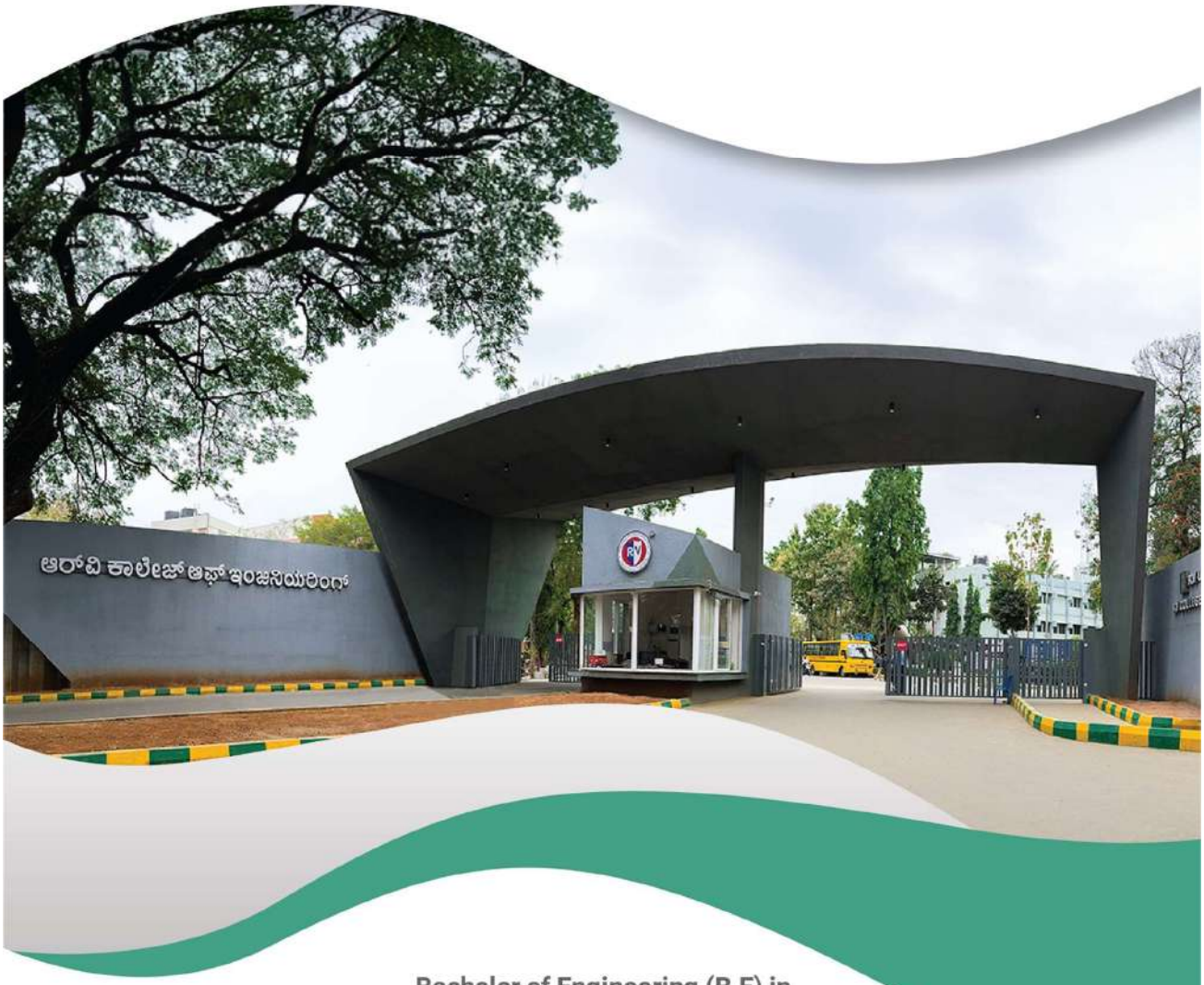
RV College of Engineering®

# Undergraduate Programs



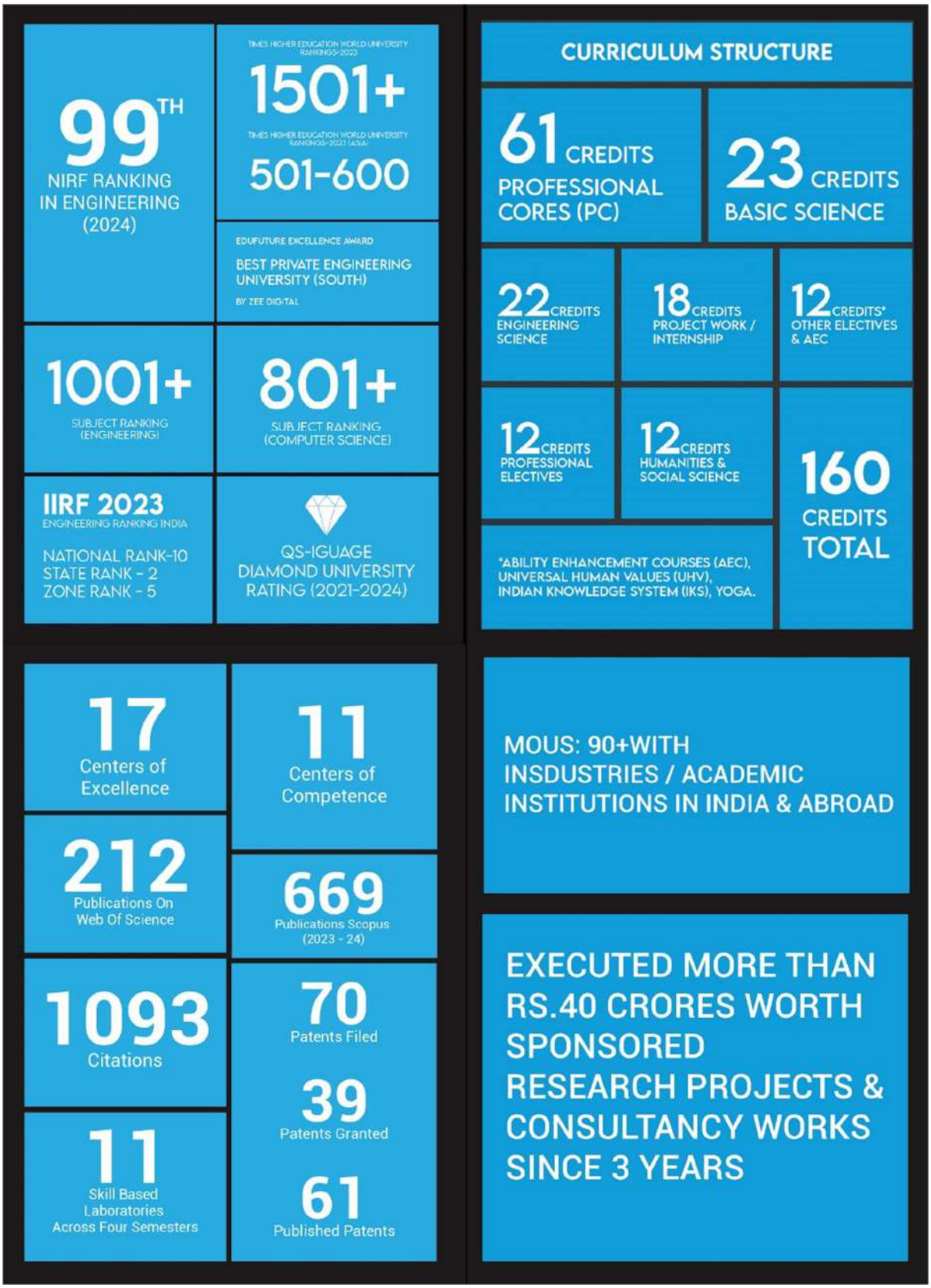

## Bachelor of Engineering (B.E) in

# CHEMICAL Engineering

Scheme and Syllabus Of V & VI Semester
(2022 Scheme)

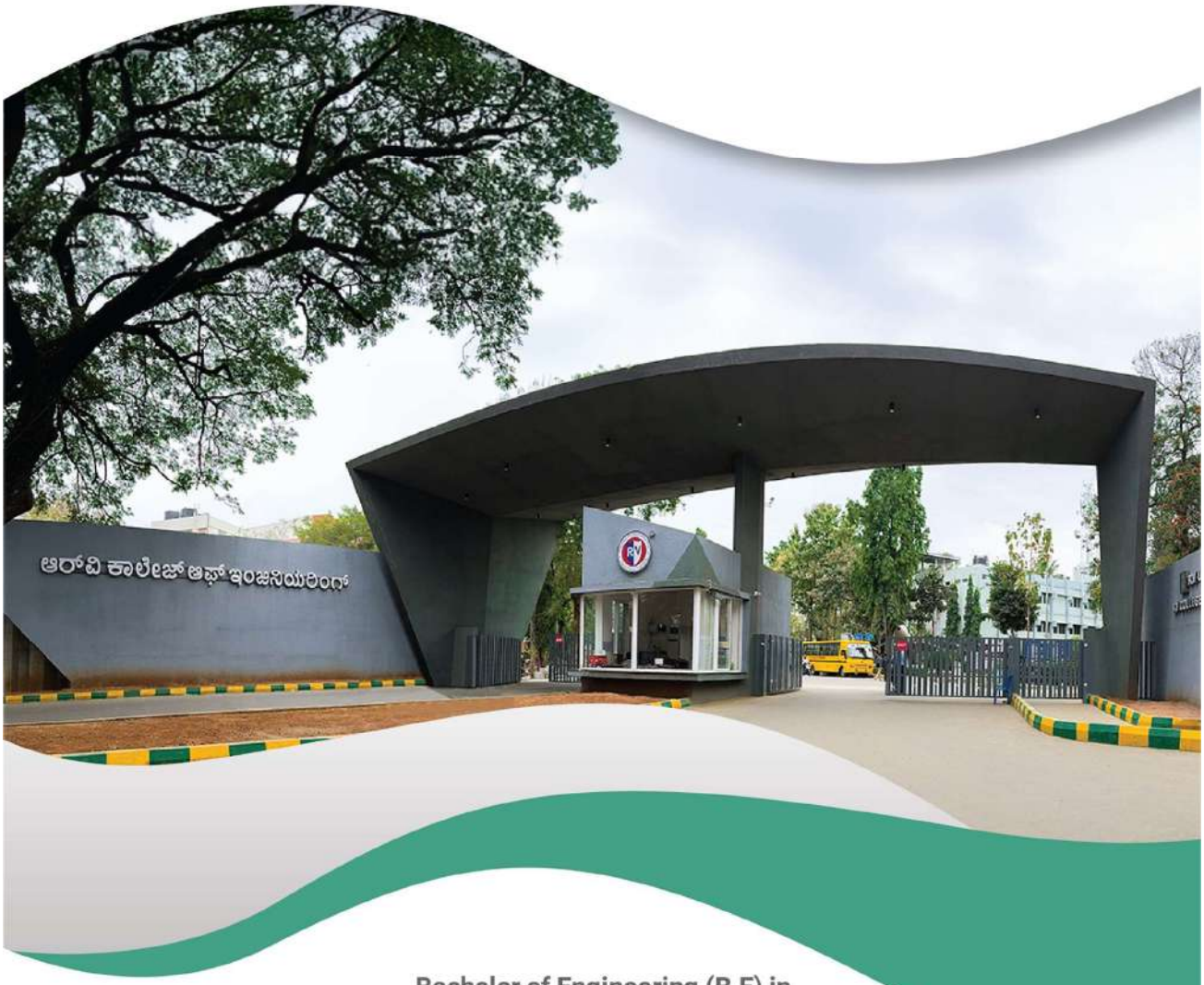
B.E. Programs : AS, BT, CH, CS, CS - AI, CS - CD, CS - CY, CV, EC, EE, EI, ET, IM, IS, ME.
M. Tech (13) MCA, M.Sc. (Engg.)
Ph.D. Programs : All Departments are recognized as Research Centres by VTU Except AI & AS

**2024**


99TH
NIRF RANKING IN ENGINEERING (2024)
TIMES HIGHER EDUCATION WORLD UNIVERSITY RANKINGS-2023
1501+
TIMES HIGHER EDUCATION WORLD UNIVERSITY RANKINGS-2023 (ASIA)
501-600
EDUFUTURE EXCELLENCE AWARD
BEST PRIVATE ENGINEERING UNIVERSITY (SOUTH)
BY ZEE DIGITAL
1001+
SUBJECT RANKING (ENGINEERING)
801+
SUBJECT RANKING (COMPUTER SCIENCE)
IIRF 2023
ENGINEERING RANKING INDIA
NATIONAL RANK-10
STATE RANK - 2
ZONE RANK - 5
QS-IGUAGE DIAMOND UNIVERSITY RATING (2021-2024)
CURRICULUM STRUCTURE
61 CREDITS PROFESSIONAL CORES (PC)
23 CREDITS BASIC SCIENCE
22 CREDITS ENGINEERING SCIENCE
18 CREDITS PROJECT WORK / INTERNSHIP
12 CREDITS* OTHER ELECTIVES & AEC
12 CREDITS PROFESSIONAL ELECTIVES
12 CREDITS HUMANITIES & SOCIAL SCIENCE
160 CREDITS TOTAL
*ABILITY ENHANCEMENT COURSES (AEC), UNIVERSAL HUMAN VALUES (UHV), INDIAN KNOWLEDGE SYSTEM (IKS), YOGA.
17 Centers of Excellence
11 Centers of Competence
212 Publications On Web Of Science
669 Publications Scopus (2023 - 24)
1093 Citations
70 Patents Filed
39 Patents Granted
61 Published Patents
11 Skill Based Laboratories Across Four Semesters
MOUS: 90+WITH INSDUSTRIES / ACADEMIC INSTITUTIONS IN INDIA & ABROAD
EXECUTED MORE THAN RS.40 CRORES WORTH SPONSORED RESEARCH PROJECTS & CONSULTANCY WORKS SINCE 3 YEARS

RV College of Engineering®

# Undergraduate Programs




## Bachelor of Engineering (B.E) in

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**2024**

## DEPARTMENT VISION

Imparting quality technical education in Chemical Engineering to promote leadership in research, innovation and sustainable technology through teamwork.

## DEPARTMENT MISSION

- Impart quality education in basic and applied areas of Chemical Engineering.
- Enable students and faculty to achieve proficiency in the areas of Chemical Processes, Energy, Unit Operations and Computational Chemical Engineering using state-of-art laboratories and modern infrastructure.
- Encourage faculty and students to make career in research and contribute towards innovative processes and products.
- Develop inclusive technologies with a focus on new materials and sustainability.
- Collaborate with industries and research Institutes for academics and research.
- Inculcate leadership qualities, entrepreneurial skills, societal and ethical values in students and faculty.

## PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

**PEO 1**: Exhibit knowledge of basic sciences, concepts and principles of Chemical Engineering.

**PEO 2**: Comprehend, analyze, design and implement engineering systems with a focus on research,innovation and sustainability.

**PEO 3**: Work in multidisciplinary team and cater to the needs of process industries with appropriate safety, health and environmental regulations.

**PEO 4**: Demonstrate effective communication skills, leadership qualities and develop into successfulentrepreneurs.

## PROGRAM SPECIFIC OUTCOMES (PSOs)

| PSO | Description |
|---|---|
| PSO1 | Gain knowledge of Chemical Engineering fundamentals and demonstrate problem formulation capabilities |
| PSO2 | Analyze and solve engineering problems with a focus on environment and sustainability |
| PSO3 | Contribute to multidisciplinary research using relevant Chemical Engineering tools |

# ABBREVIATIONS

| Sl. No. | Abbreviation | Meaning |
|---|---|---|
| 1. | VTU | Visvesvaraya Technological University |
| 2. | BS | Basic Sciences |
| 3. | CIE | Continuous Internal Evaluation |
| 4. | SEE | Semester End Examination |
| 5. | CE | Professional Core Elective |
| 6. | GE | Global Elective |
| 7. | HSS | Humanities and Social Sciences |
| 8. | CV | Civil Engineering |
| 9. | ME | Mechanical Engineering |
| 10. | EE | Electrical & Electronics Engineering |
| 11. | EC | Electronics & Communication Engineering |
| 12. | IM | Industrial Engineering & Management |
| 13. | EI | Electronics & Instrumentation Engineering |
| 14. | CH | Chemical Engineering |
| 15. | CS | Computer Science & Engineering |
| 16. | TE | Telecommunication Engineering |
| 17. | IS | Information Science & Engineering |
| 18. | BT | Biotechnology |
| 19. | AS | Aerospace Engineering |
| 20. | PY | Physics |
| 21. | CY | Chemistry |
| 22. | MA | Mathematics |
| 23. | AEC | Ability Enhancement Courses |

# INDEX

# Bachelor of Engineering in
# CHEMICAL ENGINEERING

| V Semester | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Course Title** | **Credit Allocation** | | | | **BoS** | **Category** | **Max Marks CIE** | | **SEE Duration (H)** | **Max Marks SEE** | |
| | | | **L** | **T** | **P** | **Total** | | | **Theory** | **Lab** | | **Theory** | **Lab** |
| 1 | HS351TA | Entrepreneurship and Intellectual Property Rights | 3 | 0 | 0 | 3 | HS | Theory | 100 | *** | **3** | 100 | *** |
| 2 | CH352IA | Process Dynamics and Control | 3 | 0 | 1 | 4 | CH | Theory + Practice | 100 | 50 | **3** | 100 | *** |
| 3 | CH353IA | Transport Phenomena | 3 | 0 | 1 | 4 | CH | Theory + Practice | 100 | 50 | **3** | 100 | 50 |
| 4 | CH354TA | Mass Transfer-I | 3 | 1 | 0 | 4 | CH | Theory | 100 | | **3** | 100 | 50 |
| 5 | CH255TBX | Professional Core Elective-I (Group-B) | 3 | 0 | 0 | 3 | CH | Theory | 100 | *** | **3** | 100 | *** |
| 6 | CH256TCX | Professional Core Elective-II (Group C) | 2 | 0 | 0 | 2 | CH | **NPTEL** | 50 | *** | **3** | 50 | *** |
| | | **Total** | | | | **20** | | | | | | | |

| ELECTIVES | | |
|---|---|---|
| **GROUP-B** | | |
| **Sl.No** | **Course code** | **Course Title** |
| 1 | CH255TBA | Processing of polymers and polymer composites |
| 2 | CH255TBB | Pilot Plant and Scale up Studies |
| 3 | CH255TBC | Design of Piping Systems |
| 4 | CH255TBD | Chemical Plant Utilities |
| **GROUP-C (NPTEL)**<br>**(NPTEL courses are subject to change based on the availability of the course on the NPTEL Platform)** | | |
| **Sl. No.** | **Course Code** | **Course Title** |
| 1 | CH256TCA | Electrochemical Technology in Pollution Control |
| 2 | CH256TCB | Rheology and Processing of Paints, Plastic, and Elastomer Based Composites |
| 3 | CH256TCC | Computational Process Design |
| 3 | CH256TCD | Physical and Electrochemical Characterizations in Chemical Engineering |
| 4 | CH256TCE | Adsorption Science and Technology: Fundamentals and Applications |

