**ANNA UNIVERSITY:: CHENNAI 600025**
**NON-AUTONOMOUS COLLEGES AFFILIATED TO ANNA UNIVERSITY**
**REGULATIONS 2021**
**M.TECH. CHEMICALENGINEERING**

## PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

| | |
|---|---|
| I. | To prepare students for successful career in industry and academia that meets the needs of national and global organizations by imparting state of the art knowledge of tools and techniques for analysis and design |
| II. | To provide opportunity for students to work as part of team on multidisciplinary projects by imparting training of research methodologies, modern tools emphasizing theoretical, experimental and computational approaches |
| III. | To develop communication, decision making, motivational human relations and ethical attitude in students |
| IV. | To provide students a familiarity with professional issues in chemical engineering related to the global economy and to emerging technologies and thereby promoting student awareness of life-long learning |

## PROGRAMME OUTCOMES (POs)

| | |
|---|---|
| PO1 | An ability to independently carry out research/investigation and development work to solve practical problems |
| PO2 | An ability to write and present a substantial technical report/document |
| PO3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program |
| PO4 | An Ability to apply advanced concepts of chemical engineering to the analysis, design , development and optimization of chemical reactors, processes and chemical plants, analyze and interpret data to meet the desired needs of society, professionally and ethically |
| PO 5 | An ability to Know the importance of safety and sustainable environmental aspects in the design and operation of process engineering systems. |
| PO6 | An ability to Identify, formulate, and solve chemical engineering problems using modern engineering tools necessary for engineering practice. |

## MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVE WITH PROGRAMME OUTCOMES

| PEOs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **I.** | ✓ | | ✓ | ✓ | ✓ | ✓ |
| **II.** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **III.** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **IV.** | ✓ | | ✓ | ✓ | ✓ | ✓ |

**MAPPING OF COURSE OUTCOMES AND PROGRAMME OUTCOMES**

| YEAR | SEM | COURSE NAME | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|---|---|
| YEAR I | SEMESTER I | Advanced Mathematical Methods | 1 | 2 | 3 | - | 1 | - |
| | | Advanced Separation Process | 1 | - | 3 | 3 | 2 | - |
| | | Fluid Phase Equilibria | 1 | - | 3 | 3 | 1 | - |
| | | Catalytic Reaction Engineering | 1 | - | 3 | 3 | 1 | - |
| | | Research Methodology and IPR | 3 | 1 | - | - | - | - |
| | | Professional elective I | | | | | | |
| | | Audit Course * | | | | | | |
| | | Computational Programming Laboratory for Chemical Engineers | 3 | 3 | 3 | 2 | - | 3 |
| | SEMESTER II | Chemical Process Design | 2 | - | 3 | 3 | 1 | - |
| | | Advanced Transport Phenomena | 2 | - | 3 | 3 | - | - |
| | | Advanced Process Control | 2 | - | 3 | 3 | - | - |
| | | Multi Component Distillation | 2 | - | 3 | 3 | 2 | - |
| | | Professional elective II | | | | | | |
| | | Professional elective III | | | | | | |
| | | Audit Course * | | | | | | |
| | | Separation Techniques Laboratory | 2 | 3 | 3 | 3 | - | 3 |
| | | Seminar | 2 | 3 | 3 | - | 3 | - |
| YEAR II | SEMESTER III | Process Modelling and Simulation | 3 | - | 3 | 3 | - | 2 |
| | | Professional elective IV | | | | | | |
| | | Open Elective | | | | | | |
| | | Project Work I | 3 | 3 | 3 | 3 | 2 | 1 |
| | | Internship | | | | | | |
| | SEMESTER IV | Project Work II | 3 | 3 | 3 | 3 | 2 | 1 |

**ANNA UNIVERSITY:: CHENNAI 600025**
**NON-AUTONOMOUS COLLEGES AFFILIATED TO ANNA UNIVERSITY**
**REGULATIONS 2021**
**M.TECH. CHEMICALENGINEERING**
**I TO IV SEMESTERS CURRICULA AND SYLLABUS**

**SEMESTERI**

| SL. NO. | COURSE CODE | COURSE TITLE | CATE-GORY | PERIOD PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **THEORY** | | | | | | | | |
| 1. | MA4154 | Advanced Numerical Methods | FC | 4 | 0 | 0 | 4 | 4 |
| 2. | CX4101 | Advanced Separation Process | PCC | 3 | 0 | 0 | 3 | 3 |
| 3. | CX4102 | Fluid Phase Equilibria | PCC | 3 | 0 | 0 | 3 | 3 |
| 4. | CX4103 | Catalytic Reaction Engineering | PCC | 3 | 1 | 0 | 4 | 4 |
| 5. | RM4151 | Research Methodology and IPR | RMC | 2 | 0 | 0 | 2 | 2 |
| 6. | | Professional Elective I | PEC | 3 | 0 | 0 | 3 | 3 |
| 7. | | Audit Course - I * | AC | 2 | 0 | 0 | 2 | 0 |
| **PRACTICALS** | | | | | | | | |
| 8. | CX4111 | Computational Programming Laboratory for Chemical Engineers | PCC | 0 | 0 | 4 | 4 | 2 |
| | | | **TOTAL** | **20** | **1** | **4** | **25** | **21** |

***Audit course is optional**

**SEMESTER II**

| SL. NO. | COURSE CODE | COURSE TITLE | CATE-GORY | PERIOD PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **THEORY** | | | | | | | | |
| 1. | CX4201 | Chemical Process Design | PCC | 3 | 1 | 0 | 4 | 4 |
| 2. | CX4202 | Advanced Transport Phenomena | PCC | 3 | 1 | 0 | 4 | 4 |
| 3. | CX4203 | Advanced Process Control | PCC | 3 | 1 | 0 | 4 | 4 |
| 4. | CX4204 | Multi component Distillation | PCC | 3 | 1 | 0 | 4 | 4 |
| 5. | | Professional Elective II | PEC | 3 | 0 | 0 | 3 | 3 |
| 6. | | Professional Elective III | PEC | 3 | 0 | 0 | 3 | 3 |
| 7. | | Audit Course II* | AC | 2 | 0 | 0 | 2 | 0 |
| **PRACTICALS** | | | | | | | | |
| 8. | CX4211 | Separation Techniques Laboratory | PCC | 0 | 0 | 4 | 4 | 2 |
| 9. | CX4212 | Seminar | EEC | 0 | 0 | 2 | 2 | 1 |
| | | | **TOTAL** | **20** | **4** | **6** | **30** | **25** |

***Audit course is optional**

## SEMESTER III

| SL. NO. | COURSE CODE | COURSE TITLE | CATE-GORY | PERIOD PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **THEORY** | | | | | | | | |
| 1. | CX4301 | Process Modelling and Simulation | PCC | 3 | 1 | 0 | 4 | 4 |
| 2. | | Professional Elective IV | PEC | 3 | 0 | 0 | 3 | 3 |
| 3. | | Open Elective | OEC | 3 | 0 | 0 | 3 | 3 |
| **PRACTICALS** | | | | | | | | |
| 4. | CX4311 | Project Work I | EEC | 0 | 0 | 12 | 12 | 6 |
| 5. | CX4312 | Internship | EEC | 0 | 0 | 0 | 0 | 1 |
| | | | **TOTAL** | **9** | **1** | **12** | **22** | **17** |

## SEMESTER IV

| Sl. No. | COURSE CODE | COURSE TITLE | CATE GORY | PERIOD PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **PRACTICALS** | | | | | | | | |
| 1. | CX4411 | Project Work II | EEC | 0 | 0 | 24 | 24 | 12 |
| | | | **TOTAL** | **0** | **0** | **24** | **24** | **12** |

**TOTAL NO. OF CREDITS: 75**

## FOUNDATION COURSES (FC)

| S. NO | COURSE CODE | COURSE TITLE | PERIODS PER WEEK | | | CREDITS | SEMESTER |
|---|---|---|---|---|---|---|---|
| | | | Lecture | Tutorial | Practical | | |
| 1. | MA4154 | Advanced Mathematical Methods | 4 | 0 | 0 | 4 | 1 |

## PROFESSIONAL CORE COURSES (PCC)

| S. NO | COURSE CODE | COURSE TITLE | PERIODS PER WEEK | | | CREDITS | SEMESTER |
|---|---|---|---|---|---|---|---|
| | | | Lecture | Tutorial | Practical | | |
| 1. | CX4101 | Advanced Separation Processes | 3 | 0 | 0 | 3 | 1 |
| 2. | CX4102 | Fluid Phase Equilibria | 3 | 0 | 0 | 3 | 1 |
| 3. | CX4103 | Catalytic Reaction Engineering | 3 | 1 | 0 | 4 | 1 |
| 4. | CX4111 | Computational Programming in Chemical Engineering Laboratory | 0 | 0 | 4 | 2 | 1 |
| 5. | CX4201 | Chemical Process Design | 3 | 1 | 0 | 4 | 2 |
| 6. | CX4202 | Advanced Transport Phenomena | 3 | 1 | 0 | 4 | 2 |
| 7. | CX4203 | Advanced Process Control | 3 | 1 | 0 | 4 | 2 |
| 8. | CX4204 | Multi component Distillation | 3 | 1 | 0 | 4 | 2 |
| 9. | CX4211 | Separation Techniques laboratory | 0 | 0 | 4 | 2 | 2 |
| 10. | CX4301 | Process Modeling and Simulation | 3 | 1 | 0 | 4 | 3 |
| | | | | | **TOTAL CREDITS** | **34** | |

## LIST OF PROFESSIONAL ELECTIVE COURSES

### SEMESTER I, ELECTIVE I

| Sl. No. | COURSE CODE | COURSE TITLE | CATE-GORY | PERIOD PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | CX4001 | Multiphase Flow | PEC | 3 | 0 | 0 | 3 | 3 |
| 2. | CX4002 | Environmental Risk Assessment | PEC | 3 | 0 | 0 | 3 | 3 |
| 3. | CX4003 | Design and Analysis of Experiments | PEC | 3 | 0 | 0 | 3 | 3 |
| 4. | CX4004 | Electrochemical Process | PEC | 3 | 0 | 0 | 3 | 3 |

### SEMESTER II, ELECTIVE II

| SL. NO. | COURSE CODE | COURSE TITLE | CATE-GORY | PERIOD PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | CX4005 | Fluidization Engineering | PEC | 3 | 0 | 0 | 3 | 3 |
| 2. | CX4006 | Energy Management | PEC | 3 | 0 | 0 | 3 | 3 |
| 3. | CX4007 | Pilot Plant and Scale Up Methods | PEC | 3 | 0 | 0 | 3 | 3 |
| 4. | CX4008 | Fuel Cell Technology | PEC | 3 | 0 | 0 | 3 | 3 |

### SEMESTER II, ELECTIVE III

| Sl. No. | COURSE CODE | COURSE TITLE | CATE-GORY | PERIOD PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | CX4009 | Computational Fluid Dynamics | PEC | 3 | 0 | 0 | 3 | 3 |
| 2. | CX4010 | Remote Sensing and GIS Applications in Environmental Management | PEC | 3 | 0 | 0 | 3 | 3 |
| 3. | CX4011 | Project Engineering of Process Plants | PEC | 3 | 0 | 0 | 3 | 3 |
| 4. | CX4012 | Process Intensification | PEC | 3 | 0 | 0 | 3 | 3 |
| 5. | CX4013 | Membrane Technology for Water and Wastewater Treatment | PEC | 3 | 0 | 0 | 3 | 3 |

## SEMESTER III, ELECTIVE IV

| Sl. No. | COURSE CODE | COURSE TITLE | CATE-GORY | PERIOD PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | CX4014 | Gas Transportation | PEC | 3 | 0 | 0 | 3 | 3 |
| 2. | CX4015 | Green Chemistry and Engineering | PEC | 3 | 0 | 0 | 3 | 3 |
| 3. | CX4016 | Environmental Sustainability | PEC | 3 | 0 | 0 | 3 | 3 |
| 4. | CX4017 | Process Optimization | PEC | 3 | 0 | 0 | 3 | 3 |
| 5. | CX4018 | Polymer Technology | PEC | 3 | 0 | 0 | 3 | 3 |
| 6. | CX4019 | Environmental Nanotechnology | PEC | 3 | 0 | 0 | 3 | 3 |

## RESEARCH METHODOLOGY AND IPR COURSES (RMC)

| S. NO | COURSE CODE | COURSE TITLE | PERIODS PER WEEK | | | CREDITS | SEMESTER |
|---|---|---|---|---|---|---|---|
| | | | Lecture | Tutorial | Practical | | |
| 1. | RM4151 | Research Methodology and IPR | 2 | 0 | 0 | 2 | 1 |
| | | | | | **TOTAL CREDITS** | **2** | |

## EMPLOYABILITY ENHANCEMENT COURSES (EEC)

| S. NO | COURSE CODE | COURSE TITLE | PERIODS PER WEEK | | | CREDITS | SEMESTER |
|---|---|---|---|---|---|---|---|
| | | | Lecture | Tutorial | Practical | | |
| 1. | CX4212 | Seminar | 0 | 0 | 2 | 1 | 1 |
| 2. | CX4311 | Project Work I | 0 | 0 | 12 | 6 | 3 |
| 3. | CX4312 | Internship | 0 | 0 | 0 | 1 | 3 |
| 4. | CX4411 | Project Work II | 0 | 0 | 24 | 12 | 4 |
| | | | | | **TOTAL CREDITS** | **20** | |



## AUDIT COURSES

**REGISTRATION FOR ANY OF THESE COURSES IS OPTIONAL TO STUDENTS**

| Sl. No. | COURSE CODE | COURSE TITLE | CATE-GORY | PERIOD PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | AX4091 | English for Research Paper Writing | AC | 2 | 0 | 0 | 0 | 0 |
| 2. | AX4092 | Disaster Management | AC | 2 | 0 | 0 | 0 | 0 |
| 3. | AX4093 | Constitution of India | AC | 2 | 0 | 0 | 0 | 0 |
| 4. | AX4094 | நற்றமிழ் இலக்கியம் | AC | 2 | 0 | 0 | 0 | 0 |

## LIST OF OPEN ELECTIVES FOR PG PROGRAMMES

| SL. NO. | COURSE CODE | COURSE TITLE | PERIODS PER WEEK | | | CREDITS |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1. | OCE431 | Integrated Water Resources Management | 3 | 0 | 0 | 3 |
| 2. | OCE432 | Water, Sanitation and Health | 3 | 0 | 0 | 3 |
| 3. | OCE433 | Principles of Sustainable Development | 3 | 0 | 0 | 3 |
| 4. | OCE434 | Environmental Impact Assessment | 3 | 0 | 0 | 3 |
| 5. | OIC431 | Blockchain Technologies | 3 | 0 | 0 | 3 |
| 6. | OIC432 | Deep Learning | 3 | 0 | 0 | 3 |
| 7. | OME431 | Vibration and Noise Control Strategies | 3 | 0 | 0 | 3 |
| 8. | OME432 | Energy Conservation and Management in Domestic Sectors | 3 | 0 | 0 | 3 |
| 9. | OME433 | Additive Manufacturing | 3 | 0 | 0 | 3 |
| 10. | OME434 | Electric Vehicle Technology | 3 | 0 | 0 | 3 |
| 11. | OME435 | New Product Development | 3 | 0 | 0 | 3 |
| 12. | OBA431 | Sustainable Management | 3 | 0 | 0 | 3 |
| 13. | OBA432 | Micro and Small Business Management | 3 | 0 | 0 | 3 |
| 14. | OBA433 | Intellectual Property Rights | 3 | 0 | 0 | 3 |
| 15. | OBA434 | Ethical Management | 3 | 0 | 0 | 3 |
| 16. | ET4251 | IoT for Smart Systems | 3 | 0 | 0 | 3 |
| 17. | ET4072 | Machine Learning and Deep Learning | 3 | 0 | 0 | 3 |
| 18. | PX4012 | Renewable Energy Technology | 3 | 0 | 0 | 3 |
| 19. | PS4093 | Smart Grid | 3 | 0 | 0 | 3 |
| 20. | CP4391 | Security Practices | 3 | 0 | 0 | 3 |
| 21. | MP4251 | Cloud Computing Technologies | 3 | 0 | 0 | 3 |
| 22. | IF4072 | Design Thinking | 3 | 0 | 0 | 3 |
| 23. | MU4153 | Principles of Multimedia | 3 | 0 | 0 | 3 |
| 24. | DS4015 | Big Data Analytics | 3 | 0 | 0 | 3 |
| 25. | NC4201 | Internet of Things and Cloud | 3 | 0 | 0 | 3 |
| 26. | MX4073 | Medical Robotics | 3 | 0 | 0 | 3 |
| 27. | VE4202 | Embedded Automation | 3 | 0 | 0 | 3 |

## SUMMARY

| Sl. No. | Name of the Programme: M.TECH. CHEMICAL ENGINEERING | | | | | |
|---|---|---|---|---|---|---|
| | SUBJECT AREA | CREDITS PER SEMESTER | | | | CREDITS TOTAL |
| | | I | II | III | IV | |
| 1. | FC | 04 | 00 | 00 | 00 | 04 |
| 2. | PCC | 12 | 18 | 04 | 00 | 34 |
| 3. | PEC | 03 | 06 | 03 | 00 | 12 |
| 4. | RMC | 02 | 00 | 00 | 00 | 02 |
| 5. | OEC | 00 | 00 | 03 | 00 | 03 |
| 6. | EEC | 00 | 01 | 07 | 12 | 20 |
| 7. | Non Credit/Audit Course | ✓ | ✓ | 00 | 00 | |
| 8. | **TOTAL CREDIT** | **21** | **25** | **17** | **12** | **75** |

**MA4154 ADVANCED NUMERICAL METHODS**

| L | T | P | C |
|---|---|---|---|
| 4 | 0 | 0 | 4 |

**COURSE OBJECTIVES :**

- To study various numerical techniques to solve linear and non-linear algebraic and transcendental equations.
- To compare ordinary differential equations by finite difference and collocation methods.
- To establish finite difference methods to solve Parabolic and hyperbolic equations.
- To establish finite difference method to solve elliptic partial differential equations.
- To provide basic knowledge in finite elements method in solving partial differential equations.

**UNIT I ALGEBRAIC EQUATIONS 12**

Systems of linear equations : Gauss elimination method – Pivoting techniques – Thomas algorithm for tri diagonal system – Jacobi, Gauss Seidel, SOR iteration methods – Conditions for convergence - Systems of nonlinear equations : Fixed point iterations, Newton's method, Eigenvalue problems : Power method and Given's method.

**UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12**

Runge - Kutta methods for system of IVPs – Numerical stability of Runge - Kutta method – Adams - Bashforth multistep method, Shooting method, BVP : Finite difference method, Collocation method and orthogonal collocation method.

**UNITIII FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATIONS 12**

Parabolic equations : Explicit and implicit finite difference methods – Weighted average approximation - Dirichlet's and Neumann conditions – Two dimensional parabolic equations – ADI method : First order hyperbolic equations – Method of numerical integration along characteristics – Wave equation : Explicit scheme – Stability.

**UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12**

Laplace and Poisson's equations in a rectangular region : Five point finite difference schemes, Leibmann's iterative methods, Dirichlet's and Neumann conditions – Laplace equation in polar coordinates : Finite difference schemes – Approximation of derivatives near a curved boundary while using a square mesh.

**UNIT V FINITE ELEMENT METHOD 12**

Basics of finite element method : Weak formulation, Weighted residual method – Shape functions for linear and triangular element – Finite element method for two point boundary value problems, Laplace and Poisson equations.

**TOTAL : 60 PERIODS**

**COURSE OUTCOMES :**

After completing this course, students should demonstrate competency in the following skills:

- Solve an algebraic or transcendental equation, linear system of equations and differential equations using an appropriate numerical method.
- Solving the initial boundary value problems and boundary value problems using finite difference and finite element methods.
- Solving parabolic and hyperbolic partial differential equations by finite difference methods.
- Compute solution of elliptic partial differential equations by finite difference methods.
- Selection of appropriate numerical methods to solve various types of problems in engineering and science in consideration with the minimum number of mathematical operations involved, accuracy requirements and available computational resources.

**REFERENCES :**


1. Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", 9th Edition, Cengage Learning, New Delhi, 2016.
2. Gupta S.K., "Numerical Methods for Engineers",4th Edition, New Age Publishers, 2019.
3. Jain M. K., Iyengar S. R., Kanchi M. B., Jain, "Computational Methods for Partial Differential Equations", New Age Publishers ,1993.
4. Sastry, S.S., "Introductory Methods of Numerical Analysis", 5th Edition, PHI Learning, 2015.
5. Saumyen Guha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2010.
6. Smith, G. D., "Numerical Solutions of Partial Differential Equations: Finite Difference Methods", Clarendon Press, 1985.


| | PO01 | PO02 | PO03 | PO04 | PO05 | PO06 |
|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 3 | - | - | - |
| CO2 | 2 | 1 | 3 | - | - | - |
| CO3 | 2 | 1 | 3 | - | - | - |
| CO4 | 2 | 1 | 3 | - | - | - |
| CO5 | 3 | 3 | 3 | - | - | - |
| Avg. | 2.2 | 1.4 | 3 | - | - | - |

**CX4101 ADVANCED SEPARATION PROCESS L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To learn about the filtration processes and its applications.
- To impart knowledge about membrane separation process and its applications
- To achieve knowledgeaboutseparation by adsorption techniques
- To gain knowledgeabout ionic separation process
- To various techniques available for separation.

**UNIT I GENERAL 12**

Review of conventional processes, recent advances in separation techniques based on size, surface properties, ionic properties and other special characteristics of substances. Process concept, theory and equipment used in cross flow filtration, cross flow electrofiltration, dual functional filter, surface based solid-liquid separations involving a second liquid, siroflocfilter.

**UNIT II MEMBRANE SEPARATIONS 8**

Types and choice of membranes, plate and frame, tubular, spiral wound and hollow fibre Membrane reactors and their relative merits, commercial, pilot plant and laboratory membrane pemeators involving dialysis, reverse osmosis, nano-filtration, ultrafiltration, microfiltration and Donnan dialysis ,economics of membrane operations ,ceramic membranes.

**UNIT III SEPARATION BY ADSORPTION TECHNIQUES 8**

Mechanism, types and choice of adsorbents, normal adsorption techniques, affinity chromatography and immuno chromatography, types of equipment and commercial processes, recent advances and process economics dielectrophoresis, Ion Exchange chromatography and electrodialysis, Commercial processes

**UNIT IV IONIC SEPARATION 8**

Controlling factors, applications, types of equipment employed for electrophoresis,di electrophoresis ,ion exchange chromatography and electrodialysis, commercial process

**UNIT V OTHER TECHNIQUES 9**

Separations involving lyophilization, pervaporation and permeation techniques for solids, liquids and gases, industrial viability and examples, zone melting, addictive crystallization, other separation processes, supercritical fluid extraction, oils pill management, industrial effluent treatment by modern techniques.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

On successful completion of the course, the students will be able to

CO1: **Understand** the key concepts of conventional and advanced aspects of separation processes, and the selection of separation processes.

CO2: **Understand** the concepts and **develop** design equations for membrane separation processes.

CO3: **Understand** the principles and processes of adsorption and chromatographic techniques and to design an absorber to achieve specific separation.

CO4: **Analyze** the separation system for multi-component mixtures, design separation process based on electrical properties.

CO5: **Apply** the latest concepts like super critical fluid extraction, pervaporation, lyophilisation etc., also to understand Innovative techniques for controlling and managing oil spills in Chemical process industries.

