RV College of Engineering®

# Master of Technology (M.Tech)

# DIGITAL COMMUNICATION ENGINEERING

Scheme And Syllabus Of I & 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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**2024**

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## Department Vision

Imparting quality education in Electronics and Telecommunication Engineering through focus on fundamentals, research and innovation for sustainable development

## Department Mission

1. Provide comprehensive education that prepares students to contribute effectively to the profession and society in the field of Telecommunication.
2. Create state-of-the–art infrastructure to integrate a culture of research with a focus on Telecommunication Engineering Education
3. Encourage students to be innovators to meet local and global needs with ethical practice
4. Create an environment for faculty to carry out research and contribute in their field of specialization, leading to Centre of Excellence with focus on affordable innovation.
5. Establish a strong and wide base linkage with industries, R&D organization and academic Institutions.

## PROGRAM OUTCOMES (POs)

PO1: Acquire in-depth knowledge of Digital Communication Engineering with an ability to analyse, synthesize, evaluate existing and new technologies.
PO2: Learn and apply modern engineering tools to solve complex engineering problems
PO3: Engage in life-long learning independently, to contribute for multidisciplinary research work.
PO4: Independently carry out research /investigation and development work to solve practical problems.
PO5: Write and present a substantial technical report/document.
PO6: Demonstrate a degree of mastery over the area of Digital Communication Engineering. The mastery would be at a level higher than the requirements in the appropriate bachelor program.

## PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Analyze, design and implement emerging Telecommunications systems using devices, sub-systems, propagation models, networking of Wireless and Wire line communication systems.
PSO2: Exhibit Technical skills necessary to choose careers in the design, installation, testing, management and operation of Telecommunication systems.

# 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. | I | Theory Integrated with Laboratory |
| 40. | VTU | Visvesvaraya Technological University |

## POST GRADUATE 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 |

# INDEX

| I SEMESTER M.Tech | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | MMA211TB | Linear Algebra and Probability Theory | 3 | 1 | 0 | **4** | MA | Theory | 1.5 | 100 | 3 | 100 |
| 2 | MDC212IA | Modulation and Coding Theory | 3 | 0 | 1 | **4** | ET | Theory+Lab | 1.5 | 100+50 | 3+3 | 100+50 |
| 3 | MDC213IA | Multirate systems and Adaptive filters | 3 | 0 | 1 | **4** | ET | Theory+Lab | 1.5 | 100+50 | 3+3 | 100+50 |
| 4 | XXXX14AX | Professional Core Courses (Cluster Electives) (Group-A) | 3 | 1 | 0 | **4** | XX | Theory | 1.5 | 100 | 3 | 100 |
| 5 | MDC415DL | Design Thinking lab | 0 | 0 | 2 | **2** | ET | Lab | 1.5 | 50 | 3 | 50 |
| 6 | HSS116EL | Technical English for Professionals | 0 | 0 | 1 | **1** | HSS | Lab (ONLINE) | 1.5 | 50 | -- | -- |
| **Total Credits** | | | | | | **19** | | | | | | |

*Cluster-wise Courses Common to PG Programs

**Clusters**
CSE Cluster - PG Programs (CSE, CNE, SE, IT)
ECE Cluster - PG Programs (VLSI, CS, PE, DC)
ME Cluster - PG Programs (PDM, MD)
CV Cluster - PG Programs (ST, HT)
BT Cluster - PG Programs (BT)

| Code | * Professional Core Courses (Cluster Electives) (Group-A) |
|---|---|
| MCS214A1 | Programming, Data Structures and Algorithms |
| MDC214A2 | Multimedia Communications |
| MPE214A3 | Electric and Hybrid Vehicles |
| MVE214A4 | Digital System Design with FPGA |

| II SEMESTER M.Tech | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | MDC233IA | Optical Communication Networks | 3 | 0 | 1 | **4** | ET | Theory+Lab | 1.5 | 100+50 | 3+3 | 100+50 |
| 2 | MDC234IA | Antenna Arrays and Applications | 3 | 0 | 1 | **4** | ET | Theory+Lab | 1.5 | 100+50 | 3+3 | 100+50 |
| 3 | MDCX23BX | Program Specific Courses (Elective) (Group-B) | 3 | 1 | 0 | **4** | ET | Theory | 1.5 | 100 | 3 | 100 |
| 4 | MDCX24CX | Professional Core Courses (Cluster Electives) (Group-C) | 3 | 1 | 0 | **4** | XX | Theory | 1.5 | 100 | 3 | 100 |
| 5 | XXX325DX | Interdisciplinary Courses (Global Electives) (Group-D) | 3 | 0 | 0 | **3** | XX | Theory | 1.5 | 100 | 3 | 100 |
| 6 | MIM426RT | Research Methodology (NPTEL) | 2 | 0 | 0 | 2 | IM | NPTEL | -- | -- | ONLINE | 50 |
| 7 | MDC427SL | Skill labs (CoCs & CoE) | 0 | 0 | 2 | **2** | ET | Lab | 1.5 | 50 | 3 | 50 |
| **Total Credits** | | | | | | **23** | | | | | | |

| Code | Program Specific Courses (Elective) (Group-B) |
|---|---|
| MDC323B1 | Quantum Cryptography |
| MDC323B2 | Signal Processing Applications with Machine Learning |
| MDC323B3 | New Generation Networks |
| MDC323B4 | RF Integrated circuits |
| MCS323B1 | Advanced 5G and Applications |

| Code | * Professional Core Courses (Cluster Electives) (Group-C) |
|---|---|
| MCS324C1 | Computer Vision with DL |
| MDC324C2 | Adhoc Networks |
| MPE324C3 | Intelligent Control Techniques in Electrical Drives |
| MVE324C4 | Semiconductor Manufacturing |

*Cluster-wise Courses Common to PG Programs

**Clusters**

CSE Cluster - PG Programs (CSE, CNE, SE, IT)
ECE Cluster - PG Programs (VLSI, CS, PE, DC)
ME Cluster - PG Programs (PDM, MD)
CV Cluster - PG Programs (ST, HT)
BT Cluster - PG Programs (BT)

| Interdisciplinary Courses (Global Electives) (Group-D) | | | |
|---|---|---|---|
| Course Code | Course Title | Course Code | Course Title |
| MBT325DA | Nature Impelled Engineering | MET325DH | Electronic Navigation Systems |
| MBT325DB | Clinical Data Management | MET325DJ | Vehicular Communication Ecosystem |
| MCN325DC | Cyber Forensics and Cyber Laws | MIM325DK | Essentials of Project Management |
| MCV325DD | Industrial Safety and Health | MIS325DM | User Interface & User Experience |
| MCV325DE | Advanced Technologies for Transportation Systems | MMA325DN | Mathematical Methods for Data Science |
| MEC325DF | Design & Implementation of Human-Machine Interface | MME325DO | Industry 4.0: The Smart Manufacturing |
| MEE325DG | Electric Vehicle Technology | MME325DQ | Industrial Internet of Things (IIoT) |

| III SEMESTER M.Tech | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | MDC331TA | Wireless communication: Concepts and Applications | 3 | 1 | 0 | **4** | ET | Theory | 1.5 | 100 | 3 | 100 |
| 2 | MDCX32EX | Professional Elective Courses (NPTEL) | 2 | 0 | 0 | **2** | ET | NPTEL | -- | -- | ONLINE | 50 |
| 3 | MDC433P | Minor Project | 0 | 0 | 6 | **6** | ET | Project | 1.5 | 50 | 3 | 50 |
| 4 | MDC434N | Internship | 0 | 0 | 6 | **6** | ET | Internship | 1.5 | 50 | 3 | 50 |
| **Total Credits** | | | | | | **18** | | | | | | |

| Code | Professional Elective Courses Group E (NPTEL) |
|---|---|
| MDC232E1 | CMOS Digital VLSI Design |
| MCE332E2 | Data Science for Engineers |
| MPE232E3 | Machine Learning |
| MDC232E4 | Microwave Integrated Circuits |

| IV SEMESTER M.Tech | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | MDCX41FX | Program Specific Courses (NPTEL-Elective) | 2 | 0 | 0 | **2** | XX | NPTEL | -- | -- | ONLINE | 50 |
| 2 | MDC442P | Major Project | 0 | 0 | 18 | **18** | ET | Project | -- | 100 | 3 | 100 |
| **Total Credits** | | | | | | **20** | | | | | | |

| Code | Program specific course-F (Online-NPTEL) |
|---|---|
| MDC341F1 | Introduction to Information Theory |
| MCE341F2 | Embedded System Design with ARM |
| MDC241F3 | Fundamentals of MIMO Wireless Communication |
| MDC241F4 | VLSI Signal Processing |

| SEMESTER: I | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MMA211TB | **Linear Algebra and Probability Theory** | CIE Marks | : | 100 |
| Credits L-T-P | : | 3-1-0 | *Theory: Common to* MDC, MCE, MCN, MPE, MSE, MIT | SEE Marks | : | 100 |
| Hours | : | 45L+45EL+30T | | SEE Duration | : | 3 Hours |

| UNIT - I | 9 Hours |
|---|---|

**Vector spaces and Linear Transformations:** Vector spaces and subspaces, linear independence, basis and dimension, Four fundamental subspaces, linear transformations, matrix representation, Rank-nullity theorem.

| UNIT – II | 9 Hours |
|---|---|

**Orthogonality and least square approximations:**
Orthogonal vectors, orthogonal projections, orthogonal bases, Orthogonal complement subspaces, Gram-Schmidt orthogonalization process, QR factorization, Least Square problems, application to linear models.

| UNIT – III | 9 Hours |
|---|---|

**Symmetric matrices and Quadratic forms:**
Real symmetric matrices, Eigen values and Eigen vectors, Diagonalization, Quadratic forms, constrained optimization, positive definiteness, Singular Value Decomposition, Pprincipal Component Analysis.

| UNIT – IV | 9 Hours |
|---|---|

**Random variables and Probability Distributions**
Random variables-discrete and continuous, probability mass function, probability density function, cumulative distribution function, mean and variance.
Discrete distributions - Binomial and Poisson, Continuous distributions – Uniform and Normal.

| UNIT – V | 9 Hours |
|---|---|

**Sampling and Inferential statistics:**
Population and sample, sample mean and sample proportion, central limit theorem, Sampling distributions - Sampling distributions of means, Sampling distributions of proportions.
Principles of Statistical Inference, Null and alternative hypothesis, Type I and Type II errors, level of significance, One – tailed and Two – tailed tests, z-test, t-test.

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

| | | |
|---|---|---|
| CO1 | : | Explore the fundamental concepts of linear algebra, random variables, probability distributions, sampling, inferential statistics. **(PO1)** |
| CO2 | : | Apply theoretical concepts of linear algebra, discrete and continuous random variables, probability distributions, sampling, inferential statistics to evaluate the problems of engineering applications. **(PO1, PO4)** |
| CO3 | : | Analyze the solution of the engineering problems solved using appropriate techniques of linear algebra, random variables, probability distributions, sampling theory, inferential statistics. **(PO1, PO4, PO5, PO6)** |
| CO4 | : | Enhance the comprehensive understanding of linear algebra, random variables, probability distributions, sampling theory, inferential statistics gained to demonstrate the problems arising in many practical situations. **(PO1, PO4, PO5, PO6)** |

**Reference Books**

1. Linear Algebra and its Applications, David C. Lay, 3rd Edition, 2002, Pearson Education India, ISBN:13: 978-81-7758-333-5.
2. Linear Algebra and its Applications, Gilbert Strang, Cengage Learning, 4th Edition, 2006, ISBN: 97809802327.
3. Introduction to Probability and Statistics for Engineers and Scientists, Sheldon Ross, 5th Edition, 2014, Academic Press, ISBN: 13-978-0123948113.