# Bachelor of Engineering in
# CHEMICAL ENGINEERING

| VI SEMESTER | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Course Title** | **Credit Allocation** | | | | **BoS** | **Category** | **Max Marks CIE** | | **SEE Duration (H)** | **Max Marks SEE** | |
| | | | **L** | **T** | **P** | **Total** | | | **Theory** | **Lab** | | **Theory** | **Lab** |
| 1 | HS261TA | Principles of Management and Economics | 3 | 0 | 0 | 3 | HS | Theory | 100 | *** | | 100 | *** |
| 2 | CH362IA | Process Modeling and Simulation | 3 | 0 | 1 | 4 | CH | Theory + Practice | 100 | 50 | | 100 | **50** |
| 3 | CH363IA | Mass Transfer-II | 3 | 0 | 1 | 4 | CH | Theory + Practice | 100 | 50 | | 100 | 50 |
| 4 | CH364TA | Heterogeneous Reaction Systems | 3 | 1 | 0 | 4 | CH | Theory | 100 | *** | | 100 | *** |
| 5 | CH365TDX | Professional Core Elective-III (Group- D) | 3 | 0 | 0 | 3 | CH | Theory | 100 | *** | | 100 | *** |
| 6 | XX366TEX | Institutional Electives – I (Group E) | 3 | 0 | 0 | 3 | XX | Theory | 100 | *** | | **100** | *** |
| 7 | CH367P | Interdisciplinary Project | 0 | 0 | 3 | 3 | CH | Project | *** | 100 | | *** | 100 |
| | | **Total** | | | | **24** | | | | | | | |

| ELECTIVES | | |
|---|---|---|
| **GROUP-D Professional Core Elective** | | |
| **Sl.No** | **Course code** | **Course Title** |
| **1** | CH365TDA | Food Engineering |
| **2** | CH365TDB | Fuel Cell Technology |
| **3** | CH365TDC | Process Engineering and Economics |
| **4** | CH365TDD | Energy Storage Technology |

| **GROUP-F Institutional Electives – I** | | | |
|---|---|---|---|
| **Sl. No.** | **Course Code** | **BoS** | **Course Title** |
| 1 | AS266TEA | AS | Fundamentals of Aerospace Engineering |
| 2 | BT266TEB | BT | Bioinformatics |
| 3 | CH266TEC | CH | Industrial Safety Engineering |
| 4 | CS266TED | CS | Robotics Process Automation |
| 5 | CV266TEE | CV | Intelligent Transport Systems |
| 6 | CV266TEF | CV | Integrated Health Monitoring of Structures |
| 7 | CM266TEG | CM | Advanced Energy Storage for E-Mobility |
| 8 | EC266TEH | EC | Human Machine Interface (HMI) |
| 9 | EE266TEJ | EE | Energy Auditing and Standards |
| 10 | EI266TEK | EI | Biomedical Instrumentation |
| 11 | ET266TEM | ET | Telecommunication Systems |
| 12 | ET266TEN | ET | Mobile Communication Networks and Standards |
| 13 | IS266TEO | IS | Mobile Application Development |
| 14 | IM266TEQ | IM | Elements of Financial Management |
| 15 | IM266TER | IM | Optimization Techniques |
| 16 | ME266TES | ME | Automotive Mechatronics |
| 17 | MA266TEU | MA | Mathematical Modelling |
| 18 | MA266TEV | MA | Mathematics of Quantum Computing |
| 19 | HS266TEW | HS | Applied Psychology for Engineers |
| 20 | HS266TEY | HS | Universal Human Values |

| V Semester | | | | | | |
|---|---|---|---|---|---|---|
| **FUNDAMENTALS OF ENTREPRENEURSHIP & INTELLECTUAL PROPERTY RIGHTS (Theory)** | | | | | | |
| **Course Code** | **:** | **HS351TA** | | **CIE** | **:** | **100 Marks** |
| **Credits: L: T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **42 L** | | **SEE Duration** | **:** | **3 Hours** |

| **Unit-I** | **08Hrs** |
|---|---|
| **Introduction to Entrepreneurship**: Definition and Scope of Entrepreneurship, Importance of Entrepreneurship in Engineering Innovation and Economic Growth, Techniques for Identifying Entrepreneurial Opportunities, Types of Entrepreneurs: Innovative, Imitative, Fabian, Characteristics and Traits of Successful Entrepreneurs.<br>**Role in economic development**- Emerging Trends in Entrepreneurship, Entrepreneur and Entrepreneurship, characteristics of Entrepreneur, Myths about Entrepreneurship, Entrepreneur vs Intrapreneur, Role of Entrepreneurial Teams<br>**Activities**: Case study on Entrepreneurship in Indian Scenario, Ideation Workshops and Hackathons, | |
| **Unit – II** | **08 Hrs** |
| **Entrepreneurial Opportunity Evaluation**: Identifying Market Opportunities and Trends, Integration of Engineering Principles in Ideation Process, Cross-Disciplinary Collaboration for Technological Innovation, Assessing Market Feasibility and Demand Analysis, Evaluating Technical Feasibility: Prototype Development, Proof of Concept, Financial Feasibility Analysis: Cost Estimation, Revenue Projection, Break-Even Analysis**.**<br>**Business Planning and Strategy Development**: Elements of a Business Plan, Executive Summary, Company Description, Market Analysis, writing a Business Plan: Structure and Components, Strategic Planning: Vision, Mission, Goals, Objectives, SWOC Analysis, Competitive Strategy: Porter's Generic Strategies, Differentiation, Cost Leadership, Focus Strategy, Growth Strategies: Organic Growth, Mergers and Acquisitions, Strategic Alliances<br>**Activities**: Writing a Business Plan on given templates, Developing Business Models and Prototypes Based on Generated Ideas | |
| **Unit –III** | **08Hrs** |
| **Entrepreneurial Marketing and Sales:** Basics of Marketing: Product, Price, Place, Promotion (4Ps), Market Segmentation, Targeting, and Positioning (STP), Branding and Product Development Strategies, Creating a Unique Value Proposition (UVP) Digital Marketing: Social Media Marketing, Content Marketing, SEO, SEM, Sales Techniques and Customer Relationship Management (CRM). Entrepreneurial Finance and Resource Management: Sources of Financing: Equity Financing, Debt Financing, Venture Capital, Angel Investors, Crowdfunding, Financial Management: Budgeting, Cash Flow Management, Financial Statements Analysis, Risk Management and Insurance, Human Resource Management: Recruitment, Training, Performance Evaluation, Legal and Ethical Issues in Entrepreneurship: Intellectual Property Rights, Contracts, Corporate Governance<br>Activities:Case Studies and Practical Applications | |
| **Unit –IV** | **09 Hrs** |
| **Introduction to IP :** Types of Intellectual Property<br>**Patents:** Introduction, Scope and salient features of patent; patentable and non-patentable inventions, Patent Procedure - Overview, Transfer of Patent Rights; protection of traditional knowledge, Infringement of patents and remedy, Case studies, Patent Search and Patent Drafting, Commercialization and Valuation of IP.<br>**Trade Marks:** Concept, function and different kinds and forms of Trade marks, Registrable and non-registrable marks. Registration of Trade Mark; Deceptive similarity; Transfer of Trade Mark, ECO Label, Passing off, Infringement of Trade Mark with Case studies and Remedies. | |
| **Unit –V** | **09 Hrs** |

| |
|---|
| **Trade Secrets:** Definition, Significance, Tools to protect Trade secrets in India.<br>**Industrial Design:** Introduction of Industrial Designs Features of Industrial, Design. Procedure for obtaining Design Protection, Revocation, Infringement and Remedies, Case studies.<br>**Copy Right:** Introduction, Nature and scope, Rights conferred by copy right, Copy right protection, transfer of copy rights, right of broad casting organizations and performer's rights, Exceptions of Copy Right, Infringement of Copy Right with case studies. |

| **Course Outcomes:** After going through this course, the student will be able to | |
|---|---|
| **CO1** | Understand the concepts of entrepreneurship and cultivate essential attributes to become an entrepreneur or Intrapreneur and demonstrate skills such as problem solving, team building, creativity and leadership. |
| **CO2** | Comprehend the process of opportunity identification of market potential and customers while developing a compelling value proposition solution. |
| **CO3** | Analyse and refine business models to ensure sustainability and profitability and build a validated MVP of their practice venture idea and prepare business plan, conduct financial analysis and feasibility analysis to assess the financial viability of a venture. |
| **CO4** | Apply insights into the strategies and methods employed to attain a range of benefits from these IPs and deliver an investible pitch deck of their practice venture to attract stakeholders |
| **CO5** | Knowledge and competence related exposure to the various Legal issues pertaining to Intellectual Property Rights with the utility in engineering perspectives.. |

| **Reference Books** | |
|---|---|
| **1.** | Donald F. Kuratko ,"Entrepreneurship: Theory, Process, and Practice", South-Western Pub publishers, 10th edition, 2016,978-ISBN-13: 1305576247 |
| **2.** | Eric Ries, "The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses", Crown Currency Publishers,1st Edition, 2011, ISBN-13: 978-0307887894. |
| **3.** | Dr B L Wadehra, Law Relating to Intellectual Property, universa Law publishers 05th edition, ISBN : 9789350350300 . |
| **4** | Intellectual Property Rights: Unleashing Knowledge Economy, Prabuddha Ganguly, 1st Edition, 2001, Tata McGraw Hill Publishing Company Ltd., New Delhi, ISBN: 0074638602. |

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

| | | |
|---|---|---|
| 3. | **EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar / presentation / demonstration (20**) ADDING UPTO 40 MARKS**. | **40** |
| **MAXIMUM MARKS FOR THE CIE** | | **100** |

| **RUBRIC FOR SEMESTER END EXAMINATION (THEORY)** | | |
|---|---|---|
| **Q.NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only; wherein one sub division will be a caselet in the related topics) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| **TOTAL** | | **100** |

| emester: V | | | | | | |
|---|---|---|---|---|---|---|
| **PROCESS DYNAMICS AND CONTROL**<br>**Category: Professional Core**<br>**(Theory and Practice)** | | | | | | |
| **Course Code** | **:** | **CH352IA** | | **CIE Marks** | **:** | **100 + 50** |
| **Credits: L:T:P** | **:** | **3:0:1** | | **SEE Marks** | **:** | **100 + 50** |
| **Total Hours** | **:** | **45L+30P** | | **SEE Duration** | **:** | **3 Hours** |

| **Unit-I** | **09 Hrs** |
|---|---|
| **First order Systems:** Transfer functions, transient response, Forcing functions and responses, physical examples of first order systems: mercury in glass thermometer, liquid level system, mixing process in tanks and stirred tank reactors, Linearization of non-linear first order systems.<br>**Response of first order system in series:** Interacting and non-interacting systems. | |
| **Unit – II** | **09 Hrs** |
| **Second order Systems:** Examples of second order systems: U-tube manometer, Damped vibrator. Overdamped, critically damped and terms for second order under damped process, Transportation lag | |
| **Unit –III** | **09 Hrs** |
| **Controllers:** Controllers, components of a control system, closed loop and open loop systems, Transfer functions for two position, proportional, Proportional +Reset (P+I), Proportional + Rate (P+D), Proportional + Reset +Rate controller (P+I+D)<br>**Final Control element:** actuators, valve body, valve characteristics | |
| **Unit –IV** | **09 Hrs** |
| **Closed Loop Systems:** Control System, servo and regulator problem, Overall transfer function for single-loop systems and multi loop control system, overall transfer function for set-point change and load change.<br>Transient response of simple control systems | |
| **Unit –V** | **09 Hrs** |
| **Stability:** Concept of Stability, Stability criterion, Routh Herwitz test for stability, Root Locus method.<br>**Frequency Response:** Bode diagrams for first, second order systems and controllers, Bode stability criteria, Ziegler-Nichols tuning method. | |

**Laboratory Component**

| | **List of experiments** |
|---|---|
| **1** | Time constant determination and response to step change of thermometer: First order |
| **2** | Single tank system: First order |
| **3** | Non interacting First order elements in series |
| **4** | Interacting First order elements in series |
| **6** | Level Controller (P, I, D, PID controllers) |
| **7** | Flow controller (P, I, D, PID controllers |
| **8** | Pressure controller (P, I, D, PID controllers) |
| **9** | Temperature controller (P, I, D, PID controllers) |
| **10** | Control valve characteristics |
| **11** | Controller Tuning |

| **Course Outcomes:** After completing the course, the students will be able to | |
|---|---|
| **CO 1** | Recall the concepts of Laplace transforms and first & second order systems |
| **CO 2** | Compute transfer functions for first, second order and control systems |
| **CO 3** | Analyze the response of first & second order systems and controllers for various inputs |
| **CO 4** | Determine the overall transfer function of single and closed loop control system and evaluate the stability of control systems |

| **Reference Books** |
|---|

| | |
|---|---|
| 1 | Process system Analysis and Control: Steven E. LeBlanc, Donald R. Coughanowr, Third Edition, 2017, McGraw Hill, ISBN- 978-1259098437 |
| 2 | Chemical Process Control: George Stephanopoules, First Edition, 2015, Pearson Education, ISBN- 978-9332549463 |
| 3 | Coulson and Richardson's Chemical Engineering: Richardson J. F. Et. Al, 4th Edition,2006, Elsevier, ISBN 978-8131204528 |
| 4 | Process modeling, simulation and Control for Chemical Engineers: Luyben, 2nd Edition, 2013, McGraw Hill Education, 978-9332901681 |
| | Process Dynamics and Control; Seborg, Edgar, Mellichamp, Doyle; 3rd Edition, Wiley, 2013, ISBN-978-8126541263 |

| **RUBRICFOR 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. Each quiz is evaluated for 10 marks adding up to 20 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 **50Marks**, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.** | **40** |
| 3. | **EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10) Designing & Modeling (10) **Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**. | **40** |
| 4. | **LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (30 Marks), lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (10 Marks) adding up to 50 Marks. THE FINAL MARKS WILL BE 50 MARKS | **50** |
| | **MAXIMUM MARKS FOR THE CIE (THEORY AND PRACTICE)** | **150** |

| **RUBRIC FOR SEMESTER END EXAMINATION (THEORY)** | | |
|---|---|---|
| **Q.NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type of questions covering entire syllabus | 20 |
| | **PART B** (Maximum of THREE Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

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

| Semester: V | | | | | | |
|---|---|---|---|---|---|---|
| **TRANSPORT PHENOMENA**<br>**Category: Professional Elective**<br>**(Theory and Practice)** | | | | | | |
| **Course Code** | **:** | **CH353IA** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:1** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45L+30P** | | **SEE Duration** | **:** | **3.00 Hours** |

| **Unit-I** | **09 Hrs** |
|---|---|
| **Shell momentum balance:**<br>Shell momentum balance, Equation continuity and equation of motion, Development of steady state models using shell momentum balance approach for falling film, pipe, annulus, wetted wall column and solution of these models. | |
| **Unit – II** | **09 Hrs** |
| **Equations of change:**<br>Use of Equations of change, their modifications simplifications. Application of equations of change to deduce models and interpret the solutions for annulus, pipe, wetted wall column, falling film, flow through narrow slit, Couette flow, rotating cylinder. | |
| **Unit –III** | **09 Hrs** |
| **Heat Transfer models:**<br>Shell energy balance, heat conduction in an annulus (varying k), models for electrical heat source, viscous heat source, nuclear heat source | |
| **Unit –IV** | **09 Hrs** |
| **Mass Transfer Models:**<br>Shell mass balance and boundary conditions, Application of shell mass balance to simple steady state mass transfer models: diffusion through stagnant gas, determination of diffusivity, diffusion with heterogeneous reaction, homogeneous reaction, diffusion and reaction in porous catalyst | |
| **Unit –V** | **09 Hrs** |
| Turbulent Flow: Introduction to turbulent flow, Comparison of Laminar and turbulent flow (For circular and non-circular conduits), Time smoothed equations of change-Reynold's decomposition and stresses, Near wall turbulent flow region (Qualitative treatment). Boussinesq eddy viscosity-concept of free and wall turbulence, Prandtl mixing length. | |

**Laboratory Component:**
Flow visualization and analysis using CFD simulations are to be performed on the following systems using ANSYS package.

| **Sl No** | **Details of the experiment** |
|---|---|
| Velocity Profile, shear stress distribution, Pressure distribution, Streamlines in | |
| 1 | Circular Conduits |
| 2 | Non-circular conduits |
| 3 | Expansion and contraction |
| 4 | Annulus |
| Temperature Profile, flux distribution in | |
| 5 | Flow through heated pipe |
| 6 | Composite wall |
| 7 | Natural Convection |
| Targeted effect studies in | |
| 8 | Simulation of Orifice meter |
| 9 | Simulation of Venturi-meter |
| 10 | Effect of roughness |
| 11 | Boundary layer |
| 12 | Reacting flows |

| Course Outcomes: After completing the course, the students will be able to | |
|---|---|
| **CO1:** | Apply fundamentals of science to arrive at force, momentum, heat and mass balance equations. |
| **CO2:** | Develop and solve the models for steady state heat, mass and momentum transfer systems. |
| **CO3:** | Analyze and interpret the solutions of the models. |
| **CO4:** | Use equations of change to formulate and solve steady state models |

| Reference Books | |
|---|---|
| **1** | R. Byron Bird et al, Transport Phenomena, 2nd Ed., Wiley, 2013, ISBN: 978-81-265-08008--2 |
| **2** | Harry C. Hershey (Author), Robert S. Brodkey Transport Phenomena: A Unified Approach: A Unified Approach, Vol 1, Bordkey Publishing, 2013, ISBN 0-9726635-9-2. |
| **3** | Fundamentals of Momentum, Heat and Mass Transfer, James R. Welty et al., 4th Ed., Wiley India, 2007, ISBN: 978-81-265-1526-4. |
| **4** | Introduction to transport phenomena: momentum, heat and mass, Bodh Raj, PHI Learning Private Ltd, New Delhi, 2012, ISBN-978-81-203-4518-8 |

| RUBRICFOR 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. Each quiz is evaluated for 10 marks adding up to 20 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 **50Marks**, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.** | **40** |
| 3. | **EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10) Designing & Modeling (10) **Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**. | **40** |
| 4. | **LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (30 Marks), lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (10 Marks) adding up to 50 Marks. THE FINAL MARKS WILL BE 50 MARKS | **50** |
| | **MAXIMUM MARKS FOR THE CIE (THEORY AND PRACTICE)** | **150** |

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q.NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type of questions covering entire syllabus | 20 |
| | **PART B** (Maximum of THREE Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| RUBRIC FOR SEMESTER END EXAMINATION (LAB) | | |
|---|---|---|
| **Q.NO.** | **CONTENTS** | **MARKS** |

| | | |
|---|---|---|
| 1 | Write Up | 10 |
| 2 | Conduction of the Experiments | 30 |
| 3 | Viva | 10 |
| | **TOTAL** | **50** |

| V Semester | | | | | | |
|---|---|---|---|---|---|---|
| **MASS TRANSFER-I**<br>**Category: Professional Core**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **CH354TA** | | **CIE Marks** | **:** | **100 + 50** |
| **Credits: L:T:P** | **:** | **3:1:0** | | **SEE Marks** | **:** | **100 + 50** |
| **Total Hours** | **:** | **45L+30T** | | **SEE Duration** | **:** | **3 Hours** |

| **Unit-I** | **09 Hrs** |
|---|---|
| **Molecular and Eddy Diffusion in Fluids:**<br>Molecular and Eddy Diffusion in Fluids: Fick's Law of diffusion, N and J type fluxes, measurement and calculation of diffusivities in stationary fluid, equi-molar, counter diffusion, mass transfer coefficients, theories of mass transfer. | |
| **Unit – II** | **09 Hrs** |
| **Inter Phase Mass Transfer:**<br>Interphase Mass Transfer: Equilibrium diffusion between phases, relationship between local and overall mass transfer co-efficients, Material balance for stages operations in co-current and counter-current. processes, NTU and HTU concepts.<br>**Crystallization:** Solubility and Equilibrium curve, theories of crystallization Material and energy balances, Swensen walker and vacuum crystallizers. | |
| **Unit –III** | **09 Hrs** |
| **Gas Absorption:**<br>Mechanism of gas absorption, equilibrium in gas absorption, application of mass transfer theories to absorption, absorption in wetted wall columns, values of transfer coefficient, absorption in packed tower and spray tower, calculation of HETP, HTU, NTU, calculation of height of packed and spray tower. | |
| **Unit –IV** | **09 Hrs** |
| **Drying:**<br>Equilibria, drying rate curves, batch and continuous drying equipments, mechanism of drying, and calculation of drying period for batch and continuous operations. | |
| **Unit –V** | **09 Hrs** |
| **Adsorption:**<br>Theories of adsorption, industrial adsorbents, single and multistage cross current and fixed bed adsorption operations and calculations. | |

| **Course Outcomes:** After completing the course, the students will be able to | |
|---|---|
| **CO 1** | Understand the basic concepts of the mass transfer |
| **CO 2** | Apply the principles of mass transfer for two phase fluid systems |
| **CO 3** | Identify the factors that influence the mass transfer operations |
| **CO 4** | Estimate factors governing the transfer operation |

| **Reference Books** | |
|---|---|
| 1 | Mass Transfer Operations, Robert Treybal, 3rd Edition, 2017, Mc Graw Hill Education, ISBN: 1259029158 |
| 2 | Mc Cabe and Smith W L, "Unit Operations in Chemical Engineering", Mc Graw Hill, New York, 7th edition, 2007, ISBN: 0072848235. |
| 3 | Coulson and Richardson, "Chemical Engineering – Volume 1", Elsevier (Indian reprint), New Delhi, 6th edition, 2006, ISBN: 0750625570. |

| | |
|---|---|
| 4 | Geankoplis C J, "Transport Processes and Unit Operations", Prentice Hall, New Delhi, 4th edition, 2000. ISBN: 8120326148. |

| RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY) | | |
|---|---|---|
| # | COMPONENTS | MARKS |
| 1. | **QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks 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 THEORY** | **100** |