**Course Articulation Matrix**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 1 | - | 3 | 3 | - | - |
| CO2 | 1 | - | 3 | 3 | 2 | - |
| CO3 | 1 | - | 3 | 3 | 2 | - |
| CO4 | 1 | - | 3 | 3 | 2 | - |
| CO5 | 1 | - | 3 | 3 | 2 | - |
| Overall | 1 | - | 3 | 3 | 2 | - |

**REFERENCES:**


1. Humphrey,J and G.Keller, Separation ProcessTechnology,McGraw-Hill,1997
2. King,C.J.,—SeparationProcessesǁ,TataMcGrawHillCo.,Ltd.,1982.
3. Nakagawal,O.V.,—Membrane Science and Technology ǁ,MarcelDekker,1992.
4. Rousseau, R. W., —Handbook of Separation Process Technology ǁ, John Wiley, NewYork,1987.


**CX4102 FLUID PHASE EQUILIBRIA L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To impart knowledge on energy, laws of thermodynamics to applications that require quantitative knowledge of thermodynamic properties at macroscopic level
- To gain knowledge about stability and phase transition of thermodynamic systems.
- To impart knowledge about multi component mixtures
- To gain knowledge about phase equilibrium typically encountered in design of chemical processes such as separation operations.
- To impart knowledge about chemical equilibrium

**UNIT I BASIC CONCEPTS 9**

Energy and first Law; Reversibility and second Law; Review of Basic Postulates, Equilibrium criteria ,Legendre Transformation and Maxwell‘s relations

**UNIT II STABILITY AND PHASE TRANSITION 9**

Stability of thermodynamic systems, first order phase transitions and critical phenomenon, phase rule, single component phase diagrams, thermodynamic properties from volumetric and thermal data

**UNIT III MULTICOMPONENT MIXTURES 9**

Partial molar properties, fugacities in gas and liquid mixtures, activity coefficients, Ideal and Non-ideal solutions, Gibbs-Duhem equation, Wilson, NRTL, and UNIQUAC equations, UNIFAC method

**UNIT IV PHASE EQUILIBRIUM 9**

VLE - Equations of state, corresponding states, Henry's Law, lattice theory, criticality, high pressure VLE. Other phase equilibriums-SLE/LLE/VLLE.

**UNITV CHEMICAL EQUILIBRIUM 9**

Homogeneous gas and liquid phase reactions, heterogeneous reactions – phase and chemical equilibrium

**TOTAL:45 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

CO1: **Apply** the concepts of energy, laws of thermodynamics to applications that require quantitative knowledge of thermodynamic properties at macroscopic level.

CO2: **Understand** and **apply** the thermodynamics of phase equilibria in design of chemical processes such as separation operations.

CO3: **Relate** the theoretical results used to physical systems that convert matter and energy in terms of the laws of thermodynamics.

CO4: **Analyze** many of the thermodynamic properties of dilute solutions can be derived analytically from statistical formulations.

CO5: **Apply** the various phase equilibrium models in practical situations

**Course Articulation Matrix**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 1 | - | 3 | 3 | 1 | - |
| CO2 | 1 | - | 3 | 3 | 1 | - |
| CO3 | 1 | - | 3 | 3 | 1 | - |
| CO4 | 1 | - | 3 | 3 | 1 | - |
| CO5 | 1 | - | 3 | 3 | 1 | - |
| Overall | 1 | - | 3 | 3 | 1 | - |



**REFERENCES**


1. Prausnitz, J.M., Lichten thaler R.M. and Azevedo, E.G.,Molecular thermo dynamics of fluid-phase Equilibria,3rd Edn, Prentice Hall Inc., New Jersey,1999.
2. Rao., Y.V.C., Chemical Engineering Thermodynamics, University Press, Hyderabad,2005
3. Tester, J. W. and M. Modell, Thermodynamics and Its Applications. 3rd Edn. Prentice Hall, New Jersey,1997.
4. Stanely M. Walas., - Phase Equilibria in Chemical Engineering, Butterworth Publishers., 1985.
5. Mats Hillert.,- Phase Equilibria, Phase Diagrams and Phase transformations., 2nd Edn., Cambridge University Press., 2007

**CX4103 CATALYTIC REACTION ENGINEERING L T P C**
**3 1 0 4**

**COURSE OBJECTIVES:**

- To impart knowledge about catalyst and its characterization
- To gain knowledge about kinetic of heterogeneous catalytic reactions and design of reactors
- To create knowledge on transport processes with reactions catalyzed by solids
- To obtain knowledge on catalyst deactivation process.
- To gain knowledge about modeling of reactors.

**UNIT I CATALYSTANDITSCHARACTERIZATION 12**

General definition of catalysts, Design for catalysts – Primary constituents, secondary constituents; Catalyst supports. Methods of determining catalysts activity – static methods, Study of structure pore radii; Mercury porosimetry, determination of true and apparent densities of catalysts; Structural study of electron microscopy, determination of mechanical strength of catalysts-static methods, dynamic methods; Methods of thermal analysis.

**UNIT II KINETICS OF HETEROGENEOUS CATALYTIC REACTIONS 10**

Adsorption on Solid Catalysts. Rate Equations. Complex Catalytic Reactions. Experimental Reactors. Model Discrimination and Parameter Estimation. Sequential Design of Experiments. Physico chemical tests

**UNIT III TRANSPORT PROCESSES WITH REACTIONS CATALYZED BY SOLIDS 12**

Reaction of a component of a fluid at the surface of a solid. Mass and heat transfer resistances. Molecular-,Knudsen ,and surface diffusion in pores. Diffusion and reaction in a catalyst particle. Influence of diffusion limitations on the selectivity's of coupled reactions. Criteria for the importance of intra-particle diffusion limitations. Multiplicity of steady states in catalyst particles. Diagnostic experimental criteria for the absence of internal and external mass transfer limitations. Non isothermal particles.

**UNIT IV CATALYST DEACTIVATION 10**

Types of Catalyst Deactivation. Kinetics of Catalyst Poisoning. Kinetics of Catalyst Deactivation by Coke Formation.

**UNITV THE MODELING OF CHEMICAL REACTORS. 16**

Approach. Aspects of Mass-, Heat- and Momentum Balances. Fixed bed catalytic reactors. Design and Modeling of Fixed Bed Reactors. Pseudo-homogeneous Models-The Basic One-Dimensional Model. One-Dimensional Model with Axial Mixing. Two-Dimensional Pseudo- homogeneous Models.One-Dimensional Model Accounting for Interfacial and Intra-particle Gradients. Two-Dimensional Heterogeneous Models. Fluidized bed and transport reactors- Introduction. Technological Aspects of Fluidized Bed and Riser Reactors. Some Features of the Fluidization and Transport of Solids. Heat Transfer in Fluidized Beds. Modeling of Fluidized Bed Reactors. Modeling of a Transport of Riser Reactor. Catalytic Cracking of Vacuum GasOil.

**TOTAL : 60 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

CO1: **Understand** properties and function of Catalyst
CO2: **Apply** the kinetics of heterogeneous reactions in the design of reactors
CO3: **Apply** the transport process in the design of reactors
CO4: **Understand** catalyst deactivation process and kinetics of catalyst poisoning
CO5: **Design** various types of heterogeneous Reactors

**Course Articulation Matrix**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 1 | - | 3 | 3 | 1 | - |
| CO2 | 1 | - | 3 | 3 | 1 | - |
| CO3 | 1 | - | 3 | 3 | 1 | - |
| CO4 | 1 | - | 3 | 3 | 1 | - |
| CO5 | 1 | - | 3 | 3 | 1 | - |
| overall | 1 | - | 3 | 3 | 1 | - |

**REFERENCES:**


1. Charles G.Hill, JR. , An Introduction to Chemical Engineering Kinetics& Reactor Design, ,John Wiley&Sons,1977.
2. Octave Levenspiel,Chemical Reaction Engineering, John Wiley & Sons,3rd Edition,1999.
3. Gilbert F. Froment and Kenneth Bischoff, Chemical Reactor Analysis and Design, John Wiley&Sons,2nd Edition,1990.
4. H.Scott Fogler, Elements of Chemical Reaction Engineering, , Prentice Hall International Series,3rd Edition,2000.
5. Mark E. Davis and RobertJ.Davis, Fundamentals of Chemical Reaction Engineering, McGrawHill,2003.


**RM4151 RESEARCH METHODOLOGY AND IPR L T P C**
**2 0 0 2**

**UNIT I RESEARCH DESIGN 6**

Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys.

**UNIT II DATA COLLECTION AND SOURCES 6**

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

**UNIT III DATA ANALYSIS AND REPORTING 6**

Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

**UNIT IV INTELLECTUAL PROPERTY RIGHTS 6**

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

**UNIT V PATENTS 6**

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licences, Licensing of related patents, patent agents, Registration of patent agents.

**TOTAL: 30 PERIODS**

**REFERENCES**


1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
3. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.

4. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

| CX4111 | COMPUTATIONAL PROGRAMMING LABORATORY FOR CHEMICAL ENGINEERS | L T P C 0 0 4 2 |
|---|---|---|

**COURSE OBJECTIVE:**

- To give the students an understanding the fundamentals concepts in mathematics
- To make understanding the chemical engineering problems solving using MATLAB
- To make understanding the students to design using computer programming

**SUGGESTEDEXERCISES**

1. Equations of state using Newton‘s method
2. Regression for parameter estimation using a set of data points
3. Equilibrium flash distillation(Multicomponent Ideal)
4. Batch Reactor
5. CSTR in Series Stagewise contacting equipment
6. Solving a simple flow sheet by simultaneous approach
7. Simulation of batch Distillation (binary ideal).
8. Gravity Flow Tank
9. Heat Exchanger
10. Plug Flow Reactor
11. Absorber

**Specific examples in ASPEN/HYSYS/MATLAB/EXCEL**

1. Solving equation of state, regression of parameters using EXCEL/MATLAB
2. CalculationofReynoldsnumber,frictionfactorandpressuredropusingEXCEL/MATLAB
3. Calculation of heat transfer coefficient in a Heat Exchanger using EXCEL/MATLAB
4. CalculationofminimumRefluxratioforbinary/tertiarysysteminafractionatorsusing

**EXCEL/ MATLAB**

1. Calculation of HTU and NTU in a Absorber using EXCEL/MATLAB
2. Calculation of Antoine‘s coefficient using EXCEL/MATLAB
3. EstimationofsettlingvelocityofsolidsinliquidsusingStoke‘slawusingEXCEL/MATLAB
4. CalculationofminimumnumberofstagesinadistillationcolumnusingEXCEL/MATLAB
5. Solving mass and energy balance problems using EXCEL/MATLAB
6. Calculation of Power in Reciprocating compressor using EXCEL/MATLAB
7. Steady state simulation of Heat Exchanger using ASPENPLUS/ HYSYS
8. Steady state simulation of a CSTR using ASPENPLUS/HYSYS
9. Steady state simulation of Flash vessel using ASPEN PLUS/HYSYS
10. Steady state simulation of Distillation Column using ASPENPLUS/HYSYS
11. Steady state simulation of an Absorption column using ASPENPLUS/HYSYS
12. Dynamic simulation of Heat Exchanger using ASPENPLUS/ HYSYS
13. Dynamic simulation of a CSTR using ASPENPLUS/HYSYS
14. Dynamic simulation of Flash vessel using ASPENPLUS/HYSYS
15. Dynamic simulation of Distillation Column using ASPENPLUS/HYSYS
16. Dynamic simulation of an Absorption column using ASPENPLUS/HYSYS
17. Developing Heat and Mass balance diagram using ASPEN PLUS/ HYSYS

**LIST OF EQUIPMENTS FOR A BATCH OF 18 STUDENTS:**

- Standalone desktops/serverwithrespectivesimulationsoftwares18Nos.
- Softwares
- MATLAB Single user license
- Open source office
- Open source chemical engineering simulation software.

**TOTAL: 60 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

CO1: Explain the various software's used in chemical engineering industries and its applications

CO2: **Learn** Microsoft excel for solving various chemical engineering problems

CO3: **Learn** about the role of MATLAB/ASPEN/HYSYS in various chemical industries and its applications

**Course Articulation Matrix**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 2 | - | 3 |
| CO2 | 3 | 3 | 3 | 2 | - | 3 |
| CO3 | 3 | 3 | 3 | 2 | - | 3 |
| OVERALL | 3 | 3 | 3 | 2 | - | 3 |

**REFERENCES:**


1. Bequette.B.W,—ProcessDynamics‖:Modelling,AnalysisandSimulation,‖PrenticeHall(1998)
2. Himmelblau.D.M.andBischoff.K.B,—ProcessAnalysisandSimulation‖,Wiley,1988.
3. Strang.G.,‖Introduction to Linear Algebra‖, Cambridge Press, 4th edition, 2009.
4. William. Luyben,—Process Modelling, simulation and control for Chemical Engineers,2nd Edn.,McGra w Hill International Editions, New York, 1990
5. Chapra.S.C. and Canale.R.P. —Numerical Methods for Engineers ‖,McGraw Hill,2001


**CX4201 CHEMICAL PROCESS DESIGN L T P C**
**3 1 0 4**

**COURSE OBJECTIVES:**

- To impart basic knowledge about chemical process design and its importance in industries
- To create knowledge on choice of selecting reactors and separators , performance of reactors and practical reactors.
- To gain knowledge about synthesis of reaction and separation system.
- To impart knowledge about sequencing of distillation columns
- To create knowledge about types of heat exchanger network and utilities for the target of energy and cost.

**UNIT I INTRODUCTION 12**

The Hierarchy of Chemical process Design- Overall process Design, approaches to design.

**UNIT II CHOICE OF REACTORSAND SEPARATOR 12**

Reaction path, reactor performance, practical reactors, Separation of Heterogeneous mixtures, homogeneous fluid mixtures.

**UNIT III SYNTHESIS OF REACTION –SEPARATIONSYSTEMS 12**

Process recycle, Batch processes, process yield

**UNIT IV DISTILLATIONSEQUENCING 12**

Using simple columns, using columns with more than two products, Distillation Sequencing Using thermal coupling.

**UNIT V HEAT EXCHANGER NETWORK & UTILITIES – ENERGYTARGETS 12**

Heat recovery pinch, The Problem table Algorithm, Utilities Selection, Energy targets capital& total Cost targets -Number of Heat Exchanger Units, Area Targets, Number of Shells Targets, Capital Cost Targets, Total Cost Targets.

**TOTAL : 60 PERIODS**

**OUTCOME:**

The students will be able to

CO1: **Understand** various aspects of process design project objectives, approaches of process design.

CO2**: Understand** various Choice of reactors and its performance assessment, reactor configuration

design of different types of separations process for homogeneous and heterogeneous mixtures.

CO3: **Analyze** Recycle systems in order to optimize the process

CO4**. Analyze distillation** Sequencing to optimize distillation process

CO5: **Understand** the types of Heat exchanger networks and apply for the target of energy and costs

**Course articulation matrix**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 2 | - | 3 | 3 | 1 | - |
| **CO2** | 2 | - | 3 | 3 | - | - |
| **CO3** | 2 | - | 3 | 3 | - | - |
| **CO4** | 2 | - | 3 | 3 | - | - |
| **CO5** | 2 | - | 3 | 3 | - | - |
| **Overall** | 2 | - | 3 | 3 | 1 | - |

**REFERENCES**


1. Douglas, J.M., “Conceptual Design of Chemical Process”, McGraw Hill, NewYork,1988.
2. Smith, R. Chemical Process: Design and Integration,”, John Wiley and Sons 2005


**CX4202 ADVANCED TRANSPORT PHENOMENA L T P C**

**3 1 0 4**

**UNITI BASIC CONCEPTS 12**

Phenomenological Equations and Transport properties, Rheological behavior of fluids, Balance Equations –Differential and Integral equations.

**UNITII APPLICATIONSOFDIFFERENTIALEQUATIONSOFCHANGE 12**

Applications in laminar and turbulent transport in compressible and incompressible fluids. Boundary layer theory.

**UNITIII APPLICATIONSOFINTEGRALEQUATIONSOFCHANGE 12**

Macroscopic balance for isothermal and non isothermal systems and their applications in Momentum, Heat and Mass transport problems.

**UNITIV INTERPHASEANDMULTIPHASEMOMENTUMTRANSFER 12**

Friction factor, Fluid –Fluid systems, Flow patterns in vertical and horizontal pipes, Formulation of bubbles and drops and their size distribution, Solid–fluid systems, Forces acting on stagnant and moving solids,Flow through porous medium, capillary tube model and its applications.

**UNITV INTERPHASETRANSPORTINNON-ISOTHERMALSYSTEMS 12**

Heat Transfer coefficient, Forced convection in tubes, around submerged objects, Heat Transfer by free convection,film type and drop wise condensation and equations for heat transfer, Heat transfer

in boiling liquids. Mass Transfer co-efficient in single and multiple phases at low and high mass transfer rates, Film theory, Penetration theory, Boundary layer theory, Macroscopic balance to solve steady and Unsteady state problems.

**TOTAL:60 PERIODS**

**OUTCOME:**

The students will be able to

CO1: **Understand** and identify transport properties for the three transport phenomena and analyze the mechanisms of molecular and turbulent momentum, energy and masstransport.

CO2: **Formulate** the differential forms and integral form of the equations of change for momentum, heat and mass transport in compressible and incompressible fluids for steady-state and unsteady flows

CO3: **Apply** RTT for macroscopic balances for isothermal and non isothermal systems

CO4:**Evaluate** the flow behavior for external and internal flows

CO5: **Evaluate** thermal conductivity and mass diffusivity for flow through porous media.

**Course Articulation Matrix**

| CourseOutcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 2 | - | 3 | 3 | - | - |
| CO2 | 2 | - | 3 | 3 | - | - |
| CO3 | 2 | - | 3 | 3 | - | - |
| CO4 | 2 | - | 3 | 3 | - | - |
| CO5 | 2 | - | 3 | 3 | - | - |
| Overall | 2 | - | 3 | 3 | - | - |

**REFERENCES**


1. Bird R.B., Stewart, W. E. and Lightfoot, E. N., “Transport Phenomena”, 2nd Edn. John Wiley and Sons,2002.
2. Brodkey,R.S. and Hershey, H.C.,“Transport Phenomena A Unified Approach”, Brodkey Publishing,2003.
3. Welty, J.R., Wicks, C. E. and Wilson, R. E., “Fundamentals of Momentum, Heat MassTransfer”,5th Edn., JohnWiley and Sons, 2007


**CX4203 ADVANCED PROCESS CONTROL L T P C**

**3 1 0 4**

**COURSE OBJECTIVES**

- To impart knowledge about advanced control strategies
- To create knowledge about internal model control
- To impart knowledge about multivariable control
- To achieve knowledge about discrete systems
- To impart knowledge about digital feedback systems

**UNIT I ADVANCED CONTROL STRATEGIES 12**

Feed forward, cascade, dead time compensation, split range, selective and override control; automatic tuning and gain scheduling

**UNIT II INTERNALMODEL CONTROL 12**

Model based control – IMC structure – development and design; IMC based PID control, MPC

**UNIT III MULTIVARIABLE CONTROL 12**

Control loop interaction – general pairing problem, relative gain array and application, sensitivity. Multivariable control – zeros and performance limitations, directional sensitivity and operability,

decoupling

**UNIT IV DISCRETE SYSTEMS 12**

Z – Transform and inverse Z – transform properties, Discrete – Time Response of dynamic system, Pulse Transfer Function, Closed Loop System Stability.

**UNITV DIGITAL FEEDBACK CONTROLLERS 12**

Design of digital feedback controllers, digital approximation of classical, effect of sampling, Case study of Industrial Instrumentation and Control system, DCS, PLC, shutdown system.

**TOTAL: 60 PERIODS**

**COURSE OUTCOMES**

The students will be able to

CO1: **Understand**the advanced control strategies
CO2: **Design** of IMC based PID control and MPC
CO3: **Understand** multivariable control and its applications in process industries
CO4: **Understand** discrete systems and its applications
CO5: **Understand** the design of digital feedback controllers.

**Course Articulation Matrix**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 2 | - | 3 | 3 | - | - |
| CO2 | 2 | - | 3 | 3 | - | - |
| CO3 | 2 | - | 3 | 3 | - | - |
| CO4 | 2 | - | 3 | 3 | - | - |
| CO5 | 2 | - | 3 | 3 | - | - |
| Overall | 2 | - | 3 | 3 | - | - |

**REFERENCES**


1. Bequette, B. W., Process Control: Modeling, Design, and Simulation, PrenticeHall, 2003
2. KannanM. Moudgalya, Digital Process Control, John Wiley & SonsLtd,2007
3. Stephanopolous, G., “Chemical Process Control”, Prentice Hall of India, NewDelhi,1985.


**CX4204 MULTI COMPONENT DISTILLATION L T P C**
**3 1 0 4**

**COURSE OBJECTIVES:**

- To impart knowledge about thermodynamic principles of multicomponent distillation
- To inculcate knowledge about thermodynamic property evaluation of multicomponent mixtures
- To impart knowledge about methods of calculating minimum reflux ratio
- To create knowledge about various methods of mutlticomponentdistillation column design
- To impart knownledge about design of mutlticomponent distillation column and computation of plate efficiency

**UNIT I THERMODYNAMIC PRINCIPLES 12**

Fundamental Thermodynamic principles involved in the calculation of vapor – liquid equilibria and enthalpies of multi component mixtures – Use of multiple equation of state for the calculation of K values – Estimation of the fugacity coefficients for the vapor phase of polar gas mixtures – calculation of liquid – phase activity coefficients.

**UNITII THERMODYNAMIC PROPERTYEVALUATION 12**

Fundamental principles involved in the separation of multi component mixtures – Determination of bubble-point and Dew Point Temperatures for multi component mixtures – equilibrium flash distillation calculations for multi component mixtures – separation of multi component mixtures at total reflux.

**UNITIII MINIMUM REFLUX RATIO FORMCD SYSTEM 12**

General considerations in the design of columns – Column sequencing – Heuristics for column sequencing – Key components – Distributed components – Non-Distributed components – Adjacent keys. Definition of minimum reflux ratio – calculation of Rm for multi component distillation – Underwood method – Colburnmethod.

**UNITIV VARIOUS METHODS OF MCDCOLUMNDESIGN 12**

Theta method of convergence – Kb method and the constant composition method -Application of the Theta method to complex columns and to system of columns – Lewis Matheson method – Stage and reflux requirements – Short cut methods and Simplified graphical procedures.

**UNITV VARIOUS TYPES OF MCD COLUMNS 12**

Design of sieve, bubble cap, valve trays and structured packing columns for multi component distillation – computation of plate efficiencies.

**TOTAL : 60 PERIODS**

**COURSE OUTCOMES:**

Students will able to

CO1: Understand basic thermodynamics properties such as fugacity coefficient ,activity coefficient with respect to multi component mixtures

CO2: **Understand** basic principle involved in separation multi component mixture and MC distillation

CO3: **Apply**available methods for calculating minimum reflux ratio in a multi component distillation column

CO4: **Analyze** different methods used in designing a multi component distillation column

CO5: **Design** various types of multi component distillation column

**Course Articulation Matrix**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 2 | - | 3 | 3 | - | - |
| CO2 | 2 | - | 3 | 3 | - | - |
| CO3 | 2 | - | 3 | 3 | - | - |
| CO4 | 2 | - | 3 | 3 | 2 | - |
| CO5 | 2 | - | 3 | 3 | - | - |
| Overall | 2 | - | 3 | 3 | 2 | - |

**REFERENCES**


1. Holland, C.D., “Fundamentals of Multi Component Distillation”, McGraw Hill Book Company,1981
2. Van Winkle, “Distillation Operations”, McGraw Hill Publications,1987.