4. Probability and Statistics for Computer Scientists, Michael Baron, CRC Press, 2nd Edition, 2014, ISBN- 13: 978-1-4822-1410-9.

| **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.<br>**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.<br>**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 | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC212IA | **Modulation and Coding Theory** | CIE Marks | : | 100 + 50 |
| Credits L-T-P | : | 3-0-1 | *(Theory & Practice)* | SEE Marks | : | 100 + 50 |
| Total Hours | : | 45L+45EL+30P | *(Professional Core Course with Integrated Lab) -1* | SEE Duration | : | 3+3 Hours |

| **UNIT – I** | **9 Hours** |
|---|---|
| **Digital Modulation Techniques:** Digital Modulation Formats, Coherent Binary Modulation Techniques, Coherent Quadrature –Modulation Techniques, Non-Coherent Binary Modulation Techniques, Comparison of Binary and Quaternary Modulation Techniques, M-ary Modulation Techniques, Effect of Inter symbol Interference, Bit Versus Symbol Error Probabilities, Synchronisation, Applications | |
| **UNIT – II** | **9 Hours** |
| **Convolutional Codes:** Structure of Convolutional Codes, Tree, Trellis, and State Diagrams, The Transfer Function of a Convolutional Code, Systematic, Non recursive, and Recursive Convolutional Codes, The Inverse of a Convolutional Encoder and Catastrophic Codes, Decoding of Convolutional Codes, Maximum-Likelihood Decoding of Convolutional Codes — The Viterbi Algorithm, Distance Properties of Binary Convolutional Codes | |
| **UNIT – III** | **9 Hours** |
| Communication through band limited linear filter channels: Optimum receiver for channels with ISI and AWGN, Linear equalization, Decision feedback equalization. | |
| **UNIT – IV** | **9 Hours** |
| Spread Spectrum Signals for Digital Communication: Model of Spread Spectrum Digital Communication System, Direct Sequence Spread Spectrum Signals, Frequency-Hopped Spread Spectrum Signals, CDMA, time-hopping SS, Synchronization of SS systems. | |
| **UNIT – V** | **9 Hours** |
| Digital Communication Through Fading Multi-Path Channels: Characterization of fading multi-path channels, the effect of signal characteristics on the choice of a channel model, frequency-Non selective, slowly fading channel, diversity techniques for fading multi-path. channels, Digital signal over a frequency-selective, slowly fading channel | |
| **LABORATORY** | **30 Hours** |
| 1. Link level simulation to evaluate BER performance of modulation techniques with and without channel coding<br>2. Comparative analysis of communication systems in AWGN and fading channels with BER tool<br>3. SDR implementation and performance analysis of Equalizer for QPSK signal passed through a frequency-selective fading channel.<br>4. Implementation of Spread Spectrum Techniques-CDMA<br>5. Innovative Lab Experiments: Development of PHY layer for different wireless standards using SDR kit | |

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

| | | |
|---|---|---|
| CO1 | : | Analyze channel behaviours and the performance of different modulation and coding techniques. |
| CO2 | : | Design and analyze Equalizers for mitigation of channel distortions |
| CO3 | : | Apply coding and spreading techniques for digital Communication systems |
| CO4 | : | Design and demonstrate various modulation, coding, spreading, equalization techniques and measure their performance. |

**Reference Books**

1. John G. Proakis, Masoud Salehi, Digital Communications, 5th edition, McGraw Hill, 2007, ISBN-10933920479
2. Simon Haykin,, Digital Communications, John Wiley and Sons, 2021, ISBN 9780471629474 / 0471629472
3. Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2005, ISBN:9780511841224
4. Bernard Sklar, Digital Communications - Fundamentals and Applications", 3ed, Pearson Education (Asia) Ptv. Ltd, 2021, ISBN-13: 9780137569076

**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. **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** |

**RUBRIC 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** |

**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 |
| | **SEE THEORY TOTAL** | **100** |

**RUBRIC FOR SEMESTER END EXAMINATION (SEE-Lab)**

| Q.NO. | CONTENTS | MARKS |
|---|---|---|
| 1 | Write Up | 10 |
| 2 | Conduction of the Experiments | 30 |
| 3 | Viva | 10 |
| | **SEE LAB TOTAL** | **50** |
| | **MAXIMUM MARKS FOR THE SEE** | **150** |

| SEMESTER: I | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC213IA | **Multirate systems and Adaptive filters** | CIE Marks | : | 100 + 50 |
| Credits L-T-P | : | 3-0-1 | *(Theory & Practice)* | SEE Marks | : | 100 + 50 |
| Total Hours | : | 45L+45EL+30P | *(Professional Core Course with Integrated Lab) -1* | SEE Duration | : | 3+3Hours |

| **UNIT – I** | **9 Hours** |
|---|---|
| Design of Digital Filters: General Considerations, Design of FIR filters using windowing, frequency sampling technique, Design of FIR differentiators and Hilbert Transformers. | |
| **UNIT – II** | **9 Hours** |
| Multi rate Digital Signal Processing: Decimation by a factor D, Interpolation by a factor I, Sampling rate conversion by a Rational Factor I/D. Implementation of sampling Rate Conversion, Multistage implementation of sampling rate conversion, Sampling rate conversion by an Arbitrary Factor. | |
| **UNIT – III** | **9 Hours** |
| Applications of Multi rate Digital Signal Processing: Digital Filter, Quadrature Mirror Filter Bank, Subband coding, New Modulation Formats: FBMC, GFDM, and UFMC, From OFDM to FBMC: Principles and Comparisons. | |
| **UNIT – IV** | **9 Hours** |
| Adaptive Filters: Applications of Adaptive filters, Adaptive Direct-Form FIR Filters- The LMS algorithm, and Adaptive Direct Form Filters- RLS algorithm. | |
| **UNIT – V** | **9 Hours** |
| Machine learning in Signal Processing: Introduction, Supervised learning, unsupervised learning, semi supervised learning, Reinforcing learning, Use cases of signal processing using supervised and Unsupervised learning | |
| **LABORATORY** | **30 Hours** |
| Design of FIR Filters, Decimation and Interpolation using sequence, multicarrier signals, Design of Adaptive filter and ML algorithms for signal Processing applications. | |

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

| | | |
|---|---|---|
| CO1 | : | Elucidate the fundamentals of filters, multicarrier signals, machine learning and multirate systems. |
| CO2 | : | Apply appropriate techniques to design filters and multirate systems for various applications |
| CO3 | : | Analyze machine-learning algorithms for signal processing applications and evaluate their performance. |
| CO4 | : | Demonstrate and analyze the functioning of multicarrier signals, multirate systems and filters. |

**Reference Books**

1. John G. Proakis and Manolakis, “Digital Signal Processing”, Prentice Hall, 4th Edition, 2007, ISBN: 9788131710005.
2. Fa-Long Luo, Charlie (Jianzhong) Zhang,” Signal Processing for 5G Algorithms and Implementations”, John Wiley & Sons, 2016, ISBN 9781119116479.
3. Robert O Cristi, “Modern Digital Signal Processing”, 1st edition,Cengage publishers India, 2004,ISBN 13: 9780534400958
4. Sudeep Tanwar, Anand Nayyar, Rudra Rameshwar, “Machine Learning in Signal Processing –Applications, Challenges, And the Road Ahead”, CRC Press Taylor & Francis Group, 1st edition, 2022, ISBN 9780367618902.

| 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. **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** |
| **RUBRIC 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** |

| 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 |
| | **SEE THEORY TOTAL** | **100** |
| **RUBRIC FOR SEMESTER END EXAMINATION (SEE-Lab)** | | |
| **Q.NO.** | **CONTENTS** | **MARKS** |
| 1 | Write Up | 10 |
| 2 | Conduction of the Experiments | 30 |
| 3 | Viva | 10 |
| | **SEE LAB TOTAL** | **50** |
| | **MAXIMUM MARKS FOR THE SEE** | **150** |

| Semester: I | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MCS214A1 | **Programming, Data Structures and Algorithms** | CIE | : | 100 Marks |
| Credits: L:T:P | : | 3:1:0 | (Theory) | SEE | : | 100 Marks |
| Total Hours | : | 45L+45EL+30T | *Professional Core Courses (Cluster Electives) (Group-A)* | SEE Duration | : | 03 Hours |

| **Unit-I** | **9Hrs** |
|---|---|
| **Introduction to data structures:** Introduction to oops concepts. Introduction to data representation, Linear Lists, Linked Representation<br>**Algorithm Analysis:** Mathematical Background, Model, What to Analyze, Running Time Calculations. | |
| **Unit – II** | **9Hrs** |
| **Stack and queue:** Stack and queue implementation using linear list and linked list. Stack application-Parenthesis matching, Queue application-railroad car rearrangement.<br>**Hashing:** Hash table representation- ideal hashing, hashing with linear open addressing, hash tables with chains | |
| **Unit –III** | **9Hrs** |
| **Binary and other Trees:** Trees, Binary Trees, Properties and Representation of Binary Trees-Formula Based Representation, Linked Representation, Common Binary Tree Operations.<br>**Binary Search Tree (BST).** Organizing data in a BST. Inserting and deleting items in a BST. | |
| **Unit –IV** | **9Hrs** |
| **Priority Queues (Heaps):** Model, Simple Implementations, Binary Heap, Leftist Heaps.<br>**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** | **9Hrs** |
| **Searching and Sorting Techniques:**<br>Sorting Techniques: Bubble sort, Merge sort, Selection sort', Heap sort, Insertion Sort. Searching Techniques: Sequential Searching, Binary Searching, Search Trees.<br>**Algorithm Design Techniques:**<br>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++, M. A. Weiss. 3rd Edition, Addison-Wesley, ISBN-10: 032144146X & ISBN-13: 9780321441461 |
| **2.** | Data structures, Algorithms and applications in C++, Sartaj Sahani, 1st Edition, McGraw Hill; 2000, ISBN: 10:007236226X |
| **3.** | Data Structures Using C++, D.S. Malik, 2nd Edition, 2009, Cengage Learning, ISBN- 13: 978-0-324-78201-1 |
| **4**. | Data Structures & Algorithms in Java, Goodrich, Goldwasser, 6th Edition, Wiley Publications , ISBN: 978-1-118-77133-4 |
| **5.** | Data structures and algorithms in Java, Robert Lafore,2nd Edition, ISBN-13: 978-0672324536, ISBN- 10: 0672324539 |

| **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 of 20 marks each.<br>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 | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC214A2 | **MULTIMEDIA COMMUNICATIONS** | CIE Marks | : | 100 |
| Credits L-T-P | : | 3-1-0 | *(Theory)* | SEE Marks | : | 100 |
| Total Hours | : | 45L+45EL+30T | *Professional Core Courses (Cluster Electives) (Group-A)* | SEE Duration | : | 3 Hours |

| UNIT – I | 9 Hours |
|---|---|
| Multimedia Communications: Multimedia information representation, multimedia networks, multimedia applications, network QoS and application QoS. | |
| **UNIT – II** | **9 Hours** |
| 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** | **9 Hours** |
| 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** | **9 Hours** |
| Multimedia Entertainment Networks: Introduction, Cable TV networks, Satellite TV networks, Terrestrial TV networks. High speed PSTN access Technologies. | |
| **UNIT – V** | **9 Hours** |
| 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, protocols 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 the various broadcasting systems and standards |

**Reference Books**

1. Fred Halsall, Multimedia Communications, 2001, Pearson education, ISBN: 978-81-317-0994-8.
2. K. R. Rao, Zoran S. Bojkovic, Dragorad A. Milovanovic, Introduction to Multimedia Communications 2014, Wiley, ISBN 13 978-0-471-46742-7.
3. K. R. Rao, Zoran S. Bojkovic, Dragorad A. Milovanovic, Multimedia Communication Systems, 2004, Pearson education, ISBN: 013031398X.
4. Behrouz A Forouzan, Data Communications and Networking, 2015, 4th Edition, McGraw Hill publication, ISBN-13:978-0-07-063414-5.

| 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. **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** |
| | **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 | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MPE214A3 | **ELECTRIC AND HYBRID VEHICLES** | CIE Marks | : | 100 |
| Credits L-T-P | : | 3-1-0 | *(Theory)* | SEE Marks | : | 100 |
| Total Hours | : | 45L+45EL+30T | *Professional Core Courses (Cluster Electives) (Group-A* | SEE Duration | : | 3 Hours |