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: V | | | |
|---|---|---|---|
| **PROCESSING OF POLYMERS AND POLYMER COMPOSITES**<br>**Category: Professional Core Elective**<br>**(Theory)** | | | |
| **Course Code** | **CH255TBA** | **CIE Marks:** | **100** |
| **Credits: L:T:P** | **3:0:0** | **SEE Marks:** | **100** |
| **Total Hours** | **45 L** | **SEE Duration:** | **3 Hrs** |

| **UNIT-I** | **09Hrs** |
|---|---|
| **Introduction of Processing of polymers and polymer composites**<br>Introduction to polymer composites: definition, types, advantages, and applications Fundamentals of polymer processing techniques: extrusion, injection molding, compression molding. | |
| **UNIT-II** | **07Hrs** |
| **Polymer Processing Techniques**<br>Extrusion: principles, types, equipment, and applications, Injection molding: process steps, equipment, mold design, and applications, Compression molding: process overview, materials used, advantages, and limitations, Blow molding: principles, types (extrusion, injection, stretch), and applications. | |
| **UNIT-III** | **08Hrs** |
| **Polymer Composite Processing**<br>Introduction to polymer composite processing techniques: lay-up, filament winding, pultrusion, resin transfer molding (RTM).<br>Fiber reinforcement: types of fibers (glass, carbon, aramid), properties, and selection criteria. | |
| **UNIT-IV** | **07Hrs** |
| **Advanced Processing Technologies**<br>Additive manufacturing (3D printing) of polymers and polymer composites: principles, materials, applications,<br>Smart processing techniques for polymers and composites: self-healing, self-repair, and shape memory polymers | |
| **UNIT-V** | **07Hrs** |
| **Processing Optimization and Quality Control**<br>Process optimization techniques: Design of Experiments (DOE), statistical process control (SPC), Quality control measures in polymer processing: inspection methods, defect detection, and prevention, Environmental and sustainability considerations in polymer processing.<br>Case studies and industrial applications demonstrating optimized processing and quality control | |

| **Course Outcomes: After completing the course, the students will be able to** | |
|---|---|
| 1 | Understanding of Polymer Fundamentals |
| 2 | Apply the principles, of Polymer processing and its Applications in polymer matrix composites |
| 3 | Apply the principles, of Advanced Polymer processing and its Applications in polymer matrix composites |
| 4 | Applying Optimization techniques and Quality Control in the application of |

| **Reference Books** | |
|---|---|
| **1.** | K. K. Chawla and Jitendra K. Pandey "Handbook of Polymer Nanocomposites: Processing, Performance and Application". |
| **2.** | Handbook of Industrial Polyethylene and Technology: Definitive Guide to Manufacturing, Properties, Processing, Applications, and Markets" by Mark A. Spalding and Ananda Chatterjee |
| **3.** | Rainer Albrecht and Thomas Gries Manufacturing Techniques for Polymer Matrix Composites (PMCs)" |

| | |
|---|---|
| **4.** | M.H.Ferry, A.V.Becker, "Hand book of Polymer science and Technology", CBS Publishers and Distributors. ISBN: 81-239-1132-7 |
| **5.** | V.R.Gowarikar, N.V.Viswanathan, Jayadev Sreedhar, "Polymer Science", New Age International Pvt.Ltd, 2012: ISBN: 0-85226-307-4 |


| **RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)** | | |
|---|---|---|
| **#** | **COMPONENTS** | **MARKS** |
| 1. | **QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & each quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.** | **20** |
| 2. | **TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). THREE tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 150 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.** | **40** |
| 3. | **EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) ADDING UPTO 40 MARKS**. | **40** |
| | **MAXIMUM MARKS FOR THE CIE THEORY** | **100** |
| | | |

| **RUBRIC FOR SEMESTER END EXAMINATION (THEORY)** | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: V | | | | | | |
|---|---|---|---|---|---|---|
| **PILOT PLANT STUDIES AND SCALE UP METHODS**<br>**Category: Professional Core Elective**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **CH255TBB** | | **CIE** | **:** | **100** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100** |
| **Total Hours** | **:** | **40L** | | **SEE Duration** | **:** | **3 Hours** |
| **Unit-I** | | | | | | **09 Hrs** |
| **Introduction**: Process development, Need for pilot plants, Scale-up procedures, basic terminologies-prototypes, models, scale ratios and elements<br>**Principles of Similarity:** Geometric, Static, dynamic, kinematics, thermal and chemical similarity with examples | | | | | | |
| **Unit – II** | | | | | | **09 Hrs** |
| **Dimensional Analysis:** Significance of Dimensionless Numbers**,** Generalized dimensionless equations from Differential equation for static systems, flow systems, thermal systems, mass transfer processes, Homogeneous and heterogeneous chemical processes. | | | | | | |
| **Unit –III** | | | | | | **09Hrs** |
| **Regimes:** Concept of static, dynamic, thermal, chemical and mixed regimes<br>**Similarity criteria and scale equations :** Static-Load and Mass controlling, mixed regimes; Dynamic-Viscosity, gravity and surface tension controlled dynamic regime; Thermal-Conduction, Convection and Radiation controlled; Chemical – Mass transfer controlled, Surface reaction controlled and mixed, extrapolation and boundary effects. | | | | | | |
| **Unit –IV** | | | | | | **09 Hrs** |
| **Scale-up of Mixing Equipment** – Scale-up based on Power number, Scale-up based on Peripheral speed, Scale–up of baffled and un-baffled mixers.<br>**Scale-up of Heat Transfer Systems** – Scale –up for Forced Convection and Natural Convection, Scale-up of Overall heat transfer coefficients by Wilson's method and Regression Analysis methods. | | | | | | |
| **Unit –V** | | | | | | **09Hrs** |
| **Scale-up of Chemical Reaction systems -** Equality of RTD, Scale-up rules for homogenous reactions, Scale-up rules for heterogeneous reaction systems.<br>**Scale-up of Mass Transfer Systems –** Scale-up rules for overall-Mass Transfer Coefficients, Analysis of parameters like Liquid distribution, Flooding Velocities, Pressure Drop and height of Packing ; Scale-up of Distillation systems, Absorption systems, Liquid Extraction systems | | | | | | |

| **Course Outcomes: After completing the course, the students will be able to** | |
|---|---|
| **CO1** | Identify the need for pilot plant. |
| **CO2** | Explain the concept of Similitude and compare the regimes |
| **CO3** | Perform Dimensional analysis on flow, heat and mass transfer processes |
| **CO4** | Establish Similarity criteria and develop the scale equations for chemical processes |

| **Reference Books** | |
|---|---|
| 1. | Dimensional Analysis and Scale-up in Chemical Engineering, Marko Zlokarnik,1991, Springer-Verlag, ISBN 9783540541028 |
| 2. | Scale up of Chemical Processes, Scale up of Chemical Processes, 1985, John Wiley & Sons, ISBN 0471057479 |
| 3. | Pilot Plants Models and scale up method in Chemical Engineering, Johnstone and Thring, 1957, McGraw Hill, ISBN: 978-0071422949 |
| 4. | Scale-up in Chemical Engineering, Marko Zlokarnik, 2006, Wiley-VCH, ISBN 9783527314218 |

| RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY) | | |
|---|---|---|
| # | **COMPONENTS** | **MARKS** |
| 1. | **QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & each quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.** | **20** |
| 2. | **TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). THREE tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 150 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.** | **40** |
| 3. | **EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20) **ADDING UPTO 40 MARKS**. | **40** |
| | **MAXIMUM MARKS FOR THE CIE THEORY** | **100** |
| | | |

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: V | | | | | | |
|---|---|---|---|---|---|---|
| **DESIGN OF PIPING SYSTEMS**<br>**Category: Professional Core Elective**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **CH255TBC** | | **CIE** | **:** | **100** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100** |
| **Total Hours** | **:** | **40L** | | **SEE Duration** | **:** | **3 Hours** |

| **Unit-I** | **08 Hrs** |
|---|---|
| **Fundamentals for piping design:** Pipes and tubes, Euler's equation of motion, continuity equation, Bernoulli's equation, gas laws.<br>**Hydraulic Design Considerations:** Pipe sizing, Pressure drop in pipes, Calculation of pump head<br>**Materials of Construction in Pipes and tubes:** Selection of piping materials, physical properties of pipe materials, recommended piping materials. | |
| **Unit – II** | **08 Hrs** |
| **Pipe Fittings:** Branching, Tees, Reducers, Elbows, Swage, Caps, Couplings, Socket Weld Fittings, Screwed Fittings,<br>**Valves and allied Fittings**: Valves, functions of valves, valve materials and methods of construction, pressure drop in valves, valve size, types of valves, valve fittings | |
| **Unit –III** | **08 Hrs** |
| **Pipe Supports:** Rest Support, Hanger Support, Anchor Support, Dummy Leg Support, Guides, braces and spans, stiffening ribs, pipe clamping, flexible hanger supports<br>**Standards and codes for Piping design :** American Standards - ASTM, ANSI, API, ASME, British Standards, DIN Standards , Indian Standards.<br>**Fundamentals of Piping Layout :** Terminologies of piping layout , Considerations for piping layout. | |
| **Unit –IV** | **08 Hrs** |
| **Piping Fabrication:** Piping fabrication, welding joints in pipe lines, welding processes used in piping fabrication, preparation of pipe edges, welding electrodes, heat treatment of weld joints, inspection of weld joints, repair of defective weld joints, acceptance standards.<br><br>**Expansion Effects and Compensating Methods:** Pipe expansions, methods of compensation, thermal force calculation, methods of compensation, permissible equivalent stresses caused by' additional external loads expansion devices calculation of anchor force using a bellow below material and life, use of hinged compensators. | |
| **Unit –V** | **08 Hrs** |
| **Thermal Insulation:** Functions of thermal insulators, modes of heat transfer, insulating materials, temperature drop in a pipeline, application of insulation, calculation of condensate, desuperheaters.<br>**Corrosion Erosion in Pipelines:** Corrosion control in a critical task, corrosion process, corrosion reaction, types of corrosion, anticorrosive protective coatings, cathodic protection of pipelines, abrasion.<br>Safety analysis and colour coding in Piping design. | |

| **Course Outcomes: After completing the course, the students will be able to** | |
|---|---|
| **CO1** | Recollect the fundamentals of fluid transport |
| **CO2** | Choose appropriate materials of construction for piping. |
| **CO3** | Size the pipelines adhering to appropriate standards and codes |
| **CO4** | Determine the specific need and choose pipes/pipe fittings, supports, expansion devices for various processes. |

| **Reference Books** | |
|---|---|
| 1. | G K. Sahu, "Handbook of Piping Design", 1st Edition, New Age Publishers, 1998. ISBN: 9788122424560 |
| 2. | Mohinder L. Nayyar, "Piping Hand Book", 7th Edition, Mc. Graw Hill Publication, 1996. ISBN 0-07-047106-1 |
| 3. | Don W. Green; Robert H. Perry. Perry's Chemical Engineers' Handbook, Eighth Edition (McGraw-Hill: New York, Chicago, San Francisco, Lisbon, London, Madrid, Mexico City, Milan, New Delhi, San Juan, Seoul, Singapore, Sydney, Toronto, 2008, 1997, 1984, 1973, 1963, 1950, 1941, 1934) |

| **RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)** | | |
|---|---|---|
| **#** | **COMPONENTS** | **MARKS** |
| 1. | **QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & each quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.** | **20** |
| 2. | **TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). THREE tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 150 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.** | **40** |
| 3. | **EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20) **ADDING UPTO 40 MARKS**. | **40** |
| | **MAXIMUM MARKS FOR THE CIE THEORY** | **100** |

| **RUBRIC FOR SEMESTER END EXAMINATION (THEORY)** | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: V | | | | | | |
|---|---|---|---|---|---|---|
| **CHEMICAL PLANT UTILITIES**<br>**Category: Professional Core Elective**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **CH255TBD** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45L** | | **SEE Duration** | **:** | **3 Hours** |

| **Unit-I** | **09 Hrs** |
|---|---|
| Introduction Utilities: Different utilities, Role of utilities in process plant operations and criteria for selection and estimation of suitable utilities. Water: Water resources, Process water, Cooling water, Drinking water and boiler feed water quality standards. | |
| **Unit – II** | **09 Hrs** |
| Steam and Power Steam generation in chemical plants. Types of boilers and waste heat boilers. Fuels- types and characteristics, cogeneration power plants.<br>Boiler performance related calculations. Economy of steam generation with different fuels, related calculation. | |
| **Unit –III** | **09 Hrs** |
| Refrigeration and Insulation Different refrigeration systems and their characteristics, Air-conditioning systems. Coefficient of performance, Power requirements and refrigeration effect-related calculations for each type of refrigeration system, Refrigerant properties and selection. Insulation materials, selection, economics of insulation, Insulating factors, Properties and classification, Cold insulation,<br>and cryogenic insulation. | |
| **Unit –IV** | **09 Hrs** |
| Compressors and Vacuum Pumps Types of compressors and vacuum pumps and their performance characteristics. Methods of vacuum generation and their limitations, materials handling under vacuum, piping for vacuum systems, lubrication and oil removal in compressors and vacuum pumps. | |
| **Unit –V** | **09 Hrs** |
| Air and Water Cooling Types of air coolers, construction and working of air coolers, cooling towers<br>working principle, operating principles of cooling towers, types of cooling tower and their operation, hot water distribution systems, air flow distribution systems. | |

| **Course Outcomes: After completing the course, the students will be able to** | |
|---|---|
| **CO1** | Recall the utilities necessary for chemical plant |
| **CO2** | Explain the energy utility requirement and material properties to safeguard chemical plants. |
| **CO3** | To gain knowledge on heating, cooling and air conditioning systems. |
| **CO4** | Identify and use utility equipment in process industries. |

| **Reference Books** | |
|---|---|
| 1. | Industrial Hazards and Plant Safety, Banerjee S, 1st Edition, 2002, CRC press, ISBN:560320699 |
| 2. | Basic Refrigeration and Air Conditioning, P N Ananthanarayanan, 4th Edition, 2013, McGraw Hill Education (India) Private Limited, ISBN: 9383286563 |
| 3. | Mass Transfer Operations, Robert Treybal, 3rd Edition, 2017, McGraw Hill Education, ISBN: 1259029158 |
| 4. | Securing Utility and Energy Infrastructures, Larry Ness, 1st Edition, 2006, Wiley-Inter science, ISBN: 047170525X. |

| | | |
|---|---|---|
| 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 upto 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 based seminar/presentation/demonstration (20**)**<br>**Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**. | **40** |
| | **MAXIMUM MARKS FOR THE CIE THEORY** | **100** |

| **RUBRIC FOR SEMESTER END EXAMINATION (THEORY)** | | |
|---|---|---|
| **CONTENTS** | **MARKS** | |
| **PART A** | | |
| Objective type questions covering entire syllabus | 20 | |
| **PART B**<br>(Maximum of TWO Sub-divisions only) | | |
| Unit 1 : (Compulsory) | 16 | |
| Unit 2 : Question 3 or 4 | 16 | |
| Unit 3 : Question 5 or 6 | 16 | |
| Unit 4 : Question 7 or 8 | 16 | |
| Unit 5: Question 9 or 10 | 16 | |
| | **TOTAL** | **100** |

| VI Semester | | | | | | |
|---|---|---|---|---|---|---|
| **PRINCIPLES OF MANAGEMENT & ECONOMICS (Theory)** | | | | | | |
| **Course Code** | **:** | **HS261TA** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45 Hrs** | | **SEE Duration** | **:** | **3.00 Hours** |
| **Unit-I** | | | | | | **06 Hrs** |
| **Introduction to Management:** Management Functions – POSDCORB – an overview, Management levels & Skills, Management History - **Classical Approach:** Scientific Management, Administrative Theory, **Quantitative Approach:** Operations Research, **Behavioral Approach:** Hawthorne Studies, **Contemporary Approach:** Systems Theory, Contingency Theory. **Caselets / Case studies** | | | | | | |
| **Unit – II** | | | | | | **10 Hrs** |
| **Foundations of Planning:** Types of Goals & Plans, Approaches to Setting Goals & Plans, Strategic Management Process, Corporate strategies – types of corporate strategies, BCG matrix, Competitive Strategies – Porters Five force Model, types of Competitive Strategies. **Caselets / Case studies**<br>**Organizational Structure & Design:** Overview of Designing Organizational Structure - Work Specialization, Departmentalization, Chain of Command, Span of Control, Centralization & Decentralization, Formalization, Mechanistic & Organic Structures. **Caselets / Case studies** | | | | | | |
| **Unit –III** | | | | | | **10 Hrs** |
| **Motivation:** Early Theories of Motivation - Maslow's Hierarchy of Needs Theory, McGregor's Theory X & Theory Y, Herzberg's Two Factor Theory. Contemporary Theories of Motivation: Adam's Equitytheory, Vroom's Expectancy Theory. **Caselets / Case studies**<br>**Leadership:** Behavioral Theories: Blake & Mouton's Managerial Grid, Contingency Theories of Leadership: Hersey & Blanchard's Situational Leadership, Contemporary Views of Leadership: Transactional & Transformational Leadership. **Caselets / Case studies** | | | | | | |
| **Unit –IV** | | | | | | **10 Hrs** |
| **Introduction to Economics:** Microeconomics and Macroeconomics, Circular flow model of economics, An Overview of Economic Systems.<br>**Essentials of Microeconomics:** Demand, Supply, and Equilibrium in Markets for Goods and Services, Price Elasticity of Demand and Price Elasticity of Supply, Elasticity and Pricing, Numericals on determining price elasticity of demand and supply. Changes in Income and Prices Affecting Consumption Choices, Monopolistic Competition, Oligopoly. | | | | | | |
| **Unit –V** | | | | | | **09 Hrs** |
| **Macroeconomic Indicators:** Prices and inflation, Consumer Price Index, Exchange rate, Labor Market, Money and banks, Interest rate. Gross Domestic product (GDP) - components of GDP, Measures of GDP: Outcome Method, Income method and Expenditure method, Numericals on GDP Calculations, ESG an overview.<br>**Macroeconomic models**- The classical growth theory, Keynesian cross model, IS-LM-model, The AS-AD model, The complete Keynesian model, The neo-classical synthesis. National Budgeting process in India | | | | | | |

| **Course Outcomes: After completing the course, the students will be able to:-** | |
|---|---|
| **CO1** | Elucidate the principles of management theory & recognize the characteristics of an organization. |
| **CO2** | Demonstrate the importance of key performance areas in strategic management and design appropriate organizational structures and possess an ability to conceive various organizational dynamics. |
| **CO3** | Compare and contrast early and contemporary theories of motivation and select and implement the right leadership practices in organizations that would enable systems orientation. |
| **CO4** | Demonstrate an understanding on the usage and application of basic economic principles. |

| | |
|---|---|
| **CO5** | Appreciate the various measures of macro-economic performance and interpret the prevailing economic health of the nation. |

| **Reference Books:** | |
|---|---|
| | Management, Stephen Robbins, Mary Coulter &NeharikaVohra, 15th Edition, 2021, Pearson Education Publications, ISBN: 13: 978-0-13-558185-8 |
| 2. | Management, James Stoner, Edward Freeman & Daniel Gilbert Jr, 6th Edition, 2009, PHI, ISBN: 81-203-0981-2. |
| 3. | Principles of Microeconomics, Steven A. Greenlaw, David Shapiro, 2nd Edition, 2017, ISBN:978-1-947172-34-0 |
| 4. | Macroeconomics: Theory and Policy, Dwivedi D.N, 5th Edition, 2021, McGraw Hill Education; ISBN : 9789353163334 |

| **RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)** | | |
|---|---|---|
| **#** | **COMPONENTS** | **MARKS** |
| 1. | **QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.** | **20** |
| 2. | **TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). THREE tests will be conducted. Each test will be evaluated for 50 Marks, adding up to 150 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.** | **40** |
| 3. | **EXPERIENTIAL LEARNING:** Some of the Experiential learning topics may include Reading Leadership books and summarizing, Analysis and interpretation of various economic reports, Visit to various organizations to understand organizational mechanics. Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20) **ADDING UPTO 40 MARKS**. | **40** |
| **MAXIMUM MARKS FOR THE CIE THEORY** | | **100** |

| **RUBRIC FOR SEMESTER END EXAMINATION (THEORY)** | | |
|---|---|---|
| **Q.NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only; wherein one sub division will be a caselet in the related topics) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| **TOTAL** | | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **PROCESS MODELING AND SIMULATION**<br>**Category: Professional Core**<br>**(Theory and Practice)** | | | | | | |
| **Course Code** | **:** | **CH362IA** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:1** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **42L+30P** | | **SEE Duration** | **:** | **3Hours** |
| **Unit-I** | | | | | | **8 Hrs** |
| **Modeling in Chemical Engineering**: Introduction, Fundamental laws, scope of coverage, principles of formulation, modeling aspects, classification of models. Continuity equation, equations of motion, transport equations, equations of state, equilibrium, and chemical kinetics with examples. | | | | | | |
| **Unit – II** | | | | | | **8 Hrs** |
| **Models in Separation processes**: Steady state single and multiple stage solvent extraction, unsteady state single stage solvent extraction, multistage gas absorption, single component vaporizer and ideal binary distillation column, batch distillation, multi-component flash drum. | | | | | | |
| **Unit –III** | | | | | | **9 Hrs** |
| **Models in reactors:** Series of Isothermal, constant hold-up CSTRs, CSTRs with variable hold-ups, Non-isothermal CSTR, Batch reactor and reactor with mass transfer, gas phase pressurized CSTR**.** | | | | | | |
| **Unit –IV** | | | | | | **9 Hrs** |
| **Models in heat transfer operation:** Cooling of tanks, unsteady state heat transfer by conduction, unsteady state steam heating of Liquid.<br>**Models in fluid flow operation:** Fluid through packed bed column, flow of a film on the outside of a circular tube, Basic tank model –Level V/s time, Two-heated tanks**.** | | | | | | |
| **Unit –V** | | | | | | **8 Hrs** |
| **Numerical methods**: Introduction to simulation, Role of computers and numerical methods in simulation, iterative convergence methods – interval halving, Newton-Raphson method, False-position, Wegstein and Muller methods, numerical integration of ODEs – Euler and Runge- Kutta. | | | | | | |