**CX4211 SEPARATION TECHNIQUES LABORATORY L T P C**
**0 0 4 2**

**COURSE OBJECTIVES:**

- To understand the basics of various separation techniques and to select appropriate separation methodology,
- To determine the mass transfer coefficient for designing the size of the separator
- To understand the preparatory and analytical chromatographic techniques.

**List of Experiments:**

1. Determination of VLE for a binary mixture at different temperatures
2. Determination of VLE & VLLE for a ternary mixture (azeotropic binary mixture and entrainer)
3. LLE of Extraction system of Type I, II and Type IIIsystems
4. Study of extraction efficiency for the extraction of essential oils
5. Aqueous Two Phase Extraction and Design of ATPE using Hofmeister Series
6. Cross flow filtration using Microfiltration to characterize Specific cake resistance and filter medium resistance ofmembranes
7. Tangential flow filtration using Ultrafiltration for finding flux in membranes and to characterize concentration polarization and fouling
8. Verification of Vant Hoff Equation and design of reverse osmosissystems
9. Adsorption Equilibria and fixed bed adsorption studies for generation of breakthroughcurves
10. Gas Hold up studies in sparged column, bubble column, wetted wall column
11. Determination of mass transfer coefficient in a wetted wallcolumn
12. Preparative HPLC
13. Thin Layer and paper chromatography
14. Calculation of yield in crystallization process
15. Simulation of refinery operations ( catalytic cracking, hydrocracking) using ASPENHYSYS

**TOTAL: 60 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

CO1: **Determine** the VLE for binary and VLLE for ternary mixtures

CO2: **Determine** LLE for Type I, II, III L-L or L-S ternary mixtures

CO3: **Understand** and apply chromatographic techniques

CO4: **Analyze** the performance in Cross Flow and Tangential Flow Filtration

CO5: **Design** RO systems based on Vant Hoff Equation and Simulate Industrial processes using ASPEN HYSYS

**Course Articulation Matrix**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 3 | 3 | - | - |
| CO2 | 2 | 3 | 3 | 3 | - | - |
| CO3 | 2 | 3 | 3 | 3 | - | - |
| CO4 | 2 | 3 | 3 | 3 | - | - |
| CO5 | 2 | 3 | 3 | 3 | - | 3 |
| Overall | 2 | 3 | 3 | 3 | - | 3 |

**REFERENCES**


1. Seader, J. D., Henley, E. J., & Roper, D. K. (1998). Separation process principles.
2. Wankat, P. C. (2006). *Separation process engineering*. Pearson Education.
3. Wankat, P. C. (1990). Rate-controlled separations.
4. Braithwaite, A., & Smith, J. F. (2012). *Chromatographic methods*. Springer Science & Business Media.
5. Baker, R. W. (2012). *Membrane technology and applications*. John Wiley &Sons.

**CX4212** **SEMINAR** **L T P C**
**0 0 2 1**

**COURSE OBJECTIVES:**

- To provide exposure to the recent developments.
- To improve the students presentation skills.
- To make the students to come out of stage fear

Students are expected to present a seminar along with report on any technical topic

**COURSE OUTCOMES:**

The students will have the
CO1: Ability to communicate well
CO2: Ability to review, prepare and present technological developments
CO3: Ability to face the placement interviews

**Course Articulation Matrix:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 3 | - | 3 | - |
| CO2 | 2 | 3 | 3 | - | 3 | - |
| CO3 | 2 | 3 | 3 | - | 3 | - |
| Overall | 2 | 3 | 3 | - | 3 | - |

**CX4301** **PROCESS MODELING AND SIMULATION** **L T P C**
**3 1 0 4**

**COURSE OBJECTIVES:**

- To understand the basics of modelconstruction.
- To learn about solving model equations and validation of themodels.

**UNITI INTRODUCTION 12**

Introduction to modeling and simulation, classification of mathematical models, conservation equations and auxiliary relations.

**UNITII STEADY STATE LUMPED SYSTEMS 12**

Degree of freedom analysis, single and network of process units, systems yielding linear and non-linear algebraic equations, flowsheeting – sequential modular and equation oriented approach, tearing,partitioningandprecedenceordering,solutionoflinearandnon-linearalgebraicequations.

**UNITIII UNSTEADY STATE LUMPED SYSTEMS 12**

Analysis of liquid level tank, gravity flow tank, jacketed stirred tank heater, reactors, flash and distillation column, solution of ODE initial value problems, matrix differential equations, simulation of closed loop systems.

**UNITIV STEADY STATE DISTRIBUTED SYSTEM 12**

Analysis of compressible flow, heat exchanger, packed columns, plug flow reactor, solution of ODE boundary value problems.

**UNITV UNSTEADY STATE DISTRIBUTED SYSTEM 12**

Analysis laminar flow in pipe, sedimentation, boundary layer flow, conduction, heat exchanger, heat transfer in packed bed, diffusion, packed bed adsorption, plug flow reactor, hierarchy in model development, classification and solution of partial differential equations - Empirical modeling, parameter estimation, population balance and stochastic modeling.

**TOTAL : 60 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

CO1: Understand the fundamentals of modeling and their applications to transport/energy equations, chemical and phase equilibriakinetics

CO2: Associate the model with constitutive relations such as phenomenological laws, rate equations, equations of state, property estimationmethods

CO3: Create the mathematical models for different unit operations equipments such as stirred tank heaters, Heat exchangers, Evaporators, Reactors, distillation columns

CO4: Analyze the principles of steady state/unsteady state lumped systems and steady state/ unsteady state distributed systems

CO5: Apply relevant solution methods for the mathematical models with relevant initial and/or boundaryconditions

**Course Articulation Matrix**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | - | 3 | 3 | - | 2 |
| CO2 | 3 | - | 3 | 3 | - | 2 |
| CO3 | 3 | - | 3 | 3 | - | 2 |
| CO4 | 3 | - | 3 | 3 | - | 2 |
| CO5 | 3 | - | 3 | 3 | - | 2 |
| OVERALL | 3 | - | 3 | 3 | - | 2 |

**REFERENCES**


1. Felder, R. M. and Rousseau, R. W., “Elementary Principles of Chemical Processes“, John Wiley,2000.
2. Franks, R. G. E., “Mathematical Modelling in Chemical Engineering“, John Wiley, 1967.
3. Luyben, W.L., "Process Modelling Simulation and Control", McGraw-Hill BookCo., 1973.
4. Ramirez, W., "Computational Methods in Process Simulation", 2nd Edn.,Butterworth’s, New York,2000.


**CX4311 PROJECT WORK I L T P C**

**0 0 12 6**

**OBJECTIVES:**

**The course aims to enable the students to**

- identify the problem/process relevant to their field of interest that can be carried out
- search databases and journals to collect and analyze relevant data
- plan, learn and perform experiments to find the solution
- prepare project report

**TOTAL : 180 PERIODS**

Individual students will identify a problem relevant to his/her field of study, collect and analyze literature, design, and carryout experiment, collect data, interpret the result and prepare the project report.

**OUTCOMES:**

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

CO1 Identify the research/industrial problems

CO2 Collect and analyze the relevant literature

CO3 Design, conduct experiment and analyse the data

CO4 Prepare project report

**Course Articulation Matrix**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 1 | 1 |
| Overall | 3 | 3 | 3 | 3 | 2 | 1 |

**CX4312** **INTERNSHIP** **L T P C**
**0 0 0 1**

Students shall undergo training in R&D institutions / Academics / Industries for a minimum period of 15 days. At the end of internship students must submit a report for internal evaluation.

**CX4411** **PROJECT WORK II** **L T P C**
**0 0 24 12**

**The course aims to**

- train students to analyze the problem/ think innovatively to develop new methods/product /process
- make them understand how to find solutions/ create products economically and in an environmentally sustainable way
- enable them to acquire technical and experimental skills to conduct experiment, analyze the results and prepare project report
- enable them to effectively think about strategies to commercialize the product .

**TOTAL : 360 PERIODS**

Individual students will identify a problem relevant to his/her field of study, collect and analyze literature, design, and carryout experiment, collect data, interpret the result and prepare the project report.

**COURSE OUTCOMES**

**At the end of the project the student will be able to**

CO1 Formulate and analyze problems for developing new methods/solutions/processes
CO2 Plan and conduct experiments to find solutions in a logical manner
CO3 Analyze the results, interpret and prepare project report/know the strategies for commercialization

**Course Articulation Matrix:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 1 | 1 |
| Overall | 3 | 3 | 3 | 3 | 2 | 1 |

**CX4001** **MULTIPHASE FLOW** **L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To understand the fundamental parameters in multiphase flow
- To study the mechanism of interaction between particles
- To study the models and correlations for different flow types
- To analyze the equations of motion for multi phase flow
- To study the experimental methods for measuring hydrodynamic parameters

**UNIT I CHARACTERISTICS OF MULTIPHASE FLOWS 9**

Significance of multiphase flows, important non-dimensional numbers, parameters of characterization, particle size measurement, size distribution and moments, size distribution models

**UNIT II PARTICLE FLUID INTERACTION 9**

Equation of motion for a single particle, calculation of drag, motion of a particle in two dimensions, effects of unsteady and non-uniform flow fields, effect of acceleration, effect of coupling; Interaction between particles, mechanism of interaction, inter-particle forces, hard sphere model, soft sphere model, discrete element modeling, semi-empirical methods, kinetic theory, force chains.

**UNIT III MODELING OF MULTI-PHASE FLOWS 9**

Flow patterns - identification and classification - flow pattern maps and transition – momentum and energy balance - homogeneous and separated flow models - correlations for use with homogeneous and separated flow models - void fraction and slip ratio correlations - influence of pressure gradient - empirical treatment of two phase flow - drift flux model - correlations for bubble, slug and annular flows

**UNIT IV CONSERVATION EQUATIONS 9**

Averaging procedures - time, volume, and ensemble averaging, quasi-one-dimensional flow, two-fluid volume-averaged equations of motion, turbulence and two-way coupling

**UNIT V MULTI-PHASE SYSTEMS 9**

Flow regime and hydrodynamic characteristics of packed bed, fluidized bed, pneumatic conveying, bubble column, trickle beds; Conventional and novel measurement techniques for multi phase systems including CARPT, Laser Doppler anemometry, Particle Image Velocimetry.

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

CO1: Understand the significance of multiphase flows and different flow pattern in multiphase flow
CO2: Understand the determination of hydrodynamic parameters in the multiphase flow system
CO3: Understanding the concept of different flow models
CO4: Understand the one dimensional two dimensional flow equation in turbulent condition
CO5: Understanding the hydrodynamic characteristics in different contactors and measurement techniques in multiphase flow

**COURSE ARTICULATIONMATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 3 | 2 | 1 | 1 |
| CO2 | 2 | 1 | 3 | 2 | 1 | 1 |
| CO3 | 2 | 1 | 3 | 3 | 1 | 1 |
| CO4 | 2 | 1 | 3 | 2 | 1 | 1 |
| CO5 | 2 | 1 | 3 | 2 | 1 | 1 |
| Overall | 2 | 1 | 3 | 2 | 1 | 1 |

**REFERENCES**


1. Clift, R., Weber, M.E. and Grace, J.R., Bubbles, Drops, and Particles, Academic Press, New York, 2005.
2. Crowe, C. T., Sommerfeld, M. and Tsuji, Y., Multiphase Flows with Droplets and Particles, CRC Press, 2011
3. Fan, L. S. and Zhu, C., Principles of Gas – solid Flows, Cambridge University Press, 2005
4. Govier, G. W. and Aziz, K., —The Flow of Complex Mixture in Pipes, Van Nostrand Reinhold, New York, 1972
5. Kleinstreuer, C., Two – phase Flow : Theory and Applications, Taylor & Francis, 2003

6. Rhodes, M., Introduction to Particle Technology, John Wiley & Sons, New York, 2008
7. Wallis, G. B., One Dimensional Two Phase Flow, McGraw Hill Book Co., New York

**CX4002 ENVIRONMENTAL RISK ASSESMENT L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To study the tools to for quantitative risk assessment
- To develop a basic understanding of health hazards and risk assessment
- To gain knowledge about emergency risk management process
- To learn about different risk Hazard and accident models
- To analyze the past accidents and to frame policies for the future

**UNIT I RISK ANALYSIS 9**

Risk analysis introduction, quantitative risk assessment, rapid risk analysis –comprehensive risk analysis–identification, evaluation and control of risk

**UNIT II RISK ASSESSMENT 9**

Risk assessment – introduction and available methodologies, Risk assessment steps, Hazard identification, Hazard assessment (consequence analysis), probabilistic hazard assessment (Fault tree analysis)

**UNIT III EMERGENCY PLANNING 9**

Overall risk contours for different failure scenarios – disaster management plan – emergency planning – onsite and offsite emergency planning, risk management ISO 14000, EMS models – case studies–marketing terminal gas processing complex.

**UNIT IV HAZARD MODELS 9**

Safety measures design in process operations. Accidents modeling– release modeling, toxic release and dispersion modeling, fire and explosion modeling.

**UNIT V POLICIES FOR MITIGATION 9**

Past accident analysis: Flux borough – Mexico – Bhopal analysis. Government policies to manage environmental risk

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

Students will able to

CO1: Understand the methods and processes employed in environmental health and risk assessment

CO2: Apply different tools to aid the risk assessment analysis

CO3: Gain knowledge on environmental laws and regulations to develop guidelines, procedures and processes for health and safety issues

CO4: Use epidemiological data and to analyze the various methods of risk assessment.

CO5: analyse the policies through realistic case studies

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 1 | 2 | 1 | 1 | 3 | - |
| CO2 | 1 | 2 | 1 | 1 | 3 | - |
| CO3 | 1 | 2 | 1 | 1 | 3 | - |
| CO4 | 1 | 2 | 1 | 1 | 3 | - |
| CO5 | 1 | 2 | 1 | 1 | 3 | - |
| Overall | 1 | 2 | 1 | 1 | 3 | - |

**REFERENCES**


1. Crowl, D. A. and Louvar, J. F., Chemical process safety; Fundamentals with applications, Prentice Hall Publication Inc., 2002
2. Houstan, H. B., Process safety analysis, Gulf publishing company, 1997
3. Khan, F. I. and Abbasi, S. A., Risk assessment of chemical process industries; Emerging technologies, Discovery publishing house, New Delhi, 1999
4. Paul Pritchard., Environmental Risk Management, Routledge, 2000
5. Ted W Simon., Environmental Risk Assessment - a Toxicological Approach, 2nd Edn., CRC Press., 2019


**CX4003 DESIGN AND ANLYSIS OF EXPERIMENTS L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To learn about the statistical tools and design principles of experiments
- To learn about the usage of single factor testing methods
- To learn and apply the Factorial design techniques
- To know various special experimental design techniques
- To learn about various Taguchi's Techniques

**UNIT I CONCEPTS AND TERMINOLOGY 5**

Review of hypothesis testing – P Value, —tllVs paired—tll test, simple comparative experiment, planning of experiment – steps, Terminology - factors, levels, variables, Design principles – replication, randomization, blocking, confounding, Analysis of variance, sum of squares, degrees of freedom.

**UNIT II SINGLE FACTOR EXPERIMENTS 10**

Completely randomized design, Randomized block design, effect of coding the observations, Latin Square design, orthogonal contrasts, comparison of treatment means – Duncan's multiple range test, Newman-Keuel's test, Fisher's LSD test, Tukey's test.

**UNIT III FACTORIAL EXPERIMENTS 10**

Main and interaction effects, Rules for sum of squares and expected mean square, two and three factor full factorial design, 2k designs with two and three factors, Yate's algorithm, practical applications

**UNIT IV SPECIAL EXPERIMENTAL DESIGNS 10**

Blocking and confounding in 2k design, nested design, split – plot design, two level fractional factorial design, fitting regression models, introduction to response surface methods- Central composite design.

**UNIT V TAGUCHI TECHNIQUES 10**

Introduction, Orthogonal designs, data analysis using ANOVA and response graph, parameter design – noise factors, objective functions (S/N ratios), multi-level factor OA designs, applications

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

CO1: Understand sampling and sampling distribution
CO2: Apply Hypothesis testing with different confidence intervals
CO3: Perform ANOVA and regression analysis
CO4: Perform statistically designed experiments with and without blocking
CO5: Model the given data using Response Surface Methodology

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 2 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 2 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 2 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 2 | 2 |
| Overall | 3 | 3 | 3 | 3 | 2 | 2 |

**REFERENCES**


1. Angela M. Dean and Daniel Voss, Design and Analysis of Experiments, Springer texts in Statistics, 2000
2. Douglus C. Montgomery, Design and Analysis of Experiments, John Wiley & Sons, 2005
3. Philip J. Ross, Taguchi Techniques for Quality Engineering, Prentice Hall, 1989
4. George W Cobb., - Introduction to Design and Analysis of Experiments, Wiley India Exclusive (CBS), 2015
5. Panneerselvam R., - Design and Analysis of Experiments, PHI Learning, 2012


**CX4004 ELECTRO CHEMICAL PROCESS L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To gain a strong knowledge about the fundamentals of electrochemical process
- To analyze the transport properties within a electrochemical cell
- To analyze and estimate the reaction kinetics in a cell
- To study the various models of reactors
- To understand the process of design and scale-up of reactors

**UNIT I INTRODUCTION OF ELECTROCHEMICAL PROCESS 9**

Industrial importance of electrolytic processes, Basic concepts and definitions, Criteria for reactor performance, Electrochemical and catalytic reactions and reactors - Fundamentals of reaction kinetics, rate of electrochemical reaction, electrochemical thermodynamics, practical cell voltage requirements and polarization, single electrochemical reactions, potentiostatic operations of first order reaction and galvanostatic operation of first order reactions.

**UNIT II ASPECTS OF MASS AND HEAT TRANSFER IN ELECTROLYTIC CELL SYSTEMS 9**

Basic aspects of fluid dynamics, mass transfer-mass flux in a fully developed turbulent regime,entranceandexiteffects,obtainingnumericalvaluesofmasstransfercoefficientbycalculationand experiment, mass transfer in two phase flow, energetic and energy balances, CSTR with general order reactions, effect of mass transport and side reaction.

**UNIT III RATE PROCESSES AND REACTION MODELS 9**

Rate processes, kinetics of elementary reactions, reaction mechanism and rate laws, transition state theory, derivation of kinetic relationships, reaction models.

**UNIT IV REACTOR MODELS 9**

General considerations, batch reactor and continuous reactor - Fed batch, continuous, cell recycle, plug flow reactor, two stage reactors, Reactor dynamics and stability - Reactors with non-ideal mixing. Other types of reactors-fluidized bed reactors; packed bed reactors, bubble column reactors, trickle bed reactors.

**UNIT V ELECTROLYTIC REACTOR DESIGN, SELECTION AND SCALE-UP 9**

Electrolytic reactor designs, Electrolytic reactor selection, scale up of electrolytic reactors, effect of

scale up on mass transfer, effect of scale up on current distribution, multiple electrode models and time factors.

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

CO1: Understand the application electrochemical principles in chemical processing
CO2: Evaluate the transport properties like heat ,mass and momentum transfer in cell systems
CO3: Understand and analyze the reaction mechanisms with electrochemical systems.
CO4: Learn and design various non-ideal reactors.
CO5: Design various electrolytic reactors, Understand and perform scale up in electrolytic reactors

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 3 | 3 | 1 | 3 |
| CO2 | 3 | 1 | 3 | 3 | 1 | 3 |
| CO3 | 3 | 1 | 3 | 3 | 1 | 3 |
| CO4 | 3 | 1 | 3 | 3 | 1 | 3 |
| CO5 | 3 | 1 | 3 | 3 | 1 | 3 |
| Overall | 3 | 1 | 3 | 3 | 1 | 3 |

**REFERENCES:**


1. F. Goodridge, K. Scott, Electro chemical process engineering. A guide to the design of electrolytic plant, Plenum Press, 1995
2. Bockris, John O'M, Bockris, Ralph E. White, B. E. Conway, Modern aspects of electrochemistry, volume28 , Plenum Press, New York 1985
3. Newman and Thomas Alyea, Electrochemical systems, 3rd edition, Wiley & Sons, Hoboken, 2004
4. Pletcher, D., and Walsh, F. C., Industrial electrochemistry, 2nd edition, Chapman and Hall, London, 1990
5. Hartmut Wendt, Gerhard Kreysa, Electrochemical engineering, Science and technology in chemical and other industries, Springer, 1999
6. Krishnan Rajeshwar, Jorge G. Ibanez, Environmental Electrochemistry, Fundamentals and applications in Pollution Abatement, Academic Press, Inc, 1997




**CX4005 FLUIDIZATION ENGINEERING**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

- To understand the basics of fluidization of solid particles
- To study the dynamics inside a fluidized bed
- To gain knowledge about the mixing and segregation behaviour in fluidized particles
- To develop mass and energy balance in fluidized beds
- To know about latest developments in fluidization engineering and their applications

**UNIT I INTRODUCTION** **5**

The Fluidized state, Nature of hydrodynamic suspension, particle forces, species of Fluidization, Regimization of the fluidized state, operating models for fluidization systems, Applications of fluidization systems

**UNIT II HYDRODYNAMICS OF FLUIDIZATION SYSTEMS 12**

General bed behaviour, pressure drop, Flow regimes, Incipient Fluidization, Pressure fluctuations, Phase Hold ups, Measurement Techniques, Empirical Correlations for Solids hold up, liquid hold up and gas hold up. Flow models – generalized wake model, structural wake model and other important models.

**UNIT III SOLID MIXING AND SEGREGATION 8**

Phase juxta positions operation shifts, Reversal points, Degree of segregation, Mixing Segregation equilibrium, Generalised fluidization of poly disperse systems, liquid phase mixing and gas phase mixing.

**UNIT IV HEAT AND MASS TRANSFER IN FLUIDIZATION SYSTEMS 12**

Mass transfer – Gas Liquid mass transfer, Liquid Solid mass transfer and wall to bed mass transfer, Heat transfer – column wall – to – bed heat transfer, Immersed vertical cylinder to bed heat transfer, Immersed horizontal cylinder to bed heat transfer.

**UNIT V MISCELLANEOUS SYSTEMS 8**

Conical Fluidized bed, Moving bed, Slurry bubble columns, Turbulent bed contactor, Two phase and Three phase inverse fluidized bed, Draft tube systems, Semi fluidized bed systems, Annular systems, Typical applications, Geldart's classification for powder assessment, Powder characterization and modeling by bed collapsing.

