNOWLEDGE & ATTITUDE PROFILE

- **WK1:** A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.
- **WK2:** Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
- **WK3:** A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
- **WK4:** Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
- **WK5:** Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.
- **WK6:** Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
- **WK7:** Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.
- **WK8:** Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
- **WK9:** Ethics, inclusive behaviour and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

INNOVATIVE TEAMS OF RVCE

Ashwa Mobility Foundation (AMF): Designs and fabricates Formula-themed race cars and mobility solutions to address urban transportation issues.

Astra Robotics Team: Focuses on designing and building application-specific robots.

Coding Club: Helps students gain coding skills and succeed in competitions like GSoC and ACM-ICPC.

Entrepreneurship Development Cell (E-Cell): Promotes entrepreneurship through workshops, speaker sessions, and mentoring for startups.

Frequency Club Team: Works on software and hardware, emphasizing AI and Machine Learning.

Team Garuda: Develops a supermileage urban concept electric car and E-mobility products.

Team Jatayu: Builds low-cost UAVs with autonomous capabilities for various tasks.

Solar Car Team: Aims to create a solar electric vehicle for sustainable transportation.

Team Antariksh: Focuses on space technology and the development of operational rockets.

Team Chimera: Builds a Formula Electric Car through R&D in E-Mobility.

Helios Racing Team: Designs and tests All-Terrain Vehicles, participating in SAE's BAJA competitions.

Team Hydra: Develops autonomous underwater vehicles for tasks like water purification.

Team Krushi: Creates low-cost farming equipment to assist farmers in cultivation and harvesting.

Team Vyoma: Designs and tests radio-controlled aircraft and UAVs.

Team Dhruva: Engages in astronomy-related activities and collaborates on projects with organizations like ICTS and IIA.

Ham Club: Promotes Amateur Radio and explores technical innovations in communications, especially for disaster response.

Cultural Activity Teams

1. AALAP (Music club)
2. DEBSOC (Debating society)
3. CARV (Dramatics club)
4. FOOTPRINTS (Dance club)
5. QUIZCORP (Quizzing society)
6. ROTARACT (Social welfare club)
7. RAAG (Youth club)
8. EVOKE (Fashion team)
9. f/6.3 (Photography club)
10. CARV ACCESS (Film-making

NSS of RVCE

NCC of RVCE

VISION

Leadership in Quality Technical Education, Interdisciplinary Research & Innovation, with a Focus on Sustainable and Inclusive Technology

MISSION

- To deliver outcome based Quality education, emphasizing on experientiallearning with the state of the art infrastructure.
- To create a conducive environment for interdisciplinary research and innovation.
- To develop professionals through holistic education focusing on individual growth, discipline, integrity, ethics and social sensitivity.
- To nurture industry-institution collaboration leading to competency enhancement and entrepreneurship.
- To focus on technologies that are sustainable and inclusive, benefiting all sections of the society.

QUALITY POLICY

Achieving Excellence in Technical Education, Research and Consulting through an Outcome Based Curriculum focusing on Continuous Improvement and Innovation by Benchmarking against the global Best Practices.

CORE VALUES

Professionalism, Commitment, Integrity, Team Work, Innovation