**List of experiments:**

| |
|---|
| 1. Simulation of Shell and Tube Heat Exchanger |
| 2. Simulation of Centrifugal Pump/Compressor |
| 3. Simulation of Flash drum/Separator |
| 4. Simulation of single stream gas heater/cooler |
| 5. Simulation of CSTR |
| 6. Simulation of Distillation Column |
| 7. Simulation of Atmospheric distillation of crude oil |
| 8. Simulation of aromatic stripper with recycling |
| 9. Simulation of Benzene production |
| 10. Simulation of methanol-water separation using RADFRAC |
| 11. Simulation of various reactor types to model a single reaction |
| 12. Simulation of cyclo hexane production |
| |

| **Course Outcomes: After completing the course, the students will be able to** | |
|---|---|
| **CO1:** | Recall the fundamental laws in modeling chemical engineering systems |
| **CO2:** | Explain modeling and simulation of simple chemical engineering systems |
| **CO3:** | Apply mathematical tools to solve model equations |
| **CO4:** | Analyze chemical engineering systems for model development |

| Reference Books | |
|---|---|
| **1** | Process Modeling, Simulation and Control for Chemical Engineers, William L. Luyben McGraw Hill 2nd Edition, 1999, ISBN: 978-0070391598. |
| **2** | Process Plant Simulation, B V Babu, 1st Edition, 2004, Oxford University Press, ISBN: 978-0-19-566805-6. |
| **3** | Elements of Chemical Reaction Engineering, H Scott Fogler, 3rd Edition, Prentice Hall of India, 2004, ISBN: 7502741003. |
| **4** | Process Heat Transfer, D.Q.Kern, 1st Edition, 2012, Tata McGraw Hill, ISBN: 007034190. |

| **RUBRICFOR 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. Each quiz is evaluated for 10 marks adding up to 20 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 upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.** | **40** |
| 3. | **EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10) Designing & Modeling (10) **Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**. | **40** |
| 4. | **LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (30 Marks), lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (10 Marks) adding up to 50 Marks. THE FINAL MARKS WILL BE 50 MARKS | **50** |
| **MAXIMUM MARKS FOR THE CIE (THEORY AND PRACTICE)** | | **150** |

| **RUBRIC FOR SEMESTER END EXAMINATION (THEORY)** | | |
|---|---|---|
| **Q.NO.** | **CONTENTS** | **MARKS** |
| **PART A** | | |
| 1 | Objective type of questions covering entire syllabus | 20 |
| **PART B** (Maximum of THREE Sub-divisions only) | | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

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

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **MASS TRANSFER-II**<br>**Category: Professional Core**<br>**(Theory and Practice)** | | | | | | |
| **Course Code** | **:** | **CH363IA** | | **CIE** | **:** | **100 + 50 Marks** |
| **Credits: L:T:P** | **:** | **3:0:1** | | **SEE** | **:** | **100 + 50 Marks** |
| **Total Hours** | **:** | **45L + 30P** | | **SEE Duration** | **:** | **3 Hours** |

| **Unit-I** | **09 Hrs** |
|---|---|
| **Packed Tower Absorption:** Liquid phase holdup and pressure drop in absorption towers. Design of packed towers (height and diameter). Problems on packed tower absorption. | |
| **Unit – II** | **09Hrs** |
| **Distillation:** Flash Distillation, Steam Distillation, Extractive Distillation, Azeotropic Distillation, Molecular Distillation, and Vacuum Distillation. | |
| **Unit –III** | **09 Hrs** |
| **Distillation:** Multi-stage rectification column. Design using McCabe Thiele method for binary mixtures. Side stream in distillation columns, Multiple feed to distillation columns. Plate to plate calculations using Lewis Sorel Method. | |
| **Unit –IV** | **09 Hrs** |
| **Liquid-Liquid Extraction**: Ternary equilibrium, solvent selection, single stage extraction, multistage cross-current and countercurrent extraction. | |
| **Unit –V** | **09 Hrs** |
| **Leaching**: Introduction, equilibrium and phase diagrams. Calculations for single stage and multistage leaching operations. Numerical problems on leaching. | |

| **Laboratory Experiments** |
|---|
| 1. Diffusion of Organic vapors in Air |
| 2. Simple /Differential Distillation |
| 3. Packed Column distillation |
| 4. Steam Distillation |
| 6. Solid Liquid Leaching |
| 7. Surface Evaporation |
| 8. Tray Dryer |
| 9. Adsorption Studies |
| 10. Liquid Liquid/Vapor Liquid Equilibrium |
| 11. Liquid Extraction (Cross Current: Single and multi-Stages) |
| 12. Holdup Studies in Packed Columns |
| 13. Wetted Wall Column/Mass Transfer Coefficient Estimation |

| **Course Outcomes: After completing the course, the students will be able to** | |
|---|---|
| **CO1** | Recall the principles of various mass transfer operations |
| **CO2** | Comprehend the significance of the equilibrium and the stage-wise calculations |
| **CO3** | Apply design principles to design the mass transfer equipment |
| **CO4** | Analyze the efficiency of multistage crosscurrent and countercurrent operations |

| **Reference Books** | |
|---|---|
| 1 | Mass Transfer Operations, Robert E Treybal, McGraw Hill, 3rd Edition, 2017, ISBN:978 0070 651760 |
| 2. | Unit Operations in Chemical Engineering, McCabe & Smith, McGraw Hill, 7th Edition, 2022, ISBN:978 0072 848236 |
| 3. | Coulson and Richardson, Chemical Engineering Volume 1 and Volume 2, Pergemen Press, 6th Edition, 2017, ISBN: 0750644451 |
| 4. | Badger and Banchero, Introduction to Chemical Engineering, Tata McGraw Hill, 1st Edition 1997, ISBN:9780070850279. |

| RUBRICFOR 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. Each quiz is evaluated for 10 marks adding up to 20 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 **50Marks**, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.** | **40** |
| 3. | **EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10) Designing & Modeling (10) **Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**. | **40** |
| 4. | **LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (30 Marks), lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (10 Marks) adding up to 50 Marks. THE FINAL MARKS WILL BE 50 MARKS | **50** |
| **MAXIMUM MARKS FOR THE CIE (THEORY AND PRACTICE)** | | **150** |

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q.NO.** | **CONTENTS** | **MARKS** |
| **PART A** | | |
| 1 | Objective type of questions covering entire syllabus | 20 |
| **PART B** (Maximum of THREE Sub-divisions only) | | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

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

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **HETEROGENEOUS REACTION SYSTEM**<br>**Category: Professional Core**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **CH364TA** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:1:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **40L** | | **SEE Duration** | **:** | **3Hours** |

| **Unit-I** | **08 Hrs** |
|---|---|
| **Introduction to Heterogeneous Reaction Systems:** Examples for heterogeneous catalytic reactions and heterogeneous non-catalytic reactions, contacting patterns for 2 phase systems, Rate equations for heterogeneous reactions, Overall rates for linear and nonlinear process.<br>**Fluid Particle Reaction Kinetics:** Selection of a model, Rate of reaction for shrinking Spherical Particles, Determination of rate controlling mechanism | |
| **Unit – II** | **08 Hrs** |
| **Catalysis:** Introduction to catalyst, Promoters, inhibitors. Properties of catalysts, characterization of catalyst, mechanisms of catalysis, catalyst preparation, catalyst poisoning., Rate Controlling Steps and Adsorption Isotherms: Langmuir adsorption Isotherms, Eliey-Rideal mechanism. Rate controlling steps, rates of adsorption, surface reaction and desorption. Wheelers model, Types of diffusion in porous catalysts, effectiveness of catalyst. | |
| **Unit –III** | **08 Hrs** |
| **Catalyst Characterisation:** Determination of the surface area of the catalyst (BET method), Pore volume distribution, Scanning Electron Microscopy, X-Ray Diffraction Technique<br>**Catalyst Deactivation:** Mechanism of deactivation, activity, rate equations for deactivation reactions. | |
| **Unit –IV** | **08 Hrs** |
| **Fluid-Fluid Reactions:** Kinetic regimes for mass transfer and reaction, rate equation for Instantaneous reaction, Fast reaction, Intermediate rate, Rate equation for slow reaction, Film conversion parameter, clues for kinetic regimes, slurry reaction kinetics, Design of towers for fast and slow reactions. | |
| **Unit –V** | **08 Hrs** |
| **Experimental Methods For Finding Rates**: Differential and Integral Reactor. Differential and integral analysis.<br>**Design of Reactors:** Fluid-particle, fluid- fluid reactor design, Slurry Reactor, Packed bed catalytic reactor, Trickle bed reactor, Three phase fluidized bed Reactor. | |

| **Course Outcomes: After completing the course, the students will be able to:-** | |
|---|---|
| **CO1** | Define the rate equations for heterogeneous reactions |
| **CO2** | Predict the rate controlling mechanism |
| **CO3** | Analyze adsorption isotherms by conducting adsorption studies |
| **CO4** | Interpret experimental data and determine rate equations, design the reactors for fluid-solid and fluid-fluid reactions |

| **Reference Books** | |
|---|---|
| 1. | Chemical Reaction Engineering, Levenspiel Octave, 3rd Edition, 2006, John Wiley and Sons, 1999, ISBN 978-812651000 |
| 2. | Chemical Engg Kinetics, J. M. Smith, 7th Edition , 2004, Mc Graw Hill, , ISBN 978-0070145870 |
| 3. | Elements of Chemical Reaction Engineering, 5th Edition, 2016, H. Scott Foggler, Prentice Hall, ISBN 978-8126510009 |
| 4. | Chemical and Catalytic Reaction Engineering, James J. Carberry, Dover Publications; Dover ed edition, 2001, ISBN-13: 978-0486417363 |

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

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **FOOD ENGINEERING**<br>**Category: Professional Core Elective**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **CH365TDA** | | **CIE** | **:** | 100 Marks |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | 100 Marks |
| **Total Hours** | **:** | **40L** | | **SEE Duration** | **:** | 3 Hours |

| **UNIT-I** | **08 Hrs** |
|---|---|
| **Introduction to Food Engineering**: Introduction: general aspects of food industry, world food demand and Indian scenario, Physical properties of food materials: Rheological models, Water activity, Fluid Flow in Food Processing: Liquid Transport Systems; Pipes for Processing Plants, Pumps for food plants. | |
| **UNIT-II** | **08 Hrs** |
| **Food processing and preservation:** Food deterioration – Causes, Aims and objectives of preservation and processing.<br>**High-temperature preservation**: Introduction to Thermal Processing; Pasteurization; Commercial Sterilization Kinetics of Microbial Death; Thermal Death Time; Heat Transfer in Thermal Processing; Integrated F Value; Batch & continuous Retorts for Thermal Processing<br>**Non-thermal preservation**: Cold sterilization: Gamma irradiation; Microwave & Ohmic heating, Pulsed Electric Field, High Pressure Processing | |
| **UNIT-III** | **08 Hrs** |
| **Low-temperature preservation: P**rinciples of low temperature preservation; freezing rate & freezing point; physical properties of frozen food; food quality during frozen storage; freezing equipment, plate freezer, blast freezer, fluidized bed freezer, scraped surface freezer; cryogenic and immersion freezing; prediction of freezing time using Plank's equation & Nagaoka's equation.<br>**Food contamination and adulteration**: Types of adulterants and contaminants, Intentional adulterants, incidental adulterants and its effects, food laws and standards, Hazard analysis and critical control points or HACCP, Food Safety and Standards Authority of India (FSSAI). | |
| **UNIT-IV** | **08 Hrs** |
| **Food additives**: Introduction and need for food additives. Types of additives – antioxidants, chelating agents, coloring agents, curing agents, emulsions, flavors and flavor enhancers, flavor improvers, humectants and anti-caking agents, leavening agents, nutrient supplements, non - nutritive sweeteners, pH control agents, stabilizers and thickeners, other additives. Additives and food safety | |
| **UNIT-V** | **08 Hrs** |
| **Extrusion processes**: Introduction to Extrusion, Basic Principles, Extrusion Systems, Cold Extrusion, Extrusion Cooking, Single Screw Extruders, Twin-Screw Extruders.<br>**Packaging concepts**: Introduction to packaging, food protection, product containment, commutation, convenience, mass transfer in packaging materials, and permeability of packaging material to fixed gases, innovations in food packaging, passive packaging, active packaging, intelligent packaging, food packaging and product shelf-life. Advances in aseptic processing and packaging, nutrition labelling. | |

| **Course Outcomes: After completing the course, the students will be able to** | |
|---|---|
| **CO1:** | Identify sources of contaminants, adulterants and hazard analysis to ensure the safe food processing. |
| **CO2:** | Comprehend the engineering solutions involved in the packaging improvements for sustainable development of food industry |
| **CO3:** | Apply biocompatible additives and packaging for food products |
| **CO4:** | Evaluate different food processing and preservation technologies |

| Reference Books | |
|---|---|
| **1** | R.Paul Singh and Dennis R. Introduction to Food Engineering, Elsevier Science & Technology, 5th Edition, ISBN: 9780123985309, 2013. |
| **2** | P.G. Smith, Introduction to Food Process Engineering Second Edition, Springer Press, ISBN 978-1-4419-7661-1, 2009 |
| **3** | Subbulakshmi G. and Shobha A. Udupi, Food Processing and Preservation, New Age International Pvt. Ltd., ISBN: 8122412831, 2001 |
| **4** | Food Engineering 1, Gustavo V. Barbosa-Canovas & Pablo Juliano http://www.eolss.net/ebooklib/ebookcontents/e5-10-themecontents.pdf (ebook) |

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

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **FUEL CELL TECHNOLOGY**<br>**Category: Professional Core Elective**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **CH365TDB** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45L** | | **SEE Duration** | **:** | **3Hours** |

| **Unit-I** | **09 Hrs** |
|---|---|
| **Introduction:** Fuel cell definition, historical developments, working principle of fuel cell, components of fuel cell, EMF of the cell, Fuel Cell Reactions, fuels for cells and their properties. | |
| **Unit – II** | **09 Hrs** |
| **Fuel Cell Types:** Classification of fuel cells, alkaline fuel cell, polymer electrolyte fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, advantages and disadvantages of each . | |
| **Unit –III** | **09Hrs** |
| **Fuel Cell Reaction Kinetics**: activation kinetics, open circuit voltage, intrinsic maximum efficiency, voltage efficiency, Faradaic efficiency, overall efficiency, over-voltages and Tafel equation. | |
| **Unit –IV** | **09 Hrs** |
| **Fuel Cell Characterization**: current – voltage curve, in-situ characterization, current – voltage measurement, current interrupt measurement, cyclic voltammetry, electrochemical impedance spectroscopy and ex-situ characterization techniques. | |
| **Unit –V** | **09 Hrs** |
| **Applications and fueling:** applications of fuel cells in various sectors, hydrogen production, storage, handling and safety issues. | |

| **Course Outcomes: After completing the course, the students will be able to** | |
|---|---|
| **CO1** | Identify the fuel cell components and understand the working principle |
| **CO2** | Comprehend the efficiencies and losses associated with a fuel cell |
| **CO3** | Use characterization techniques to evaluate the performance of a fuel cell |
| **CO4** | Access the suitability of a fuel cell specific to an application |

| **Reference Books** | |
|---|---|
| 1 | Fuel Cell Systems Explained, Andrew L. Dicks, David A. J. Rand, John Wiley & Sons, 3rd Edition, 2018, ISBN 978 1118 613528 |
| 2. | Fuel Cell Fundamentals, O 'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, John Wiley & Sons, 3rd Edition, 2016, ISBN 978 1119 113805 |
| 3. | Fuel Cells Principles and Applications, Viswanathan and M Aulice Scibioh, Universities Press, 1st Edition, 2009, ISBN 13: 978 1420 060287 |
| 4. | Recent Trends in Fuel Cell Science and Technology, Basu. S, Springer, 1st Edition, 2007, ISBN 978 0387 688152 |

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

| | | |
|---|---|---|
| | be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.** | |
| 3. | **EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**. | **40** |
| | **MAXIMUM MARKS FOR THE CIE THEORY** | **100** |

| **RUBRIC FOR SEMESTER END EXAMINATION (THEORY)** | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **PROCESS ENGINEERING ECONOMICS**<br>**Category: Professional Core Elective**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **CH365TDC** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45L** | | **SEE Duration** | **:** | **3 Hours** |

| **Unit-I** | **09 Hrs** |
|---|---|
| Process Design Development: Process development – Feasibility survey, Material & Energy Balance, Equipment design & selection, Analysis of Process flow sheet, Plant location and layout, Factors affecting plant design. | |
| **Unit – II** | **09 Hrs** |
| Basics of Engineering Economics: Elements of project cost – cost information, total capital investment and total capital cost, operation cost, interest, project financing, cost estimation, investment costs, taxes and insurance, depreciation, time value of money. | |
| **Unit –III** | **09 Hrs** |
| Profitability, Alternative Investments and Replacements: Profitability, Cash flow diagrams, break even analysis , measures of process profitability, methods of evaluation of profitability – Rate of return on investment , Discounted cash flow based on full-life performance , Net present worth , Capitalized costs, Payout period , Simplified model for economic analysis of process design,<br>Alternative investments and Replacement. | |
| **Unit –IV** | **09 Hrs** |
| Optimum design and design strategy : Procedures for determining optimum conditions- Single and multi-variable procedures, graphical and analytical procedures, Significance of breakeven chart for optimum analysis, Optimum rate of production- concept of minimum cost of the product, maximum cost of the product and case of maximum profit. Economics of material selection and fabrication<br>selection | |
| **Unit –V** | **09 Hrs** |
| Equipment cost: Heat transfer equipment costs, Mass transfer equipment costs, Plate and packed towers, dryers, cost estimation for reactor equipment components, cost of piping Design report: types of report, organization of the report. | |

| **Course Outcomes: After completing the course, the students will be able to:-** | |
|---|---|
| **CO1** | Define the basic terminologies of process development and economics. |
| **CO2** | Explain concepts of process development, elements of project costing |
| **CO3** | Calculate various cost elements and draw cash flow diagrams and determine optimum cost. |
| **CO4** | Analyze process flow sheets, design reports and do break even analysis. |

| **Reference Books** | |
|---|---|
| 1. | Plant Design and Economics for Chemical Engineers, M.S. Peters and K.D. Timmerhaus – 4th Edition, 2003, McGraw Hill, ISBN: 0072392665. |
| 2. | Industrial Organization and Engineering Economics, T.R.Banga and S.C. Sharma, 22nd Edition, 2007, Khanna Publishers, ISBN: 81-7409-078-9. |
| 3. | Chemical Process Economics, J. Happel and D.J. Jordan, 2005, Marcal Dekker Inc., ISBN: 0824761553 |