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

Students would be able to

CO1: Understand the basics of fluidization and know the various industrial applications of fluidization

CO2: Learn the concepts of hydrodynamics in fluidized bed

CO3: Comprehend the formation and growth of bubble dynamics

CO4: Understand the bed behavior for various geometries of fluidized beds

CO5: Identify with the transport processes of fluidized beds and applications of fluidized beds

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 3 | 2 | 1 | 2 |
| CO2 | 2 | 1 | `3 | 2 | 1 | 2 |
| CO3 | 2 | 1 | 3 | 2 | 1 | 2 |
| CO4 | 2 | 1 | 3 | 2 | 1 | 2 |
| CO5 | 2 | 1 | 3 | 2 | 1 | 2 |
| Overall | 2 | 1 | 3 | 2 | 1 | 2 |



**REFERENCES**


1. Fan, L. S., Gas – liquid Solid Fluidization Engineering, Butterworths, 1989
2. Kunii, D., and Levenspiel, O., Fluidization Engineering, 2nd Edn., Butterworth - Heinemann, London, 1991
3. Kwauk M., Fluidization - Idealized and Bubble less, with applications, Science Press, 2009
4. D. Gidaspow., Multiphase flow and fluidization: continuum and kinetic theory description, Elsevier Science & Technology Books, 1993
5. L. G. Gibilaro, Fluidization - dynamics, Butterworth-Heinemann, 2001


**CX4006 ENERGY MANAGEMENT**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

- To prepare the students for the next generation with the focus on sustainable lifestyle

- To analyze and forecast the demand for energy for the future and its impact on the environment
- To study and predict the pattern and growth of energy consumption
- To learn energy conservation techniques and practices to implement in chemical process industries
- To develop knowledge about decision making for suitable alternation of energy resource

**UNIT I INTRODUCTION 9**

Energy sources; coal, oil, natural gas; nuclear energy; hydroelectricity, other fossil fuels; geothermal; supply and demand; depletion of resources; need for conservation; uncertainties; national and international issues

**UNIT II ENERGY DEMAND FORECAST 9**

Forecasting techniques, energy demand, magnitude and pattern, input and output analysis, energy modeling and optimal mix of energy sources - Energy - various forms, energy storage, structural properties of environment.

**UNIT III ENERGY CONSUMPTION 9**

Bio-geo-chemical cycles; society and environment population and technology, Energy and evolution, growth and change, patterns of consumption in developing and advances countries, commercial generation of power requirements and benefit.

**UNIT IV ENERGY CONSERVATION IN PROCESS INDUSTRIES 9**

Chemical industries, classification, conservation in unit operation such as separation, cooling tower, drying, conservation applied to refineries, petrochemical, fertilizers, cement, pulp and paper, food industries, chloroalkali industries, conservation using optimization techniques.

**UNIT V ALTERNATE ENERGY SOURCES 9**

Sources of continuous power, wind and water, geothermal, tidal and solar power, MHD, fuel cells, hydrogen as fuel, Cost analysis, capacity; production rate, system rate, system cost analysis, corporate models, production analysis and production using fuel inventories, input-output analysis, economics, tariffs. Energy audit

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

CO1: Gain knowledge about various energy resources
CO2: Acquire knowledge about various techniques for energy auditing
CO3: Integrate available energy resources and demand
CO4: Apply to optimization techniques for energy conservation in industries.
CO5: Evaluate and identify suitable renewable resource based on availability

.

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 1 | 1 | 2 | - | 1 | - |
| CO2 | 1 | 1 | 2 | - | 1 | - |
| CO3 | 1 | 1 | 2 | - | 1 | - |
| CO4 | 1 | 1 | 2 | - | 1 | - |
| CO5 | 1 | 1 | 2 | - | 1 | - |
| Overall | 1 | 1 | 2 | - | 1 | - |

**REFERENCES**


1. Gramlay, G. M., Energy, Macmillan Publishing Co., New York, 1975
2. Krentz, J. H., Energy Conservation and Utilisation, Allyn and Bacur Inc., 1976
3. Loftiness, R. L., Energy Hand Book, Van Nostrand Reinhold Company, New York, 1978
4. Rused, C. K., Elements of Energy Conservation, McGraw - Hill Book Co., 1985
5. Murphy, W. R., Energy Management, Elsevier / BSP Books Pvt. Ltd., 2003

**CX4007 PILOT PLANT AND SCALE-UP METHODS**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

- To impart knowledge on fundamentals of scale up
- To provide the students with the knowledge to use dimensional analysis in scale-up
- To impart knowledge to solve problems in scale up of Heat transfer equipment
- To impart knowledge to solve problems in scale up of Mass transfer equipment
- To do develop scale up design of Chemical reactors

**UNIT I PRINCIPLES OF SIMILARITY, PILOT PLANTS & MODELS 9**

Introduction to scale-up methods, pilot plants, models and principles of similarity

**UNIT II DIMENSIONAL ANALYSIS AND SCALE-UP CRITERION 9**

Dimensional analysis, regime concept, similarity criterion and scale up methods used in chemical engineering

**UNIT III SCALE-UP OF HEAT TRANSFER EQUIPMENT 9**

Typical problems in scale-up of mixing equipment and heat transfer equipment

**UNIT IV SCALE-UP OF MASS TRANSFER EQUIPMENT 9**

Scale-up of distillation columns and packed towers for continuous and batch processes

**UNIT V SCALE-UP OF CHEMICAL REACTORS 9**

Kinetics, reactor development & scale – up techniques for chemical reactors

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

CO1: Understand the fundamentals of Similarity, Pilot plants &Models
CO2: Evaluate dimensional analysis and scale –up methods.
CO3: Apply relevant scale –up methods for heat transfer operations
CO4: Apply relevant scale –up methods for mass transfer operations
CO5: Apply relevant scale –up methods for chemical reactors operations

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 1 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 1 | 3 |
| CO3 | 3 | 3 | 3 | 3 | 1 | 3 |
| CO4 | 3 | 3 | 3 | 3 | 1 | 3 |
| CO5 | 3 | 3 | 3 | 3 | 1 | 3 |
| Overall | 3 | 3 | 3 | 3 | 1 | 3 |

**REFERENCES:**


1. Donald G. Jordan, "Chemical Process Development" (Part 1 and 2), Interscience Publishers, 1988
2. Johnstone and Thring, "Pilot Plants Models and Scale-up methods in Chemical Engg.", McGraw Hill, New York, 1962
3. Marko Zlokarnik, Dimensional Analysis and Scale up in Chemical Engg.", Springer Verlag, Berlin, Germany, 1986
4. Worstell Jonathan., Scaling Chemical Processes: Practical Guides in Chemical Engineering, Elsevier - Health Sciences Division, 2016
5. Attilio Bisio., and Robert L. Kabel., Scale up of Chemical Processes: Conversion from Laboratory Scale Tests to Successful Commercial Size Design., Wiley-Interscience., 1985

**CX4008** **FUEL CELL TECHNOLOGY** **L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To understand the basics of fuel cell operations and their classification
- To understand the reaction kinetics and limiting steps in fuel cell
- To learn various models in fuel cells and specific integration with other systems
- To develop an understanding of the significance of Hydrogen fuel cell technology
- To gain knowledge on fuel cell power plant and applications

**UNIT I INTRODUCTION** **9**

Overview of fuel cells: materials for fuel cells: Low and high temperature fuel cells; Fuel cell thermo dynamics- heat, work potentials ,prediction of reversible voltage, fuel cell efficiency.

**UNIT II FUEL CELL KINETICS** **9**

Fuel cell reaction kinetics - electrode kinetics, overvoltage, Tafel equation, charge transfer reaction, exchange currents, electro catalysis - design, activation kinetics, Fuel cell charge and mass transport – flow field, transport in electrode and electrolyte

**UNIT III CHARACTERIZATION** **9**

Fuel cell characterization - in-situ and ex-situ characterization techniques, i-v curve, frequency response analysis; Fuel cell modeling and system integration: 1D model–analytical solution and CFD models

**UNIT IV HYDROGEN FUEL CELL** **9**

Balance of plant; Hydrogen production from renewable sources and storage; safety issues, cost expectation and life cycle analysis of fuel cells

**UNIT V FUEL CELL POWER PLANT** **9**

Fuel cell power plants: fuel processor, fuel cell power section (fuel cell stack), power conditioner; automotive applications, portable applications

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

CO1: Understand the fundamentals of fuel cells
CO2: Write the kinetics and transport in the flow field.
CO3: Analyze and characterize fuel cell performance
CO4: Integrate fuel cell in systems with the help of models
CO5: Perform life cycle analysis for a proposed fuel cell system and understand the constituents of a complete fuel cell power plant

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 2 | 1 | 1 | - |
| CO2 | 2 | 1 | 2 | 1 | 1 | - |
| CO3 | 2 | 1 | 2 | 1 | 1 | - |
| CO4 | 2 | 1 | 2 | 1 | 1 | - |
| CO5 | 2 | 1 | 2 | 1 | 1 | - |
| Overall | 2 | 1 | 2 | 1 | 1 | - |

**REFERENCES**


1. Bard, A. J., L. R., Faulkner, Electrochemical Methods, Wiley, N.Y.(2004) RefBook
2. Basu, S. (Ed) Fuel Cell Science and Technology, Springer, N.Y. (2007)
3. Fuel cell technology handbook, edited by Gregor Hoogers, CRC Press 2003
4. Liu, H., Principles of fuel cells, Taylor&Francis, N.Y. (2006)
5. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, NY (2006)

**CX4009 COMPUTATIONAL FLUID DYNAMICS**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

- To know the significance of computational fluid dynamics in transport processes
- To understand the finite difference approximation technique and error minimization
- To learn the finite volume method to solve diffusion problems in industrially important applications.
- To learn to apply CFD tools in flow field computations
- To impart technical competence in building and conducting CFD simulations.

**UNIT I CONSERVATION LAWS AND TURBULENCE MODELS 9**

Governing equations of fluid flow and heat transfer –mass conservation, momentum and energy equation, differential and integral forms, conservation and non-conservation form. Characteristics of turbulent flows, time averaged Navier Strokes equations, turbulence models-one and two equation, Reynolds stress, LES and DNS

**UNIT II FINITE DIFFERNCE APPROXIMATION 9**

Mathematical behaviour of PDE, finite difference operators, basic aspects of discretization by FDM, explicit and implicit methods, error and stability analysis

**UNIT III FINITE VOLUME METHOD 15**

Diffusion problems – explicit and implicit time integration; Convection - diffusion problems – properties of discretization schemes, central, upwind, hybrid, QUICK schemes; Solution of discretized equations.

**UNIT IV FLOW FIELD COMPUTATION 6**

Pressure velocity coupling, staggered grid, SIMPLE algorithm, PISO algorithm for steady and unsteady flows

**UNIT V GRID GENERATION 6**

Physical aspects, simple and multiple connected regions, grid generation by PDE solution, grid generation by algebraic mapping

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

CO1: Understand the basics of CFD and governing equations for conservation of mass momentum and energy

CO2: Understand mathematical characteristics of partial differential equations.

CO3: Learn computational solution techniques for time integration of ordinary differential equations and understand various discretization techniques used in CFD

CO4: Understand flow field computation techniques for steady and unsteady flows

CO5: Understand various turbulence models and grid generation techniques.

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 3 | 3 | - | 3 |
| CO2 | 3 | 1 | 3 | 3 | - | 3 |
| CO3 | 3 | 1 | 3 | 3 | - | 3 |
| CO4 | 3 | 1 | 3 | 3 | - | 3 |
| CO5 | 3 | 1 | 3 | 3 | - | 3 |
| Overall | 3 | 1 | 3 | 3 | - | 3 |

**REFERENCES**

1. Anderson, J. D., Computational Fluid Dynamics: The Basics with Applications, McGraw-Hill, 1995
2. Chung, T. J., Computational Fluid Dynamics, Cambridge University Press, 2003
3. Fletcher, C. A. J., Computational Techniques for Fluid Dynamics, Springer Verlag, 1997
4. Ghoshdastidar, P. S., Computer Simulation of flow and heat transfer, Tata McGraw – Hill Publishing Company Ltd. 1998
5. Muralidhar, K., and Sundararajan, T., Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 2001
6. Subas, V. Patankar, Numerical heat transfer fluid flow, Hemisphere Publishing Corporation, 1980
7. Taylor, C. and Hughes, J .B., Finite Element Programming of the Navier Stokes Equation, Pineridge Press Limited, U.K., 1981
8. Versteeg, H. K. and Malalasekera, W., Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson Education Ltd., 2007

| CX4010 | REMOTE SENSING AND GIS APPLICATIONS IN ENVIRONMENTAL MANAGEMENT | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

- To enable the students to understand the application of remote sensing
- To understand the classification of remote sensing techniques
- To learn the usage of data and image processing in remote predictions
- To know data analysis and data structures separately and in combination with GIS techniques
- To apply RS and GIS in environmental monitoring and resource management

**UNIT I OVERVIEW OF REMOTE SENSING 5**

Historical Perspective, Principles of remote sensing, components of Remote Sensing, Energy source and electromagnetic radiation, Energy interaction, Spectral response pattern of earth surface features

**UNIT II REMOTESENSING TECHNOLOGY 11**

Classification of Remote Sensing Systems, Energy recording technology, Aerial photographs, Photographic systems – Across track and along track scanning, Multispectral remote sensing, Thermal remote sensing, Microwave remote sensing – Active and passive sensors, RADAR, LIDAR, Satellites and their sensors, Indian space programme - Research and development

**UNIT III DATA PROCESSING 11**

Characteristics of Remote Sensing data, Photogrammetry – Satellite data analysis–Visual image interpretation, Digital image processing – Image rectification, enhancement, transformation, Classification, Data merging, RS–GIS Integration, Image processing software

**UNIT IV GEOGRAPHICAL INFORMATION SYSTEM 6**

GIS Concepts – Spatial and non spatial data, Vector and raster data structures, Data analysis, Data base management–GIS software

**UNIT V REMOTE SENSING AND GIS APPLICATIONS 12**

Monitoring and management of environment, Conservation of resources, Sustainable land use, Coastal zone management–Limitations: case studies

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

CO1: Gain knowledge about the fundamental principles of remote sensing and its application in mapping of geography

CO2: Classify remote sensing and recording systems
CO3: Utilize remote sensing data and analyze using image processing techniques.
CO4: Understand GIS concepts and data structures
CO5: Understand techniques for monitoring and managing the environmental changes

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 1 | 1 | 2 | 1 | - | - |
| CO2 | 1 | 1 | 2 | 1 | - | - |
| CO3 | 1 | 1 | 2 | 1 | - | - |
| CO4 | 1 | 1 | 2 | 1 | - | - |
| CO5 | 1 | 1 | 2 | 1 | - | - |
| Overall | 1 | 1 | 2 | 1 | - | - |

**REFERENCES**


1. Lillesand, T. M. and Kiefer, R. W, Remote sensing and image interpretation, John Wiley and sons, New York, 2004
2. Golfried Konechy, Geoinformation: Remote sensing, Photogrammetry and Geographical Information Systems, CRC press, 1st Edition, 2002
3. Burrough, P. A. and McDonnell, R. A., Principles of Geographic Information systems Oxford University Press, New York, 2001
4. Lintz, J. and Simonet, Remote sensing of Environment, Addison Wesley Publishing Company, New Jersey, 1998
5. Pmapler and Applications of Imaging RADAR, Manual of Remote Sensing, Vol.2, ASPR, 2001


**CX4011 PROJECT ENGINEERING OF PROCESS PLANTS** **L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To know the systematic procedure to initiate a project
- To learn the various aspects of financial planning
- To know the criteria for site selection and commissioning a project
- To gain knowledge about design for safety and pollution control
- To understand the government taxation and regulation policies

**UNIT I INTRODUCTION** **9**

Project definition, Project Profile and standards, Feedback information (MIS), Evaluation and Modification, Selection, Criteria

**UNIT II PROJECT PLANNING** **9**

Planning the process, Strategic and Managerial Planning, Organizing the process planning, cost and costing, Cost Control systems, Economic Balancing, Network Planning, Methods (PERT/CPM), Engineering Flow Diagrams, Cost requirements, Analysis and Estimation of Process Feasibilities (Technical/Economical) Analysis, Cost – Benefit Ratio Analysis, Project Budgeting, Capital Requirements, capital Market, Cash Flow Analysis, Breakeven strategies.

**UNIT III SITE SELECTION AND COMMISSIONING** **9**

Plant Engineering Management, Objectives, Programme, Control, Plant Location and Site Selection, Layout diagrams, storage of raw materials: Selection and procurement to equipment and machineries, Installation, Re-commission, Commissioning and performance appraisal, Strategies choice and Influence, Product planning and development, Provision and maintenance of service facilities.

**UNIT IV POLLUTION ABATEMENT AND SAFETY IN DESIGN 9**

Process safety, Materials safety and Handling regulations, Safety in equipment and machinery operations, Design considerations of safety organization and control, Pollution, Pollution control and Abatement, Industrial Safety Standard Analysis

**UNIT V TAX AND GOVERNMENT POLICIES 9**

Government regulations on procurement of raw materials and its allocation, Export – Import regulations, Pricing policy, Industrial licensing procedure, Excise and other commercial taxes, Policies on depreciation and corporate tax, Labour laws, Social welfare legal measurements, Factory act, Regulations of Pollution Control Board.

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

CO1: Obtain basic knowledge on subject and various graphical representations of a process plant
CO2: Carry out the primary techno-economic feasibility of project.
CO3: Understand the sequential process in starting a Chemical Plant
CO4: Gain knowledge on Safety, Environmental and Legal aspects of Process Plants
CO5: Obtain knowledge on procedures involved in Taxes, Export/ Import, Licensing etc.,

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 3 | 3 | 2 | 1 |
| CO2 | 3 | 1 | 3 | 3 | 2 | 1 |
| CO3 | 3 | 1 | 3 | 3 | 2 | 1 |
| CO4 | 3 | 1 | 3 | 3 | 2 | 1 |
| CO5 | 3 | 1 | 3 | 3 | 3 | 1 |
| Overall | 3 | 1 | 3 | 3 | 3 | 1 |

**REFERENCES**


1. Cheremisinoff, N. P., Practical Guide to Industrial Safety: Methods for Process Safety Professionals, CRC Press, 2001
2. Couper, J. R., Process Engineering Economics, CRC Press, 2003
3. Perry, J. H., Chemical Engineer's Hand Book, 8th Ed., McGraw Hill, New York, 2007
4. Peters, M. S., Timmerhaus, C. D. and West, R. E., Plant Design and Economics for Chemical Engineers, 5th Edn., McGraw Hill, 2003
5. Silla, H., Chemical Process Engineering: Design and Economics, CRC Press, 2003
6. Vinoski, W., Plant Management Handbook, Pearson Education, Limited, 1998
7. Watermeyer, P., Handbook for Process Plant Project Engineers, John Wiley and Sons, 2002




**CX4012 PROCESS INTENSIFICATION**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

- To understand the concept of Process Intensification.
- To know the limitations of intensification by miniaturization
- To apply the techniques of intensification to mixing in chemical processes.
- To develop heating equipment used for intensifying the processes.
- To infer alternative solutions in the environmental protection, energy economy and social acceptance.

**UNIT I INTRODUCTION 9**

Introduction: Techniques of Process Intensification (PI) Applications, The philosophy and

opportunities of Process Intensification, Main benefits from process intensification, Process Intensifying Equipment, Process intensification toolbox, Techniques for PI application.

**UNIT II MINIATURIZATION AND MICROFABRICATION 9**

Process Intensification through micro reaction technology: Effect of miniaturization on unit operations and reactions, Implementation of Micro-reaction Technology, From basic Properties To Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential Solutions, Micro-fabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes.

**UNIT III MIXING AND PROCESS INTENSIFICATION 9**

Scales of mixing, Flow patterns in reactors, mixing in stirred tanks: Scale up of mixing, Heat transfer. Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer Ultrasound Atomization, Nebulizers, High intensity inline MIXERS reactors Static mixers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, Higbe reactors.

**UNIT IV HEAT EXCHANGER INTENSIFICATION 9**

Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modeling, Reactive Extraction Case Studies: Absorption of NOx Coke Gas Purification. Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers, Micro channel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example.

**UNIT V: ENERGY INTENSIFICATION 9**

Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell, Microwaves, Electrostatic fields, Sono-crystallization, Reactive separations, Super critical fluids

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

At the end of this course, students are able to:

CO1: Assess the values and limitations of process intensification, cleaner technologies and waste minimization options.

CO2: Measure and monitor the usage of raw materials and wastes generating from production and frame the strategies for reduction, reuse and recycle.

CO3: Obtain alternative solutions ensuring a more sustainable future based on environmental protection, economic viability and social acceptance.

CO4: Analyze data, observe trends and relate this to other variables.

CO5: Plan for research in new energy systems, materials and process intensification.

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 1 | 1 | 3 | 2 | - | 2 |
| CO2 | 1 | 1 | 3 | 2 | - | 2 |
| CO3 | 1 | 1 | 3 | 2 | - | 2 |
| CO4 | 1 | 1 | 3 | 2 | - | 2 |
| CO5 | 1 | 1 | 3 | 2 | - | 2 |
| Overall | 1 | 1 | 3 | 2 | - | 2 |

**REFERENCES:**

1. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003.

2. Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth Heinemann, 2008
3. Kamelia Boodhoo (Editor), Adam Harvey (Editor), Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, Wiley, 2013
4. Segovia-Hernández, Juan Gabriel, Bonilla-Petriciolet, Adrián (Eds.)., Process Intensification in Chemical Engineering Design Optimization and Control, Springer, 2016
5. Reay, Ramshaw, Harvey, Process Intensification, Engineering for Efficiency, Sustainability and Flexibility, Butterworth-Heinemann, 2013

| CX4013 | MEMBRANE TECHNOLOGY FOR WATER AND WASTE WATER TREATMENT | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

- To make students understand the principles behind separation systems
- To gain knowledge about membrane processes and systems
- To know the historical developments in membrane bioreactor technology
- To study the pretreatment system required for membrane safety and improved life
- To gain knowledge from past case studies to design and achieve ZLD

**UNIT I INTRODUCTION 9**

Solid Liquid separation systems – Filtration systems – Theory of Membrane separation – mass Transport Characteristics Cross Flow filtration - Membrane Filtration-Types and choice of membranes, porous, nonporous, symmetric and asymmetric–Plate and Frame, spiral wound and hollow fibre membranes – Liquid Membranes

**UNIT II MEMBRANE PROCESSES AND SYSTEMS 9**

Microfiltration – Ultra filtration – NanoFiltration – Reverse Osmosis – Electro dialysis – Pervaporation - Membrane manufactures – Membrane Module / Element designs – Membrane System components – Design of Membrane systems - pump types and Pump selection – Plant operations – Economics of Membrane systems: reject management, recycling of used membrane

**UNIT III MEMBRANE BIOREACTORS 9**

Introduction and Historical Perspective of MBRs, Biotreatment Fundamentals, Biomass Separation MBR Principles, Fouling and Fouling Control, MBR Design Principles, Design Assignment, Alternative MBR Configurations, Commercial Technologies, Case Studies

**UNIT IV PRETREATMENT SYSTEMS 9**

Membrane Fouling – Pretreatment methods and strategies – monitoring of Pretreatment –Langlier Index, Silt Density Index, Chemical cleaning, Biofoulant control

**UNIT V CASE STUDIES 9**

Case studies on the design of membrane based water and wastewater treatment systems – zero Liquid effluent discharge Plants

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

On successful completion of the course, the students will be able to

CO1: Understand the basic principle, different types of membrane and membrane modules
CO2: Understand the various membrane process and design of membrane systems
CO3: Understand the concepts of MBRs, Configuration and their design aspects
CO4: Understand operational issues, limitations and System Configuration
CO5: Design, using appropriate combinations of unit processes and waste water treatment plant

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 1 | 1 | 3 | 3 | 1 | 1 |
| CO2 | 1 | 1 | 3 | 3 | 1 | 1 |
| CO3 | 1 | 1 | 3 | 3 | 1 | 1 |
| CO4 | 1 | 1 | 3 | 3 | 1 | 1 |
| CO5 | 2 | 1 | 3 | 3 | 1 | 1 |
| Overall | 1 | 1 | 3 | 3 | 1 | 1 |

**REFERENCES**


1. Jorgen Wagner, Membrane Filtration handbook, Practical Tips and Hints, Second Edition, Revision 2, Osmonics Inc., 2001
2. K. Yamamoto and Urase T, Membrane Technology in Environmental management, special issue, Water Science and technology, Vol.41, IWA Publishing, 2000
3. Mulder, M., Basic Principle of Membrane Technology, Kluwer Academic Publishers, 1996
4. Rajindar Singh., Membrane Technology and Engineering for Water Purification Application, Systems Design and Operation, 2nd Edn. Butterworth - Heinemann., 2015
5. Nicholas P. Hankins., and Rajindar Singh., Emerging Membrane Technology for Sustainable Water Treatment, Elsevier Science., 2016


**CX4014 GAS TRANSPORTATION L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To gain knowledge on pipeline transportation
- To study about pipeline transport of multi phase components
- To learn about the selection of right type of pipe transport and accessories
- To gather knowledge about various types of pipes, pipeline protection techniques and
- To know the fundamentals of design of pipeline

**UNIT I INTRODUCTION 9**

Introduction, widespread use, the various types, the advantages and the special features of pipelines

**UNIT II MULTI PHASE FLOW IN PIPELINES 9**

The fluid mechanics of various types of pipe flow including incompressible and compressible flows of Newtonian fluids, non-Newtonian fluids, flow of solid / liquid mixture (slurry), flow of solid / air mixture (pneumatic transport), and flow of capsules (capsule pipelines)

**UNIT III TYPES OF PIPES AND ACCESSORIES 9**

Various types of pipes (steel, concrete, PE, PVC, etc.), valves (gate, globe, ball, butterfly, etc.) and pressure regulators in pipelines, Blowers and compressors (for gases), Various kinds of flow meters, sensors, pigs (scrapers) and automatic control systems used in pipelines

**UNIT IV PIPELINE PROTECTION 9**

Various means to protect pipelines against freezing, abrasion and corrosion, such as cathodic protection, Planning, construction and operation of pipelines, including modern use of advanced technologies such as global positioning systems (GPS), directional drillings, automatic control using computers, and pipe line integrity monitoring such as leak detection.