**UNIT – I** **9 Hours**

**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** **9 Hours**

**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** **9 Hours**

**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** **9 Hours**

**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** **9 Hours**

**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.

| 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. **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** |
| | **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 | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MVE214A4 | **DIGITAL SYSTEM DESIGN WITH FPGA** | CIE | : | 100 Marks |
| Credits: L: T:P | : | 3:1:0 | *(Theory)* | SEE | : | 100 Marks |
| Total Hours | : | 45L+45EL+30T | *Professional Core Courses (Cluster Electives) (Group-A)* | SEE Duration | : | 03 Hourrs |

| **Unit-I** | **9 Hours** |
|---|---|
| **Introduction to Verilog and Design Methodology:** Verilog IEEE standards,<br>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.<br>Introduction to Design Methodology: Digital Systems and Embedded Systems, Real-world circuits. Design Methodology: Design Flow-Architecture. | |
| **Unit – II** | **9 Hours** |
| **Verilog Modelling Styles:**<br>Behavioral Modelling: Latches and Level-Sensitive Circuits in Verilog, Cyclic Behavioural Models of Flip-Flops and Latches, Behavioural Models of Multiplexers, Encoders, Decoders and Arithmetic Circuits.<br>Dataflow Modelling: Boolean Equation-Based Models of Combinational Logic, Propagation Delay and Continuous Assignments. Linear-Feedback Shift Register. Tasks & Functions.<br>Structural Modelling: Design of Combinational Logic, Verilog Structural Models, Top-Down Design and Nested Modules. (Hands-on using Xilinx Vivado tool) | |
| **Unit –III** | **9 Hours** |
| **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** | **9 Hours** |
| **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. | |
| **Unit –V** | **9 Hours** |
| **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.<br>**Algorithms and Architectures for Digital Processors:** Algorithms, Nested-Loop Programs, and Data Flow Graphs. **Design Example:** Halftone Pixel Image Converter Baseline Design for a Halftone Pixel Image Converter: NLP-Based Architectures for the Halftone Pixel Image Converter, Concurrent ASMD-Based Architecture for a Halftone Pixel Image Converter<br>**Digital Filters and Signal Processors:** Finite-Duration Impulse Response (FIR) Filter, Digital Filter Design Process, Infinite-Duration Impulse Response (IIR) Filter. (Examples such as counter, sequence detector, sequence generator etc are implemented on Airtex-7 FPGA board) | |

| **Course Outcomes: After completing the course, the students will be able to** | |
|---|---|
| **CO1** | Define the IEEE-1364 standard and identify different modeling styles to build digital systems. |
| **CO2** | Analyze digital systems and build small-scale applications using Interfacing concepts. |
| **CO3** | Design and verify the behavior of digital circuits using digital flow. |
| **CO4** | Demonstrate the skill of cost-effective system designs through proper selection of implementation. |

| Reference Books | |
|---|---|
| **1.** | Advanced Digital Design with the Verilog HDL, Michael D. Ciletti, 2nd Edition, 2015, PHI, ISBN: 978–0–07–338054–4. |
| **2.** | Digital Design: An Embedded Systems Approach Using VERILOG, Peter J. 1st Edition, 2010, Ashenden, Elsevier, ISBN: 978-0-12-369527-7 |
| **3.** | Digital Systems Design Using Verilog, Charles Roth, Lizy K. John, ByeongKil Lee,1st Edition, 2015, Cengage Learning, ISBN-10: 1285051076 |
| **4**. | Fundamentals of Digital Logic with Verilog Design, Stephen Brown and Zvonko Vranesic, 6th Edition, 2014, McGraw Hill publication, ISBN: 978–0–07–338054–4 |
| **5.** | Verilog HDL: A Guide to Digital Design & Synthesis, Samir Palnitkar, SunSoft Press, 1st Edition, 1996, ISBN: 978-81-775-8918-4. |

| 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** |

| RUBRICS FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q.NO.** | **CONTENTS** | **MARKS** |
| Each unit consists of TWO Questions of 20 marks each.<br>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 | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC415DL | **DESIGN THINKING LAB** | CIE Marks | : | 50 |
| Credits L-T-P | : | 0-0-2 | *(Design Thinking/Skill Lab)* | SEE Marks | : | 50 |
| Hours/Week | : | 4(2+2*) | *(Practice)* | SEE Duration | : | 2 Hours |

**Contents**

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 broad area identified for the specialization Digital communication is **Smart city: Connectivity, Navigation and surveillance**. The students are encouraged to apply the 5 stages in the Design Thinking Process to solve the problems in the area identified.

| **Course Outcomes:** After going through this course, the student 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

**RUBRIC FOR CONTINUOUS INTERNAL EVALUATION (CIE-Lab)**

The evaluation of the work will be done by the committee appointed by the Head, Dept of ETE. The student should submit a report on the Case Study. 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. 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** |

* Non-contact hours

| SEMESTER: I | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | HSS116EL | **Technical English for professionals** | CIE Marks | : | 50 |
| Credits L-T-P | : | 0-0-1 | *(online-Lab)* | SEE Marks | : | 50 |
| Hours/Week | : | 2 | *(Humanities and Social Sciences)* | SEE Duration | : | 2 Hours |

| **Unit-I** | **10 Hours** |
|---|---|
| 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 Hours** |
| 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 Hours** |
| 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 going through this course the student 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. |

**Reference Books**

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).<br>**Parameters for evaluation of the Presentation**<br>a. Clarity in the presentation/ Speaking/Presentation skills.<br>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 | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC233IA | **Optical Communication Networks** | CIE Marks | : | 100 + 50 |
| Credits L-T-P | : | 3-0-1 | *(Theory & Practice)* | SEE Marks | : | 100 + 50 |
| Hours | : | 45L+45EL+30P | *(Professional Core Course with Integrated Lab) -1* | SEE Duration | : | 3+3 Hours |

| **UNIT – I** | **9 Hours** |
|---|---|
| **Optical Components:** Optical sources, Detectors. Couplers, Isolators, Circulators, Multiplexers, filters, Gratings, Interferometer | |
| **UNIT – II** | **9 Hours** |
| Optical Receivers: Ideal Receivers, Practical detection receivers, Optical preamplifier, Noise Considerations, Bit error rates, Coherent detection, Timing Recovery<br>Transmission System Engineering: System model, Power penalty, Transmitter, Receiver, Different Optical Amplifiers, | |
| **UNIT – III** | **9 Hours** |
| Optical networks: Client layers of the optical layer, SONET/SDH, Multiplexing, layers, Frame Structure.<br>WDM network elements: Optical line terminal, Optical line amplifiers, Optical cross connectors, Wavelength conversion. | |
| **UNIT – IV** | **9 Hours** |
| WDM network Design: design concepts, Cost trade off, statistical dimensioning model, LTD and RWA problems, Routing and wavelength assignment | |
| **UNIT – V** | **9 Hours** |
| Passive Optical Networks: PON Architectures Review, TDM-PON, WDM PON, APON/BPON,G- PON, EPON, and Super PON, Comparisons of different PONs | |
| **LABORATORY** | **30 Hours** |
| Characterization and Performance analysis of analog optical links using kits.<br>Characterization and Performance analysis of digital optical links using kits<br>Investigate the characteristics of source and receiver<br>Power budget Analysis using Optisystem.<br>Simulation of long haul and P2P optical communication link and analyse the performance using Optisystem.<br>Study of TDM and WDM schemes | |

**Course Outcomes:**

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

| | | |
|---|---|---|
| CO1 | : | Analyze the roles of optical components in enabling efficient data transmission |
| CO2 | : | Apply optical signal detection and noise analysis to optimize receiver performance. |
| CO3 | : | Analyze optical network architectures and PON technologies |
| CO4 | : | Design WDM networks |

**Reference Books**

1. Rajiv Ramswami, N Sivaranjan, “Optical Networks”, 3rd Edition, 2009, M Kauffman Publishers, ISBN-10: 9780123740922

2. Cedric F. Lam, “Passive Optical Networks Principles and Practice”, 1ed,2007, Academic Press, ISBN-10 : 0123738539, ISBN-13 : 978-0123738530

3. Gerd Keiser, “Optical Fiber Communication”, 4th Edition, 2011, McGraw Hill, ISBN-10: 1259006875.

4. G P Agarwal, “Fiber Optics Communication Systems”, 3rd Edition, 2002, John Wiley and Sons, New York,

ISBN-978-0470505113..

| 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. **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** |

| RUBRIC 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** |

| 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 |
| | **SEE THEORY TOTAL** | **100** |

| RUBRIC FOR SEMESTER END EXAMINATION (SEE-Lab) | | |
|---|---|---|
| **Q.NO.** | **CONTENTS** | **MARKS** |
| 1 | Write Up | 10 |
| 2 | Conduction of the Experiments | 30 |
| 3 | Viva | 10 |
| | **SEE LAB TOTAL** | **50** |
| | **MAXIMUM MARKS FOR THE SEE** | **150** |

| SEMESTER: II | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC234IA | **ANTENNA ARRAYS AND APPLICATIONS** | CIE Marks | : | 100 + 50 |
| Credits L-T-P | : | 3-0-1 | *(Theory & Practice)* | SEE Marks | : | 100 + 50 |
| Hours | : | 45L+45EL+30P | *(Professional Core Course with Integrated Lab) -1* | SEE Duration | : | 3+3 Hours |

| **UNIT – I** | **9 Hours** |
|---|---|
| **Antenna Basics:** Radiation Pattern, Radiation Power Density, Radiation Intensity, Beam width, Directivity, Numerical Techniques, Antenna Efficiency, Gain, Realized Gain, Beam Efficiency, Bandwidth, Polarization, Input Impedance, Antenna Radiation Efficiency<br>**Arrays:** Two-Element Array, N-Element Linear Array: Uniform Amplitude and Spacing, N-Element Linear Array: Directivity, Design Procedure, N-Element Linear Array: Uniform Spacing, Nonuniform Amplitude, Super directivity, Planar Array | |
| **UNIT – II** | **9 Hours** |
| **Broad band Antenna:** Equiangular Spiral Antennas, Log-Periodic Antennas, Fundamental Limits of Electrically Small Antennas, Fractal Antennas<br>**RF Antennas:** E-Plane Sectoral Horn, H-Plane Sectoral Horn, Pyramidal Horn, Paraboloid reflector, Microstrip Antennas: Introduction, Advantages and Limitations, Rectangular Microstrip antenna, feeding methods, Transmission line Model Analysis | |
| **UNIT – III** | **9 Hours** |
| **Introduction to Smart Antennas:** Need for Smart Antennas, Overview, Smart Antenna Configurations, Space Division Multiple Access, Architecture of Smart Antenna System, Benefits, Drawbacks, Basic Principles, And Mutual Coupling Effects.<br>**Beamforming:** Fixed Weight Beamforming Basics - Maximum Signal-to-Interference Ratio,<br>Minimum Mean-Square Error, Adaptive Beamforming - Least Mean Squares, Sample Matrix Inversion, Recursive Least Squares. | |
| **UNIT – IV** | **9 Hours** |
| **Angle-of-Arrival Estimation:** Array Correlation Matrix, AOA Estimation Methods -Bartlett AOA Estimate, Capon AOA Estimate, Linear Prediction AOA Estimate, Maximum Entropy AOA Estimate, Pisarenko Harmonic Decomposition AOA Estimate, Min-Norm AOA Estimate, MUSIC AOA Estimate, Root-MUSIC AOA Estimate | |
| **UNIT – V** | **9 Hours** |
| **Antenna Measurements:** Antenna Ranges, Radiation Patterns, Gain Measurements, Directivity Measurements, Impedance Measurements, Polarization Measurements, Radiation Efficiency, Current Measurements | |
| **LABORATORY** | **30 Hours** |
| Experiments are performed using MATLAB/ HFSS<br>1. Radiation characteristics of Microstrip patch, Horn and Parabolic antenna with microstrip test bench<br>2. Beam area and Directivity calculation for Antenna using MATLAB<br>3. Design of Wire Antennas (Dipole Antenna, Loop Antennas) using HFSS<br>4. Linear Arrays Introduction, Broadside Array, End-Fire Array using MATLAB<br>5. Scanning Performances of Phased Array Antenna and their Design<br>6. Horn Antennas Design (Pyramidal and Circular) Using HFSS<br>7. Microstrip Patch Antenna and their Array Configuration Using HFSS<br>8. DoA Algorithms for smart Antennas | |

| | | |
|---|---|---|
| **Course Outcomes:** After going through this course the student will be able to: | | |
| CO1 | : | Elucidate parameters and principles of Adaptive Antennas, Application specific Antennas |
| CO2 | : | Apply and analyze the characteristics of antennas and array structures. |
| CO3 | : | Analyze and compare various techniques employed in designing Adaptive Antennas with Beam forming and DOA algorithms |
| CO4 | : | Study and Characterize antennas using different measurement techniques. |

**Reference Books**

1. Balanis, C.A., Ioannides, "Introduction to Smart Antennas. Synth. Lect. Antennas", P.I.: 2(1), 1–175,2007, 9781598291766
2. Frank B Gross, "Smart Antennas with Matlab: Principles and Applications in Wireless Communication", McGraw-Hill Professional, New York, 2015, ISBN- 978-0-07-182494-1
3. Frank B Gross, "Frontiers in Antennas: Next Generation Design & Engineering", Mcgraw Hill Publications, 2011, ISBN: 9780071637930.
4. Lal Chand Godara, "Smart antenna", CRC press, London, 2004, ISBN: 9780849312069.