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

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **ENERGY STORAGE TECHNOLOGY**<br>**Category: Professional Core Elective**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **CH365TDD** | | **CIE** | **:** | **100** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100** |
| **Total Hours** | **:** | **40L** | | **SEE Duration** | **:** | **3 Hours** |

| **Unit-I** | **06 Hrs** |
|---|---|
| **Introduction:** Origin of energy storage, Fossil Fuels and the Carbon Cycle, necessity of energy storage systems, Classification of energy storage systems -physical, temporal and economic classification. | |
| **Unit – II** | **09 Hrs** |
| **Electrical Energy Storage:** General principle of electrical energy storage, principle of double layer capacitor, concept of charging and discharging, pseudo-capacitance, process of charging and discharging.<br>Super capacitor materials for energy storage, distinction between energy and power Storage, application of Supercapacitors, concept of efficiency, losses and ageing | |
| **Unit –III** | **08 Hrs** |
| **Electrochemical energy storage**: Redox reactions in batteries, Nernst equation, current and capacity in electrochemical storage, Lead-acid batteries, Li-ion batteries – reactions, electrode materials, electrode and electrolyte requirements, ageing an degradation of Li-ion batteries. | |
| **Unit –IV** | **09 Hrs** |
| **Chemical Energy Storage**: Carbon neutral chemical fuels, hydrogen for energy strorage, Hydrogen production methods – electric methods, steam reforming, gasification, thermochemical water splitting, photolytic and electrolytic methods, Fuel cell – basics and types, Hydrogen storage, biomethanation. | |
| **Unit –V** | **08 Hrs** |
| **Thermal Energy Storage:** Thermal energy storage - principles and types , principle of sensible thermal storage and materials used, principle of latent thermal storage and materials used, concept of thermochemical Storage, Materials for thermal energy storage. | |

| **Course Outcomes: After completing the course, the students will be able to:-** | |
|---|---|
| **CO1** | Define the basic terminologies of process development and economics. |
| **CO2** | Explain concepts of process development, elements of project costing |
| **CO3** | Calculate various cost elements and draw cash flow diagrams and determine optimum cost. |
| **CO4** | Analyze process flow sheets, design reports and do break even analysis. |

| **Reference Books** | |
|---|---|
| i. | Energy Storage- Fundamentals, Materials and Applications, Robert Huggins, 2016, Springer International Publishing, ISBN- 978-3-319-33108-9, https://doi.org/10.1007/978-3-319-21239-5 |
| 2. | Energy Storage Technologies and Applications, C. Michael Hoff, 2022, Artech House, ISBN-9781630819095 |
| 3. | Energy Storage Systems - Volume 1, EOLSS- UNESCO, ISBN: 978-1-84826-162-4 |
| 4. | Energy Storage Systems - Volume 2, EOLSS- UNESCO, ISBN: 978-1-84826-163-1 |

| RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY) | | |
|---|---|---|
| **#** | **COMPONENTS** | **MARKS** |
| 1. | **QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & each quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.** | **20** |
| 2. | **TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). THREE tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 150 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.** | **40** |
| 3. | **EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20) **ADDING UPTO 40 MARKS**. | **40** |
| | **MAXIMUM MARKS FOR THE CIE THEORY** | **100** |
| | | |

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **FUNDAMENTALS OF AEROSPACE ENGINEERING**<br>**Category: Institutional Elective Course-I**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **AS266TEA** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45L** | | **SEE Duration** | **:** | **3.00 Hours** |

| **Unit-I** | **09 Hrs** |
|---|---|
| **Basics of Flight Vehicles:** History of aviation, International Standard atmosphere (ISA), Temperature, pressure and altitude relationships, Simple Problems on Standard Atmospheric Properties, Classification of aircrafts, Anatomy of an aircraft & Helicopters, Basic components and their functions. | |
| **Unit – II** | **10 Hrs** |
| **Aircraft Aerodynamics:** Bernoulli's theorem, Centre of Pressure, Lift and Drag, Types of Drag, Aerodynamic Coefficients, Aerodynamic Centre, Wing Planform Geometry, Airfoil Nomenclature, Basic Aerodynamic characteristics of Airfoil, Simple Numericals on Lift and Drag. | |
| **Unit –III** | **12 Hrs** |
| **Aerospace Propulsion:** Introduction, Turbine Engines: Brayton Cycle, Operation of Turbojet, Turboprop, Turbofan, Turboshaft, RAMJET and SCRAMJET Engines, Rocket Engines: Principles of operation of Solid, Liquid, Hybrid, Nuclear and Electric Rockets.<br>**Introduction to Space Mechanics:** Basic Orbital Mechanics-Types of Trajectories, Escape and Orbital Velocities, Kepler's Laws of Planetary Motion, Simple Numericals. | |
| **Unit –IV** | **06 Hrs** |
| **Aerospace Structures and Materials:** General types of construction-Monocoque, Semi-Monocoque & Geodesic, Structure of Wing and Fuselage, Metallic and Composite Materials. | |
| **Unit –V** | **08 Hrs** |
| **Aircraft Systems & Instruments:** Instrument Displays, Basic Air data systems & Pitot Probes-Mach meter, Air speed indicator, Vertical speed indicator, Altimeter.<br>**Basics of Aircraft Systems:** Hydraulic and pneumatic systems, Electrical System, Aircraft Fuel System, Environmental Control System. | |

| **Course Outcomes:** At the end of this course the student will be able to | |
|---|---|
| **CO1** | Identify the fundamental nuances of Aerospace Engineering and appreciate their significance on the Flight Vehicles design and performance |
| **CO2** | Interpret the design parameters that influence the design of the Aerospace Vehicles systems and its sub-systems |
| **CO3** | Evaluate critically the design strategy involved in the development of Aerospace vehicles |
| **CO4** | Categorically appraise the operation of the Aerospace Vehicles for different operating conditions |

| **Reference Books** | |
|---|---|
| **1** | Introduction to Flight, John D. Anderson, 7th Edition, 2011, McGraw-Hill Education, ISBN 9780071086059. |
| **2** | Fundamentals of Aerodynamics, Anderson J .D, 5th Edition, 2011, McGraw-Hill International Edition, New York ISBN:9780073398105. |
| **3** | Rocket Propulsion Elements, Sutton G.P., 8th Edition, 2011, John Wiley, New York, ISBN: 1118174208, 9781118174203. |
| **4** | Aircraft structural Analysis, T.H.G Megson, 2010, Butterworth-Heinemann Publications, ISBN: 978-1-85617-932-4 |
| **5** | Ian Moir, Allan Seabridge, "Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration", John Wiley & Sons, 3rd edition, 2011, ISBN: 9781119965206 |

| RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY) | | |
|---|---|---|
| # | **COMPONENTS** | **MARKS** |
| 1. | **QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks 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 THEORY** | **100** |
| **RUBRIC FOR SEMESTER END EXAMINATION (THEORY)** | | |
| **Q. NO** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | **20** |
| | **PART B**<br>(Maximum of THREE Sub-divisions only) | |
| 2 | Unit 1: (Compulsory) | **16** |
| 3 & 4 | Unit 2: Question 3 or 4 | **16** |
| 5 & 6 | Unit 3: Question 5 or 6 | **16** |
| 7 & 8 | Unit 4: Question 7 or 8 | **16** |
| 9 & 10 | Unit 5: Question 9 or 10 | **16** |
| | **TOTAL** | **100** |

| Semester: VI | | | | | |
|---|---|---|---|---|---|
| **BIOINFORMATICS**<br>**Category: Institutional Elective -I**<br>**(Theory)** | | | | | |
| **Course Code** | **:** | **BT266TEB** | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45 Hrs** | **SEE Duration** | **:** | **3.00 Hours** |

| **Unit-I** | **09 Hrs** |
|---|---|
| **Introduction to tools and databases:** Introduction to Bioinformatics, Goals, Scope, Applications, Sequence databases, Structure databases, Special databases – genome and microarray, Applications of these databases, examples, Database similarity search: Unique requirements of database searching, Heuristic Database Searching, Basic Local Alignment Search Tool (BLAST), FASTA, Comparison of FASTA and BLAST, Database Searching with Smith-Waterman Method | |
| **Unit – II** | **09 Hrs** |
| **Sequence Analysis:** Types of Sequence alignment -Pairwise and Multiple sequence alignment, Alignment algorithms, Scoring matrices, Statistical significance of sequence alignment. Multiple Sequence Alignment: Scoring function, Exhaustive algorithms, Heuristic algorithms, Profiles and Hidden Markov Models: Position-Specific scoring matrices, Profiles, Markov Model and Hidden Markov Model, Scoring matrices – BLOSSUM and PAM<br>**Molecular Phylogenetics:** Introduction, Terminology, Forms of Tree Representation. Phylogenetic Tree Construction Methods - Distance-Based, Character-Based Methods and Phylogenetic Tree evaluation. | |
| **Unit –III** | **09 Hrs** |
| **Introduction to Next-Generation Sequencing (NGS) analysis**: Sanger sequencing principles - history and landmarks, of Sequencing Technology Platforms, A survey of next-generation sequencing technologies, A review of DNA enrichment technologies, Base calling algorithms, Base quality, phred values, Reads quality checks, Interpretations from quality checks. Adapter and primer contamination. Processing reads using clipping of reads-Advantages and disadvantages of processing of reads, automation in NGS analysis and advantages (shell scripting) | |
| **Unit –IV** | **09 Hrs** |
| **Structural analysis & Systems Biology:** Gene prediction programs – ab initio and homology-based approaches. ORFs for gene prediction. Detection of functional sites and codon bias in the DNA. Predicting RNA secondary structure, Protein structure basics, structure visualization, comparison and classification. Protein structure predictive methods using protein sequence, Protein identity based on composition. Structure prediction - Prediction of secondary structure, tertiary structure prediction methods, Scope, Applications. Concepts, implementation of systems biology, Mass spectrometry and Systems biology, Flux Balance analysis. | |
| **Unit –V** | **09 Hrs** |
| **Drug Screening:** Introduction to Computer-aided drug discovery, target selection, ligand preparation and enumeration, molecular docking, post-docking processing, molecular dynamics simulations, applications and test cases, AI/ML in Drug discovery | |

| **Course Outcomes: After completing the course, the students will be able to:-** | |
|---|---|
| **CO1** | Gain proficiency in utilizing a range of bioinformatics tools and databases for comprehensive sequence and structural analysis. |
| **CO2** | Investigate and apply innovative sequencing technologies and analytical methods to solve complex biological questions and advance research in genomics and molecular biology. |
| **CO3** | Demonstrate expertise in NGS technologies, including performing data quality assessments, read processing, and managing large-scale data. |
| **CO4** | Apply bioinformatics tools for modeling and simulating biological processes, with a focus on gene prediction using both ab initio and homology-based approaches. |

| Reference Books | |
|---|---|
| 1. | Xiong J. Essential bioinformatics. Cambridge University Press; 2006 Mar 13. |
| 2. | Buehler LK, Rashidi HH, editors. Bioinformatics basics: applications in biological science and medicine. CRC Press; 2005 Jun 23. |
| 3. | Ghosh Z, Mallick BM. Bioinformatics principles and Applications. Oxford University Press; 2018 Jun 13. |
| 4. | Low L, Tammi MT. Introduction to next generation sequencing technologies. Bioinformatics. WORLD SCIENTIFIC. 2017 Jul 26:1-21. |
| 5. | Bioinformatics: Sequence and Genome Analysis; D W Mount; 2014; CSHL Press; 2nd edn; ISBN: 9780879697129. |
| 6. | Computational Systems Biology; A Kriete and R Eils; 2006; Academic Press; Illustrated edn; ISBN: 978-01-208-87866. |

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

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only; wherein one sub division will be a caselet in the related topics) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | |
|---|---|---|---|---|---|
| **INDUSTRIAL SAFETY ENGINEERING**<br>**Category: Institutional Elective Course - I**<br>**(Theory)** | | | | | |
| **Course Code** | **:** | **CH266TEC** | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **40L** | **SEE Duration** | **:** | **3.00 Hours** |

| **Unit-I** | **08 Hrs** |
|---|---|
| **Introduction Safety:**<br>Introduction to industrial safety engineering, major industrial accidents, safety and health issues, key concepts and terminologies, Hazard theory, Hazard triangle, Hazard actuation, Actuation transition, Causal factors, problems on OSHA | |
| **Unit – II** | **08 Hrs** |
| **Risk assessment and control:** Risk assessment, Risk perception, acceptable risk, problems on net present value, internal rate of return, payback period concepts including real life examples.<br>**Hazard Identification Methods:** Preliminary Hazard List (PHL), worksheets, case study. Preliminary Hazard Analysis (PHA), Fault tree and Event tree analysis. Design and development of fault tree and event tree for high pressure reactor system. | |
| **Unit –III** | **08 Hrs** |
| **Hazard analysis:** Hazard and Operability Study (HAZOP): Guide words, HAZOP matrix, Procedure, HAZOP studies on reactors, heat exchanger, design of HAZOP table, Failure Modes and Effects Analysis (FMEA) concept, methodology, problems of FMEA, examples. | |
| **Unit –IV** | **08 Hrs** |
| **Risk analysis on capital budgeting:** Risk adjusted discount rate (RADAR) method, certainty equivalent approach, scenario analysis, probability distribution, quantification of risk using statistical parameters and associated problems. | |
| **Unit –V** | **08 Hrs** |
| **Safety in process industries and case studies: Personnel Protection Equipment (PPE):** Safety glasses, face shields, welding helmets, absorptive lenses, hard hats, types of hand PPE, types of foot PPE, types of body PPE. Bhopal gas tragedy, Chernobyl nuclear disaster, Chemical plant explosion and fire. | |

| **Course Outcomes: After completing the course, the students will be able to:-** | |
|---|---|
| **CO1** | Understand the risk assessment techniques used in process industry |
| **CO2** | Interpret the various risk assessment tools. |
| **CO3** | Use hazard identification tools for safety management. |
| **CO4** | Analyze tools and safety procedures for protection in process industries. |

| **Reference Books** | |
|---|---|
| 1. | Functional Safety in the Process Industry: A Handbook of practical Guidance in the application of IEC61511 and ANSI/ISA-84, Kirkcaldy K.J.D Chauhan, 2012, North corolina,Lulu publication, ISBN:1291187235. |
| 2. | Safety Instrumented Systems Verification Practical probabilistic calculations, Goble and William M., 2005, Pensulvania ISA publication, ISBN:155617909X. |
| 3. | Industrial safety and risk Management, Laird Wilson and Doug Mc Cutche, 1st Edition, 2003,The University of alberta press,Canada, ISBN: 0888643942. |
| 4. | ndustrial Safety, Health and Environment Management Systems, R K Jain, Sunil S Rao, 4th Edition, 2005, Khanna Publishers, New Delhi, ISBN: 8174092102. |

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

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **ROBOTOC PROCESS AUTOMATION**<br>**Category : Institutional Elective Course-I**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **CS266TED** | | **CIE** | **:** | **100** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100** |
| **Total Duration** | **:** | **36L** | | **SEE Duration** | **:** | **3.00 Hrs** |

| **Unit – I** | **8 Hrs** |
|---|---|
| **RPA Concepts**: RPA Basics, History of Automation, what is RPA? RPA vs Automation, Processes & Flowcharts, Programming Constructs in RPA, What Processes can be Automated? Types of Bots, Workloads that can be automated.<br>**RPA Advanced Concepts**: Standardization of processes, Setting up the Centre of Excellence, RPA Development methodologies, Difference from SDLC, RPA journey, RPA business case, RPA Team, Process Design Document/Solution Design Document, Industries best suited for RPA, Risks & Challenges with RPA, RPA and emerging ecosystem. | |
| **Unit – II** | **7 Hrs** |
| **RPA Tool Introduction:** Introduction to UiPath - the User Interface, Types of Variables, Variables in UiPath, Managing Arguments, The Arguments Panel, Namespaces; Control flow statements in UiPath, Sequences and Flowcharts, Control Flow Activities<br>Data Manipulation Introduction, Data Manipulation Operations, Types of data storing variables, Text Manipulation, main string methods.<br>**UiPath Recording:** Basic, Desktop and Web Recording, Image and Native Citrix Recording, Input/output methods, Types of OCR, Data Scraping, Advanced Scraping techniques. | |
| **Unit – III** | **7 Hrs** |
| **Advanced Automation Concepts:** Selectors, Types of Selectors (Full, partial, dynamic), Defining and Assessing Selectors, Customization, Debugging.<br>Image, Text & Advanced Citrix Automation – Introduction, Keyboard based automation, Information Retrieval, Best Practices<br>Excel Data Tables & PDF, Data Tables in RPA, Excel and Data Table, Extracting Data from Data Table, Anchors, Using anchors in PDF | |
| **Unit – IV** | **7 Hrs** |
| **Email Automation, Exceptions and Deploying Bots:** Introduction to Email Automation, Key concepts of email, email protocols, email automation in UiPath, email as input and output.<br>Debugging and Exception Handling, Types of exception, Debugging Tools, Strategies for solving issues, Catching errors.<br>Overview of orchestration Server, orchestrator functionalities, Connecting Bot to orchestrator | |
| **Unit – V** | **7 Hrs** |
| **Hyperautomation**: Components and application of Hyperautomation, Automation versus hyperautomation, Benefits and challenges of hyperautomation, use cases, Phases (Integration, Discover, Orchestration and Governance), Trends in Hyperautomation (low-code/no-code platform, HaaS) | |

| | **Course Outcomes: After completing the course, the students will be able to** |
|---|---|
| **CO1** | Understand RPA principles, its features and applications |
| **CO2** | Demonstrate proficiency in handling variables and decision making inside a workflow and data manipulation techniques |
| **CO3** | Gain insights into recording, Email Automation and exception handling and orchestrator. |
| **CO4** | Analyze the trends in automation and chose business strategy to design a real-world automation workflow. |

| **Reference Books:** | |
|---|---|
| **1.** | Alok Mani Tripathi, "Learning Robotic Process Automation, Publisher: Packt Publishing, Release Date: March 2018 ISBN: 9781788470940 |
| **2.** | PASCAL BORNET, Intelligent automation: Welcome to the world of hyperautomation, World Scientific Publishing Company, ISBN-13: 978-9811235481 December 2020 |
| **3.** | UiPath pdf manuals |
| **4.** | https://www.uipath.com/rpa/robotic-process-automation |
| **5.** | https://www.ibm.com/topics/hyperautomation |
| **6.** | https://www.pega.com/hyperautomation |

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

| **RUBRIC FOR SEMESTER END EXAMINATION (THEORY)** | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B** (Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **INTELLIGENT TRANSPORTATION SYSTEMS**<br>**Category: Institutional Elective Course-I**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **CV266TEE** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **40L** | | **SEE Duration** | **:** | **3.00 Hours** |

| **Unit-I** | **08 Hrs** |
|---|---|
| **Introduction to Intelligent Transportation Systems (ITS):** Historical background, Urbanisation, Motorisation, Transport system characteristics, Transport problems and issues, Challenges and opportunities in ITS: ITS-Today and tomorrow, ITS training and education needs, Role and importance of ITS in context of Indian Transport system and opportunity for sector growth of ITS. | |
| **Unit – II** | **08 Hrs** |
| **ITS Architecture**: introduction, Functionalities required for User service, Logical architecture, Physical architecture, Equipment and Market packages, Need of ITS Architecture to solve problems in Urban area.<br>Technology building blocks for ITS: Introduction, Data acquisition, Communication tools, Data analysis and Traveller information. Various detection, Identification and collection methods for ITS. | |
| **Unit –III** | **08 Hrs** |
| **Traffic management system components and ITS**: Introduction, objectives, traffic management measures, ITS for traffic management, Development of traffic management system, Traffic Management Centre, Advance Traffic Management System, Advanced Traveller Information System, Advance Vehicle Control Systems, Advance Public Transport System, Commercial Vehicle Operations, ITS For Intermodal Freight Transport. | |
| **Unit –IV** | **08 Hrs** |
| **ITS Evaluation** – Project selection at the planning level, Deployment Tracking, Impact Assessment, Benefits by ITS components, Evaluation Guidelines. ITS for Law Enforcement: Introduction, Enhance and support the enforcement traffic rules and regulations, ITS Funding options. | |
| **Unit –V** | **08 Hrs** |
| ITS Standards-Standard development process, National ITS architecture and standards, ITS standards application areas, National Transportation Communications for ITS Protocol, Standards testing. ITS for smart cities and 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, |
| 5 | R.P Roess, E.S. Prassas, W.R. McShane. Traffic Engineering, Pearson Educational International, Third Edition, 2004, ISBN-13: 978-0-13-459971-7. |