**UNIT V PIPELINE DESIGN 9**

Structural design of pipe line load considerations and pipe deformation and failure. Economics of pipelines including life-cycle, Cost analysis and comparison of the cost effectiveness of pipelines with alternative modes of transport such as truck or railroad. Legal, safety and environmental

issues about pipelines

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

On successful completion of the course, the students will be able to
CO1: Understand the types and uses of pipelines in fluid transportation
CO2: Understand the mechanics of three-phase flow
CO3: Acquire knowledge about variety of pipelines and their accessories for specific applications
CO4: Learn the modern techniques adopted for pipeline protection, integrity and leak detection
CO5: Perform structural design and life cycle analysis for pipeline transportation

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 3 | 1 | 3 | 1 |
| CO2 | 3 | 1 | 3 | 1 | 3 | 1 |
| CO3 | 3 | 1 | 3 | 1 | 3 | 1 |
| CO4 | 3 | 1 | 3 | 1 | 3 | 1 |
| CO5 | 3 | 1 | 3 | 1 | 3 | 1 |
| Overall | 3 | 1 | 3 | 1 | 3 | 1 |

**REFERENCES**


1. Liu, H., R. L. Gandhi, M. R. Carstens and G. Klinzing, "Freight pipelines: current status and anticipated use," (Report of American Society of Civil Engineers (ASCE) Task Committee on freight Pipelines), ASCE J. of Transportation Engr., vol. 124, no. 4, pp.300-310, Jul/Aug 1998
2. Liu, H. and T. Marrero, "Pipeline engineering research and education at university in the United States, "C.D. Proc., Of Intl. Conf. on Engr. Education (ICEE-98), Rio de Janeiro Brazil, 15 pages, August 17-20,1998
3. Saeid Mokhatab., William A. Poe and James G., Handbook of Natural Gas Transmission and Processing, Gulf Professional Publishing, 2006
4. A P Szilas., Production and transport of oil and gas, Elsevier Science Ltd., 1986
5. Mikhail V Luri., Modeling of Oil Product and Gas Pipeline Transportation, Wiley-VCH., 2008


**CX4015 GREEN CHEMISTRY AND ENGINEERING**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

- To make students aware of global environmental issues
- To impart knowledge about pollution caused by conventional process plants
- To learn concepts behind pollution prevention, environmental risks, green chemistry
- To understand the advantages of process integration
- To know the methods to evaluate environmental costs and life cycle assessments.

**UNIT I INTRODUCTION** **9**

Overview of Major Environmental Issues, Global Environmental Issues, Air Quality Issues, Water Quality Issues, Ecology, Natural Resources, Description of Risk., Value of Risk Assessment in the Engineering Profession. Risk-Based Environmental Law, Risk Assessment Concepts, Hazard Assessment, Dose-Response, Risk Characterization

**UNIT II ENVIRONMENTAL CHEMICAL EXPOSURE** **9**

Pollution Prevention - Pollution Prevention Concepts and Terminology, Chemical Process Safety, Responsibilities for Environmental Protection, Environmental Persistence, Classifying Environmental Risks Based on Chemical Structure, Exposure Assessment for Chemicals in the Ambient Environment

**UNIT III GREEN SYNTHESIS PROCESSES 9**

Green Chemistry: Green Chemistry Methodologies, Quantitative / Optimization – Based Frameworks for the Design of Green Chemical Synthesis Pathways, Green Chemistry Pollution Prevention in Material Selection for Unit Operations. Pollution Prevention for Chemical Reactors, Pollution Prevention for Separation Devices, Pollution Prevention Applications for Separative Reactors, Pollution Prevention in Storage Tanks and Fugitive Sources

**UNIT IV PROCESS INTEGRATION 9**

Process Energy Integration - Process Mass Integration, Case Study of a Process Flow sheet - Estimation of Environmental Fates of Emissions and Wastes

**UNIT V ESTIMATION OF REALISTIC ENVIRONMENTAL COST 9**

Magnitudes of Environmental Costs: A Framework for Evaluating Environmental Costs, Hidden Environmental Costs. Liability Costs, Internal Intangible Costs, External Intangible Costs, Introduction to Product Life Cycle Concepts. Life-Cycle Assessment: Life-Cycle Impact Assessments. Streamlined Life-Cycle Assessments, Uses of Life-Cycle Studies

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

On successful completion of the course, the students will be able to

CO1: Understand the need for green processes in order to sustain natural resources

CO2: Understand the environmental depletion and risks due to pollution caused by chemical industries

CO3: Understand the fundamental concepts Green Chemistry and material selection for pollution reduction

CO4: Integrate processes for optimal chemical usage and hazardous emissions

CO5: Evaluate the magnitude of environmental costs and hidden loses due to pollution

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 3 | - | 1 | 1 |
| CO2 | 3 | 1 | 3 | - | 3 | 1 |
| CO3 | 3 | 1 | 3 | - | 3 | 1 |
| CO4 | 3 | 1 | 3 | - | 3 | 1 |
| CO5 | 3 | 1 | 3 | - | 3 | 1 |
| Overall | 3 | 1 | 3 | - | 3 | 1 |

**REFERENCES**


1. Allen, D.T., Shonnard, D.R, Green Engineering: Environmentally Conscious Design of Chemical Processes. Prentice Hall PTR 2002
2. Mukesh Doble and Anil Kumar Kruthiventi, Green Chemistry and Engineering, Elsevier, Burlington, USA, 2007
3. Concepcion Jimenez Gonzalez., and David JC Constable., Green Chemistry and Engineering, John Wiley & Sons Inc., 2011
4. Suresh S., and Sundaramurthy S., Green Chemical Engineering: An Introduction to Catalysis, Kinetics, and Chemical Processes, CRC Press, 2014
5. Anne E. Marteel - Parrish, and Martin A. Abraham., Green Chemistry and Engineering: A Pathway to Sustainability, Wiley-VCH., 2013


**CX4016 ENVIRONMENTAL SUSTAINABILITY**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

- To prepare students to take responsibility of Environmental protection
- To emphasize the concept of sustainable development
- To emphasize the importance of biodiversity protection

- To gain knowledge on impact of industrial pollution on the environment
- To acquire interest to sustainable development and pollution economics

**UNIT I INTRODUCTION 9**

Valuing the Environment: Concepts, Valuing the Environment: Methods, Property Rights, Externalities, and Environmental Problems

**UNIT II CONCEPT OF SUSTAINABILITY 9**

Sustainable Development: Defining the Concept, the Population Problem, Natural Resource Economics: An Overview, Energy, Water, Agriculture

**UNIT III SIGNIFICANCE OF BIODIVERSITY 9**

Biodiversity, Forest Habitat, Commercially Valuable Species, Stationary - Source Local Air Pollution, Acid Rain and Atmospheric Modification, Transportation

**UNIT IV POLLUTION IMPACTS 9**

Water Pollution, Solid Waste and Recycling, Toxic Substances and Hazardous Wastes, Global Warming.

**UNIT V ENVIRONMENTAL ECONOMICS 9**

Development, Poverty, and the Environment, Visions of the Future, Environmental economics and policy by Tom Tietenberg, Environmental Economics

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

On successful completion of the course, the students will be able to

CO1: Understand the value of environment and the hidden losses caused by pollution
CO2: Understand the real economics of sustainable development
CO3: Realize the loss of habitat and extinction of species due to pollution
CO4: Learn the irreversible impacts of pollution on the biosphere
CO5: Understand the impact of pollution on social life of humans and poverty

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 3 | - | 3 | - |
| CO2 | 2 | 2 | 3 | - | 3 | - |
| CO3 | 2 | 2 | 3 | - | 3 | - |
| CO4 | 2 | 2 | 3 | - | 3 | - |
| CO5 | 2 | 2 | 3 | - | 3 | - |
| Overall | 2 | 2 | 3 | - | 3 | - |

**REFERENCES**


1. Andrew Hoffman, Competitive Environmental Strategy - A Guide for the Changing Business Landscape, Island Press.
2. Stephen Doven, Environment and Sustainability Policy: Creation, Implementation, Evaluation, the Federation Press, 2005
3. Robert Brinkmann., Introduction to Sustainability, Wiley-Blackwell., 2016
4. Niko Roorda., Fundamentals of Sustainable Development, 3rd Edn, Routledge, 2020
5. Bhavik R Bakshi., Sustainable Engineering: Principles and Practice, Cambridge University Press, 2019

**CX4017** **PROCESS OPTIMIZATION** **L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To develop optimization target and objectives
- To learn mathematical tools for linear programming
- To learn the mathematical methods for NLP unconstrained optimization problems
- To learn the mathematical methods for constrained optimization problems
- To understand the techniques in multi objective optimization

**UNIT I INTRODUCTION 5**

Problem formulation, degrees of freedom analysis, objective functions, constraints and feasible region, Types of optimization problem

**UNIT II LINEAR PROGRAMMING 10**

Simplex method, Barrier method, sensitivity analysis, Examples

**UNIT III NON-LINEAR UNCONSTRAINED OPTIMIZATION 10**

Convex and concave functions unconstrained NLP, Newton‘s method Quasi-Newton’s method, Examples

**UNIT IV CONSTRAINED OPTIMIZATION 10**

Direct substitution, Quadratic programming, Penalty Barrier Augmented Lagrangian Methods

**UNIT V MULTI OBJECTIVE OPTIMIZATION 10**

Weighted Sum of Squares method, Epsilon constrains method, Goal attainment, Examples. Introduction to optimal control and dynamic optimization

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

CO1: Understand the basics problem formulation and optimization.
CO2: Understand mathematical characteristics of Linear programming.
CO3: Learn computational solution techniques for nonlinear unconstrained optimization.
CO4: Understand various techniques used in constrained optimization
CO5: Understand the optimal and dynamic optimization

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 3 | 1 | - | 1 |
| CO2 | 3 | 2 | 3 | 1 | - | 1 |
| CO3 | 3 | 2 | 3 | 1 | - | 1 |
| CO4 | 3 | 3 | 3 | 1 | - | 1 |
| CO5 | 3 | 2 | 3 | 1 | - | 1 |
| Overall | 3 | 2 | 3 | 1 | - | 1 |

**REFERENCES**


1. Diwaker, U. W., Introduction to Applied Optimization, Kluwer, 2003
2. Edgar, T. F., Himmelblau, D. M. and Ladson, L. S., Optimization of Chemical Processes, 2nd Ed., McGraw Hill, New York, 2003
3. Joshi, M. C., and Moudgalya, K. M., Optimization, The Fory and Practice, Narosa, New Delhi, 2004
4. Rao, S. S., Engineering Optimization: Theory and Practice, New Age Publishers, 2000
5. Del Castilo., and Enrique., Process Optimization, Springer US, 2007

**CX4018**

## POLYMER TECHNOLOGY

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

- To provide students with the knowledge of polymerization
- To impart knowledge on the usage of polymers in industries
- To learn the techniques for the synthesis of elastomers
- To know the role of various additives in polymer formation
- To emphasize polymer quality control and analysis

**UNIT I GENERAL ASPECTS OF POLYMERS 9**

Classification, mechanisms and methods of polymerization, properties-molecular weight, glass transition temperature, crystallinity, thermal, electrical and mechanical properties

**UNIT II APPLICATION ORIENTED POLYMERS 9**

Resins – PVC - Silicon oil and resin, fibrous polymers - nylon 66, poly acrylo nitrile, adhesives epoxides, phenol formaldehyde, urea formaldehyde

**UNIT III ELASTOMERS 9**

Natural rubber, styrene - butadiene, poly isopropane - neoprene, silicon rubber, thermoplastic elastomer

**UNIT IV PROCESSING OF POLYMERS 9**

Processing additives, plasticizer, antiaging additives, surface and optical properties, modifiers, fire retardants, additives for rubber and elastomer, various molding techniques

**UNIT V PHYSICAL AND CHEMICAL TESTING OF PLASTICS 9**

Mechanical properties, tensile strength and hardness, electrical properties, volume resistivity, dielectric strength, optical properties glass, light transmission and refractive index, chemical analysis - elemental and functional analysis.

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

On successful completion of the course, the students will be able to

CO1: Understand the basic concepts about polymer.
CO2: Learn about application orientated polymers
CO3: Gain knowledge about elastomers
CO4: Understand the processing of polymers
CO5: Understand the physical properties , test the physical properties plastics and chemical analysis of plastics

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 1 | 1 | 3 | 1 | - | 1 |
| CO2 | 1 | 1 | 3 | 1 | - | 1 |
| CO3 | 1 | 1 | 3 | 1 | - | 1 |
| CO4 | 1 | 1 | 3 | 1 | - | 1 |
| CO5 | 1 | 1 | 3 | 1 | - | 1 |
| Overall | 1 | 1 | 3 | 1 | - | 1 |

**REFERENCES**


1. Miles, D. C., & Briston, J. H., Polymer Technology, Chemical publishing Co: Inc: NY: 1979
2. Maturine Morton, “Rubber Technology”, 3rd Edition, Van Nostrand Re Inhold, NY: 1987
3. Masic, L., “Thermoplastics Materials Engineering”, Applied science publishers Ltd, NY: 1986
4. B. R. Gupta., Polymer Processing Technology, Asian Books, 2008
5. Fred W. Billmeyer., Textbook of Polymer Science, 3rd Edn. Wiley, 2007

**CX4019 ENVIRONMENTAL NANOTECHNOLOGY**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

- To learn the background of nanotechnology and its applications
- To develop knowledge in synthesizing nanomaterials and fabrication of components
- To know how to characterize and classify nanomaterials
- To study the critical behavioral change in the nanomaterials after synthesis
- To make students understand the need for nanotech in environmental applications

**UNIT I GENERAL** **9**

Background of nanotechnology, particle size and surface area, quantum dot - Converging science and technology, nanotechnology as a tool for sustainability, health, safety and environmental issues

**UNIT II SYNTHESIS AND FABRICATION OF NANOMATERIALS** **9**

Preparation of nano scale metal oxides, metals, CNT, functionalized nano porous adsorbents, nano composite- Chemical vapour deposition, sol gel, sonochemical, microwave, solvo-thermal, plasma, pulsed laser abalation, magnetron sputtering, electro spinning, Molecular imoring

**UNIT III CHARACTERISATION OF NANOMATERIALS** **9**

AFM, STM, SEM, TEM, XRD, ESCA, IR & Raman, UV-DRS, of nanomaterials for structural & chemical nature

**UNIT IV OTHER FEATURES OF NANO PARTICLES** **9**

Nanoparticle transport, aggregation & deposition, Energy applications- HYDROGEN storage

**UNIT V ENVIRONMENTAL APPLICATIONS** **9**

Gas sensors, microfludics and lab on chip, catalytic and photocatalyic applications, Nonmaterials for ground water remediation, nanomaterials as adsorbents, membrane process

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

Students will able to

CO1: Understand fundamental concepts about nanotechnology
CO2: Learn synthesis process of nanotechnology
CO3: Gain known about various methods of characterization nanoparticles
CO4: Study the applications nanoparticles in various fields
CO5: Learn in detail about the applications of nanomaterials in environmental pollution control

**COURSE ARTICULATION MATRIX:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 1 | 1 | 3 | 1 | 3 | 3 |
| CO2 | 1 | 1 | 3 | 1 | 3 | 3 |
| CO3 | 1 | 1 | 3 | 1 | 3 | 3 |
| CO4 | 1 | 1 | 3 | 1 | 3 | 3 |
| CO5 | 1 | 1 | 3 | 1 | 3 | 3 |
| Overall | 1 | 1 | 3 | 1 | 3 | 3 |

**REFERENCES**


1. Environmental applications of nanomaterials-Synthesis, Sorbents and Sensors, edited by Glen E Fryxell and Guozhong Cao, worldscibooks, UK
2. Environmental nanotechnology, Mark Wisener, Jeo Yues Bolteru, 2007, McGraw Hill
3. The Chemistry of Nanomaterials: Synthesis, Properties and applications, Edited by C. N. R. Rao

4. Mullller, A.K., Cheetham Copyright 8 2004 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim Handbook of Nanotechnology, Edi-Bharat Bhushan, Springer, 2004
5. Mark Ratner., and Daniel Ratner., Nanotechnology, Pearson Education, 2003

## AUDIT COURSES

**AX4091 ENGLISH FOR RESEARCH PAPER WRITING L T P C**
**2 0 0 0**

**COURSE OBJECTIVES:**

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

**UNIT I INTRODUCTION TO RESEARCH PAPER WRITING 6**

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

**UNIT II PRESENTATION SKILLS 6**

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

**UNIT III TITLE WRITING SKILLS 6**

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

**UNIT IV RESULT WRITING SKILLS 6**

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

**UNIT V VERIFICATION SKILLS 6**

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission

**TOTAL: 30 PERIODS**

**COURSE OUTCOMES:**

CO1 –Understand that how to improve your writing skills and level of readability
CO2 – Learn about what to write in each section
CO3 – Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

**REFERENCES:**

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

**AX4092** **DISASTER MANAGEMENT** **L T P C**
**2 0 0 0**

**COURSE OBJECTIVES:**

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

**UNIT I INTRODUCTION 6**

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

**UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 6**

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

**UNIT III DISASTER PRONE AREAS IN INDIA 6**

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

**UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 6**

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

**UNIT V RISK ASSESSMENT 6**

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

**TOTAL : 30 PERIODS**

**COURSE OUTCOMES:**

CO1: Ability to summarize basics of disaster
CO2: Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

**REFERENCES:**


1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep& Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi,2001.

**AX4093** **CONSTITUTION OF INDIA** **L T P C**
**2 0 0 0**

**COURSE OBJECTIVES:**

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

**UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION**

History, Drafting Committee, (Composition & Working)

**UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION**

Preamble, Salient Features

**UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES**

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

**UNIT IV ORGANS OF GOVERNANCE**

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

**UNIT V LOCAL ADMINISTRATION**

District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: ZilaPachayat. Elected officials and their roles, CEO ZilaPachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

**UNIT VI ELECTION COMMISSION**

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

**TOTAL: 30 PERIODS**

**COURSE OUTCOMES:**

Students will be able to:

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

**SUGGESTED READING**


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


| AX4094 | நற்றமிழ் இலக்கியம் | L T P C<br>2 0 0 0 |
|---|---|---|

**UNIT I சங்க இலக்கியம் 6**

1. தமிழின் துவக்க நூல் தொல்காப்பியம்
   – எழுத்து, சொல், பொருள்
2. அகநானூறு (82)
   - இயற்கை இன்னிசை அரங்கம்
3. குறிஞ்சிப் பாட்டின் மலர்க்காட்சி
4. புறநானூறு (95,195)

- போரை நிறுத்திய ஔவையார்

**UNIT II அறநெறித் தமிழ் 6**

1. அறநெறி வகுத்த திருவள்ளுவர்
   - அறம் வலியுறுத்தல், அன்புடைமை, ஒப்புரவறிதல், ஈகை, புகழ்
2. பிற அறநூல்கள் - இலக்கிய மருந்து
   – ஏலாதி, சிறுபஞ்சமூலம், திரிகடுகம், ஆசாரக்கோவை
   (தூய்மையை வலியுறுத்தும் நூல் )

**UNIT III இரட்டைக் காப்பியங்கள் 6**

1. கண்ணகியின் புரட்சி
   - சிலப்பதிகார வழக்குரை காதை
2. சமூகசேவை இலக்கியம் மணிமேகலை
   - சிறைக்கோட்டம் அறக்கோட்டமாகிய காதை

**UNIT IV அருள்நெறித் தமிழ் 6**

1. சிறுபாணாற்றுப்படை
   - பாரி முல்லைக்குத் தேர் கொடுத்தது, பேகன் மயிலுக்குப் போர்வை கொடுத்தது, அதியமான் ஔவைக்கு நெல்லிக்கனி கொடுத்தது, அரசர் பண்புகள்
2. நற்றிணை
   - அன்னைக்குரிய புன்னை சிறப்பு
3. திருமந்திரம் (617, 618)
   - இயமம் நியமம் விதிகள்
4. தர்மச்சாலையை நிறுவிய வள்ளலார்
5. புறநானூறு
   - சிறுவனே வள்ளலானான்
6. அகநானூறு (4) - வண்டு
   நற்றிணை (11) - நண்டு
   கலித்தொகை (11) - யானை, புறா

ஐந்திணை 50 (27) - மான்

ஆகியவை பற்றிய செய்திகள்

**UNIT V** **நவீன தமிழ் இலக்கியம்** **6**

1. உரைநடைத் தமிழ்,
   - தமிழின் முதல் புதினம்,
   - தமிழின் முதல் சிறுகதை,
   - கட்டுரை இலக்கியம்,
   - பயண இலக்கியம்,
   - நாடகம்,
2. நாட்டு விடுதலை போராட்டமும் தமிழ் இலக்கியமும்,
3. சமுதாய விடுதலையும் தமிழ் இலக்கியமும்,
4. பெண் விடுதலையும் விளிம்பு நிலையினரின் மேம்பாட்டில் தமிழ் இலக்கியமும்,
5. அறிவியல் தமிழ்,
6. இணையத்தில் தமிழ்,
7. சுற்றுச்சூழல் மேம்பாட்டில் தமிழ் இலக்கியம்.

**TOTAL : 30 PERIODS**

**<u>தமிழ் இலக்கிய வெளியீடுகள் / புத்தகங்கள்</u>**

1. தமிழ் இணைய கல்விக்கழகம் (Tamil Virtual University)
   - www.tamilvu.org
2. தமிழ் விக்கிப்பீடியா (Tamil Wikipedia)
   -https://ta.wikipedia.org
3. தர்மபுர ஆதீன வெளியீடு
4. வாழ்வியல் களஞ்சியம்
   - தமிழ்ப் பல்கலைக்கழகம், தஞ்சாவூர்
5. தமிழ்கலைக் களஞ்சியம்
   - தமிழ் வளர்ச்சித் துறை (thamilvalarchithurai.com)
6. அறிவியல் களஞ்சியம்
   - தமிழ்ப் பல்கலைக்கழகம், தஞ்சாவூர்

**OCE431 INTEGRATED WATER RESOURCES MANAGEMENT L T P C**
**3 0 0 3**

**OBJECTIVE**

- Students will be introduced to the concepts and principles of IWRM, which is inclusive of the economics, public-private partnership, water & health, water & food security and legal & regulatory settings.