**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. **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** |

**RUBRIC 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** |

**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 |
| | **SEE THEORY TOTAL** | **100** |
| **RUBRIC FOR SEMESTER END EXAMINATION (SEE-Lab)** | | |
| **Q.NO.** | **CONTENTS** | **MARKS** |
| 1 | Write Up | 10 |
| 2 | Conduction of the Experiments | 30 |
| 3 | Viva | 10 |
| | **SEE LAB TOTAL** | **50** |
| | **MAXIMUM MARKS FOR THE SEE** | **150** |

| SEMESTER: II | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC323B1 | **Quantum Cryptography** | CIE Marks | : | 100 |
| Credits L-T-P | : | 3-1-0 | *(Theory)* | SEE Marks | : | 100 |
| Hours | : | 45L+45EL+30T | *Program Specific Courses (Elective) (Group-B)* | SEE Duration | : | 3 Hours |

| **UNIT – I** | **9 Hours** |
|---|---|

**Introduction:** Quantum Bits, Multiple Qubits, Combining Qubits Using the Tensor Product, Simple Measurements, Unitary Transformations and Gates, The Bloch Sphere.

Classical cryptography: Block Ciphers and Data Encryption Standards: Traditional Block Cipher Structure, The Data Encryption Standard, A DES Example, The Strength of DES. Advanced Encryption Standard: AES Transformation Functions, AES Key Expansion

| **UNIT – II** | **9 Hours** |
|---|---|

**Classical cryptography:** Public Key Cryptography- Principles of Public-Key Cryptosystems, The RSA Algorithm.

**Cryptographic Hash Functions:** Applications of Cryptographic Hash Functions, Two Simple Hash Functions, Hash Functions Based on Cipher Block Chaining, Secure Hash Algorithm (SHA).

| **UNIT - III** | **9 Hours** |
|---|---|

Digital signatures: Digital Signatures, Elgamal Digital Signature Scheme, Schnorr Digital Signature Scheme.

**Quantum Tools and a First Protocol:** Probability Notation, Density Matrices, General Measurements, The Partial Trace, Secure Message Transmission. Implementing Quantum Cryptography.

| **UNIT – IV** | **9 Hours** |
|---|---|

**The Power of Entanglement:** Entanglement, Purifications, Two Applications, Bell Nonlocality, The Monogamy of Entanglement

**Quantum Distribution Keys:** Honest and Dishonest , Secure Key Distribution, Distributing Keys Given a Special Classical Channel, Information Reconciliation, Everlasting Security

| **UNIT – V** | **9 Hours** |
|---|---|

**Cryptosystems based on quantum key distribution:** A key distribution scheme, A secret-key encryption scheme, Combining quantum and classical cryptography, Implementation of a QKD-based cryptosystem.

**Quantum Key Distribution Protocols:** BB'84 Quantum Key Distribution, A Modified Protocol, Security of BB'84 Key Distribution, Correctness of BB'84 Key Distribution.

**Course Outcomes:**

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

| | | |
|---|---|---|
| CO1 | : | Explore fundamental concepts of classical cryptography, digital signatures and quantum Principles |
| CO2 | : | Apply the concepts of classical cryptographic algorithms and quantum algorithms to ensure the security of transmitted information. |
| CO3 | : | Analyse the working of Quantum Cryptographic Algorithms and classical Cryptographic Algorithms |
| CO4 | : | Evaluate the performance of Quantum Cryptographic Algorithms |

**Reference Books**

1. Gilles Van Assche, "Quantum Cryptography and Secret-Key Distillation", Cambridge University Press 2006, ISBN-10 0-521-86485-2.

2. Michael A. Nielson, Isaac L Chuang– "Quantum Computation and Quantum Information", Cambridge University Press 2010, ISBN 978-1-107-00217-3

3. Cryptography and Network Security, Behrouz A. Forouzan, Tata McGraw-Hill, 2008, ISBN-13: 978-0-13-187319-3.

4. William Stallings, "Cryptography and Network Security - Principles and Practices" Pearson Education Limited, 7th Edition, 2017.ISBN-13:978-0134444284, ISBN-10:0134444280.

| **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. **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** |
| | **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: II | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC323B2 | **Signal Processing Applications with Machine Learning** | CIE Marks | : | 100 |
| Credits L-T-P | : | 3-1-0 | *(Theory)* | SEE Marks | : | 100 |
| Hours | : | 45L+45EL+30T | *Program Specific Courses (Elective) (Group-B)* | SEE Duration | : | 3 Hours |

| **UNIT – I** | **9 Hours** |
|---|---|
| **Introduction to ML**: Distance based classification, Nearest neighbor classification, Hilbert space, Fusion of machine learning in signal processing, Benefits of adopting machine learning in signal processing, Machine learning algorithms | |
| **UNIT – II** | **9 Hours** |
| **Signal Processing applications:** Design of Phase shifters, Interfacing of Digital Systems with different sampling rates, Narrow band filters, Transmultiplexers – TDM to FDM conversion, FDM to TDM conversion, Noise Reduction and Two-Band Digital Crossover, Digital Audio Equalizer, Generation and Detection of DTMF Tones Using the Goertzel Algorithm. | |
| **UNIT – III** | **9 Hours** |
| **Adaptive filter applications:** Noise Cancellation, System Modeling, Line Enhancement Using Linear Prediction, Canceling Periodic Interferences Using Linear Prediction, Electrocardiography Interference Cancellation, Echo Cancellation in Long-Distance Telephone Circuits. | |
| **UNIT – IV** | **9 Hours** |
| **Image Processing:** Image Processing Notation and Data Formats, Image Histogram and Equalization Image Level Adjustment and Contrast,Image Filtering Enhancement Image Pseudo-Color Generation and Detection, Image Spectra, Image Compression by Discrete Cosine Transform. | |
| **UNIT – V** | **9 Hours** |
| **Applications of Signal Processing in ML**: Audio signal processing, Audio compression, DigitalImage processing, Video compression, Digital communication, Healthcare, Seismology, speech recognition, computer vision, Economic Forecasting. | |

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

| | | |
|---|---|---|
| CO1 | : | Illustrate the working of signal processing system with the practical applications. |
| CO2 | : | Analyze digital signal processing (DSP) operations for image and audio input |
| CO3 | : | Design and analyze adaptive filters for specific applications. |
| CO4 | : | Apply machine learning algorithms to signal processing use cases. |

**Reference Books**


1. John G. Proakis and Manolakis, “Digital Signal Processing”, Prentice Hall, 4th Edition, 2007.
2. Li Tan, “Digital Signal Processing Fundamentals and Applications”, Academic Press, India, 2013.
3. Sudeep Tanwar, Anand Nayyar, Rudra Rameshwar, “Machine Learning in Signal Processing – Applications, Challenges, and the Road Ahead”, CRC Press Taylor &Francis Group, 2022.
4. E.C.Ifeachor and B.W.Jervis, “Digital Signal Processing – A Practical approach”, 2nd Edition, Pearson Education, 2002.

| 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. **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** |
| | **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: II | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC323B3 | **New Generation Networks** | CIE Marks | : | 100 |
| Credits L-T-P | : | 3-1-0 | *(Theory)* | SEE Marks | : | 100 |
| Hours | : | 45L+45EL+30T | *Program Specific Courses (Elective) (Group-B)* | SEE Duration | : | 3 Hours |

**UNIT – I** **9 Hours**

**Software Defined Networking:** Introduction, Modern Data Center, Traditional Switch Architecture, Layer 2 & 3 Control, Evolution of switches and control planes, Data Center Innovation & Needs, The Evolution of Networking Technology, Forerunners of SDN, Open Source Contributions and Network Virtualization.

**UNIT – II** **9 Hours**

Fundamental Characteristics of SDN, SDN Operation SDN Devices, SDN Controller, SDN Applications. The Open Flow Specification: Open Flow Overview, Open Flow 1.0 and Open Flow Basics, Open Flow 1.1, 1.2, and 1.3 Additions and Open Flow Limitations.

**UNIT – III** **9 Hours**

**Alternative Definitions of SDN:** Potential Drawbacks of Open SDN, Alternate SDN Methods, Network Functions Virtualization, Alternatives Overlap and Ranking, SDN in the Data Center: Definition, Data Center Demands, Tunneling Technologies, Path Technologies, Ethernet Fabrics, SDN Use Cases in the Data Center and Real-World Data Center Implementations.

**UNIT – IV** **9 Hours**

**Emerging protocol and controller models:** Impact of major network equipment manufacturers in the SDN arena, Additional SDN protocol models: Netconf protocol, BGP protocol, BGP –LS protocol, Additional SDN controller models: controllers with multiple southbound plugins, controllers with model-driven internal design.
SDN in Other Environments: Consistent Policy Configuration, Global Network View, WANs, Mobile Networks, Optical Networks

**UNIT – V** **9 Hours**

**SDN Applications:** Reactive versus Proactive Applications, Background on various Controllers like Floodlight Controller, Open Daylight Controller, Creating NV Tunnels, Offloading Flows in the Data Center, Access Control for the Campus, Traffic Engineering for Service Providers

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

| | | |
|---|---|---|
| CO1 | : | Explore the basic concepts of conventional networks and next generation networks (SDN) |
| CO2 | : | Apply the concepts of networking and implement Software defined Networks using the open flow protocol. |
| CO3 | : | Analyze the working of different Software defined Network protocol models and controller models. |
| CO4 | : | Apply and analyze the principles of Software defined Networks in diverse real-world scenarios |

**Reference Books**


1. Software Defined Networks: A Comprehensive approach, Paul Goransson, Chuck Black, Timothy Culver, 2nd Edition, Elsevier, 2014,ISBN-13: 978-0128045558, ISBN-10: 0128045558
2. Software-Defined Networks: A Systems Approach, Peterson, Cascone, O'Connor, Vachuska, and Davie, Systems Approach LLC, 2021, ISBN 1736472100, 9781736472101.
3. Software Defined Networking design and deployment, Patricia A. Morreale, James M. Anderson, 1st Edition, CRC Press, 2015, ISBN-10: 1482238632, ISBN-13: 978-1482238631
4. SDN: Software Defined Networks: An Authoritative Review of Network, Programmability Technologies, Thomas D. Nadeau, Ken Gray, 1st Edition, 2013, ISBN-13: 978-1449342302, ISBN-10: 9781449342302.

| 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. **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** |
| | **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: II | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC323B4 | **RF Integrated circuits** | CIE Marks | : | 100 |
| Credits L-T-P | : | 3-1-0 | *(Theory)* | SEE Marks | : | 100 |
| Hours | : | 45L+45EL+30T | *Program Specific Courses (Elective) (Group-B)* | SEE Duration | : | 3 Hours |

**UNIT – I** — **9 Hours**

**Introduction:**
Lower Frequency Analog Design and Microwave Design Versus Radio Frequency Integrated Circuit Design, Units for Microwave and Low-Frequency Analog Design, Radio Frequency Integrated Circuits Used in a Communications, Monolithic IC technology, MMIC design and examples.

**Brief Review of Technology:**
Review of Bipolar Transistor Description, Small-Signal Model, Small-Signal parameters, High-Frequency Effects, Noise Sources in the Transistor Model, CMOS Transistors, Hetro Bipolar Junction Transistors (HBT), FET- HEMT Technologies

**UNIT – II** — **9 Hours**

**Issues in RFIC design, noise, linearity and filtering:**
Introduction, Noise, thermal Noise, Noise figure, The noise figure of an Amplifier circuits and components in series, Linearity and Distortion in RF circuits, Third order and second order Intercepts point, the 1-dB compression point, Broad band measures of linearity. Filtering issues, image signals and image reject filtering.

**CAD Techniques**: Integrated CAD Design Environment, CAD package features, Circuit simulation Engines, Commercial CAD packages, Commercial Modelling Software. EM simulation Tools.