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

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **INTEGRATED HEALTH MONITORING OF STRUCTURES**<br>**Category: Institutional Electives - I**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **CV266TEF** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **42L** | | **SEE Duration** | **:** | **3Hours** |

| **Unit-I** | **08 Hrs** |
|---|---|
| **Structural Health**: Factors affecting Health of Structures, Causes of Distress, Regular Maintenance, Importance of maintenance<br>**Structural Health Monitoring**: Concepts, Various Measures, Analysis of behavior of structures using remote structural health monitoring, Structural Safety in Alteration. | |
| **Unit – II** | **08 Hrs** |
| **Materials:** Piezo–electric materials and other smart materials, electro–mechanical impedance (EMI) technique, adaptations of EMI technique, Sensor technologies used in SHM<br>**Structural Audit**: Assessment of Health of Structure, Collapse and Investigation, Investigation Management, SHM Procedures, SHM using Artificial Intelligence | |
| **Unit –III** | **08 Hrs** |
| **Static Field Testing:** Types of Static Tests, Simulation and Loading Methods, sensor systems and hardware requirements, Static Response Measurement. | |
| **Unit –IV** | **08 Hrs** |
| **Dynamic Field Testing:** Types of Dynamic Field Test, Stress History Data, Dynamic Response Methods, Hardware for Remote Data Acquisition Systems, Remote Structural Health Monitoring. | |
| **Unit –V** | **08 Hrs** |
| **Remote Structural Health Monitoring**: Introduction, Hardware for Remote Data Acquisition Systems, Advantages, Case studies on conventional and Remote structural health monitoring<br>**Case studies:** Structural Health Monitoring of Bridges, Buildings, Dams, Applications of SHM in offshore<br>Structures- Methods used for non-destructive evaluation (NDE) and health monitoring of structural components | |

| **Course Outcomes: After completing the course, the students will be able to:-** | |
|---|---|
| **CO1** | Diagnose the distress in the structure understanding the causes and factors. |
| **CO2** | Understand safety aspects, components and materials used in Structural Health Monitoring. |
| **CO3** | Assess the health of structure using static field methods and dynamic field tests. |
| **CO4** | Analyse behavior of structures using remote structural health monitoring |

| **Reference Books** | |
|---|---|
| 1 | Structural Health Monitoring, Daniel Balageas, Claus Peter Fritzen, Alfredo Güemes,2006, John Wiley and Sons, ISBN: 978-1905209019 |
| 2 | Health Monitoring of Structural Materials and Components Methods with Applications, Douglas E Adams, 2007,John Wiley and Sons, ISBN:9780470033135 |
| 3 | Structural Health Monitoring and Intelligent Infrastructure, J. P. Ou, H. Li and Z. D. Duan, Vol1,2006,Taylor and Francis Group, London, UK. ISBN: 978-0415396523 |
| 4 | Structural Health Monitoring with Wafer Active Sensors, Victor Giurglutiu, 2007,Academic Press Inc, ISBN: 9780128101612 |

| **RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)** | | |
|---|---|---|
| **#** | **COMPONENTS** | **MARKS** |
| 1. | **QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.** | **20** |

| | | |
|---|---|---|
| 2. | **TESTS:** Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). THREE tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 150 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.** | **40** |
| 3. | **EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) ADDING UPTO 40 MARKS**. | **40** |
| | **MAXIMUM MARKS FOR THE CIE THEORY** | **100** |

| **RUBRIC FOR SEMESTER END EXAMINATION (THEORY)** | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **ADVANCED ENERGY STORAGE FOR E-MOBILITY**<br>**Category: Institutional Electives - I**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **CM266TEG** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **42L** | | **SEE Duration** | **:** | **3.00 Hours** |

| **Unit-I** | **07 Hrs** |
|---|---|
| **Energy storage in electric vehicles**<br>Introduction to E-mobility, background of alternative energy sources and sustainability. Types of electric vehicles and their salient features along with their energy requirement. Fundamentals of advanced battery technology. Battery characteristics. Specification of advanced battery for e mobility. | |
| **Unit – II** | **08 Hrs** |
| **Advanced lithium-ion batteries**<br>Basic concepts of lithium batteries. Types of advanced cathode and anode materials employed in lithium batteries. Construction, working and future applications of lithium cobalt oxide, lithium iron phosphate, Lithium air, lithium sulfur and lithium polymer batteries with their advancement in vehicle electrification. | |
| **Unit –III** | **09 Hrs** |
| **Non lithium batteries for e mobility**<br>Limitations of lithium batteries. Overview of non-lithium battery technology. Construction and working of advanced non-Lithium batteries such as Lead acid, Nickel Metal Hydride, Redox flow, Zebra, Sodium and Magnesium batteries. Electrode materials and electrolyte considerations in non lithium batteries. Performance comparison with lithium-ion batteries. Battery requirement in charging infrastructure. | |
| **Unit –IV** | **09 Hrs** |
| **Chemistry of alternative storage devices**<br>Introduction to super capacitor. Construction, working and applications of supercapacitors along with the materials used in electrodes. Types of advanced supercapacitors. Application of supercapacitors in regenerative braking. Advancement in battery-supercapacitor hybrid, Battery-fuel cell hybrid, and Battery-solar cell hybrid electric vehicles with their advantages and limitations. | |
| **Unit –V** | **09 Hrs** |
| **Battery management and recycling:**<br>Battery management systems (BMS): Fundamentals of battery management systems and controls, State-of-charge (SoC), state-of-health (SoH) and Cell balancing techniques.<br>Battery Thermal Management: Passive and active cooling systems. Safety mechanisms, thermal runaway and thermal management.<br>Battery recycling: Economic aspects, environmental safety and process of recycling of advanced batteries. | |

| **Course Outcomes: After completing the course, the students will be able to** | |
|---|---|
| **CO1** | Implement the fundamentals of chemistry in advanced energy storage and conversion devices. |
| **CO2** | Apply the chemistry knowledge used for hybridization of various energy storage and conversion devices. |
| **CO3** | Analyze the different battery system for achieving maximum energy storage for vehicle electrification |
| **CO4** | Evaluation of efficiency of a battery with respect to cost, environmental safety, material, energy consumption and recycling. |

| Reference Books | |
|---|---|
| 1 | Battery reference book, T. R. Crompton., 3rd edition, NEWNES Reed Educational and Professional Publishing Ltd 2000, ISBN: 07506 4625 X. |
| 2 | Batteries for Electric Vehicles, D. A. J. Rand, R. Woods, and R. M. Dell, Society of Automotive Engineers, Warrendale PA, 2003. ISBN 10: 0768001277. |
| 3 | Lithium Batteries, Science and Technology, GA. Nazri and G. Pistoa, Kluwer Academic Publisher, 2003, ISBN 978-0-387-92675-9. |
| 4 | Battery Technology Handbook, H. A. Kiehne, Marcel Dekker, NYC, 2003. ISBN: 0824742494 9780824742492. |
| 5 | Electric Vehicle Technology Explained, James Larminie and John Lowry. 2nd Edition, Wiley, ISBN-13: 978-1118505429. |
| 6 | Electric Vehicle Technology and Design, Antoni Gandia. CRC Press, ISBN-13: 978-1138551912. |
| 7 | Sustainable Transportation: Problems and Solutions. William R. Black, The Guilford Press, ISBN-13: 978-1462532072. |

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

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| Q. NO. | CONTENTS | MARKS |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **HUMAN MACHINE INTERFACE**<br>**Category: Institutional Electives – I (Industry Assisted Elective-BOSCH)**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **EC266TEH** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45L** | | **SEE Duration** | **:** | **03 Hrs** |

| **Unit-I** | **09 Hrs** |
|---|---|
| **Foundations of HMI:** The Human: History of User Interface Designing, I/O channels, Hardware, Software andOperating 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,<br>Ethernet etc) | |
| **Unit – II** | **09 Hrs** |
| **Automotive Human-Machine Interfaces:** Automotive infotainment system - Evolution road map, Feature sets, System architecture, Trends, Human factors and ergonomics in automotive design, Automotive User Experience(UX) Design Principles, In-Vehicle Information Systems (IVIS), Driver-Assistance Systems (DAS) Interfaces, HMI design for adaptive cruise control, Voice and Gesture Recognition in Automotive HMIs, Touchscreen Interfaces and Controls, Usability Testing and Evaluation in Automotive HMIs, Safety Considerations and Regulations in Automotive HMIs, Emerging Technologies in Automotive HMIs, Human-Machine Interfaces for<br>Autonomous Vehicles | |
| **Unit –III** | **09 Hrs** |
| **UX and Guidelines:** Introduction to UX design - stages, theory, Design thinking, UX Study, Interaction concepts,Graphic design tools - Adobe Photoshop, Adobe XD, Blender, GIMP, Asset Design - Overview, Guidelines and<br>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.<br>**HMI on Mobile**: Four Principles of Mobile UI Design, Benefits of Mobile HMIs, Mobile HMI DevelopmentSuites. | |
| **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 MultimodalHMI, Automotive Use-Cases<br>**HMI Testing**: Limitations of Traditional Test Solutions, Case - Study: Bosch's HMI validation tool - GraphicsTest Systems (GTS).<br>**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<br>systems. |

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

| RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY) | | |
|---|---|---|
| # | COMPONENTS | MARKS |
| 1. | **QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will beconducted & 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 testwill be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.** | **40** |
| 3. | **EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome).** **ADDING UPTO 40 MARKS**. | **40** |
| **MAXIMUM MARKS FOR THE CIE** | | **100** |

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B** (Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1: (Compulsory) | 16 |
| 3 & 4 | Unit 2: Question 3 or 4 | 16 |
| 5 & 6 | Unit 3: Question 5 or 6 | 16 |
| 7 & 8 | Unit 4: Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **ENERGY AUDITING & STANDARDS**<br>**Category: Institutional Elective-I**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **EE266TEJ** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45 L** | | **SEE Duration** | **:** | **3Hours** |

| **Unit-I** | **06 Hrs** |
|---|---|
| **Types of Energy Audit and Energy-Audit Methodology:** Definition of Energy Audit, Place of Audit, Energy – Audit Methodology, Financial Analysis, Sensitivity Analysis, Project Financing Options, Energy Monitoring and Training.<br>**Survey Instrumentation:** Electrical Measurement, Thermal Measurement, Light Measurement, Speed Measurement, Data Logger and Data Acquisition System,<br>**Energy Audit of a Power Plant:** Indian Power Plant Scenario, Benefit of Audit, Types of Power Plants, Energy Audit of Power Plant. | |
| **Unit – II** | **10 Hrs** |
| **Electrical-Load Management:** Electrical Basics, Electrical Load Management, VariableFrequency Drives, Harmonics and its Effects, Electricity Tariff, Power Factor, Transmission and Distribution Losses.<br>**Energy Audit of Motors:** Classification of Motors, Parameters related to Motors, Efficiency of a Motor, Energy Conservation in Motors, BEE Star Rating and Labelling.<br>**Energy Audit of Pumps, Blowers and Cooling Towers:** Pumps, Fans and Blowers, Cooling Towers | |
| **Unit –III** | **09 Hrs** |
| **Communication & Standards:**<br>**Wireless technologies:** WPANs, LAN, Wireless metropolitan area network, cellular network, satellite communication, Zigbee, Bluetooth, LAN, NAN<br>**Wireline communication:** Phone line technology, powerline technology, coaxial cable technology; Optical communication, TCP/IP networks | |
| **Unit –IV** | **09 Hrs** |
| **Energy Audit of Boilers:** Classification of Boilers, Parts of Boiler, Efficiency of a Boiler, Role of excess Air in Boiler Efficiency, Energy Saving Methods.<br>**Energy Audit of Furnaces:** Parts of a Furnace, classification of Furnaces, Energy saving Measures in Furnaces, Furnace Efficiency<br>**Energy Audit of Steam-Distribution Systems :** S team as Heating Fluid, Steam Basics, Requirement of Steam, Pressure, Piping, Losses in Steam Distribution Systems, Energy Conservation Methods | |
| **Unit-V** | **09 Hrs** |
| **Energy Audit of Lighting Systems:** Fundamentals of Lighting, Different Lighting Systems, Ballasts, Fixtures (Luminaries), Reflectors, Lenses and Louvres, Lighting Control Systems, Lighting System Audit, Energy Saving Opportunities.<br>**Energy Audit Applied to Buildings:** Energy – Saving Measures in New Buildings, Water Audit, Method of Audit, General Energy – Savings Tips Applicable to New as well as Existing Buildings. | |

| **Course Outcomes: After completing the course, the students will be able to: -** | |
|---|---|
| **CO 1** | Explain the need for energy audit, prepare a flow for audit and identify the instruments needed. |
| **CO 2** | Design and perform the energy audit process for electrical systems. |
| **CO 3** | Design and perform the energy audit process for mechanical systems |
| **CO 4** | Propose energy management scheme for a building |

| Reference Books | |
|---|---|
| 1. | Handbook of energy audit, Sonal Desai, Kindle Edition, 2015, McGraw Hill Education, ISBN: 9339221346, 9789339221348. |
| 2. | Energy management handbook, Wayne C Turner and Steve Doty, 6th Edition, 2015, CRC Press, ISBN: 0-88173-542-6. |
| 3. | Energy management, Sanjeev Singh and Umesh Rathore, 1st Edition, 2016, Katson Books, ISBN 10: 9350141019, ISBN 13: 9789350141014. |
| 4. | Energy audit of building systems, Moncef Krarti, 2nd Edition, 2010, CRC Press ISBN: 9781439828717 |

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

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **BIOMEDICAL INSTRUMENTATION**<br>**Category: Institutional Elective- I**<br>**(Theory)** | | | | | | |
| **Course Code** | : | **EI266TEK** | | **CIE** | : | **100 Marks** |
| **Credits: L:T:P** | : | **3:0:0** | | **SEE** | : | **100 Marks** |
| **Total Hours** | : | **45L** | | **SEE Duration** | : | **03 Hrs** |

| **Unit-I** | **09 Hrs** |
|---|---|
| **Fundamentals:** Sources of Biomedical signals, Basic medical instrumentation system, General constraints in design of medical instrumentation systems.<br>**Bioelectric Signals and Electrodes**: Origin of bioelectric signals, Types of bioelectric signals, Recording electrodes, Electrode-tissue interface, Polarization, Skin contact impedance, Silver-silver chloride electrodes,<br>Electrodes for ECG, EEG, EMG, Microelectrodes. | |
| **Unit – II** | **09 Hrs** |
| **Electrocardiograph:** Electrical activity of heart, Genesis and characteristics of Electrocardiograph (ECG), Block diagram description of an Electrocardiograph, ECG lead systems, Multi-channel ECG machine.<br>**Electroencephalograph:** Genesis of EEG, Block diagram description of an EEG, 10-20 Electrode system, Computerized analysis of EEG. | |
| **Unit –III** | **09 Hrs** |
| **Patient Monitoring System:** Bedside monitors, Central Monitors, Measurement of Heart Rate, Average Heart Rate meter, Instantaneous heart rate meter, Measurement of pulse rate, Blood Pressure measurement, Direct and indirect method, Automatic blood pressure measuring apparatus using Korotkoff's method.<br>**Oximeters:** Oximetry, ear oximeter, pulse oximeter, skin reflectance oximeter and intravascular oximeter. | |
| **Unit –IV** | **09 Hrs** |
| **Blood Flow Meters:** Electromagnetic blood flow meter, Types of electromagnetic blood flow meters, Ultrasonic blood flow meters, NMR blood flow meters, Laser Doppler blood flow meters.<br>**Cardiac Pacemakers and Defibrillators:** Need for Cardiac pacemaker, External Pacemaker, Implantable Pacemaker, Types of Implantable Pacemaker, Ventricular Synchronous Demand Pacemaker and Programmable<br>Pacemaker. Need for a defibrillator, DC defibrillator, Defibrillator electrodes, DC defibrillator with synchronizer. | |
| **Unit –V** | **09 Hrs** |
| **Advances in Radiological Imaging:** X-rays-principles of generation, Conventional X-ray radiography, Fluoroscopy, Angiography, Digital radiography, Digital subtraction angiography (DSA). Basic principle of<br>computed tomography, magnetic resonance imaging system and Ultrasonic imaging system. | |

| **Course Outcomes: After completing the course, the students will be able to:-** | |
|---|---|
| **CO1** | Understand the sources of biomedical signals and basic biomedical instruments. |
| **CO2** | Apply concepts for the design of biomedical devices |
| **CO3** | Analyze the methods of acquisition and signal conditioning to be applied to the physiological parameters |
| **CO4** | Develop instrumentation for measuring and monitoring biomedical parameters. |

| Reference Books | |
|---|---|
| 1. | Handbook of Biomedical Instrumentation, R. S. Khandpur,3rd Edition, Reprint 2016, Tata McGraw-Hill, ISBN: 9780070473553. |
| 2. | Biomedical Instrumentation and Measurements, Leslie Cromwell & others, 2nd Edition, Reprint 2015, ISBN: 9780130771315. |
| 3. | Medical instrumentation: Application and Design, J. G. Webster, 3rd Edition, Reprint 2015, Wiley Publications, ISBN: 9788126511068. |
| 4. | Principles of Medical Imaging, K.Kirk Shung, Michael B. Smith and Banjamin Tsui, Academic Press, 2016, ISBN: 978-0126409703. |

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

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B** (Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1: (Compulsory) | 16 |
| 3 & 4 | Unit 2: Question 3 or 4 | 16 |
| 5 & 6 | Unit 3: Question 5 or 6 | 16 |
| 7 & 8 | Unit 4: Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **TELECOMMUNICATION SYSTEMS**<br>**Category: Institutional Elective-I**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **ET266TEM** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45 L** | | **SEE Duration** | **:** | **3 Hours** |

| **Unit-I** | **8 Hrs** |
|---|---|
| **Introduction to Electronic Communication:** The Significance of Human Communication, Communication Systems, Types of Electronic Communication, Modulation and Multiplexing, Electromagnetic Spectrum, Bandwidth, A Survey of Communication Applications.<br>**The Fundamentals of Electronics:** Gain, Attenuation, and Decibels.<br>**Radio Receivers:** Super heterodyne receiver. | |
| **Unit – II** | **10 Hrs** |
| **Modulation Schemes: Analog Modulation:** AM, FM and PM- brief review.<br>**Digital Modulation:** PCM, Line Codes, ASK, FSK, PSK & QAM (Architecture).<br>**Wideband Modulation:** Spread spectrum, FHSS, DSSS.<br>**Multiple Access:** FDMA, TDMA, CDMA. | |
| **Unit –III** | **10 Hrs** |
| **Satellite Communication:** Satellite Orbits, Satellite Communication Systems, Satellite Subsystems, Ground Stations, Satellite Applications, Global Positioning System. | |
| **Unit –IV** | **9 Hrs** |
| **Optical Communication:** Optical Principles, Optical Communication Systems, Fiber-Optic Cables, Optical Transmitters and Receivers, Wavelength-Division Multiplexing, Passive Optical Networks. | |
| **Unit –V** | **8 Hrs** |
| **Cell Phone Technologies:** Cellular concepts, Frequency allocation, Frequency reuse, Internet Telephony.<br>**Wireless Technologies:** Wireless LAN, PANs and Bluetooth, Zig Bee, Mesh Wireless Networks, WiMax, and Wireless Metropolitan Area Networks. | |

| **Course Outcomes: After completing the course, the students will be able to :-** | |
|---|---|
| **CO1** | Describe the basics of communication systems. |
| **CO2** | Analyze the importance of modulation and multiple access schemes for communication systems. |
| **CO3** | Analyze the operational concept of cell phone and other wireless technologies. |
| **CO4** | Justify the use of different components and sub-system in advanced communication systems. |

**Reference Books**


| | |
|---|---|
| 1. | Principles of Electronic Communication Systems, Louis E. Frenzel, 4th Edition, 2016, Tata McGraw Hill, ISBN: 978-0-07-337385-0. |
| 2. | Electronic Communication Systems, George Kennedy,3rd Edition, 2008, Tata McGraw Hill, ISBN: 0-02-800592-9. |
| 3. | Introduction to Telecommunications, Anu A. Gokhale, 2nd Edition, 2008, Cengage Learning ISBN: 981-240-081-8 |

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

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **Mobile Communication Networks and Standards**<br>**Category: Institutional Elective Course Stream: Electronics & Telecommunication Engineering**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **ET266TEN** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45 L** | | **SEE Duration** | **:** | **3 Hours** |

| **Unit-I** | **9 Hrs** |
|---|---|
| **Principle of Cellular Communication:** Cellular Terminology, Cell Structure and Cluster, Frequency Reuse Concept, Cluster size and System Capacity, Method of Locating Co-channel cells, Frequency Reuse distance, Co-channel Interference and Signal Quality, Co-channel interference Reduction Methods. | |
| **Unit – II** | **9 Hrs** |
| **Basic Cellular system:** Consideration of components of a cellular system- A basic cellular system connected to PSTN, Main parts of a basic cellular system, Operation of a Cellular system, Performance criteria- Voice quality, Trunking and Grade of Service, Spectral Efficiency of FDMA and TDMA systems | |
| **Unit –III** | **9 Hrs** |
| **Second generation Cellular Technology: GSM:** GSM Network Architecture, Identifiers used in GSM System, GSM channels, Authentication and Security in GSM, GSM Call Procedure, GSM Hand-off Procedures. | |
| **Unit –IV** | **9 Hrs** |
| **3G Digital Cellular Technology: GPRS:** GPRS technology, GPRS NetworkArchitecture, GPRS signalling, Mobility Management in GPRS. **UMTS:** UMTS Network Architecture, UMTS Interfaces, UMTS Air Interface Specifications, UMTS Channels**.** | |
| **Unit –V** | **9 Hrs** |
| **Wireless Personal Area Networks:** Network architecture, components, Bluetooth, Zigbee, Applications. **Wireless Local Area networks:** Network Architecture, Standards, Applications. Wireless Metropolitan Area Networks: IEEE 802.16 standards, advantages, WMAN Network architecture, Protocol stack | |

| **Course Outcomes: After completing the course, the students will be able to :-** | |
|---|---|
| **CO1** | Describe the concepts and terminologies for Cellular Communication. |
| **CO2** | Analyze the Architecture, Hand-off and Security aspects in 2G and 3G Networks. |
| **CO3** | Compare the performance features of 2G and 3G Cellular Technologies. |
| **CO4** | Analyze and Compare the architectures of various Wireless technologies and standards. |

| **Reference Books** | |
|---|---|
| 1. | Wireless Communications, T.L. Singal, 2nd Reprint 2011,Tata McGraw Hill Education Private Limited, ISBN: 978-0-07-068178-1 |
| 2. | Wireless and Mobile Networks Concepts and Protocols, Dr. Sunil Kumar S Manvi, 2010, Willey India Pvt. Ltd., ISBN: 978-81-265-2069-5. |

| | |
|---|---|
| 3. | Wireless Communication, Upena Dalal, 1st Edition, 2009, Oxford higher Education, ISBN-13:978-0-19-806066-6. |
| 4 | Wireless Communications Principles and practice, Theodore S Rappaport, 2nd Edition, Pearson, ISBN 97881-317-3186-4 |