**UNIT I CONTEXT FOR IWRM 9**

Water as a global issue: key challenges – Definition of IWRM within the broader context of development – Key elements of IWRM - Principles – Paradigm shift in water management - Complexity of the IWRM process – UN World Water Assessment - SDGs.

**UNIT II WATER ECONOMICS 9**

Economic view of water issues: economic characteristics of water good and services – Non-market monetary valuation methods – Water economic instruments – Private sector involvement in water resources management: PPP objectives, PPP models, PPP processes, PPP experiences through case studies.

**UNIT III LEGAL AND REGULATORY SETTINGS 9**

Basic notion of law and governance: principles of international and national law in the area of water management - Understanding UN law on non-navigable uses of international water courses – International law for groundwater management – World Water Forums – Global Water Partnerships - Development of IWRM in line with legal and regulatory framework.

**UNIT IV WATER AND HEALTH WITHIN THE IWRM CONTEXT 9**

Links between water and health: options to include water management interventions for health – Health protection and promotion in the context of IWRM – Global burden of Diseases - Health impact assessment of water resources development projects – Case studies.

**UNIT V AGRICULTURE IN THE CONCEPT OF IWRM 9**

Water for food production: 'blue' versus 'green' water debate – Water foot print - Virtual water trade for achieving global water and food security –- Irrigation efficiencies, irrigation methods - current water pricing policy– scope to relook pricing.

**TOTAL: 45 PERIODS**

**OUTCOMES**

- On completion of the course, the student is expected to be able to

| | |
|---|---|
| **CO1** | Describe the context and principles of IWRM; Compare the conventional and integrated ways of water management. |
| **CO2** | Select the best economic option among the alternatives; illustrate the pros and cons of PPP through case studies. |
| **CO3** | Apply law and governance in the context of IWRM. |
| **CO4** | Discuss the linkages between water-health; develop a HIA framework. |
| **CO5** | Analyse how the virtual water concept pave way to alternate policy options. |

**REFERENCES:**


1. Cech Thomas V., Principles of water resources: history, development, management and policy. John Wiley and Sons Inc., New York. 2003.
2. Mollinga .P. etal " Integrated Water Resources Management", Water in South Asia Volume I, Sage Publications, 2006.

3. Technical Advisory Committee, Integrated Water Resources management, Technical Advisory Committee Background Paper No: 4. Global water partnership, Stockholm, Sweden. 2002.
4. Technical Advisory Committee, Dublin principles for water as reflected in comparative assessment of institutional and legal arrangements for Integrated Water Resources Management, Technical Advisory Committee Background paper No: 3. Global water partnership, Stockholm, Sweden. 1999.
5. Technical Advisory Committee, Effective Water Governance". Technical Advisory Committee Background paper No: 7. Global water partnership, Stockholm, Sweden, 2003.

**OCE432 WATER, SANITATION AND HEALTH L T P C**
**3 0 0 3**

**OBJECTIVES:**

• Understand the accelerating health impacts due to the present managerial aspects and initiatives in water and sanitation and health sectors in the developing scenario

**UNIT I FUNDAMENTALS WASH 9**

Meanings and Definition: Safe Water- Health, Nexus: Water- Sanitation - Health and Hygiene – Equity issues-Water security - Food Security. Sanitation And Hygiene (WASH) and Integrated Water Resources Management (IWRM) - Need and Importance of WASH

**UNIT II MANAGERIAL IMPLICATIONS AND IMPACT 9**

Third World Scenario – Poor and Multidimensional Deprivation--Health Burden in Developing Scenario -Factors contribute to water, sanitation and hygiene related diseases-Social: Social Stratification and Literacy Demography: Population and Migration- Fertility - Mortality-Environment: Water Borne-Water Washed and Water Based Diseases - Economic: Wage - Water and Health Budgeting -Psychological: Non-compliance - Disease Relapse - Political: Political Will.

**UNIT III CHALLENGES IN MANAGEMENT AND DEVELOPMENT 9**

Common Challenges in WASH - Bureaucracy and Users- Water Utilities -Sectoral Allocation:-Infrastructure- Service Delivery: Health services: Macro and Micro- level: Community and Gender Issues- Equity Issues - Paradigm Shift: Democratization of Reforms and Initiatives.

**UNIT IV GOVERNANCE 9**

Public health -Community Health Assessment and Improvement Planning (CHA/CHIP)-Infrastructure and Investments on Water, (WASH) - Cost Benefit Analysis – Institutional Intervention-Public Private Partnership - Policy Directives - Social Insurance -Political Will vs Participatory Governance -

**UNIT V INITIATIVES 9**

Management vs Development -Accelerating Development- Development Indicators -Inclusive Development-Global and Local- Millennium Development Goal (MDG) and Targets - Five Year Plans - Implementation - Capacity Building - Case studies on WASH.

**TOTAL: 45 PERIODS**

**OUTCOMES:**

| | |
|---|---|
| **CO1** | Capture to fundamental concepts and terms which are to be applied and understood all through the study. |
| **CO2** | Comprehend the various factors affecting water sanitation and health through the lens of third world scenario. |

| | |
|---|---|
| **CO3** | Critically analyse and articulate the underlying common challenges in water, sanitation and health. |
| **CO4** | Acquire knowledge on the attributes of governance and its say on water sanitation and health. |
| **CO5** | Gain an overarching insight in to the aspects of sustainable resource management in the absence of a clear level playing field in the developmental aspects. |

**REFERENCES**


1. Bonitha R., Beaglehole R.,Kjellstorm, 2006, "Basic Epidemiology", 2nd Edition, World Health Organization.
2. Van Note Chism, N. and Bickford, D. J. (2002), Improving the environment for learning: An expanded agenda. New Directions for Teaching and Learning, 2002: 91–98. doi: 10.1002/tl.83Improving the Environment for learning: An Expanded Agenda
3. National Research Council. *Global Issues in Water, Sanitation, and Health: Workshop Summary***.** Washington, DC: The National Academies Press, 2009.
4. Sen, Amartya 1997. On Economic Inequality. Enlarged edition, with annex by JamesFoster and Amartya Sen, Oxford: Claredon Press, 1997.
5. Intersectoral Water Allocation Planning and Management, 2000, World Bank Publishers www. Amazon.com
6. Third World Network.org (www.twn.org).


**OCE433 PRINCIPLES OF SUSTAINABLE DEVELOPMENT L T P C**
**3 0 0 3**

**OBJECTIVES:**

- To impart knowledge on environmental, social and economic dimensions of sustainability and the principles evolved through landmark events so as to develop an action mindset for sustainable development.

**UNIT I SUSTAINABILITY AND DEVELOPMENT CHALLEGES 9**

Definition of sustainability – environmental, economical and social dimensions of sustainability - sustainable development models – strong and weak sustainability – defining development-millennium development goals – mindsets for sustainability: earthly, analytical, precautionary, action and collaborative– syndromes of global change: utilisation syndromes, development syndromes, and sink syndromes – core problems and cross cutting Issues of the 21 century - global, regional and local environmental issues – social insecurity - resource degradation –climate change – desertification.

**UNIT II PRINCIPLES AND FRAME WORK 9**

History and emergence of the concept of sustainable development - our common future - Stockholm to Rio plus 20– Rio Principles of sustainable development – Agenda 21 natural step-peoples earth charter – business charter for sustainable development –UN Global Compact - Role of civil society, business and government – United Nations' 2030 Agenda for sustainable development – 17 sustainable development goals and targets, indicators and intervention areas

**UNIT III SUSTAINABLE DEVELOPMENT AND WELLBEING 9**

The Unjust World and inequities - Quality of Life - Poverty, Population and Pollution - Combating Poverty - - Demographic dynamics of sustainability - Strategies to end Rural and Urban Poverty and Hunger – Sustainable Livelihood Framework- Health, Education and Empowerment of

Women, Children, Youth, Indigenous People, Non-Governmental Organizations, Local Authorities and Industry for Prevention, Precaution , Preservation and Public participation.

**UNIT IV SUSTAINABLE SOCIO-ECONOMIC SYSTEMS 10**

Sustainable Development Goals and Linkage to Sustainable Consumption and Production – Investing in Natural Capital- Agriculture, Forests, Fisheries - Food security and nutrition and sustainable agriculture- Water and sanitation - Biodiversity conservation and Ecosystem integrity – Ecotourism - Sustainable Cities – Sustainable Habitats- Green Buildings - Sustainable Transportation –– Sustainable Mining - Sustainable Energy– Climate Change –Mitigation and Adaptation - Safeguarding Marine Resources - Financial Resources and Mechanisms

**UNIT V ASSESSING PROGRESS AND WAY FORWARD 8**

Nature of sustainable development strategies and current practice**-** Sustainability in global, regional and national context –Approaches to measuring and analysing sustainability– limitations of GDP- Ecological Footprint- Human Development Index- Human Development Report – National initiatives for Sustainable Development - Hurdles to Sustainability - Science and Technology for sustainable development –Performance indicators of sustainability and Assessment mechanism – Inclusive Green Growth and Green Economy – National Sustainable Development Strategy Planning and National Status of Sustainable Development Goals

**TOTAL: 45 PERIODS**

**OUTCOMES:**

- On completion of the course, the student is expected to be able to

| | |
|---|---|
| CO1 | Explain and evaluate current challenges to sustainability, including modern world social, environmental, and economic structures and crises. |
| CO2 | Identify and critically analyze the social environmental, and economic dimensions of sustainability in terms of UN Sustainable development goals |
| CO3 | Develop a fair understanding of the social, economic and ecological linkage of Human well being, production and consumption |
| CO4 | Evaluate sustainability issues and solutions using a holistic approach that focuses on connections between complex human and natural systems. |
| CO5 | Integrate knowledge from multiple sources and perspectives to understand environmental limits governing human societies and economies and social justice dimensions of sustainability. |

**REFERENCES:**


1. Tom Theis and Jonathan Tomkin, Sustainability: A Comprehensive Foundation, Rice University, Houston, Texas, 2012
2. A guide to SDG interactions:from science to implementation, International Council for Science, Paris,2017
3. Karel Mulder, Sustainable Development for Engineers - A Handbook and Resource Guide, Rouledge Taylor and Francis, 2017.
4. The New Global Frontier - Urbanization, Poverty and Environmentin the 21st Century - *George Martine,Gordon McGranahan,Mark Montgomery and Rogelio Fernández-Castilla,* IIED and UNFPA, Earthscan, UK, 2008
5. Nolberto Munier, Introduction to Sustainability: Road to a Better Future, Springer, 2006
6. Barry Dalal Clayton and Stephen Bass, Sustainable Development Strategies- a resource book", Earthscan Publications Ltd, London, 2002.

**OCE434 ENVIRONMENTAL IMPACT ASSESSMENT L T P C**

**3 0 0 3**

**OBJECTIVES:**

- To make the students to understand environmental clearance, its legal requirements and to provide knowledge on overall methodology of EIA, prediction tools and models, environmental management plan and case studies.

**UNIT I INTRODUCTION 9**

Historical development of Environmental Impact Assessment (EIA). Environmental Clearance- EIA in project cycle. legal and regulatory aspects in India – types and limitations of EIA –EIA process-screening – scoping - terms of reference in EIA- setting – analysis – mitigation. Cross sectoral issues –public hearing in EIA- EIA consultant accreditation.

**UNIT II IMPACT INDENTIFICATION AND PREDICTION 10**

Matrices – networks – checklists – cost benefit analysis – analysis of alternatives – expert systems in EIA. prediction tools for EIA – mathematical modeling for impact prediction – assessment of impacts – air – water – soil – noise – biological — cumulative impact assessment

**UNIT III SOCIO-ECONOMIC IMPACT ASSESSMENT 8**

Socio-economic impact assessment - relationship between social impacts and change in community and institutional arrangements. factors and methodologies- individual and family level impacts. communities in transition-rehabilitation

**UNIT IV EIA DOCUMENTATION AND ENVIRONMENTAL MANAGEMENT PLAN 9**

Environmental management plan - preparation, implementation and review – mitigation and rehabilitation plans – policy and guidelines for planning and monitoring programmes – post project audit – documentation of EIA findings – ethical and quality aspects of environmental impact assessment

**UNIT V CASE STUDIES 9**

Mining, power plants, cement plants, highways, petroleum refining industry, storage & handling of hazardous chemicals, common hazardous waste facilities, CETPs, CMSWMF, building and construction projects

**TOTAL: 45 PERIODS**

**OUTCOMES:**

- On completion of the course, the student is expected to be able to

| | |
|---|---|
| **CO1** | Understand need for environmental clearance, its legal procedure, need of EIA, its types, stakeholders and their roles |
| **CO2** | Understand various impact identification methodologies, prediction techniques and model of impacts on various environments |
| **CO3** | Understand relationship between social impacts and change in community due to development activities and rehabilitation methods |
| **CO4** | Document the EIA findings and prepare environmental management and monitoring plan |
| **CO5** | Identify, predict and assess impacts of similar projects based on case studies |

**REFERENCES:**


1. EIA Notification 2006 including recent amendments, by Ministry of Environment, Forest and Climate Change, Government of India
2. Sectoral Guidelines under EIA Notification by Ministry of Environment, Forest and Climate Change, Government of India
3. Canter, L.W., Environmental Impact Assessment, McGraw Hill, New York. 1996
4. Lawrence, D.P., Environmental Impact Assessment – Practical solutions to recurrent problems, Wiley-Interscience, New Jersey. 2003
5. Lee N. and George C. 2000. Environmental Assessment in Developing and Transitional Countries. Chichester: Willey
6. World Bank –Source book on EIA ,1999

7. Sam Mannan, Lees' Loss Prevention in the Process Industries, Hazard Identification Assessment and Control, 4th Edition, Butterworth Heineman, 2012.

**OIC431 BLOCKCHAIN TECHNOLOGIES L T P C**
**3 0 0 3**

**COURSE OBJECTIVES**:

- This course is intended to study the basics of Blockchain technology.
- During this course the learner will explore various aspects of Blockchain technology like application in various domains.
- By implementing, learners will have idea about private and public Blockchain, and smart contract.

**UNIT I INTRODUCTION OF CRYPTOGRAPHY AND BLOCKCHAIN 9**

Introduction to Blockchain, Blockchain Technology Mechanisms & Networks, Blockchain Origins, Objective of Blockchain, Blockchain Challenges, Transactions and Blocks, P2P Systems, Keys as Identity, Digital Signatures, Hashing, and public key cryptosystems, private vs. public Blockchain.

**UNIT II BITCOIN AND CRYPTOCURRENCY 9**

Introduction to Bitcoin, The Bitcoin Network, The Bitcoin Mining Process, Mining Developments, Bitcoin Wallets, Decentralization and Hard Forks, Ethereum Virtual Machine (EVM), Merkle Tree, Double-Spend Problem, Blockchain and Digital Currency, Transactional Blocks, Impact of Blockchain Technology on Cryptocurrency.

**UNIT III INTRODUCTION TO ETHEREUM 9**

Introduction to Ethereum, Consensus Mechanisms, Metamask Setup, Ethereum Accounts, , Transactions, Receiving Ethers, Smart Contracts.

**UNIT-IV INTRODUCTION TO HYPERLEDGER AND SOLIDITY PROGRAMMING 10**

Introduction to Hyperledger, Distributed Ledger Technology & its Challenges, Hyperledger & Distributed Ledger Technology, Hyperledger Fabric, Hyperledger Composer. Solidity - Language of Smart Contracts, Installing Solidity & Ethereum Wallet, Basics of Solidity, Layout of a Solidity Source File & Structure of Smart Contracts, General Value Types.

**UNIT V BLOCKCHAIN APPLICATIONS 8**

Internet of Things, Medical Record Management System, Domain Name Service and Future of Blockchain, Alt Coins.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

**CO1**: Understand and explore the working of Blockchain technology
**CO2:** Analyze the working of Smart Contracts
**CO3:** Understand and analyze the working of Hyperledger
**CO4:** Apply the learning of solidity to build de-centralized apps on Ethereum
**CO5**: Develop applications on Blockchain

**REFERENCES:**

1. Imran Bashir, “Mastering Blockchain: Distributed Ledger Technology, Decentralization, and Smart Contracts Explained”, Second Edition, Packt Publishing, 2018.
2. Narayanan, J. Bonneau, E. Felten, A. Miller, S. Goldfeder, “Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction” Princeton University Press, 2016
3. Antonopoulos, Mastering Bitcoin, O’Reilly Publishing, 2014. .
4. Antonopoulos and G. Wood, “Mastering Ethereum: Building Smart Contracts and Dapps”, O’Reilly Publishing, 2018.
5. D. Drescher, Blockchain Basics. Apress, 2017.

**OIC432** **DEEP LEARNING** **L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- Develop and Train Deep Neural Networks.
- Develop a CNN, R-CNN, Fast R-CNN, Faster-R-CNN, Mask-RCNN for detection and recognition
- Build and train RNNs, work with NLP and Word Embeddings
- The internal structure of LSTM and GRU and the differences between them
- The Auto Encoders for Image Processing

**UNIT I DEEP LEARNING CONCEPTS** **6**

Fundamentals about Deep Learning. Perception Learning Algorithms. Probabilistic modelling. Early Neural Networks. How Deep Learning different from Machine Learning. Scalars. Vectors. Matrixes, Higher Dimensional Tensors. Manipulating Tensors. Vector Data. Time Series Data. Image Data. Video Data.

**UNIT II NEURAL NETWORKS** **9**

About Neural Network. Building Blocks of Neural Network. Optimizers. Activation Functions. Loss Functions. Data Pre-processing for neural networks, Feature Engineering. Overfitting and Underfitting. Hyperparameters.

**UNIT III CONVOLUTIONAL NEURAL NETWORK** **10**

About CNN. Linear Time Invariant. Image Processing Filtering. Building a convolutional neural network. Input Layers, Convolution Layers. Pooling Layers. Dense Layers. Backpropagation Through the Convolutional Layer. Filters and Feature Maps. Backpropagation Through the Pooling Layers. Dropout Layers and Regularization. Batch Normalization. Various Activation Functions. Various Optimizers. LeNet, AlexNet, VGG16, ResNet. Transfer Learning with Image Data. Transfer Learning using Inception Oxford VGG Model, Google Inception Model, Microsoft ResNet Model. R-CNN, Fast R-CNN, Faster R-CNN, Mask-RCNN, YOLO

**UNIT IV NATURAL LANGUAGE PROCESSING USING RNN** **10**

About NLP & its Toolkits. Language Modeling . Vector Space Model (VSM). Continuous Bag of Words (CBOW). Skip-Gram Model for Word Embedding. Part of Speech (PoS) Global Co-occurrence Statistics–based Word Vectors. Transfer Learning. Word2Vec. Global Vectors for Word Representation GloVe. Backpropagation Through Time. Bidirectional RNNs (BRNN) . Long Short Term Memory (LSTM). Bi-directional LSTM. Sequence-to-Sequence Models (Seq2Seq). Gated recurrent unit GRU.

**UNIT V DEEP REINFORCEMENT & UNSUPERVISED LEARNING** **10**

About Deep Reinforcement Learning. Q-Learning. Deep Q-Network (DQN). Policy Gradient Methods. Actor-Critic Algorithm. About Autoencoding. Convolutional Auto Encoding. Variational Auto Encoding. Generative Adversarial Networks. Autoencoders for Feature Extraction. Auto Encoders for Classification. Denoising Autoencoders. Sparse Autoencoders

**COURSE OUTCOMES:**

**CO1:** Feature Extraction from Image and Video Data
**CO2:** Implement Image Segmentation and Instance Segmentation in Images
**CO3**: Implement image recognition and image classification using a pretrained network (Transfer Learning)
**CO4:** Traffic Information analysis using Twitter Data
**CO5:** Autoencoder for Classification & Feature Extraction

**TOTAL : 45 PERIODS**

**REFERENCES**

1. Deep Learning A Practitioner's Approach Josh Patterson and Adam Gibson O'Reilly Media, Inc.2017
2. Learn Keras for Deep Neural Networks, Jojo Moolayil, Apress,2018

3. Deep Learning Projects Using TensorFlow 2, Vinita Silaparasetty, Apress, 2020
4. Deep Learning with Python, FRANÇOIS CHOLLET, MANNING SHELTER ISLAND,2017
5. Pro Deep Learning with TensorFlow, Santanu Pattanayak, Apress,2017

**OME431 VIBRATION AND NOISE CONTROL STRATEGIES L T P C**
**3 0 0 3**

**OBJECTIVES**

- To appreciate the basic concepts of vibration in damped and undamped systems
- To appreciate the basic concepts of noise, its effect on hearing and related terminology
- To use the instruments for measuring and analyzing the vibration levels in a body
- To use the instruments for measuring and analyzing the noise levels in a system
- To learn the standards of vibration and noise levels and their control techniques

**UNIT- I BASICS OF VIBRATION 9**

Introduction – Sources and causes of Vibration-Mathematical Models - Displacement, velocity and Acceleration - Classification of vibration: free and forced vibration, undamped and damped vibration, linear and non-linear vibration - Single Degree Freedom Systems - Vibration isolation - Determination of natural frequencies

**UNIT- II BASICS OF NOISE 9**

Introduction - Anatomy of human ear - Mechanism of hearing - Amplitude, frequency, wavelength and sound pressure level - Relationship between sound power, sound intensity and sound pressure level - Addition, subtraction and averaging decibel levels - sound spectra -Types of sound fields - Octave band analysis - Loudness.

**UNIT- III INSTRUMENTATION FOR VIBRATION MEASUREMENT 9**

Experimental Methods in Vibration Analysis.- Vibration Measuring Instruments - Selection of Sensors - Accelerometer Mountings - Vibration Exciters - Mechanical, Hydraulic, Electromagnetic and Electrodynamics – Frequency Measuring Instruments -. System Identification from Frequency Response -Testing for resonance and mode shapes

**UNIT- IV INSTRUMENTATION FOR NOISE MEASUREMENT AND ANALYSIS 9**

Microphones - Weighting networks - Sound Level meters, its classes and calibration - Noise measurements using sound level meters - Data Loggers - Sound exposure meters - Recording of noise - Spectrum analyser - Intensity meters - Energy density sensors - Sound source localization.

**UNIT- V METHODS OF VIBRATION CONTROL, SOURCES OF NOISE AND ITS CONTROL 9**

Specification of Vibration Limits – Vibration severity standards - Vibration as condition Monitoring Tool – Case Studies - Vibration Isolation methods - Dynamic Vibration Absorber – Need for Balancing - Static and Dynamic Balancing machines – Field balancing - Major sources of noise - Noise survey techniques – Measurement technique for vehicular noise - Road vehicles Noise standard – Noise due to construction equipment and domestic appliances – Industrial noise sources and its strategies – Noise control at the source – Noise control along the path – Acoustic Barriers – Noise control at the receiver -- Sound transmission through barriers – Noise reduction Vs Transmission loss - Enclosures

**TOTAL: 45 PERIODS**

**OUTCOMES:**

On Completion of the course the student will be able to

1. apply the basic concepts of vibration in damped and undamped systems
2. apply the basic concepts of noise and to understand its effects on systems
3. select the instruments required for vibration measurement and its analysis

4. select the instruments required for noise measurement and its analysis.
5. recognize the noise sources and to control the vibration levels in a body and to control noise under different strategies.