**UNIT – III** — **9 Hours**

**Impedance Matching**
Impedance matching using LC networks, bandwidth and Q factor of matching networks

**Design of passive circuit elements in IC technologies:**
Introduction, sheet resistance and the skin effect, parasitic capacitance & inductance, Poly Resistors and Diffusion Resistors, Metal-Insulator-Metal Capacitors and Poly Capacitors, Applications of On-Chip Spiral Inductors and Transformers, On-chip Transmission lines,

**UNIT – IV** — **9 Hours**

**RF and Microwave Modules**
RF System as a Cascade of Modules, A 15GHz Receiver Subsystem, Amplifiers, Filters, Noise, Diodes, Switches, Ferrite components, Local Oscillators, Mixers, Frequency Multipliers, Case studies

**UNIT – V** — **9 Hours**

**Transceivers**: Conventional UP/Down conversion architectures, Direct Conversion architectures, Modulators, Demodulators and Frequency Translators.

**Integrated Antennas**: Basic Integrated Antenna Requirements, Integrated Antenna selection and examples, Photonic Band gap antennas

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

| | | |
|---|---|---|
| CO1 | : | Explain the design concepts and performance parameters in RFICs. |
| CO2 | : | Identify different Passive Circuit Elements on RF ICs and design the matching circuits for RF systems |
| CO3 | : | Analyze and Design RF systems using the CAD tools. |
| CO4 | : | Evaluate the performance characteristics of RF subsystems. |

**Reference Books**

1. John Rogers, Calvin Plett -"Radio Frequency Integrated Circuit Design", Artech house, 2003
2. I. D. Robertson, S. Lucyszyn, "RFIC and MMIC design Technology", IEE Publications, 2001, ISBN: 0-85296- 786 -1
3. Micheal Steer, "Fundamentals of Microwave and RF Design", NC State University, 2019, Third edition
4. Inder J Bahl, "Fundamentals of RF and Microwave Transistor Amplifiers", John Wiley & sons Inc, 2009. ISBN: 978-0-470-39166-2

| 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. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks.<br>**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.<br>**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: II | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MCS323B1 | **Advanced 5G and Applications** | CIE Marks | : | 100 |
| Credits L-T-P | : | 3-1-0 | *(Theory)* | SEE Marks | : | 100 |
| Hours | : | 45L+45EL+30T | *Program Specific Courses (Elective) (Group-B)* | SEE Duration | : | 3 Hours |

| UNIT – I | 9 Hours |
|---|---|

**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 | 9 Hours |
|---|---|

**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 | 9 Hours |
|---|---|

**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 | 9 Hours |
|---|---|

**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 | 9 Hours |
|---|---|

**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 going through this course the student 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 : .ISBN-13:978-3039360161 ,3039360167 |

| **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. **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** |
| | **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: II | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **MCS324C1** | **COMPUTER VISION WITH DL** | **CIE** | **:** | **100Marks** |
| **Credits: L:T:P** | **:** | **3:1:0** | *Professional Core Courses (Cluster Electives) (Group-C)* | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | 45L+45EL+30T | **(Theory)** | **SEE Duration** | **:** | **03 Hours** |

| **Unit-I** | **9 Hrs** |
|---|---|
| **Image Formation Models:** Introduction: Overview and Applications.<br>Image formation: Digital images for representing 2D, 3D, and moving objects. The human eye and digital camera models. Photometric information: Colour: Physics of Colour, human perception of Colour, Colour models (RGB, HSI).Geometric-information: Representing points, lines, planes,<br>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** | **9 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.<br>Using Open CV: Smoothing Images, Median Filter, Gaussian Filter, Bilateral Filter, Changing the<br>Shape of Images, Thresholding, Calculating Gradients, Performing Histogram Equalization | |
| **Unit –III** | **9 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** | **9 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<br>Application: Animating pictures | |
| **Unit –V** | **9 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 Images 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/ |
| 2. | 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 |
| 3. | Computer Vision: A Modern Approach, David Forsyth and Jean Ponce, 2nd edition, 2015, Pearson Education India, ISBN-10: 9332550115, ISBN-13: 978-9332550117 |

| | |
|---|---|
| 4. | Introductory Computer Vision, Imaging Techniques and Solutions, Adrian Low, 2nd Edition, 2010, BS Publications, ISBN-13 9788178001977. |

| **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)** | | |
| **#** | **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 | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC324C2 | **ADHOC NETWORKS** | CIE Marks | : | 100 |
| Credits L-T-P | : | 3-1-0 | *(Theory)* | SEE Marks | : | 100 |
| Hours | : | 45L+45EL+30T | *Professional Core Courses (Cluster Electives) (Group-C)* | SEE Duration | : | 3 Hours |

| **UNIT – I** | **9 Hours** |
|---|---|
| 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** | **9 Hours** |
| 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** | **9 Hours** |
| Routing Protocols: Design issues and classification, Table-driven, On-demand and Hybrid routing protocols, Routing protocols with efficient flooding mechanisms, Hierarchical and Power-aware routing protocol. | |
| **UNIT – IV** | **9 Hours** |
| 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** | **9 Hours** |
| Quality of Service and Security Issues: Issues and challenges in providing QoS, Classification of QoS solutions, MAC layer solutions, Network layer solutions, QoS frameworks, Network security issues. Energy Management: Need, Classification of battery management schemes, Transmission power management schemes, System power management schemes. | |

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

| | | |
|---|---|---|
| CO1 | : | Explain the fundamentals 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

| 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. **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** |
| | **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: II | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MPE324C3 | **INTELLIGENT CONTROL TECHNIQUES IN ELECTRICAL DRIVES** | CIE Marks | : | 100 |
| Credits L-T-P | : | 3-1-0 | *(Theory)* | SEE Marks | : | 100 |
| Hours | : | 45L+45EL+30T | *Professional Core Courses (Cluster Electives) (Group-C)* | SEE Duration | : | 3 Hours |

| **UNIT – I** | **9 Hours** |
|---|---|
| **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** | **9 Hours** |
| **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** | **9 Hours** |
| **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.<br>**Learning methods:** types of learning, supervised, unsupervised, reinforced learning, knowledge representation and acquisition<br>**Theory, architecture and learning algorithm of neural network models:** McCulloc model, Hopfield model, Perceptron Network, Back propagation network. | |
| **UNIT – IV** | **9 Hours** |
| **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** | **9 Hours** |
| **Hybrid algorithms:** Neuro-fuzzy systems, ANFIS and extreme-ANFIS, derivative free optimization methods.<br>**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 going through this course the student 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. 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. |

| **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. **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** |
| | **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: II | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **MVE324C4** | **SEMICONDUCTOR MANUFACTURING** | **CIE** | **:** | **100Marks** |
| **Credits: L:T:P** | **:** | **3:1:0** | *(Theory)* | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | 45L+45EL+30T | *Professional Core Courses (Cluster Electives) (Group-C)* | **SEE Duration** | **:** | **03 Hours** |

| **Unit-I** | **9 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** | **9 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** | **9 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** | **9 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** | **9 Hrs** |
| **Statistical Process Control: Statistics Review:** Distributions & Estimation, Hypothesis Tests and Control Chart, Control Charts, Advanced Control Charts, Nested Variance, Experimental Design | |

| **Course Outcomes: 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. |

| 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)** | | |
| **#** | **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.<br>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**<br>Interdisciplinary Courses (Global Electives)<br>(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 application**s: 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.<br>**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.<br>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**<br>Interdisciplinary Courses (Global Electives)<br>(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.<br>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<br>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<br>technologies. | |

| 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 |

| 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. |

| 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.<br>**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.<br>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**<br>Interdisciplinary Courses (Global Electives)<br>(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**<br>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**<br>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**<br>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:**<br>Information Technology Law Literature and Glossary, Information Technology Law Concepts, Jurisdictional Issues in Cyber Space, scope of I.T. laws,<br>**Law and the Internet:**<br>Domain issues in Internet, Regulatory body, ICANN regulations | |
| **Unit –V** | **09 Hrs** |
| **Security Governance Objectives –**<br>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.<br>**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.<br>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**<br>Interdisciplinary Courses (Global Electives)<br>(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:<br>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<br>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.<br>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**<br>Interdisciplinary Courses (Global Electives)<br>(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.<br>**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** |
| **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.<br>**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.<br>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**<br>Interdisciplinary Courses (Global Electives)<br>(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.<br>**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:**<br>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:**<br>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<br>**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** |
| **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 | | | | | | |
|---|---|---|---|---|---|---|
| **ELECTRIC VEHICLE TECHNOLOGY**<br>Interdisciplinary Courses (Global Electives)<br>(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.<br>**Learning methods:** types of learning, supervised, unsupervised, reinforced learning, knowledge representation and acquisition<br>**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.<br>**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** |
| **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.<br>**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.<br>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**<br>Interdisciplinary Courses (Global Electives)<br>(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.<br>**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.<br>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**<br>Interdisciplinary Courses (Global Electives)<br>(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<br>**Standards and Regulations of DSRC**<br>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.<br>**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.<br>**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<br>**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.<br>**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.<br>**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.<br>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**<br>Interdisciplinary Courses (Global Electives)<br>(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.<br>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 |

| **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.<br>**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.<br>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**<br>Interdisciplinary Courses (Global Electives)<br>(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** |
| **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 | | | | | | |
|---|---|---|---|---|---|---|
| **MATHEMATICAL METHODS FOR DATA SCIENCE**<br>Interdisciplinary Courses (Global Electives)<br>(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.<br>**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** |
| **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 | | | | | | |
|---|---|---|---|---|---|---|
| **INDUSTRY 4.0: THE SMART MANUFACTURING**<br>Interdisciplinary Courses (Global Electives)<br>(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<br>**Internet of Things and New Value Proposition**: IoT in Manufacturing, Value Creation Barriers: Standards, security, and privacy concerns.<br>**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.<br>**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** |
| **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.<br>**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)<br>**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.<br>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)**<br>Interdisciplinary Courses (Global Electives)<br>(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:**<br>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.<br>**Industrial Control Systems**<br>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**<br>Temperature sensor interfacing, accelerometer sensor interfacing, MoS Gas sensor, magneto strictive sensors, speed sensor, ultrasonic sensor, smart sensors.<br>**Automatic identification and data Capture**<br>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**<br>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**<br>Introduction, Hierarchy of Industrial Networks, Network Topologies, Data Flow Management, Transmission Hardware, Network Backbones, Network Communication Standards, Fieldbus Networks<br>**Simulating Industrial Processes**<br>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**<br>Similarity measures, hierarchical clustering – single linkage, complete linkage, average linkage Non heirerchial clustering – Numericals, multidimensional scaling correspondence analysis - Numericals<br>**Prediction Models**<br>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.<br>**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**)**<br>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.<br>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 | : | MIM426RT | **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/
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.

| SEMESTER: I | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC427SL | **Skill Lab** | CIE Marks | : | 50 |
| Credits L-T-P | : | 0-0-2 | *(Design Thinking/Skill Lab)* | SEE Marks | : | 50 |
| Hours/Week | : | 4P | *(Practice)* | SEE Duration | : | 2 Hours |

**Contents**

**Communication system module:**

Usage of tools such as MATLAB, Simulink, NETSIM to develop communication modules such as transceivers,5G communication system and its SDR implementation

**RF system module**

Usage of RF design tools such as AWR/ADS to design and simulate RF active circuits such as Low noise amplifiers, Power amplifiers and Passive circuits such as power dividers, couplers

**Machine learning Application module**

To apply machine learning algorithms viz KNN, SVM, Random forest algorithms for communication applications such as spectrum sensing, Channel estimation, Indoor models

**Course Outcomes:**

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

| | | |
|---|---|---|
| CO1 | : | Apply fundamental concepts of digital communication to solve real-world problems through hands-on experiments and projects. |
| CO2 | : | Demonstrate proficiency in using industry-standard tools, software, and equipment relevant to the digital communication domain |
| CO3 | : | Analyze and troubleshoot technical issues with systematic approaches. |
| CO4 | : | Design, implement, and evaluate practical solutions or prototypes to meet specified requirements |