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

| **RUBRIC FOR SEMESTER END EXAMINATION (THEORY)** | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
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| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **MOBILE APPLICATION DEVELOPMENT**<br>**Category: Institutional Elective Course-I**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **IS266TEO** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45L** | | **SEE Duration** | **:** | **03 Hours** |

| **Unit-I** | **09 Hrs** |
|---|---|
| **Introduction:**<br>Smart phone operating systems and smart phones applications. Introduction to Android, Installing Android Studio, creating an Android app project, deploying the app to the emulator and a device. UI Design: Building a layout with UI elements, Layouts, Views and Resources, Text and Scrolling Views.<br>Activities and Intents, The Activity Lifecycle, Managing State, Activities and Implicit Intents, The Android Studio Debugger, Testing the Android app, The Android Support Library. | |
| **Unit–II** | **09 Hrs** |
| **User experience**:<br>User interaction, User Input Controls, Menus, Screen Navigation, Recycler View, Delightful user experience, Drawables, Styles, and Themes, Material Design, Testing app UI, Testing the User Interface | |
| **Unit–III** | **09 Hrs** |
| **Working in the background:**<br>Async Task and Async Task Loader, Connect to the Internet, Broadcast Receivers and Services. Scheduling and optimizing background tasks – Notifications, Scheduling Alarms, and Transferring Data Efficiently | |
| **Unit–IV** | **09 Hrs** |
| **All about data:**<br>Preferences and Settings, Storing Data, Shared Preferences. Storing data using SQLite, SQLite Database. Sharing data with content providers.<br>Advanced Android Programming: Internet, Entertainment and Services. Displaying web pages and maps, communicating with SMS and emails, Sensors. | |
| **Unit–V** | **09 Hrs** |
| **Hardware Support & devices:**<br>Permissions and Libraries, Performance and Security. Fire base and AdMob, Publish and Polish, Multiple Form Factors, Using Google Services. | |

| **Course Outcomes: After completing the course, the students will be able to** | |
|---|---|
| **CO1:** | Comprehend the basic features of android platform and the application development process. Acquire familiarity with basic building blocks of Android application and its architecture. |
| **CO2:** | Apply and explore the basic framework, usage of SDK to build Android applications incorporating<br>Android features in developing mobile applications. |
| **CO3:** | Demonstrate proficiency in coding on a mobile programming platform using advanced Android technologies, handle security issues, rich graphics interfaces, using debugging and troubleshooting tools. |
| **CO4:** | Create innovative applications, understand the economics and features of the app marketplace by offering<br>the applications for download. |

| Reference Books | |
|---|---|
| **1** | Android Programming, Phillips, Stewart, Hardyand Marsicano, Big Nerd Ranch Guide, 2nd Edition, 2015, ISBN-13 978-0134171494 |
| **2** | AndroidStudioDevelopmentEssentials-Android6, NeilSmyth,2015, Create space Independent Publishing Platform, ISBN:9781519722089 |
| **3** | Android Programming–Pushing the limits, EricHellman,2013, Wiley, ISBN-13:978-1118717370 |
| **4** | Professional Android2ApplicationDevelopment,RetoMeier, Wiley India Pvt. Ltd, 1st Edition, 2012, ISBN-13:9788126525898 |
| **5** | BeginningAndroid3, Mark Murphy, A press Springer India Pvt Ltd,1st Edition,2011, ISBN-13:978-1-4302-3297-1 |
| **6** | AndroidDeveloperTraining-https://developers.google.com/training/android/ AndroidTestingSupportLibrary-https://google.github.io/android-testing-support-library/ |

| RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY) | | |
|---|---|---|
| **#** | **COMPONENTS** | **MARKS** |
| 1. | **QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. Each quiz is evaluated for 10 marks adding up to 20 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 upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.** | **40** |
| 3. | **EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10) Designing & Modeling (10) **ADDING UPTO 40 MARKS**. | **40** |
| | **MAXIMUM MARKS FOR THE CIE THEORY** | **100** |

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q.NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B** (Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **ELEMENTS OF FINANCIAL MANAGEMENT**<br>**Category: Institutional Elective Course - I**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **IM266TEQ** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45L** | | **SEE Duration** | **:** | **3.00 Hours** |
| **Unit-I** | | | | | | **06 Hrs** |
| **Financial Management-An overview:** Financial Decisions in a firm, Goals of a firm, Fundamental principle of finance, Organization of finance function and its relation to other functions, Regulatory framework.<br>**The financial System:** Functions, Assets, Markets, Market returns, Intermediaries, regulatory framework, Growth and trends in Indian financial system. | | | | | | |
| **Unit – II** | | | | | | **10 Hrs** |
| **Financial statements, Taxes and cash flow:** Balance sheet, statement of profit and loss, items in annual report, manipulation of bottom line, Profits vs Cash flows, Taxes. **(Conceptual treatment only)**<br>**Time Value of Money:** Future value of a single amount, future value of an annuity, present value of a single amount, present value of an annuity.<br>**Valuation of securities:** Basic valuation model, bond valuation, equity valuation-dividend capitalization approach and other approaches. | | | | | | |
| **Unit –III** | | | | | | **10 Hrs** |
| **Risk and Return:** Risk and Return of single assets and portfolios, measurement of market risk, relationship between risk and return, implications.<br>**Techniques of Capital Budgeting:** Capital budgeting process, project classification, investment criteria, Net present value, Benefit-Cost ratio, Internal Rate of return, Payback period, Accounting rate of return.<br>**(Conceptual and Numerical treatment)** | | | | | | |
| **Unit –IV** | | | | | | **10 Hrs** |
| **Long term finance:** Sources- Equity capital, Internal accruals, preference capital, term loans, debentures. Raising long term finance- Venture capital, Initial Public Offer, Follow on Public Offer, Rights Issue, Private Placement, Term Loans, Investment Banking<br>**Securities Market:** Primary market vs Secondary market, Trading and Settlements, Stock market quotations and Indices, Govt. securities market, Corporate debt market. | | | | | | |
| **Unit –V** | | | | | | **09 Hrs** |
| **Working Capital – Policy and Financing:** Factors influencing working capital requirements, Current assets financing policy, operating cycle and cash cycle. Accruals, trade credit, banks, public deposits, inter-corporate deposits, short term loans, right debentures, commercial paper, Factoring<br>**(Conceptual treatment only)** | | | | | | |

| **Course Outcomes: After completing the course, the students will be able to:-** | |
|---|---|
| **CO1** | Explain the features and elements of a financial system. |
| **CO2** | Recognize the relevance basic principles of financial management in decision making. |
| **CO3** | Describe the processes and techniques of capital budgeting and working capital financing by organizations. |
| **CO4** | Demonstrate an understanding of various sources of finance. |

| **Reference Books:** | |
|---|---|
| 1. | Fundamentals of Financial Management, Prasanna Chandra, 6th Edition, 2018, McGraw Hill Education(India) Pvt. Ltd, ISBN: 978-93-392-0313-9, 93-392-0313-5 |
| 2. | Financial Management ,I M Pandey, 12th edn, 2021, Pearson, ISBN-939057725X, 978-9390577255 |

| | |
|---|---|
| 3. | Financial Management-Text, Problems and Cases, Khan M Y & Jain P K, 8th Edition, 2018, McGraw Hill Education(India) Pvt. Ltd, ISBN: 9353162181 , 9789353162184 |
| 4. | Fundamentals of Financial Management, Eugene F Brigham, Joel F Houston, 8th Edition, 2014, Cengage Learning, ISBN : 9781285065137, 1285065131. |

| **RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)** | | |
|---|---|---|
| **#** | **COMPONENTS** | **MARKS** |
| 1. | **QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. Each quiz is evaluated for 10 marks adding up to 20 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 upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.** | **40** |
| 3. | **EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10) Designing & Modeling (10) **ADDING UPTO 40 MARKS**. | **40** |
| | **MAXIMUM MARKS FOR THE CIE THEORY** | **100** |

| **RUBRIC FOR SEMESTER END EXAMINATION (THEORY)** | | |
|---|---|---|
| **Q.NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9z or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **OPTIMIZATION TECHNIQUES**<br>**Category: Institutional Elective Course-I**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **IM266TER** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **42L** | | **SEE Duration** | **:** | **03 Hours** |

| **UNIT – I** | **08 Hrs** |
|---|---|
| **Introduction:** OR Methodology, Definition of OR, Application of OR to Engineering and Managerial problems, Features of OR models, Limitations of OR.<br>**Linear Programming:** Definition, Mathematical Formulation, Standard Form, Solution Space, Types of solution – Feasible, Basic Feasible, Degenerate, Solution through Graphical Method. Problems on Product Mix, Blending, Marketing, Finance, Agriculture and Personnel.<br>**Simplex methods:** Variants of Simplex Algorithm – Use of Artificial Variables. | |
| **UNIT – II** | **09 Hrs** |
| **Simplex Algorithm:** How to Convert an LP to Standard Form, Preview of the Simplex Algorithm, Direction of Unboundedness, Why Does an LP Have an Optimal basic feasible solution, The Simplex Algorithm, Using the Simplex Algorithm to Solve Minimization Problems, Alternative Optimal Solutions, Degeneracy and the Convergence of the Simplex Algorithm, The Big M Method, The Two-Phase Simplex Method. | |
| **UNIT – III** | **09 Hrs** |
| **Transportation Problem:** Formulation of Transportation Model, Basic Feasible Solution using North-West corner, Least Cost, Vogel's Approximation Method, Optimality Methods, Unbalanced Transportation Problem, Degeneracy in Transportation Problems, Variants in Transportation Problems.<br>**Assignment Problem:** Formulation of the Assignment problem, solution method of assignment problem-Hungarian Method, Variants in assignment problem, Travelling Salesman Problem (TSP). | |
| **UNIT – IV** | **08 Hrs** |
| **Project Management Using Network Analysis:** Network construction, CPM & PERT, Determination of critical path and duration, floats. Crashing of Network. Usage of software tools to demonstrate N/W flow problems | |
| **UNIT – V** | **08 Hrs** |
| **Game Theory**: Introduction, Two person Zero Sum game, Pure strategies, Games without saddle point - Arithmetic method, Graphical Method, The rules of dominance | |

| **Course Outcomes: After going through this course the student will be able to** | |
|---|---|
| **CO1** | Understand the characteristics of different types of decision – making environments and the appropriate decision making approaches and tools to be used in each type. |
| **CO2** | Build and solve Transportation Models and Assignment Models. |
| **CO3** | Design new simple models, like: CPM, PERT to improve decision –making and develop critical thinking and objective analysis of decision problems. |
| **CO4** | Implement practical cases, by using TORA, WinQSB, Excel, GAMS. |

| **Reference Books:** | |
|---|---|
| 1. | Operation Research An Introduction, Taha H A, 10th Global Edition, 2017, Pearson Education Limited, ISBN 13: 978-1-292-16554-7 |
| 2. | Principles of Operations Research – Theory and Practice, Philips, Ravindran and Solberg, 2nd Edition, 2007, John Wiley & Sons (Asia) Pvt Ltd, ISBN 13: 978-8126512560 |
| 3. | Introduction to Operation Research, Hiller, Liberman, Nag, Basu, 10th Edition, 2017, McGraw Hill Education, ISBN 13: 978-9339221850 |

| | |
|---|---|
| 4. | Operations Research Theory and Application, J K Sharma, 6th Edition, 2009, Trinity Press, ISBN : 978-93-85935-14-5 |

| RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY) | | |
|---|---|---|
| # | COMPONENTS | MARKS |
| 1. | **QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks. Each quiz is evaluated for 10 marks adding up to 20 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 upto 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.** | **40** |
| 3. | **EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (10) Designing & Modeling (10) **ADDING UPTO 40 MARKS**. | **40** |
| | **MAXIMUM MARKS FOR THE CIE THEORY** | **100** |

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| Q.NO. | CONTENTS | MARKS |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9z or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: V | | | | | | |
|---|---|---|---|---|---|---|
| **AUTOMOTIVE MECHATRONICS**<br>**Category: Institutional Elective Course-I**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **ME266TES** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45 L** | | **SEE Duration** | **:** | **03 Hours** |

| **Unit-I** | **09 Hrs** |
|---|---|
| **Automobile Engines**<br>Classifications of Internal Combustion Engines**.** Engine nomenclature and mechanics. Mixture formation – External, internal, quality and quantity control – homogeneous and stratified injection. Thermodynamic principles of Otto and Diesel cycle. Characteristics – pressure curve and energy yield, engine speed, torque, and power | |
| **Unit-II** | **10 Hrs** |
| **Engine Auxiliary Systems:**<br>Turbocharger, Intercooler, Exhaust manifold, 3-way catalytic convertor, Exhaust Gas Recirculation system.<br>**Common Rail Fuel Injection system**- Low pressure and high pressure fuel systems, Return line, Quantity control valve and Injectors. | |
| **Unit-III** | **10 Hrs** |
| **Vehicular Auxiliary Systems:**<br>Vehicle frame and body classification- Hatchback, Sedan, SUV, Coupe, Roadster. Adaptive Brakes - Disc and drum brakes, Antilock Braking Systems, ESP, TCS. Wheels and Tyres- Toe-In, Toe-Out, Caster and Camber angle. Classification of tyres, Radial, Tubeless.<br>**Supplemental Restraint System**: Active and passive safety, Vehicle structure, Gas generator and air bags, Belt Tensioner, Acceleration sensor, Rollover sensor, Seat occupancy recognition. | |
| **Unit-IV** | **09 Hrs** |
| **EV Technology**: Types of EV's, ICE vs EV torque output, Architecture and Working of EV's. Battery Thermal Management System, Regenerative braking, Safety system and Impacts of EV on the environment. | |
| **Unit-V** | **07 Hrs** |
| **Telematics in vehicles** – Radio Transmission, Exchange of information, signal path & properties, Concept of radio waves.<br>**Sensors:** Oxygen sensors, Crankshaft/Cam shaft Sensor, Boost Pressure Sensor, Coolant Temperature Sensor, Hot Film Air Mass flow Sensor, Throttle Position Sensor, Rain/Light sensor | |

| **Course Outcomes: After completing the course, the students will be able to** | |
|---|---|
| **CO1:** | Describe the functions of Mechatronic systems in a modern automobile |
| **CO2:** | Evaluate the performance of an engine by its parameters |
| **CO3:** | Analyse the automotive exhaust pollutants as per emission norms |
| **CO4:** | Demonstrate communication of control modules using a On-Board Diagnostic kit |

| **Reference Books** |
|---|

| | |
|---|---|
| **1.** | Automotive Technology – A systems approach, Jack Erjavec, 5th Edition, Delamr Cengage Learning, ISBN-13: 978-1428311497 |
| **2.** | Automotive Engineering Fundamentals, Richard Stone and Jeffrey K. Ball, 2004, SAE International, ISBN: 0768009871 |
| **3.** | Bosch Automotive Handbook, Robert Bosch, 9th Edition, 2004, ISBN: 9780768081527 |
| **4.** | Understanding Automotive Electronics, William B Ribbens, 5th Edition, Butterworth–Heinemann, ISBN 0-7506-7008-8 |


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

| **RUBRIC FOR SEMESTER END EXAMINATION (THEORY)** | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1: (Compulsory) | 16 |
| 3 & 4 | Unit 2: (Internal Choice) | 16 |
| 5 & 6 | Unit 3: (Internal Choice) | 16 |
| 7 & 8 | Unit 4: (Internal Choice) | 16 |
| 9 & 10 | Unit 5: (Internal Choice) | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **MATHEMATICAL MODELLING**<br>**Category: Institutional Elective Course-I**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **MA266TEU** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45L** | | **SEE Duration** | **:** | **3.00 Hours** |

| **Unit-I** | **09 Hrs** |
|---|---|
| **Introduction to Mathematical Modelling:**<br>Basic concepts, steps involved in modelling, classification of models, assorted simple mathematical models from diverse fields. | |
| **Unit – II** | **09 Hrs** |
| **Mathematically Modelling Discrete Processes:**<br>Difference equations - first and second order, Introduction to Difference equations, Introduction to discrete models-simple examples, Mathematical modelling through difference equations in economics, finance, population dynamics, genetics and other real world problems. | |
| **Unit –III** | **09 Hrs** |
| **Markov modelling:**<br>Mathematical foundations of Markov chains, application of Markov Modelling to problems. | |
| **Unit –IV** | **09 Hrs** |
| **Modelling through graphs:**<br>Graph theory concepts, Modelling situations through different types of graphs. | |
| **Unit –V** | **09 Hrs** |
| **Variational Problem and Dynamic Programming:**<br>Optimization principles and techniques, Mathematical models of variational problem and dynamic programming, Problems with applications. | |

| **Course Outcomes: After completing the course, the students will be able to** | |
|---|---|
| **CO1:** | Explore the fundamental concepts of mathematical models arising in various fields engineering. |
| **CO2:** | Apply the knowledge and skills of discrete and continuous models to understand various types of analysis. |
| **CO3:** | Analyze the appropriate mathematical model to solve the real world problem and to optimize the solution. |
| **CO4:** | Distinguish the overall knowledge gained to demonstrate the problems arising in many practical situations. |

| **Reference Books** | |
|---|---|
| **1** | Mathematical Modeling, J. N. Kapur, 1st Edition, 1998, New Age International, New Delhi, ISBN:<br>81-224-0006-X. |
| **2** | Mathematical Modeling: Models, Analysis and Applications, Sandip Banerjee, 2014, Chapman and<br>Hall/CRC Textbook, ISBN 9781439854518. |
| **3** | Case studies in mathematical modeling, D. J. G. James and J. J. Mcdonald, 1981, Stanly Thames, Cheltonham, ISBN: 0470271779, 9780470271773. |
| **4** | Modeling with difference equations, D. N. Burghes, M. S. Borrie, Ellis Harwood, 1981, ISBN 13:<br>9780853122869. |

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

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only; wherein one sub division will be a caselet in the related topics) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **MATHEMATICS OF QUANTUM COMPUTING**<br>**Category: Institutional Elective-I**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **MA266TEV** | | **CIE** | **:** | **100 Marks** |
| **Credits: L: T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45L** | | **SEE Duration** | **:** | **3.00 Hours** |

| **Unit-I** | **09 Hrs** |
|---|---|
| **Introduction to Quantum Computing:**<br>Quantum superposition, Qubits, Linear algebra for quantum computing, Inner products and Tensor products of vector spaces, Quantum states in Hilbert space, The Bloch sphere, Generalized measurements, No-cloning theorem. | |
| **Unit – II** | **09 Hrs** |
| **Quantum Gates:**<br>Universal set of gates, quantum circuits, Dirac formalism, superposition of states, entanglement Bits and Qubits. Qubit operations, Hadamard Gate, CNOT Gate, Phase Gate, Z-Y decomposition, Quantum Circuit Composition, Basic Quantum circuits. | |
| **Unit –III** | **09 Hrs** |
| **Quantum Algorithm - I:**<br>Deutsch Algorithm, Deutsch-Jozsa Algorithm, Bernstein-Vazarani Algorithm, Simon periodicity algorithm, Phase estimation algorithm, Quantum Fourier transform. . | |
| **Unit –IV** | **09 Hrs** |
| **Quantum Algorithm - II:**<br>Grover search algorithm, Shor quantum factoring algorithm, Harrow-Hassidim-Lloyd (HHL) algorithm for solving linear system problems. | |
| **Unit –V** | **09 Hrs** |
| **Applications of Quantum Computing:**<br>Application to: order-finding, discrete logarithm, quantum counting, Boolean satisfiability problems(SAT), graph theory problems. | |

| **Course Outcomes: After completing the course, the students will be able to** | |
|---|---|
| **CO1:** | Explore the fundamental concepts of quantum computing. |
| **CO2:** | Apply the knowledge and skills of quantum computing to understand various types of problems arising in various fields engineering |
| **CO3:** | Analyze the appropriate quantum algorithm to solve the real-world problem and to optimize the solution. |
| **CO4:** | Distinguish the overall knowledge gained to demonstrate the problems arising in many practical situations. |

| **Reference Books** | |
|---|---|
| **1** | An introduction to Quantum Computing, Phillip Kaye, Raymond Laflamme, 2007, Oxford University press. |
| **2** | Quantum Computing for Everyone, Chris Bernhardt, 2020, The MIT Press, Cambridge. |
| **3** | Quantum Computation and Quantum Information, M. A. Nielsen & I. Chuang, 2013, Cambridge<br>University Press. |
| **4** | Quantum Computing for the quantum curious, Cirian Hughes et. al., 2021, Springer, ISBN 978-3-030-61600-7. |
| **5** | Concise guide to quantum computing, Sergei Kurgalin, Sergei Borzunov, 2021, Springer, ISBN 978-3-030-65051-3, ISBN 978-3-030-65052-0 (eBook). |