**REFERENCES:**

1. Singiresu S. Rao, “Mechanical Vibrations”, Pearson Education Incorporated, 2017.
2. Graham Kelly. Sand Shashidhar K. Kudari, “Mechanical Vibrations”, Tata McGraw –Hill Publishing Com. Ltd., 2007.
3. Ramamurti. V, “Mechanical Vibration Practice with Basic Theory”, Narosa Publishing House, 2000.
4. William T. Thomson, “Theory of Vibration with Applications”, Taylor & Francis, 2003.
5. G.K. Grover, “Mechanical Vibrations”, Nem Chand and Bros.,Roorkee, 2014.
6. A.G. Ambekar, “Mechanical Vibrations and Noise Engineering”, PHI Learning Pvt. Ltd., 2014.
7. David A. Bies and Colin H. Hansen, “Engineering Noise Control – Theory and Practice”, Spon Press, London and New York, 2009.

**OME432ENERGY CONSERVATION AND MANAGEMENT IN DOMESTIC SECTORS** **L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

1. To learn the present energy scenario and the need for energy conservation.
2. To understand the different measures for energy conservation in utilities.
3. Acquaint students with principle theories, materials, and construction techniques to create energy efficient buildings.
4. To identify the energy demand and bridge the gap with suitable technology for sustainable habitat
5. To get familiar with the energy technology, current status of research and find the ways to optimize a system as per the user requirement

**UNIT I ENERGY SCENARIO** **9**

Primary energy resources - Sectorial energy consumption (domestic, industrial and other sectors), Energy pricing, Energy conservation and its importance, Energy Conservation Act-2001 and its features – Energy star rating.

**UNIT II HEATING, VENTILLATION & AIR CONDITIONING** **9**

Basics of Refrigeration and Air Conditioning – COP / EER / SEC Evaluation – SPV system design & optimization for Solar Refrigeration.

**UNIT III LIGHTING, COMPUTER, TV** **9**

Specification of Luminaries – Types – Efficacy – Selection & Application – Time Sensors – Occupancy Sensors – Energy conservation measures in computer – Television – Electronic devices.

**UNIT IV ENERGY EFFICIENT BUILDINGS** **9**

Conventional versus Energy efficient buildings – Landscape design – Envelope heat loss and heat gain – Passive cooling and heating – Renewable sources integration.

**UNIT V ENERGY STORAGE TECHNOLOGIES** **9**

Necessity & types of energy storage – Thermal energy storage – Battery energy storage, charging and discharging– Hydrogen energy storage & Super capacitors – energy density and safety issues – Applications.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

1. Understand technical aspects of energy conservation scenario.
2. Energy audit in any type for domestic buildings and suggest the conservation measures.
3. Perform building load estimates and design the energy efficient landscape system.
4. Gain knowledge to utilize an appliance/device sustainably.
5. Understand the status and current technological advancement in energy storage field.

**REFERENCES:**

1. Yogi Goswami, Frank Kreith, Energy Efficiency and Renewable energy Handbook, CRC Press, 2016
2. ASHRAE Handbook 2020 – HVAC Systems & Equipment
3. Paolo Bertoldi, Andrea Ricci, Anibal de Almeida, Energy Efficiency in Household Appliances and Lighting, Conference proceedings, Springer, 2001
4. David A. Bainbridge, Ken Haggard, Kenneth L. Haggard, Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting, and More Using Natural Flows, Chelsea Green Publishing, 2011.
5. Guide book for National Certification Examination for Energy Managers and Energy Auditors
(Could be downloaded from www.energymanagertraining.com)
6. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.
7. Robert Huggins, Energy Storage: Fundamentals, Materials and Applications, 2nd edition, Springer, 2015
8. Ru-shiliu, Leizhang, Xueliang sun, Electrochemical technologies for energy storage and conversion, Wiley publications, 2012.

**OME433 ADDITIVE MANUFACTURING L T P C**
**3 0 0 3**

**UNIT I INTRODUCTION 9**

Need - Development - Rapid Prototyping Rapid Tooling – Rapid Manufacturing – Additive Manufacturing. AM Process Chain- Classification – Benefits.

**UNIT II DESIGN FOR ADDITIVE MANUFACTURING 9**

CAD Model Preparation - Part Orientation and Support Structure Generation -Model Slicing - Tool Path Generation Customized Design and Fabrication - Case Studies.

**UNIT III VAT POLYMERIZATION 9**

Stereolithography Apparatus (SLA)- Materials -Process -Advantages Limitations- Applications. Digital Light Processing (DLP) - Materials – Process - Advantages - Applications. Multi Jet Modelling (MJM) - Principles - Process - Materials - Advantages and Limitations.

**UNIT IV MATERIAL EXTRUSION AND SHEET LAMINATION 9**

Fused Deposition Modeling (FDM)- Process-Materials - Applications and Limitations. Sheet Lamination Process: Laminated Object Manufacturing (LOM)- Basic Principle- Mechanism: Gluing or Adhesive Bonding – Thermal Bonding- Materials- Application and Limitation - Bio-Additive Manufacturing Computer Aided Tissue Engineering (CATE) – Case studies

**POWDER BASED PROCESS**

Selective Laser Sintering (SLS): Process –Mechanism– Typical Materials and Application- Multi Jet Fusion - Basic Principle-– Materials- Application and Limitation - Three Dimensional Printing - Materials -Process - Benefits and Limitations. Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Materials – Process - Advantages and Applications. Beam Deposition Process: Laser Engineered Net Shaping (LENS)- Process -Material Delivery - Process Parameters - Materials -Benefits -Applications.

**UNIT V CASE STUDIES AND OPPORTUNITIES ADDITIVE MANUFACTURING PROCESSES 9**

Education and training - Automobile- pattern and mould - tooling - Building Printing-Bio Printing - medical implants -development of surgical tools Food Printing -Printing Electronics. Business Opportunities and Future Directions - Intellectual Property.

**TOTAL: 45 PERIODS**

**REFERENCES:**


1. Andreas Gebhardt and Jan-Steffen Hötter "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing", Hanser publications, United States, 2015, ISBN: 978-1- 56990-582-1.
2. Ian Gibson, David W. Rosen and Brent Stucker "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", 2nd edition, Springer., United States, 2015, ISBN13: 978-1493921126.
3. Amit Bandyopadhyay and Susmita Bose, "Additive Manufacturing", 1st Edition, CRC Press., United States, 2015, ISBN-13: 978-1482223590
4. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing", Hanser Gardner Publication, Cincinnati., Ohio, 2011, ISBN :9783446425521.
5. Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", Third edition, World Scientific Publishers, 2010.


**OME434 ELECTRIC VEHICLE TECHNOLOGY L T P C**
**3 0 0 3**

**UNIT I NEED FOR ELECTRIC VEHICLES 9**

History and need for electric and hybrid vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies, comparison of diesel, petrol, electric and hybrid vehicles, limitations, technical challenges

**UNIT II ELECTRIC VEHICLE ARCHITECHTURE 9**

Electric vehicle types, layout and power delivery, performance – traction motor characteristics, tractive effort, transmission requirements, vehicle performance, energy consumption, Concepts of hybrid electric drive train, architecture of series and parallel hybrid electric drive train, merits and demerits, mild and full hybrids, plug-in hybrid electric vehicles and range extended hybrid electric vehicles, Fuel cell vehicles.

**UNIT III ENERGY STORAGE 9**

Batteries – types – lead acid batteries, nickel based batteries, and lithium based batteries, electrochemical reactions, thermodynamic voltage, specific energy, specific power, energy efficiency, Battery modeling and equivalent circuit, battery charging and types, battery cooling, Ultra-capacitors, Flywheel technology, Hydrogen fuel cell, Thermal Management of the PEM fuel cell

**UNIT IV ELECTRIC DRIVES AND CONTROL 9**

Types of electric motors – working principle of AC and DC motors, advantages and limitations, DC motor drives and control, Induction motor drives and control, PMSM and brushless DC motor - drives and control , AC and Switch reluctance motor drives and control – Drive system efficiency – Inverters – DC and AC motor speed controllers

**UNIT V DESIGN OF ELECTRIC VEHICLES 9**

Materials and types of production, Chassis skate board design, motor sizing, power pack sizing, component matching, Ideal gear box – Gear ratio, torque–speed characteristics, Dynamic equation of vehicle motion, Maximum tractive effort – Power train tractive effort Acceleration performance, rated vehicle velocity – maximum gradability, Brake performance, Electronic control system, safety and challenges in electric vehicles. Case study of Nissan leaf, Toyota Prius, tesla model 3, and Renault Zoe cars.

**TOTAL: 45 PERIODS**

**REFERENCES:**


1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, 2nd edition CRC Press, 2011.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained - Wiley, 2003.
4. Ehsani, M, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2005


| OME435 | NEW PRODUCT DEVELOPMENT | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for:

1. Applying the principles of generic development process; and understanding the organization structure for new product design and development.
2. Identfying opportunity and planning for new product design and development.
3. Conducting customer need analysis; and setting product specification for new product design and development.
4. Generating, selecting, and testing the concepts for new product design and development.
5. Appling the principles of Industrial design and prototype for new product design and development.

**UNIT I INTRODUCTION TO PRODUCTDESIGN & DEVELOPMENT 9**

Introduction – Characteristics of Successful Product Development – People involved in Product Design and Development – Duration and Cost of Product Development – The Challenges of Product Development – The Product Development Process – Concept Development: The Front-End Process – Adapting the Generic Product Development Process – Product Development Process Flows – Product Development Organizations.

**UNIT II OPPORTUNITY DENTIFICATION & PRODUCT PLANNING 9**

Opportunity Identification: Definition – Types of Opportunities – Tournament Structure of Opportunity Identification – Effective Opportunity Tournaments – Opportunity Identification Process – Product Planning: Four types of Product Development Projects – The Process of Product Planning.

**UNIT III IDENTIFYING CUSTOMER NEEDS & PRODUCT SPECIFICATIONS 9**

Identifying Customer Needs: The Importance of Latent Needs – The Process of Identifying Customer Needs. Product Specifications: Definition – Time of Specifications Establishment – Establishing Target Specifications – Setting the Final Specifications

**UNIT IV CONCEPT GENERATION, SELECTION & TESTING 9**

Concept Generation: Activity of Concept Generation – Structured Approach – Five step method of Concept Generation. Concept Selection: Methodology – Concept Screening and Concepts Scoring. Concept testing: Seven Step activities of concept testing.

**UNITV INDUSTRIAL DESIGN & PROTOTYPING 9**

Industrial Design: Need and Impact–Industrial Design Process. Prototyping – Principles of Prototyping – Prototyping Technologies – Planning for Prototypes.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

1. Apply the principles of generic development process; and understand the organization structure for new product design and development.

2. Identify opportunity and plan for new product design and development.
3. Conduct customer need analysis; and set product specification for new product design and development.
4. Generate, select, and test the concepts for new product design and development.
5. Apply the principles of Industrial design and prototype for design and develop new products.

**TEXT BOOK:**

1. Ulrich K.T., Eppinger S. D. and Anita Goyal, "Product Design and Development "McGraw-Hill Education; 7 edition, 2020.

**REFERENCES:**

1. Belz A., 36-Hour Course: "Product Development" McGraw-Hill, 2010.
2. Rosenthal S.,"Effective Product Design and Development", Business One Orwin,Homewood, 1992,ISBN1-55623-603-4.

**OBA431 SUSTAINABLE MANAGEMENT LT P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To provide students with fundamental knowledge of the notion of corporate sustainability.
- To determine how organizations impacts on the environment and socio-technical systems, the relationship between social and environmental performance and competitiveness, the approaches and methods.

**UNIT I MANAGEMENT OF SUSTAINABILITY 9**

Management of sustainability -rationale and political trends: An introduction to sustainability management, International and European policies on sustainable development, theoretical pillars in sustainability management studies.

**UNIT II CORPORATE SUSTAINABILITY AND RESPONSIBILITY 9**

Corporate sustainability parameter, corporate sustainability institutional framework, integration of sustainability into strategic planning and regular business practices, fundamentals of stakeholder engagement.

**UNIT III SUSTAINABILITY MANAGEMENT: STRATEGIES AND APPROACHES 9**

Corporate sustainability management and competitiveness: Sustainability-oriented corporate strategies, markets and competitiveness, Green Management between theory and practice, Sustainable Consumption and Green Marketing strategies, Environmental regulation and strategic postures; Green Management approaches and tools; Green engineering: clean technologies and innovation processes; Sustainable Supply Chain Management and Procurement.

**UNIT IV SUSTAINABILITY AND INNOVATION 9**

Socio-technical transitions and sustainability, Sustainable entrepreneurship, Sustainable pioneers in green market niches, Smart communities and smart specializations.

**UNIT V SUSTAINABLE MANAGEMENT OF RESOURCES, COMMODITIES AND COMMONS 9**

Energy management, Water management, Waste management, Wild Life Conservation, Emerging trends in sustainable management, Case Studies.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

CO1: An understanding of sustainability management as an approach to aid in evaluating and minimizing environmental impacts while achieving the expected social impact.
CO2: An understanding of corporate sustainability and responsible Business Practices
CO3: Knowledge and skills to understand, to measure and interpret sustainabilityperformances.

CO4: Knowledge of innovative practices in sustainable business and community management
CO5: Deep understanding of sustainable management of resources and commodities

**REFERENCES:**

1. Daddi, T., Iraldo, F., Testa, Environmental Certification for Organizations and Products: Management, 2015
2. Christian N. Madu, Handbook of Sustainability Management 2012
3. Petra Molthan-Hill, The Business Student's Guide to Sustainable Management: Principles and Practice, 2014
4. Margaret Robertson, Sustainability Principles and Practice, 2014
5. Peter Rogers, An Introduction to Sustainable Development, 2006

**OBA432 MICRO AND SMALL BUSINESS MANAGEMENT L T P C**
**3 0 0 3**

**COURSE OBJECTIVES**

- To familiarize students with the theory and practice of small business management.
- To learn the legal issues faced by small business and how they impact operations.

**UNIT I INTRODUCTION TO SMALL BUSINESS 9**

Creation, Innovation, entrepreneurship and small business - Defining Small Business –Role of Owner – Manager – government policy towards small business sector –elements of entrepreneurship –evolution of entrepreneurship –Types of Entrepreneurship – social, civic, corporate - Business life cycle - barriers and triggers to new venture creation – process to assist start ups – small business and family business.

**UNIT II SCREENING THE BUSINESS OPPORTUNITY AND FORMULATING THE BUSINESS PLAN 9**

Concepts of opportunity recognition; Key factors leading to new venture failure; New venture screening process; Applying new venture screening process to the early stage small firm Role planning in small business – importance of strategy formulation – management skills for small business creation and development.

**UNIT III BUILDING THE RIGHT TEAM AND MARKETING STRATEGY 9**

Management and Leadership – employee assessments – Tuckman's stages of group development - The entrepreneurial process model - Delegation and team building - Comparison of HR management in small and large firms - Importance of coaching and how to apply a coaching model.

Marketing within the small business - success strategies for small business marketing - customer delight and business generating systems, - market research, - assessing market performance-sales management and strategy - the marketing mix and marketing strategy.

**UNIT IV FINANCING SMALL BUSINESS 9**

Main sources of entrepreneurial capital; Nature of 'bootstrap' financing - Difference between cash and profit - Nature of bank financing and equity financing - Funding-equity gap for small firms. Importance of working capital cycle - Calculation of break-even point - Power of gross profit margin- Pricing for profit - Credit policy issues and relating these to cash flow management and profitability.

**UNIT V VALUING SMALL BUSINESS AND CRISIS MANAGEMENT 9**

Causes of small business failure - Danger signals of impending trouble - Characteristics of poorly performing firms - Turnaround strategies - Concept of business valuation - Different valuation measurements - Nature of goodwill and how to measure it - Advantages and disadvantages of buying an established small firm - Process of preparing a business for sale.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES**

CO1. Familiarise the students with the concept of small business
CO2. In depth knowledge on small business opportunities and challenges
CO3. Ability to devise plans for small business by building the right skills and marketing strategies
CO4. Identify the funding source for small start ups
CO5. Business evaluation for buying and selling of small firms

**REFERENCES**

1. Hankinson,A.(2000). "The key factors in the profile of small firm owner-managers that influence business performance. The South Coast Small Firms Survey, 1997-2000." Industrial and Commercial Training 32(3):94-98.
2. Parker,R.(2000). "Small is not necessarily beautiful: An evaluation of policy support for small and medium-sized enterprise in Australia." Australian Journal of Political Science 35(2):239-253.
3. Journal articles on SME's.

**OBA433 INTELLECTUAL PROPERTY RIGHTS L T P C**
**3 0 0 3**

**COURSE OBJECTIVE**

- To understand intellectual property rights and its valuation.

**UNIT I INTRODUCTION 9**

Intellectual property rights - Introduction, Basic concepts, Patents, Copyrights, Trademarks, Trade Secrets, Geographic Indicators; Nature of Intellectual Property, Technological Research, Inventions and Innovations, History - the way from WTO to WIPO, TRIPS.

**UNIT II PROCESS 9**

New Developments in IPR, Procedure for grant of Patents, TM, GIs, Patenting under Patent Cooperation Treaty, Administration of Patent system in India, Patenting in foreign countries.

**UNIT III STATUTES 9**

International Treaties and conventions on IPRs, The TRIPs Agreement, PCT Agreement, The Patent Act of India, Patent Amendment Act (2005), Design Act, Trademark Act, Geographical Indication Act, Bayh- Dole Act and Issues of Academic Entrepreneurship.

**UNIT IV STRATEGIES IN INTELLECTUAL PROPERTY 9**

Strategies for investing in R&D, Patent Information and databases, IPR strength in India, Traditional Knowledge, Case studies.

**UNIT V MODELS 9**

The technologies Know-how, concept of ownership, Significance of IP in Value Creation, IP Valuation and IP Valuation Models, Application of Real Option Model in Strategic Decision Making, Transfer and Licensing.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES**

CO1: Understanding of intellectual property and appreciation of the need to protect it
CO2: Awareness about the process of patenting

CO3: Understanding of the statutes related to IPR
CO4: Ability to apply strategies to protect intellectual property
CO5: Ability to apply models for making strategic decisions related to IPR

**REFERENCES**

1. V. Sople Vinod, Managing Intellectual Property by (Prentice hall of India Pvt.Ltd), 2006.
2. Intellectual Property rights and copyrights, EssEss Publications.
3. Primer, R. Anita Rao and Bhanoji Rao, Intellectual Property Rights, Lastain Book company.
4. Edited by Derek Bosworth and Elizabeth Webster, The Management of Intellectual Property, Edward Elgar Publishing Ltd., 2006.
5. WIPO Intellectual Property Hand book.

**OBA434 ETHICAL MANAGEMENT L T P C**
**3 0 0 3**

**COURSE OBJECTIVE**

- To help students develop knowledge and competence in ethical management and decision making in organizational contexts.

**UNIT I ETHICS AND SOCIETY 9**

Ethical Management- Definition, Motivation, Advantages-Practical implications of ethical management. Managerial ethics, professional ethics, and social Responsibility-Role of culture and society's expectations- Individual and organizational responsibility to society and the community.

**UNIT II ETHICAL DECISION MAKING AND MANAGEMENT IN A CRISIS 9**

Managing in an ethical crisis, the nature of a crisis, ethics in crisis management, discuss case studies, analyze real-world scenarios, develop ethical management skills, knowledge, and competencies. Proactive crisis management.

**UNIT III STAKEHOLDERS IN ETHICAL MANAGEMENT 9**

Stakeholders in ethical management, identifying internal and external stakeholders, nature of stakeholders, ethical management of various kinds of stakeholders: customers (product and service issues), employees (leadership, fairness, justice, diversity) suppliers, collaborators, business, community, the natural environment (the sustainability imperative, green management, Contemporary issues).

**UNIT IV INDIVIDUAL VARIABLES IN ETHICAL MANJAGEMENT 9**

Understanding individual variables in ethics, managerial ethics, concepts in ethical psychology-ethical awareness, ethical courage, ethical judgment, ethical foundations, ethical emotions/intuitions/intensity. Utilization of these concepts and competencies for ethical decision-making and management.

**UNIT V PRACTICAL FIELD-GUIDE, TECHNIQUES AND SKILLS 9**

Ethical management in practice, development of techniques and skills, navigating challenges and dilemmas, resolving issues and preventing unethical management proactively. Role modelling and creating a culture of ethical management and human flourishing.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES**

CO1: Role modelling and influencing the ethical and cultural context.
CO2: Respond to ethical crises and proactively address potential crises situations.
CO3: Understand and implement stakeholder management decisions.
CO4: Develop the ability, knowledge, and skills for ethical management.
CO5: Develop practical skills to navigate, resolve and thrive in management situations

**REFERENCES**
1. Brad Agle, Aaron Miller, Bill O' Rourke, The Business Ethics Field Guide: the essential companion to leading your career and your company, 2016.
2. Steiner & Steiner, Business, Government & Society: A managerial Perspective, 2011.
3. Lawrence & Weber, Business and Society: Stakeholders, Ethics, Public Policy, 2020.

**ET4251 IoT FOR SMART SYSTEMS LT P C**
**3 0 0 3**

**COURSE OBJECTIVES:**
1. To study about **Internet of Things** technologies and its role in real time applications.
2. To introduce the infrastructure required for IoT
3. To familiarize the accessories and communication techniques for IoT.
4. To provide insight about the embedded processor and sensors required for IoT
5. To familiarize the different platforms and Attributes for IoT

**UNIT I INTRODUCTION TO INTERNET OF THINGS 9**
Overview, Hardware and software requirements for IOT, Sensor and actuators, Technology drivers, Business drivers, Typical IoT applications, Trends and implications.

**UNIT II IOT ARCHITECTURE 9**
IoT reference model and architecture -Node Structure - Sensing, Processing, Communication, Powering, Networking - Topologies, Layer/Stack architecture**,** IoT standards, Cloud computing for IoT, Bluetooth, Bluetooth Low Energy beacons.

**UNIT III PROTOCOLS AND WIRELESS TECHNOLOGIES FOR IOT 9**
**PROTOCOLS:**
NFC, SCADA and RFID, Zigbee MIPI, M-PHY, UniPro, SPMI, SPI, M-PCIe GSM, CDMA, LTE, GPRS, small cell.

**Wireless technologies for IoT:** WiFi (IEEE 802.11), Bluetooth/Bluetooth Smart, ZigBee/ZigBee Smart, UWB (IEEE 802.15.4), 6LoWPAN, Proprietary systems-Recent trends.

**UNIT IV IOT PROCESSORS 9**
**Services/Attributes:** Big-Data Analytics for IOT, Dependability,Interoperability, Security, Maintainability.
**Embedded processors for IOT** :Introduction to Python programming -Building IOT with RASPERRY PI and Arduino.