**Reference Books**

1. Mathuranathan Viswanathan, Wireless Communication Systems in Matlab, Independent Publication, 2nd edition,2020, ISBN-13 : 979-8648523210
2. David M. Pozar, Microwave Engineering, 2011, John Wiley & Sons, 4th Edition, 2011, ISBN: 978-0-470-63155-3,
3. https://github.com/edwardoughton/pysim5g
4. Frank B gross, Frontiers in Antennas: Next Generation Design & Engineering, 2011, McGraw Hill

| **RUBRIC FOR CONTINUOUS INTERNAL EVALUATION (CIE-Lab)** | | |
|---|---|---|
| 1 | Conduction of the Experiments & Report | 15 |
| 2 | Design and testing of the model | 20 |
| 3 | Final presentation of the model and report | 15 |
| | **MAXIMUM MARKS FOR THE SEE** | **50** |

**RUBRIC FOR SEMESTER END EXAMINATION (SEE-Lab)**

The evaluation will be done by Internal and External examiners through exhibition. 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: III | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC331TA | **Wireless communication: Concepts and Applications** | CIE Marks | : | 100 |
| Credits L-T-P | : | 3-1-0 | *(Theory)* | SEE Marks | : | 100 |
| Hours | : | 45L+45EL+30P | *(Professional Core Course)* | SEE Duration | : | 3 Hours |

| **UNIT – I** | **9 Hours** |
|---|---|
| Review of UMTS and GSM, History of 1G to 3G, need for the LTE, from UMTS to LTE and from LTE to LTE advanced, 3GPP specification for LTE, High level architecture, architecture of E- UTRAN, Evolved packet core.5G use cases and system concept: Use case requirements, 5G system concept. The 5G Architecture: Introduction, High-level requirements for the 5G architecture, Functional architecture and 5G flexibility, Physical architecture and 5G deployment. | |
| **UNIT – II** | **9 Hours** |
| Massive multiple-input multiple-output (MIMO) systems: Introduction, Theoretical background, Pilot design for massive MIMO, Resource allocation and transceiver algorithms for massive MIMO, Fundamentals of baseband and RF implementations in massive MIMO, Channel models. | |
| **UNIT – III** | **9 Hours** |
| Spectrum: Introduction ,Spectrum for 4G , Spectrum challenges in 5G ,5G spectrum landscape and requirements , Bandwidth requirements, Spectrum access modes and sharing scenarios , 5G spectrum technologies, Spectrum toolbox, Main technology components, Value of spectrum for 5G:a techno-economic perspective Security for 5G communications: Overview of a potential 5G communications system architecture, Security Issues and Challenges in 5G communication. | |
| **UNIT – IV** | **9 Hours** |
| Machine-type communications: Introduction, Fundamental techniques for MTC, Massive MTC,Massive MTC, Summary of uMTC features. Device to Device (D2D) communications: From 4G to 5G, Radio resource management for mobilebroadband D2D, Multi-hop D2D communications for proximity and emergency services, Multi operator D2D communication. | |
| **UNIT – V** | **9 Hours** |
| The 5G radio-access technologies: Access design principles for multi-user communications, Multi- carrier with filtering: a new waveform, Non-orthogonal schemes for efficient multiple access, Radio access for dense deployments, Radio access for V2X communication, Radio access for massive machine-type communication. | |

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

| | | |
|---|---|---|
| CO1 | : | Understand and describe the history and concepts of 5G networks and its architecture. |
| CO2 | : | Analyse the MIMO concepts, spectrum and security aspects in 5G communication |
| CO3 | : | Analyse principles of machine-to-machine communication and device to device communication. |
| CO4 | : | Analyse the analysis of the radio access technologies, non-orthogonal schemes, Radio access for V2X communication and massive machine-type communication |

**Reference Books**

**1.** 5G Mobile and Wireless Communication Technology, AfifOsseran, Jose F Monserrat, PatrickMarsch, Cambridge University Press, 2016.

**2.** An Introduction To LTE, LTE-Advanced, SAE, VOLTE And 4G Mobile Communications Second Edition Christopher Cox Director, Chris Cox Communications Ltd, UK , 2014 John Wiley & Sons, Ltd

**3.** Fundamentals of 5G Mobile Networks, Jonathan Rodriguez, John Wiley & Sons 2015, ISBN: 97811188675253.

**4.** 5G Core Networks Powering Digitization, Stephen Rommer, Academic Press, 2019 ISBN: 978-0-08-1030009-7.

| RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory) | | |
|---|---|---|
| CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component<br>**[20 (Q) + 40 (T) + 40 (EL) = 100 marks)** | | |
| **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.<br>**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.<br>**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: III | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC232E1 | **CMOS Digital VLSI Design** | CIE Marks | : | NA |
| Credits L-T-P | : | 2-0-0 | *(Theory - NPTEL Course online)* | SEE Marks | : | 50 |
| Hours | : | 16L | *Professional Basket Course-E (NPTEL-Online)* | 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**: COURSE PLAN :
Week 1: MOS Transistor Basic-I; L2: MOS Transistor Basic-I; L3: MOS Transistor Basic-II; L4: MOS Parasitic & SPICE Model; L5: CMOS Inverter Basics-I
**Week 2:** CMOS Inverter Basics-II; L2: CMOS Inverter Basics-III; L3: Power Analysis-I; L4: Power Analysis-II; L5: SPICE Simulation-I
**Week 3:** SPICE Simulation-II; L2: Combinational Logic Design-I; L3: Combinational Logic Design-II; L4: Combinational Logic Design-III; L5: Combinational Logic Design-IV
**Week 4:** Combinational Logic Design-V; L2: Combinational Logic Design-VI; L3: Combinational Logic Design-VII; L4: Combinational Logic Design-VIII; L5: Combinational Logic Design-IX
**Week 5:** Combinational Logic Design-X; L2: Logical Efforts-I; L3: Logical Efforts-II; L4: Logical Efforts-III; L5: Sequential Logic Design-I
**Week 6:** Sequential Logic Design-II; L2: Sequential Logic Design-III; L3: Sequential Logic Design-IV; L4: Sequential Logic Design-V; L5: Sequential Logic Design-VI
**Week 7:** Sequential Logic Design-VII; L2: Sequential Logic Design-VIII; L3: Clocking Strategies for Sequential Design-I; L4: Clocking Strategies for Sequential Design-II; L5: Clocking Strategies for Sequential Design-III
**Week 8:** Clocking Strategies for Sequential Design-IV; L2: Sequential Logic Design-IX; L3: Clocking Strategies for Sequential Design-V; L4: Concept of Memory & its Designing-I; L5: Concept of Memory & its Designing-II

**Reference Books:**
1. https://drive.google.com/file/d/1UzsGVe3htuyDJxHPlljw5ECsW2Rw2rr0/view

**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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7. Exam is conducted by NPTEL

| SEMESTER: III | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MCE332E2 | **Data Science for Engineers** | CIE Marks | : | NA |
| Credits L-T-P | : | 2-0-0 | *(Theory - NPTEL Course online)* | SEE Marks | : | 50 |
| Hours | : | 165L | *Professional Basket Course-E (NPTEL-Online)* | SEE Duration | : | 2Hours |

**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:** Course philosophy and introduction to R
**Week 2:** Linear algebra for data science
1. Algebraic view - vectors, matrices, product of matrix & vector, rank, null space, solution of over-determined set of equations and pseudo-inverse)
2. Geometric view - vectors, distance, projections, eigenvalue decomposition

**Week 3:** Statistics (descriptive statistics, notion of probability, distributions, mean, variance, covariance, covariance matrix, understanding univariate and multivariate normal distributions, introduction to hypothesis testing, confidence interval for estimates)
**Week 4:** Optimization
**Week 5:** 1. Optimization
2. Typology of data science problems and a solution framework

**Week 6:** 1. Simple linear regression and verifying assumptions used in linear regression
2. Multivariate linear regression, model assessment, assessing importance of different variables, subset selection

**Week 7:** Classification using logistic regression
**Week 8:** Classification using kNN and k-means clustering

**Reference Books:**
1. https://drive.google.com/file/d/1Kia3XhbJugl8YYnKQIrelNriWdmX7tvW/view?usp=sharing

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| SEMESTER: III | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MPE232E3 | **Machine Learning** | CIE Marks | : | NA |
| Credits L-T-P | : | 2-0-0 | *(Theory - NPTEL Course online)* | SEE Marks | : | 50 |
| Hours | : | 16L | *Professional Basket Course-E (NPTEL-Online)* | 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 the Machine Learning course
**Week 2:** Characterization of Learning Problems
**Week 3:** Forms of Representation
**Week 4:** Inductive Learning based on Symbolic Representations and Weak Theories
**Week 5:** Learning enabled by Prior Theories
**Week 6:** Machine Learning based Artificial Neural Networks
**Week 7:** Tools and Resources + Cognitive Science influences
**Week 8:** Examples, demos and exam preparations

**Reference Books:**
https://drive.google.com/file/d/1pJAMtgwNyfhVnP9nrQv_yVcrm6cBNLJH/view?usp=sharing

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| SEMESTER: III | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC232E4 | **Microwave Integrated Circuits** | CIE Marks | : | NA |
| Credits L-T-P | : | 2-0-0 | *(Theory - NPTEL Course online)* | SEE Marks | : | 50 |
| Hours | : | 16L | *Professional Basket Course-F (NPTEL-Online)* | SEE Duration | : | 2Hours |

**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**
Lecture 1: Introduction
Lecture 2: Reflection Coefficient, VSWR, Smith Chart
Lecture 3: Reflection Coefficient, VSWR
Lecture 4: Smith Chart
Lecture 5: Applications of the Smith Chart
Lecture 6: Microwave components

**Week 2**
Lecture 7: Broadband Impedance matching
Lecture 8: Multi-section transformer
Lecture 9: Maximally flat (binomial) transformer, Chebyshev transformer
Lecture 10: Non-uniform transmission line(Tapers)

**Week 3**
Lecture 11: Scattering Parameters
Lecture 12: Properties of Scattering Parameters
Lecture 13: Properties of Scattering Parameters (contd.)
Lecture 14: Signal flow graph, ABCD parameters

**Week 4**
Lecture 15: 1 and 2 port passive components
Lecture 16: 3-port microwave components
Lecture 17: Couplers
Lecture 18: Coupled line couplers

**Week 5**
Lecture 19: Resonators and narrow band filters
Lecture 20: Narrow-band filters
Lecture 21: Filter design: Image parameter method, Insertion loss method
Lecture 22: Filter synthesis, Kuroda's Identity

**Week 6**
Lecture 23: Impedance Matching Circuits for Amplifiers
Lecture 24: Micro strip matching(contd.), Mason's rule, Power gain equations
Lecture 25: Amplifier Gain Stability
Lecture 26: Amplifier Gain Stability(contd.)

**Week 7**
Lecture 27: Gain circles
Lecture 28: Gain circles(contd.)
Lecture 29: Noise
Lecture 30: Noise figure circles(contd.)

**Week 8**
Lecture 31: DC Biasing
Lecture 32: Amplifier Classes, Frequency compensation
Lecture 33: Linearity
Lecture 34: Oscillator Design

**Reference Books:**

1. https://drive.google.com/file/d/1iQGy85Ss59ahcOPLgTPGVsfG3Qclo6ji/view?usp=sharing

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7. Exam is conducted by NPTEL.

| SEMESTER: III | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC433P | **MINOR PROJECT** | CIE Marks | : | 50 |
| Credits L-T-P | : | 0-0-6 | | SEE Marks | : | 50 |
| Hours/Week | : | 12P | | SEE Duration | : | 3 Hours |
| Faculty Coordinator: | | | | | | |

**Guidelines**

(i) Student can form group of two to execute the Minor Project.

(ii) Students are required to select topics related to their PG Program Specialization after extensive Literature Survey and analyzing the Research gaps.

(iii) Students will be assigned to guides in accordance with the expertise of the faculty.

(iv) 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

(v) Minor project has to be implemented/executed in-house, using the resources available in the department/college/CoE/CoC.

(vi) Students have to note the periodic progress in the Minor Project Diary and report the work carried to their respective guides.

(vii) 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.

(viii) 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 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 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 Minor Project Work | **60%** |
| 3 | Viva voce | **20%** |

| SEMESTER: III | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC434N | **INTERNSHIP** | CIE Marks | : | 50 |
| Credits L-T-P | : | 0-0-6 | | SEE Marks | : | 50 |
| Hours/Week | : | 12 | | SEE Duration | : | 3 Hours |
| Faculty Coordinator: | | | | | | |

**Guidelines**

(i) Students can opt for undergoing internship at the industry or research organizations like BEL, DRDO, ISRO, NAL, etc.