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

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only; wherein one sub division will be a caselet in the related topics) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **APPLIED PSYCHOLOGY FOR ENGINEERS**<br>**Category: Institutional Electives – I**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **HS266TEW** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **45 Hrs** | | **SEE Duration** | **:** | **3 Hours** |
| **Unit-I** | | | | | | **08 Hrs** |
| **Introduction to Psychology**: Definition and goals of Psychology: Role of a Psychologist in the Society: Today's Perspectives (Branches of psychology- Clinical, Industrial). Psychodynamic, Behavioristic, Cognitive, Humanistic, Psychological Research and Methods to study Human Behavior: Experimental, Observation, Questionnaire and Clinical Method. | | | | | | |
| **Unit – II** | | | | | | **08 Hrs** |
| **Intelligence and Aptitude:** Concept and definition of Intelligence and Aptitude, Nature of Intelligence. Theories of Intelligence – Spearman, Thurston, Guilford Vernon. Characteristics of Intelligence tests, Types of tests. Measurement of Intelligence and Aptitude, Concept of IQ, Measurement of Multiple Intelligence – Fluid and Crystallized Intelligence. | | | | | | |
| **Unit –III** | | | | | | **10 Hrs** |
| **Personality**: Concept and definition of personality, Approaches of personality- psychoanalytical, Socio- Cultural, Interpersonal and developmental, Humanistic, Behaviorist, Trait and type approaches. Assessment of Personality: Self- report measures of Personality, Questionnaires, Rating Scales and Projective techniques, its Characteristics, advantages & limitations, examples. Behavioral Assessment. | | | | | | |
| **Unit –IV** | | | | | | **10 Hrs** |
| **Learning:** Definition, Conditioning – Classical Conditioning, Basics of Classical Conditioning (Pavlov), the process of Extinction, Discrimination and Generalization. Operant Conditioning (Skinner expt). The basics of operant conditioning, Schedules of reinforcement. Cognitive – Social approaches to learning – Latent Learning, Observational Learning, Trial and Error Method, Insightful Learning. | | | | | | |
| **Unit –V** | | | | | | **09 Hrs** |
| **Application of Psychology in Working Environment:** The present scenario of information technology, the role of psychologist in the organization, Selection and Training of Psychology Professionals to work in the field of Information Technology. **Psychological Stress**: a. Stress- Definition, Symptoms of Stress, Extreme products of stress v s Burnout, Work Place Trauma. Causes of Stress – Job related causes of stress.Sources of Frustration, Stress and Job Performance, Stress Vulnerability-Stress threshold, perceived control. Type A and Type B. **Psychological Counseling** - Need for Counseling, Types – Directed, Non- Directed, Participative Counseling. | | | | | | |

| **Course Outcomes: After completing the course, the students will be able to:-** | |
|---|---|
| **CO1** | Describe the basic theories, principles, and concepts of applied psychology as they relate to behaviors and mental processes. |
| **CO2** | Define learning and compare and contrast the factors that cognitive, behavioral, and Humanistic theorists believe influence the learning process. |
| **CO3** | Develop understanding of psychological attributes such as intelligence, aptitude, creativity, resulting in their enhancement and apply effective strategies for self-management and self-improvement. |
| **CO4** | Apply the theories into their own and others' lives in order to better understand their personalities and experiences. |
| **CO5** | Understand the application of psychology in engineering and technology and develop a route to accomplish goals in their work environment. |

| Reference Books | |
|---|---|
| 1. | Understanding Psychology Feldman R. S, IV edition, (1996) McGraw Hill India |
| 2. | Psychology Robert A. Baron, III edition (1995) Prentice Hall India. |
| 3. | Organizational Behaviour , Stephen P Robbins Pearson Education Publications, 13th Edition, ISBN – 81-317 – 1132 – 3 |
| 4. | Organisational Behaviour : Human Behaviour at Work ,John W.Newstrem and Keith Davis. Tata McGraw Hill India, 10th Edition, ISBN 0-07-046504-5 |
| 5 | Psychology-themes and variations , Wayne Weiten, IV edition, Brooks / Cole Publishing Co. |

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

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
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| | **PART B**<br>(Maximum of TWO Sub-divisions only; wherein one sub division will be a caselet in the related topics) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

| Semester: VI | | | | | | |
|---|---|---|---|---|---|---|
| **UNIVERSAL HUMAN VALUES**<br>**Category: Institutional Electives Course – I**<br>**(Theory)** | | | | | | |
| **Course Code** | **:** | **HS266TEY** | | **CIE** | **:** | **100 Marks** |
| **Credits: L:T:P** | **:** | **3:0:0** | | **SEE** | **:** | **100 Marks** |
| **Total Hours** | **:** | **42L** | | **SEE Duration** | **:** | **3.00 Hours** |

| **Unit-I** | **10 Hrs** |
|---|---|
| Introduction-Basic Human Aspiration, its fulfillment through All-encompassing Resolution. The basic human aspirations and their fulfillment through Right understanding and Resolution, Right understanding and Resolution are the activities of the Self, Self is central to Human Existence; All-encompassing Resolution for a Human Being, its details and solution of problems in the light of Resolution. | |
| **Unit – II** | **10 Hrs** |
| Right Understanding (Knowing)- Knower, Known & the Process. The domain of right understanding starts from understanding the human being (the knower, the experiencer and the doer); and extends up to understanding nature/existence – its interconnectedness and co-existence; and finally understanding the role of human being in existence (human conduct). | |
| **Unit –III** | **08 Hrs** |
| Understanding Existence (including Nature). A comprehensive understanding (knowledge) about the existence, which certainly includes the Nature. The need and the process of inner evolution (through self-exploration, self-awareness and self-evaluation)- particularly awakening to activities of the Self: Realization, Understanding and Contemplation in the Self (Realization of Co-Existence, Understanding of Harmony in Nature and Contemplation of Participation of Human in this harmony/ order leading to comprehensive knowledge about the existence). | |
| **Unit –IV** | **08 Hrs** |
| Understanding Human Being. Understanding the human being comprehensively is the first step and the core theme of this course; human being as co-existence of the self and the body, the activities and potentialities of the self, Reasons for harmony/contradiction in the self. | |
| **Unit –V** | **08 Hrs** |
| Understanding Human Conduct, All-encompassing Resolution & Holistic Way of Living. Understanding Human Conduct, Understanding different aspects of All-encompassing Resolution (understanding, wisdom, science etc.), Holistic way of living for Human Being with All-encompassing Resolution covering all four dimensions of human endeavour viz., realization, thought, behavior and work (participation in the larger order) leading to harmony at all levels from self to Nature and entire Existence. | |

| **Course Outcomes: After completion of the course the students will be able to** | |
|---|---|
| **CO1** | Understand the basic human aspiration with program of its fulfilment and meaning of resolution in the complete expanse of human living. |
| **CO2** | Understand human being in depth and see how self is central to human being |
| **CO3** | Understand existence in depth and see how coexistence is central to existence |
| **CO4** | Understand human conduct and the holistic way of living leading to human tradition |

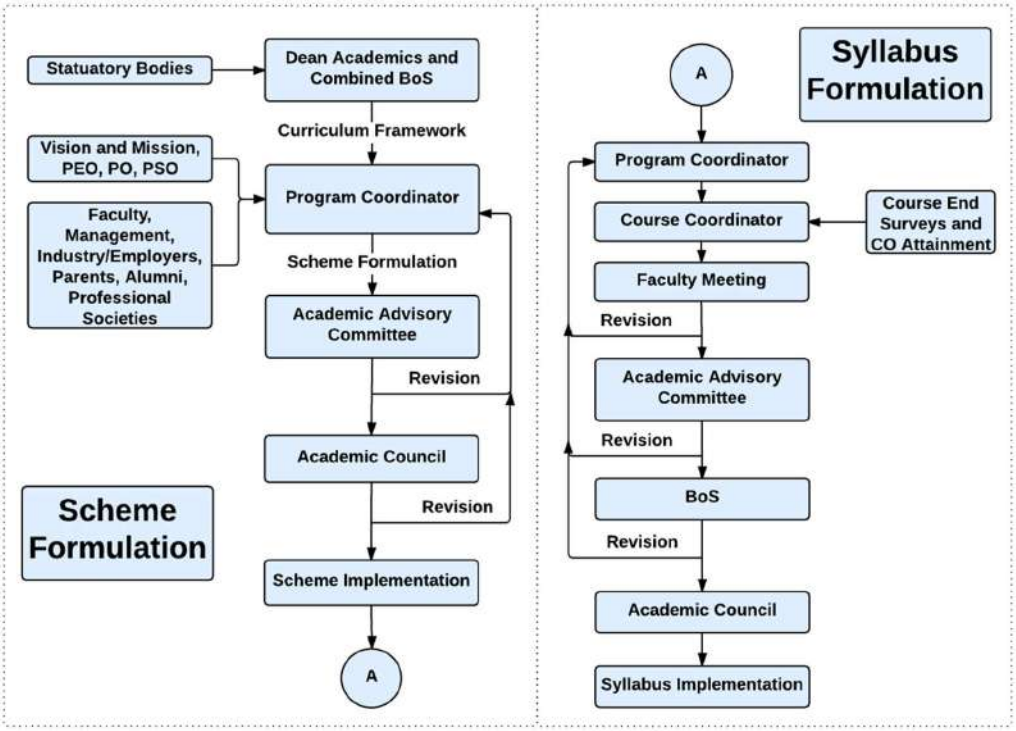
| **Reference Books** | |
|---|---|
| 1 | A foundation course in human values and professional ethics, R. R. Gaur, R Asthana, G P Bagaria, 2nd revised Edition, excel books, New Delhi – 2019, ISN 978-93-87034-47-1 |
| 2 | Avartansheel Arthshastra, A Nagraj, Divya Path Sansthan, Amarkantak, India, ISBN 978-8-174-46781-2 |

| | |
|---|---|
| 3 | Economy of Performance- a quest for social order based on non – violence, J C Kumarappa, 2010, Sarva-Seva-Sangh-Prakashan, Varanasi, India |
| 4 | Energy and Equity, Ivan Illich, 1974, The Trinity Press, Worcester & Harper Collins, USA, ISBN, 0060803274, 9780060803278 |

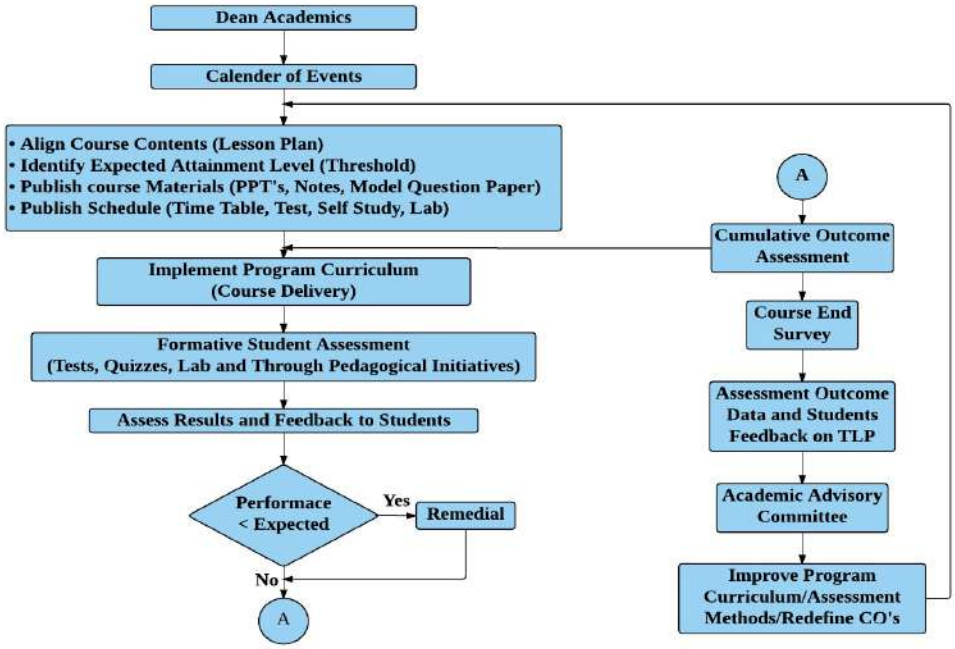
| RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY) | | |
|---|---|---|
| # | COMPONENTS | MARKS |
| 1. | **QUIZZES:** Quizzes will be conducted in online/offline mode. TWO QUIZZES will be conducted & Each Quiz will be evaluated for 10 Marks. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**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

| RUBRIC FOR SEMESTER END EXAMINATION (THEORY) | | |
|---|---|---|
| **Q. NO.** | **CONTENTS** | **MARKS** |
| | **PART A** | |
| 1 | Objective type questions covering entire syllabus | 20 |
| | **PART B**<br>(Maximum of TWO Sub-divisions only) | |
| 2 | Unit 1 : (Compulsory) | 16 |
| 3 & 4 | Unit 2 : Question 3 or 4 | 16 |
| 5 & 6 | Unit 3 : Question 5 or 6 | 16 |
| 7 & 8 | Unit 4 : Question 7 or 8 | 16 |
| 9 & 10 | Unit 5: Question 9 or 10 | 16 |
| | **TOTAL** | **100** |

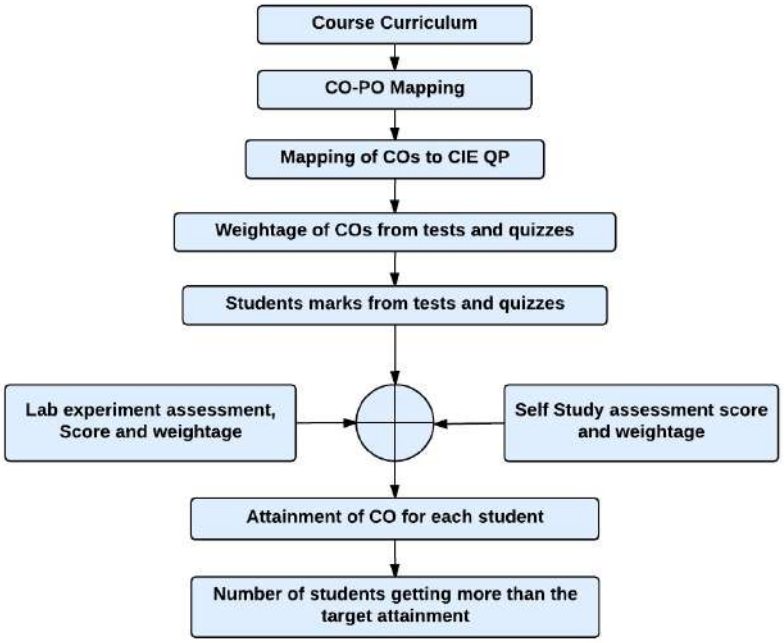
## Curriculum Design Process



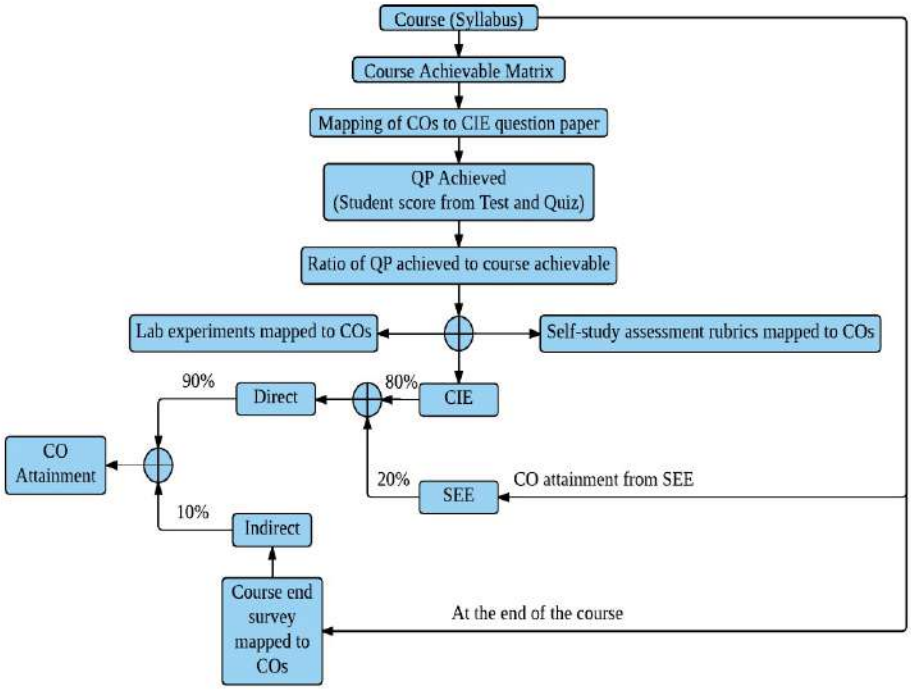

## Academic Planning and Implementation



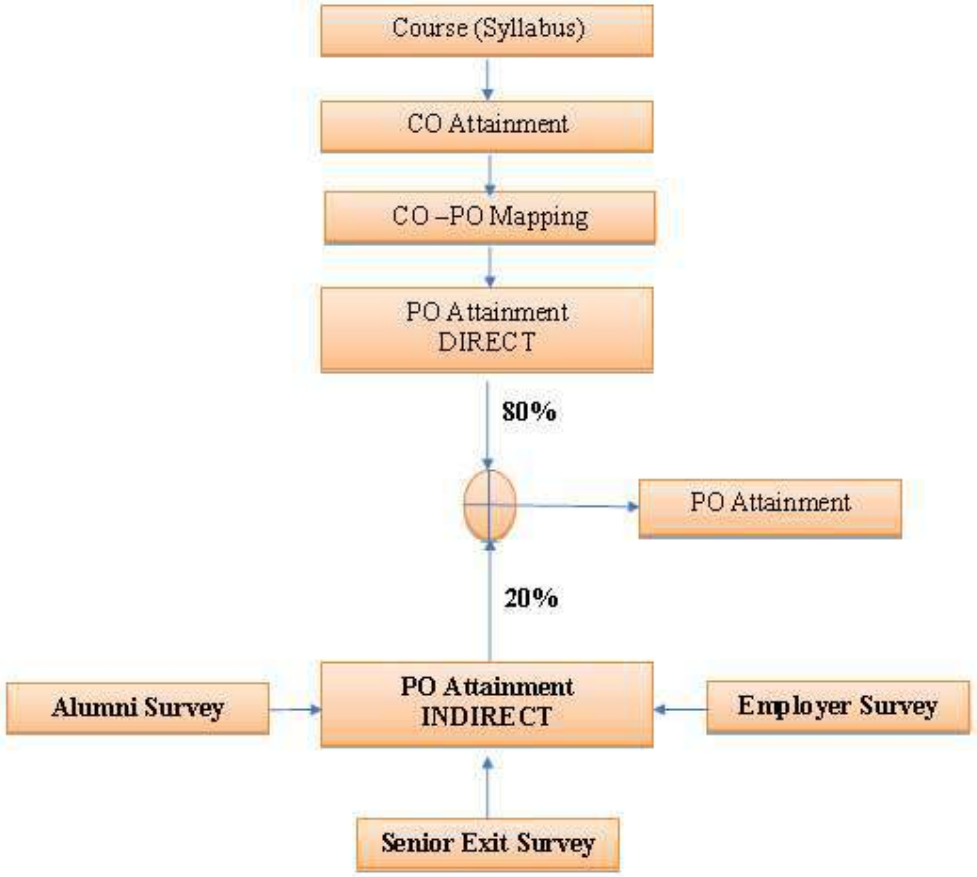
## Process For Course Outcome Attainment




## Final CO Attainment Process




## Program Outcome Attainment Process


Course (Syllabus)
CO Attainment
CO –PO Mapping
PO Attainment DIRECT
80%
PO Attainment
20%
Alumni Survey
PO Attainment INDIRECT
Employer Survey
Senior Exit Survey

# Knowledge and Attitude Profile (WK)

- **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.

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# New Program Outcomes(PO)

- **PO1:** Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
- **PO2:** Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
- **PO3:** Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
- **PO4:** Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).
- **PO5:** Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)
- **PO6**: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).
- **PO7:** Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
- **PO8:** Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
- **PO9:** Communication: Communicate effectively and inclusively within the community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences
- **PO10:** Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
- **PO11:** Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)