(ii) 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.

(iii) 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.

(iv) 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

(v) Students can approach the CoE/CoC for registering and working on relevant domain for training/internship at the CoE/CoC.

(vi) Internship must be related to the field of specialization of the respective PG program in which the student has enrolled.

(vii) Students undergoing internship training are advised to report their progress and submit periodic progress reports/diary to their respective guides.

(viii) 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.

(ix) 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 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 | : | MDC341F1 | **An Introduction to Information Theory** | CIE Marks | : | NA |
| Credits L-T-P | : | 2-0-0 | *(Theory - NPTEL Course online)* | SEE Marks | : | 50 |
| Hours | : | 16L | *Professional Basket Course-F (NPTEL-Online)* | 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: Entropy, Relative Entropy, Mutual Information;
Information Inequalities;
**Week 2:** Block to variable length coding-I: Prefix-free code
Block to variable length coding-II: Bounds on optimal codelength;
Block to variable length coding-III: Huffman coding.
**Week 3:** Variable to block length coding
The asymptotic equipartition property
Block to block coding of DMS
**Week 4:** Universal Source Coding-I: Lempel-Ziv Algorithm-LZ77
Universal source coding-II: Lempel-Ziv Welch Algorithm (LZW)
**Week 5:** Coding for sources with memory
Channel capacity of discrete memoryless channels.
**Week 6:** Joint typical sequences
Noisy channel coding theorem;
Differential entropy;
**Week 7:** Gaussian Channel;
Parallel Gaussian Channel.
**Week 8:** Rate Distortion Theory;
Blahut-Arimoto Algorithm for computation of channel capacity and rate- distortion function

**Reference Books:**

1.https://drive.google.com/file/d/1iTLcCqTzIbu8YQg-958rNWOAS6ltvz1y/view?usp=sharing

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7. Exam is conducted by NPTEL. equivalent course for the same.

| SEMESTER: IV | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MCE341F2 | **Embedded System Design with ARM** | CIE Marks | : | NA |
| Credits L-T-P | : | 2-0-0 | *(Theory - NPTEL Course online)* | SEE Marks | : | 50 |
| Hours | : | 16L | *Professional Basket Course-F (NPTEL-Online)* | 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 embedded systems and microcontrollers
**Week 2:** Instruction set architecture of ARM microcontroller, and assembly language programming
**Week 3:** D/A and A/D converter, sensors, actuators and their interfacing
**Week 4:** Microcontroller development boards and embedded programming platforms
**Week 5:** Hands-on and demonstration I: Temperature sensing unit, Light sensing unit, Sound sensing unit
**Week 6:** Hands-on and demonstration II: Feedback control system, relay control unit, driving electrical appliances like motors, bulb, pump, etc.
**Week 7:** Hands-on and demonstration III: Object tracking using GPS and GSM
**Week 8 :** Hands-on and demonstration IV: Introduction to Internet of Things, smart home concepts, motion sensing using accelerometer, control of appliances over SMS

**Reference Books:**

1.https://drive.google.com/file/d/16RVmO4e34lgRpF1A5KptEznVpsac2Va-/view?usp=sharing

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7. Exam is conducted by NPTEL.

| SEMESTER: IV | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC241F3 | **Fundamentals of MIMO Wireless Communication** | CIE Marks | : | NA |
| Credits L-T-P | : | 2-0-0 | *(Theory - NPTEL Course online)* | SEE Marks | : | 50 |
| Hours | : | 16L | *Professional Basket Course-F (NPTEL-Online)* | 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 communication systems and wireless channels
**Week 2:** Wireless channel models
**Week 3:** MIMO channel model
**Week 4:** Information Theory basics for MIMO communication
**Week 5**: Capacity of MIMO Communication systems
**Week 6:** Diversity performance of MIMO channels
**Week 7:** Space Time Coding schemes
**Week 8:** Multi-user MIMO communications

**Reference Books:**
**1.**https://drive.google.com/file/d/1svHUMUOOV4RIqxxu2nPI_4dBwLENmCKi/view

**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/
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.

| SEMESTER: IV | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC241F4 | **VLSI Signal Processing** | CIE Marks | : | NA |
| Credits L-T-P | : | 2-0-0 | *(Theory - NPTEL Course online)* | SEE Marks | : | 50 |
| Hours | : | 16L | *Professional Basket Course-F (NPTEL-Online)* | 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:** Graphical representation of DSP algorithms, signal flow graph (SFG), data flow graph (DFG) and dependence graph (DG), high level transformation, critical path.
**Week 2:** Retiming of DFG, critical path minimization by retiming, loop retiming and iteration bound
**Week 3:** Cutset retiming, design of pipelined DSP architectures, examples
**Week 4:** Parallel realization of DSP algorithms, idea of unfolding, unfolding theorem, loop unfolding
**Week 5:** Polyphase decomposition of transfer functions, hardware efficient parallel realization of FIRfilters, 2-parallel and 3-parallel filter architectures.
**Week 6:** Hardware minimization by folding, folding formula, examples from biquad digital filters,
**Week 7:** Delay optimization by folding, lifetime analysis, forward-backward data allocation, examples from digital filters
**Week 8:** Pipelining digital filters, look ahead techniques, clustered and scattered look ahead, combining parallel processing with pipelining in digital filters

**Reference Books:**

1. https://drive.google.com/file/d/1UBELdd4Wb3qIRLstAD50s3cXCXJsfleV/view?usp=sharing

**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.

| SEMESTER: IV | | | | | | |
|---|---|---|---|---|---|---|
| Course Code | : | MDC442P | **MAJOR PROJECT** | CIE Marks | : | 100 |
| Credits L-T-P | : | 0-0-18 | | SEE Marks | : | 100 |
| Hours/Week | : | 36P | | SEE Duration | : | 3 Hours |
| Faculty Coordinator: | | | | | | |

**Guidelines**

(i) Major Project is to be carried out for a duration of 18 weeks
(ii) Student have to implement the Major Project individually.
(iii) Students are required to select topics related to their PG Program Specialization after extensive Literature Survey and analyzing the Research gaps.
(iv) Students will be assigned to guides in accordance with the expertise of the faculty.
(v) 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
(vi) 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.
(vii) 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.
(viii) It is mandatory for the students to present/publish their project work in National/International Conferences/Journals
(ix) 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.
(x) 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% |

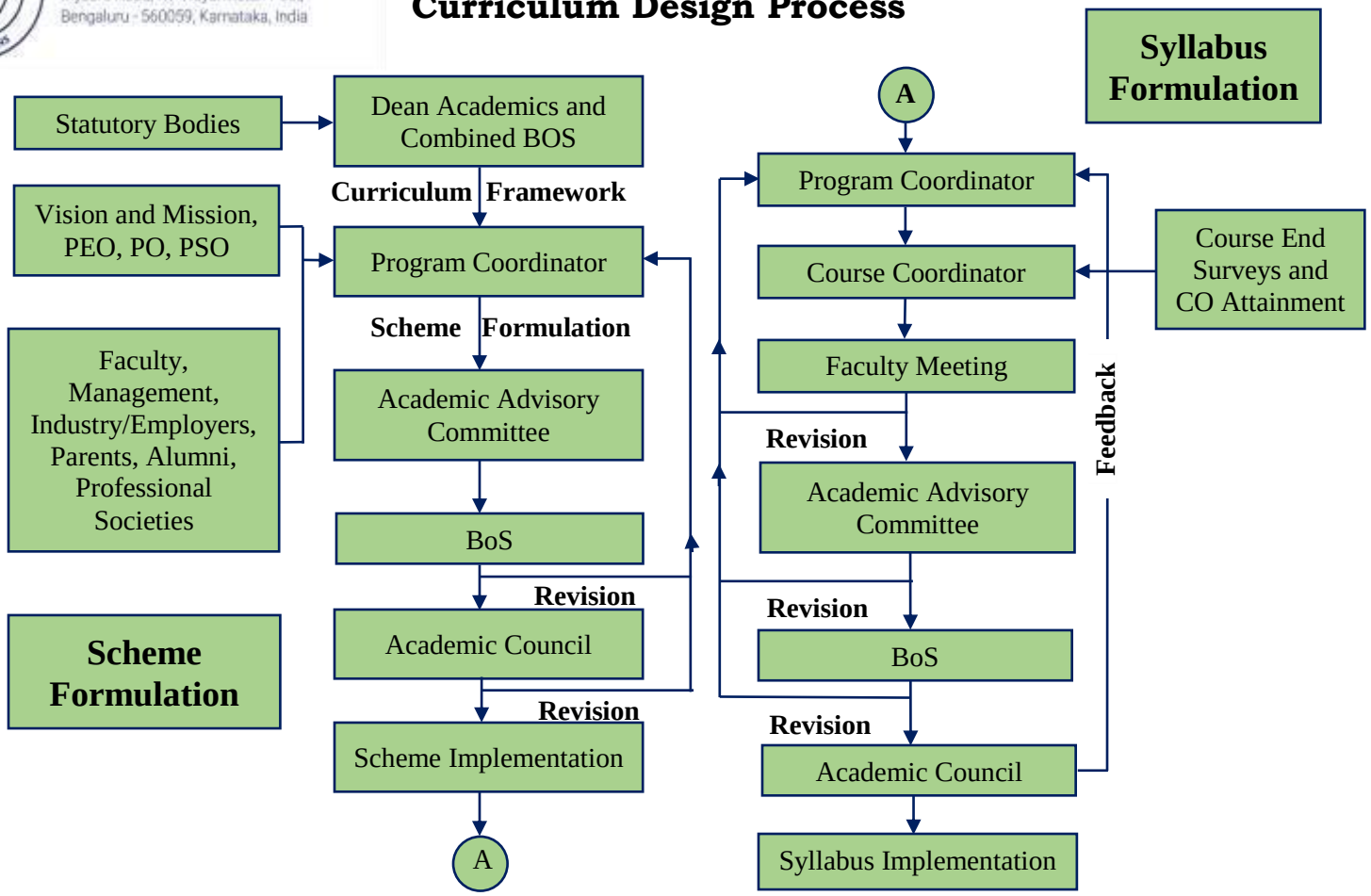
**Scheme for Semester End Evaluation (SEE):**
Major Project SEE evaluation shall be conducted in two stages. This is initiated after fulfilment of submission of Project Report and CIE marks.
Stage-1 Report Evaluation: Evaluation of Project Report shall be done by the Guide and an External examiner.
Stage-2 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**

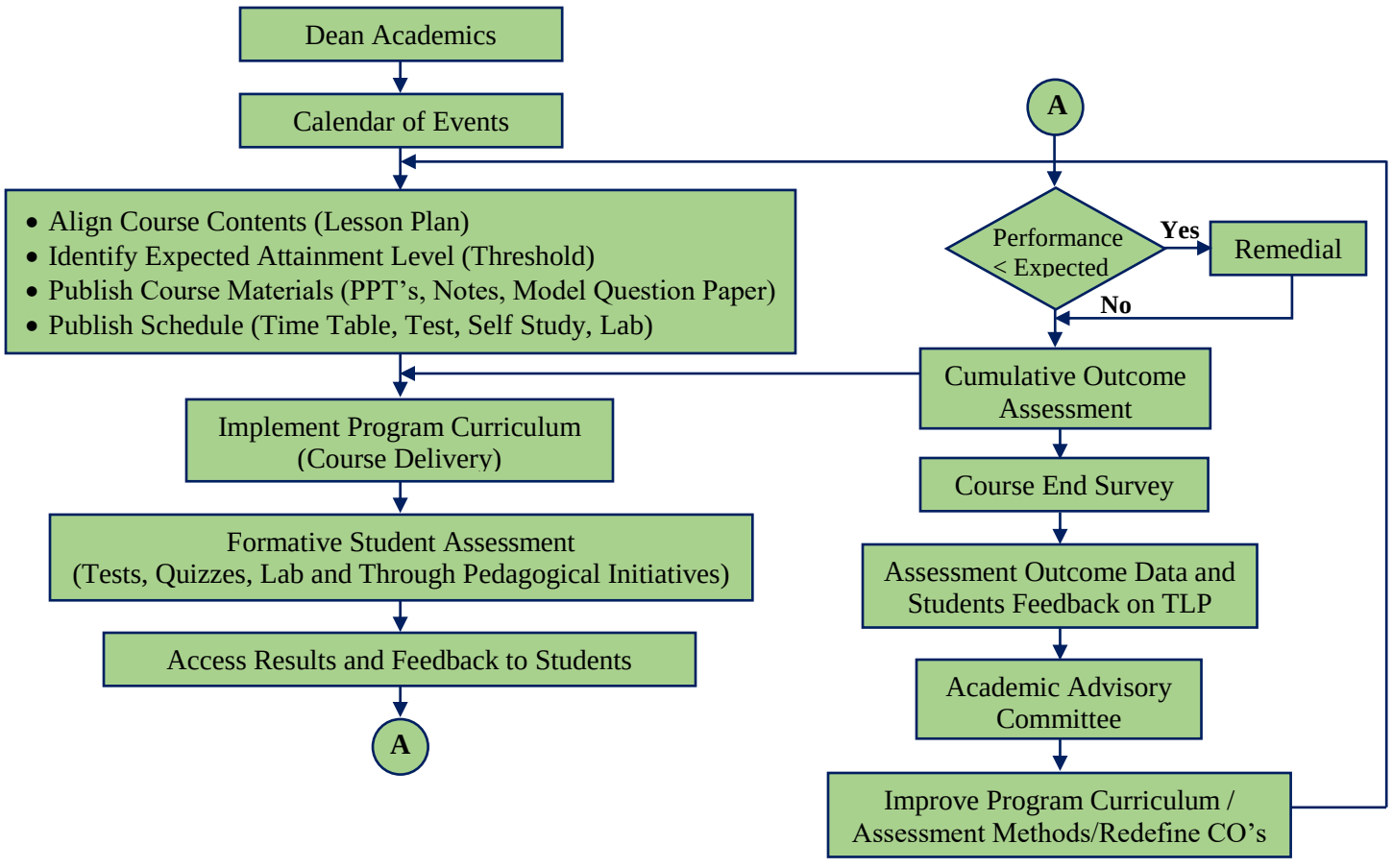
**SEE procedure is as follows:**

| | | |
|---|---|---|
| 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** |

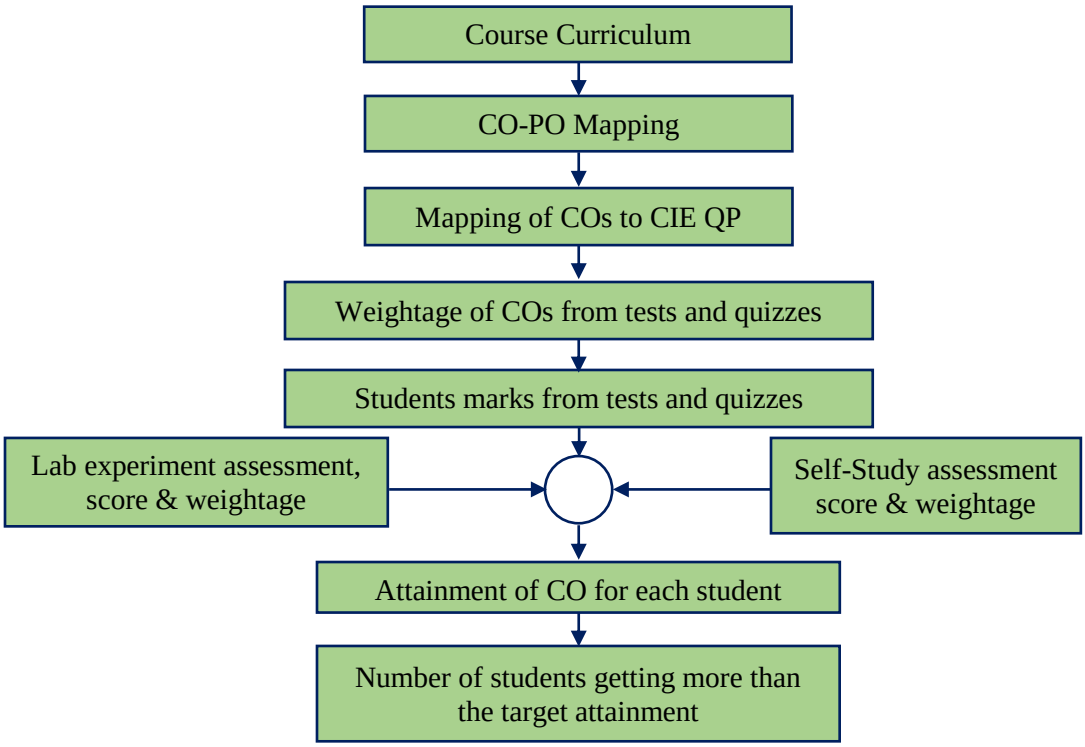
# Curriculum Design Process



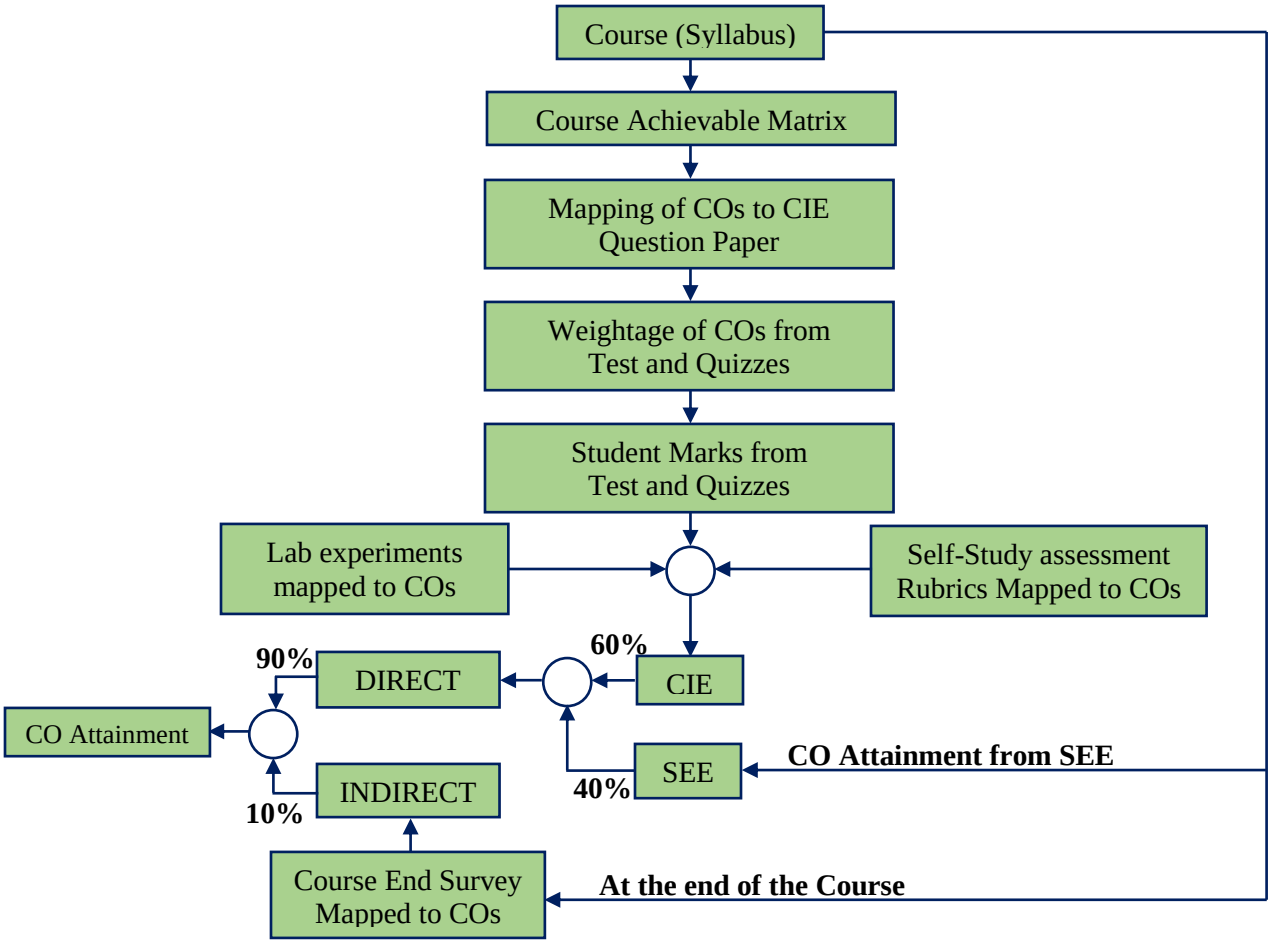

# Academic Planning and Implementation



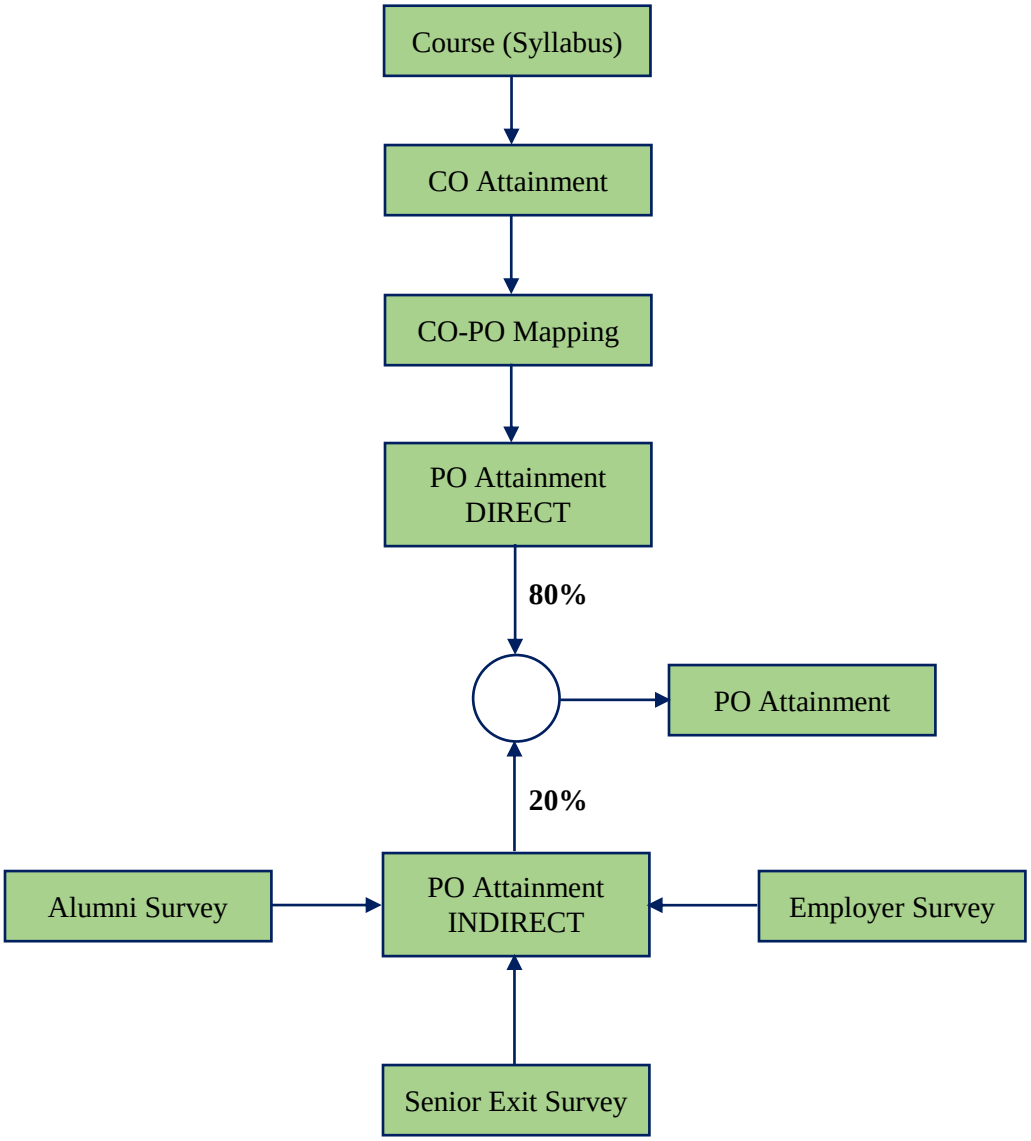
## Process For Course Outcome Attainment




## Final CO Attainment Process



# Program Outcome Attainment Process



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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