**UNIT V CASE STUDIES 9**
Industrial IoT, Home Automation, smart cities, Smart Grid, connected vehicles, electric vehicle charging, Environment, Agriculture, Productivity Applications, IOT Defense

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**
At the end of this course, the students will have the ability to
CO1: Analyze the concepts of IoT and its present developments.
CO2: Compare and contrast different platforms and infrastructures available for IoT
CO3: Explain different protocols and communication technologies used in IoT
CO4: Analyze the big data analytic and programming of IoT

CO5: Implement IoT solutions for smart applications

**REFERENCES:**


1. ArshdeepBahga and VijaiMadisetti : A Hands-on Approach “Internet of Things”,Universities Press 2015.
2. Oliver Hersent , David Boswarthick and Omar Elloumi “ The Internet of Things”, Wiley,2016.
3. Samuel Greengard, “ The Internet of Things”, The MIT press, 2015.
4. Adrian McEwen and Hakim Cassimally“Designing the Internet of Things “Wiley,2014.
5. Jean- Philippe Vasseur, Adam Dunkels, “Interconnecting Smart Objects with IP: The Next Internet” Morgan Kuffmann Publishers, 2010.
6. Adrian McEwen and Hakim Cassimally, “Designing the Internet of Things”, John Wiley and sons, 2014.
7. Lingyang Song/DusitNiyato/ Zhu Han/ Ekram Hossain,” Wireless Device-to-Device Communications and Networks, CAMBRIDGE UNIVERSITY PRESS,2015.
8. OvidiuVermesan and Peter Friess (Editors), “Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems”, River Publishers Series in Communication, 2013.
9. Vijay Madisetti , ArshdeepBahga, “Internet of Things (A Hands on-Approach)”, 2014.
10. Zach Shelby, Carsten Bormann, “6LoWPAN: The Wireless Embedded Internet”, John Wiley and sons, 2009.
11. Lars T.Berger and Krzysztof Iniewski, “Smart Grid applications, communications and security”, Wiley, 2015.
12. JanakaEkanayake, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama and Nick Jenkins, “ Smart Grid Technology and Applications”, Wiley, 2015.
13. UpenaDalal,”Wireless Communications & Networks,Oxford,2015.


**ET4072 MACHINE LEARNING AND DEEP LEARNING L T P C**

**3 0 0 3**

**COURSE OBJECTIVES:**

The course is aimed at

1. Understanding about the learning problem and algorithms
2. Providing insight about neural networks
3. Introducing the machine learning fundamentals and significance
4. Enabling the students to acquire knowledge about pattern recognition.
5. Motivating the students to apply deep learning algorithms for solving real life problems.

**UNIT I LEARNING PROBLEMS AND ALGORITHMS 9**

Various paradigms of learning problems, Supervised, Semi-supervised and Unsupervised algorithms

**UNIT II NEURAL NETWORKS 9**

Differences between Biological and Artificial Neural Networks - Typical Architecture, Common Activation Functions, Multi-layer neural network, Linear Separability, Hebb Net, Perceptron, Adaline, Standard Back propagation Training Algorithms for Pattern Association - Hebb rule and Delta rule, Hetero associative, Auto associative, Kohonen Self Organising Maps, Examples of Feature Maps, Learning Vector Quantization, Gradient descent, Boltzmann Machine Learning.

**UNIT III MACHINE LEARNING – FUNDAMENTALS & FEATURE SELECTIONS & CLASSIFICATIONS 9**

Classifying Samples: The confusion matrix, Accuracy, Precision, Recall, F1- Score, the curse of dimensionality, training, testing, validation, cross validation, overfitting, under-fitting the data, early stopping, regularization, bias and variance. Feature Selection, normalization, dimensionality reduction, Classifiers: KNN, SVM, Decision trees, Naïve Bayes, Binary classification, multi class classification, clustering.

**UNIT IV DEEP LEARNING: CONVOLUTIONAL NEURAL NETWORKS 9**

Feed forward networks, Activation functions, back propagation in CNN, optimizers, batch normalization, convolution layers, pooling layers, fully connected layers, dropout, Examples of CNNs.

**UNIT V DEEP LEARNING: RNNS, AUTOENCODERS AND GANS 9**

State, Structure of RNN Cell, LSTM and GRU, Time distributed layers, Generating Text, Autoencoders: Convolutional Autoencoders, Denoising autoencoders, Variational autoencoders, GANs: The discriminator, generator, DCGANs

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES (CO):**

At the end of the course the student will be able to

CO1 : Illustrate the categorization of machine learning algorithms.
CO2: Compare and contrast the types of neural network architectures, activation functions
CO3: Acquaint with the pattern association using neural networks
CO4: Elaborate various terminologies related with pattern recognition and architectures of convolutional neural networks
CO5: Construct different feature selection and classification techniques and advanced neural network architectures such as RNN, Autoencoders, and GANs.

**REFERENCES:**


1. J. S. R. Jang, C. T. Sun, E. Mizutani, Neuro Fuzzy and Soft Computing - A Computational Approach to Learning and Machine Intelligence, 2012, PHI learning
2. Deep Learning, Ian Good fellow, YoshuaBengio and Aaron Courville, MIT Press, ISBN: 9780262035613, 2016.
3. The Elements of Statistical Learning. Trevor Hastie, Robert Tibshirani and Jerome Friedman. Second Edition. 2009.
4. Pattern Recognition and Machine Learning. Christopher Bishop. Springer. 2006.
5. Understanding Machine Learning. Shai Shalev-Shwartz and Shai Ben-David. Cambridge University Press. 2017.




**PX4012 RENEWABLE ENERGY TECHNOLOGY L T P C**
**3 0 0 3**

**OBJECTIVES:**

To impart knowledge on

- Different types of renewable energy technologies
- Standalone operation, grid connected operation of renewable energy systems

**UNIT I INTRODUCTION 9**

Classification of energy sources – Co2 Emission - Features of Renewable energy - Renewable energy scenario in India -Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment Per Capital Consumption - $CO_2$ Emission - importance of renewable energy sources, Potentials – Achievements– Applications.

**UNIT II SOLAR PHOTOVOLTAICS 9**

Solar Energy: Sun and Earth-Basic Characteristics of solar radiation- angle of sunrays on solar collector-Estimating Solar Radiation Empirically - Equivalent circuit of PV Cell- Photovoltaic cell-characteristics: P-V and I-V curve of cell-Impact of Temperature and Insolation on I-V characteristics-Shading Impacts on I-V characteristics-Bypass diode -Blocking diode.

**UNIT III PHOTOVOLTAIC SYSTEM DESIGN 9**

Block diagram of solar photo voltaic system : Line commutated converters (inversion mode) - Boost and buck-boost converters - selection of inverter, battery sizing, array sizing - PV systems classification- standalone PV systems - Grid tied and grid interactive inverters- grid connection issues.

**UNIT IV WIND ENERGY CONVERSION SYSTEMS 9**

Origin of Winds: Global and Local Winds- Aerodynamics of Wind turbine-Derivation of Betz's limit-Power available in wind-Classification of wind turbine: Horizontal Axis wind turbine and Vertical axis wind turbine- Aerodynamic Efficiency-Tip Speed-Tip Speed Ratio-Solidity-Blade Count-Power curve of wind turbine - Configurations of wind energy conversion systems: Type A, Type B, Type C and Type D Configurations- Grid connection Issues - Grid integrated SCIG and PMSG based WECS.

**UNIT V OTHER RENEWABLE ENERGY SOURCES 9**

Qualitative study of different renewable energy resources: ocean, Biomass, Hydrogen energy systems, Fuel cells, Ocean Thermal Energy Conversion (OTEC), Tidal and wave energy, Geothermal Energy Resources.

**TOTAL : 45 PERIODS**

**OUTCOMES:**

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

CO1: Demonstrate the need for renewable energy sources.
CO2: Develop a stand-alone photo voltaic system and implement a maximum power point tracking in the PV system.
CO3: Design a stand-alone and Grid connected PV system.
CO4: Analyze the different configurations of the wind energy conversion systems.
CO5: Realize the basic of various available renewable energy sources

**REFERENCES:**

1. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford UniversityPress, 2009.
2. Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993.
3. Rai. G.D," Solar energy utilization", Khanna publishes, 1993.
4. Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI Learning Private Limited, 2012.
5. John Twideu and Tony Weir, "Renewal Energy Resources" BSP Publications, 2006
6. Gray, L. Johnson, "Wind energy system", prentice hall of India, 1995.
7. B.H.Khan, " Non-conventional Energy sources", , McGraw-hill, 2nd Edition, 2009.
8. Fang Lin Luo Hong Ye, " Renewable Energy systems", Taylor & Francis Group,2013.

**PS4093** **SMART GRID** **L T P C**

**3 0 0 3**

**COURSE OBJECTIVES**

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To know about the function of smart grid.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high performance computing for Smart Grid applications
- To get familiarized with the communication networks for Smart Grid applications

**UNIT I INTRODUCTION TO SMART GRID 9**

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Comparison of Micro grid and Smart grid, Present development & International policies in Smart Grid, Smart Grid Initiative for Power Distribution Utility in India – Case Study.

**UNIT II SMART GRID TECHNOLOGIES 9**

Technology Drivers, Smart Integration of energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV) – Grid to Vehicle and Vehicle to Grid charging concepts.

**UNIT III SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9**

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU) & their application for monitoring & protection. Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.

**UNIT IV POWER QUALITY MANAGEMENT IN SMART GRID 9**

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

**Unit V HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9**

Architecture and Standards -Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), PLC, Zigbee, GSM, IP based Protocols, Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

**TOTAL : 45 PERIODS**

**COURSE OUTCOME:**

Students able to

CO1: Relate with the smart resources, smart meters and other smart devices.
CO2: Explain the function of Smart Grid.
CO3: Experiment the issues of Power Quality in Smart Grid.
CO4: Analyze the performance of Smart Grid.
CO5**:** Recommend suitable communication networks for smart grid applications

**REFERENCES**


1. Stuart Borlase ‘Smart Grid: Infrastructure, Technology and Solutions’, CRC Press 2012.
2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, ‘Smart Grid: Technology and Applications’, Wiley, 2012.
3. Mini S. Thomas, John D McDonald, ‘Power System SCADA and Smart Grids’, CRC Press, 2015

4. Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, 'Communication Networks for Smart Grids', Springer, 2014
5. SMART GRID Fundamentals of Design and Analysis, James Momoh, IEEE press, A John Wiley & Sons, Inc., Publication.

**CP4391 SECURITY PRACTICES L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To learn the core fundamentals of system and web security concepts
- To have through understanding in the security concepts related to networks
- To deploy the security essentials in IT Sector
- To be exposed to the concepts of Cyber Security and cloud security
- To perform a detailed study of Privacy and Storage security and related Issues

**UNIT I SYSTEM SECURITY 9**

Model of network security – Security attacks, services and mechanisms – OSI security architecture -A Cryptography primer- Intrusion detection system- Intrusion Prevention system - Security web applications- Case study: OWASP - Top 10 Web Application Security Risks.

**UNIT II NETWORK SECURITY 9**

Internet Security - Intranet security- Local Area Network Security - Wireless Network Security - Wireless Sensor Network Security- Cellular Network Security - Mobile security - IOT security - Case Study - Kali Linux.

**UNIT III SECURITY MANAGEMENT 9**

Information security essentials for IT Managers- Security Management System - Policy Driven System Management- IT Security - Online Identity and User Management System. Case study: Metasploit

**UNIT IV CYBER SECURITY AND CLOUD SECURITY 9**

Cyber Forensics- Disk Forensics – Network Forensics – Wireless Forensics – Database Forensics – Malware Forensics – Mobile Forensics – Email Forensics- Best security practices for automate Cloud infrastructure management – Establishing trust in IaaS, PaaS, and SaaS Cloud types. Case study: DVWA

**UNIT V PRIVACY AND STORAGE SECURITY 9**

Privacy on the Internet - Privacy Enhancing Technologies - Personal privacy Policies - Detection of Conflicts in security policies- privacy and security in environment monitoring systems. Storage Area Network Security - Storage Area Network Security Devices - Risk management - Physical Security Essentials.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

**CO1:** Understand the core fundamentals of system security
**CO2:** Apply the security concepts to wired and wireless networks
**CO3**: Implement and Manage the security essentials in IT Sector
**CO4:** Explain the concepts of Cyber Security and Cyber forensics
**CO5:** Be aware of Privacy and Storage security Issues.

**REFERENCES**

1. John R. Vacca, Computer and Information Security Handbook, Third Edition, Elsevier 2017

2. Michael E. Whitman, Herbert J. Mattord, Principles of Information Security, Seventh Edition, Cengage Learning, 2022
3. Richard E. Smith, Elementary Information Security, Third Edition, Jones and Bartlett Learning, 2019
4. Mayor, K.K.Mookhey, Jacopo Cervini, Fairuzan Roslan, Kevin Beaver, Metasploit Toolkit for Penetration Testing, Exploit Development and Vulnerability Research, Syngress publications, Elsevier, 2007. ISBN : 978-1-59749-074-0
5. John Sammons, "The Basics of Digital Forensics- The Primer for Getting Started in Digital Forensics", Syngress, 2012
6. Cory Altheide and Harlan Carvey, "Digital Forensics with Open Source Tools",2011 Syngress, ISBN: 9781597495875.
7. Siani Pearson, George Yee "Privacy and Security for Cloud Computing" Computer Communications and Networks, Springer, 2013.

**MP4251 CLOUD COMPUTING TECHNOLOGIES L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To gain expertise in Virtualization, Virtual Machines and deploy practical virtualization solution
- To understand the architecture, infrastructure and delivery models of cloud computing.
- To explore the roster of AWS services and illustrate the way to make applications in AWS
- To gain knowledge in the working of Windows Azure and Storage services offered by Windows Azure
- To develop the cloud application using various programming model of Hadoop and Aneka

**UNIT I VIRTUALIZATION AND VIRTUALIZATION INFRASTRUCTURE 6**

Basics of Virtual Machines - Process Virtual Machines – System Virtual Machines –Emulation – Interpretation – Binary Translation - Taxonomy of Virtual Machines. Virtualization –Management Virtualization — Hardware Maximization – Architectures – Virtualization Management – Storage Virtualization – Network Virtualization- Implementation levels of virtualization – virtualization structure – virtualization of CPU, Memory and I/O devices – virtual clusters and Resource Management – Virtualization for data center automation

**UNIT II CLOUD PLATFORM ARCHITECTURE 12**

Cloud Computing: Definition, Characteristics - Cloud deployment models: public, private, hybrid, community – Categories of cloud computing: Everything as a service: Infrastructure, platform, software- A Generic Cloud Architecture Design – Layered cloud Architectural Development – Architectural Design Challenges

**UNIT III AWS CLOUD PLATFORM - IAAS 9**

**Amazon Web Services:** AWS Infrastructure- AWS API- AWS Management Console - Setting up AWS Storage - Stretching out with Elastic Compute Cloud - Elastic Container Service for Kubernetes- AWS Developer Tools: AWS Code Commit, AWS Code Build, AWS Code Deploy, AWS Code Pipeline, AWS code Star - AWS Management Tools: Cloud Watch, AWS Auto Scaling, AWS control Tower, Cloud Formation, Cloud Trail, AWS License Manager

**UNIT IV PAAS CLOUD PLATFORM 9**

Windows Azure: Origin of Windows Azure, Features, The Fabric Controller – First Cloud APP in Windows Azure- Service Model and Managing Services: Definition and Configuration, Service runtime API- Windows Azure Developer Portal- Service Management API- Windows Azure Storage Characteristics-Storage Services- REST API- Blops

**UNIT V PROGRAMMING MODEL 9**

Introduction to Hadoop Framework - Mapreduce, Input splitting, map and reduce functions, specifying input and output parameters, configuring and running a job –Developing Map Reduce Applications - Design of Hadoop file system –Setting up Hadoop Cluster- Aneka: Cloud Application Platform, Thread Programming, Task Programming and Map-Reduce Programming in Aneka

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

**CO1:** Employ the concepts of virtualization in the cloud computing
**CO2:** Identify the architecture, infrastructure and delivery models of cloud computing
**CO3:** Develop the Cloud Application in AWS platform
**CO4:** Apply the concepts of Windows Azure to design Cloud Application
**CO5:** Develop services using various Cloud computing programming models.

**REFERENCES**


1. Bernard Golden, Amazon Web Service for Dummies, John Wiley & Sons, 2013.
2. Raoul Alongi, AWS: The Most Complete Guide to Amazon Web Service from Beginner to Advanced Level, Amazon Asia- Pacific Holdings Private Limited, 2019.
3. Sriram Krishnan, Programming: Windows Azure, O'Reilly,2010.
4. Rajkumar Buyya, Christian Vacchiola, S.Thamarai Selvi, Mastering Cloud Computing , MCGraw Hill Education (India) Pvt. Ltd., 2013.
5. Danielle Ruest, Nelson Ruest, —Virtualization: A Beginner"s Guide‖, McGraw-Hill Osborne Media, 2009.
6. Jim Smith, Ravi Nair , "Virtual Machines: Versatile Platforms for Systems and Processes", Elsevier/Morgan Kaufmann, 2005.
7. John W.Rittinghouse and James F.Ransome, "Cloud Computing: Implementation, Management, and Security", CRC Press, 2010.
8. Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing, A Practical Approach", McGraw-Hill Osborne Media, 2009.
9. Tom White, "Hadoop: The Definitive Guide", Yahoo Press, 2012.


**IF4072 DESIGN THINKING L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To provide a sound knowledge in UI & UX
- To understand the need for UI and UX
- Research Methods used in Design
- Tools used in UI & UX
- Creating a wireframe and prototype

**UNIT I UX LIFECYCLE TEMPLATE 8**

Introduction. A UX process lifecycle template. Choosing a process instance for your project. The system complexity space. Meet the user interface team. Scope of UX presence within the team. More about UX lifecycles. Business Strategy. Value Innovation. Validated User Research. Killer UX Design. The Blockbuster Value Proposition. What Is a Value Proposition?.

**UNIT II CONTEXTUAL INQUIRY 10**

The system concept statement. User work activity data gathering. Look for emotional aspects of work practice. Abridged contextual inquiry process. Data-driven vs. model-driven inquiry. Organizing concepts: work roles and flow model. Creating and managing work activity notes. Constructing your work activity affinity diagram (WAAD). Abridged contextual analysis process. History of affinity diagrams.

**UNIT III DESIGN THINKING, IDEATION, AND SKETCHING 9**

Design-informing models: second span of the bridge . Some general “how to” suggestions. A New example domain: slideshow presentations. User models. Usage models. Work environment models. Barrier summaries. Model consolidation. Protecting your sources. Abridged methods for design-informing models extraction. Design paradigms. Design thinking. Design perspectives. User personas. Ideation. Sketching

**UNIT IV UX GOALS, METRICS, AND TARGETS 8**

Introduction. UX goals. UX target tables. Work roles, user classes, and UX goals. UX measures. Measuring instruments. UX metrics. Baseline level. Target level. Setting levels. Observed results. Practical tips and cautions for creating UX targets. How UX targets help manage the user experience engineering process.

**UNIT V ANALYSING USER EXPERIENCE 10**

Sharpening Your Thinking Tools. UX Research and Strength of Evidence. Agile Personas. How to Prioritize Usability Problems. Creating Insights, Hypotheses and Testable Design Ideas. How to Manage Design Projects with User Experience Metrics. Two Measures that Will Justify Any Design Change. Evangelizing UX Research. How to Create a User Journey Map. Generating Solutions to Usability Problems. Building UX Research Into the Design Studio Methodology. Dealing with Common objections to UX Research. The User Experience Debrief Meeting. Creating a User Experience Dashboard.

**SUGGESTED ACTIVITIES:**

1: Hands on Design Thinking process for a product
2: Defining the Look and Feel of any new Project
3: Create a Sample Pattern Library for that product (Mood board, Fonts, Colors based on UI principles)
4: Identify a customer problem to solve.
5: Conduct end-to-end user research - User research, creating personas, Ideation process (User stories, Scenarios), Flow diagrams, Flow Mapping

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

**CO1:** Build UI for user Applications
**CO2:** Use the UI Interaction behaviors and principles
**CO3:** Evaluate UX design of any product or application
**CO4:** Demonstrate UX Skills in product development
**CO5:** Implement Sketching principles

**REFERENCES**

1. UX for Developers: How to Integrate User-Centered Design Principles Into Your Day-to-Day Development Work, Westley Knight. Apress, 2018
2. The UX Book: Process and Guidelines for Ensuring a Quality User Experience, Rex Hartson, Pardha Pyla. Morgan Kaufmann, 2012
3. UX Fundamentals for Non-UX Professionals: User Experience Principles for Managers, Writers, Designers, and Developers, Edward Stull. Apress, 2018
4. Lean UX: Designing Great Products with Agile Teams, Gothelf, Jeff, Seiden, and Josh. O'Reilly Media, 2016
5. Designing UX: Prototyping: Because Modern Design is Never Static, Ben Coleman, and Dan Goodwin. SitePoint, 2017

**MU4153** **PRINCIPLES OF MULTIMEDIA** **L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To get familiarity with gamut of multimedia and its significance
- To acquire knowledge in multimedia components.
- To acquire knowledge about multimedia tools and authoring.
- To acquire knowledge in the development of multimedia applications.
- To explore the latest trends and technologies in multimedia

**UNIT I INTRODUCTION** **9**

Introduction to Multimedia – Characteristics of Multimedia Presentation – Multimedia Components – Promotion of Multimedia Based Components – Digital Representation – Media and Data Streams – Multimedia Architecture – Multimedia Documents, Multimedia Tasks and Concerns, Production, sharing and distribution, Hypermedia, WWW and Internet, Authoring, Multimedia over wireless and mobile networks.

**Suggested Activities:**

1. Flipped classroom on media Components.
2. External learning – Interactive presentation.

**Suggested Evaluation Methods:**

1. Tutorial – Handling media components
2. Quizzes on different types of data presentation.

**UNIT II ELEMENTS OF MULTIMEDIA** **9**

Text-Types, Font, Unicode Standard, File Formats, Graphics and Image data representations – data types, file formats, color models; video – color models in video, analog video, digital video, file formats, video display interfaces, 3D video and TV: Audio – Digitization, SNR, SQNR, quantization, audio quality, file formats, MIDI; Animation- Key Frames and Tweening, other Techniques, 2D and 3D Animation.

**Suggested Activities:**

1. Flipped classroom on different file formats of various media elements.
2. External learning – Adobe after effects, Adobe Media Encoder, Adobe Audition.

**Suggested Evaluation Methods:**

1. Demonstration on after effects animations.
2. Quizzes on file formats and color models.

**UNIT III MULTIMEDIA TOOLS** **9**

Authoring Tools – Features and Types – Card and Page Based Tools – Icon and Object Based Tools – Time Based Tools – Cross Platform Authoring Tools – Editing Tools – Painting and Drawing Tools – 3D Modeling and Animation Tools – Image Editing Tools – Sound Editing Tools – Digital Movie Tools.

**Suggested Activities:**

1. Flipped classroom on multimedia tools.
2. External learning – Comparison of various authoring tools.

**Suggested Evaluation Methods:**

1. Tutorial – Audio editing tool.
2. Quizzes on animation tools.

**UNIT IV MULTIMEDIA SYSTEMS 9**

Compression Types and Techniques: CODEC, Text Compression: GIF Coding Standards, JPEG standard – JPEG 2000, basic audio compression – ADPCM, MPEG Psychoacoustics, basic Video compression techniques – MPEG, H.26X – Multimedia Database System – User Interfaces – OS Multimedia Support – Hardware Support – Real Time Protocols – Play Back Architectures – Synchronization – Document Architecture – Hypermedia Concepts: Hypermedia Design – Digital Copyrights, Content analysis.

**Suggested Activities:**

1. Flipped classroom on concepts of multimedia hardware architectures.
2. External learning – Digital repositories and hypermedia design.

**Suggested Evaluation Methods:**

1. Quizzes on multimedia hardware and compression techniques.
2. Tutorial – Hypermedia design.

**UNIT V MULTIMEDIA APPLICATIONS FOR THE WEB AND MOBILE PLATFORMS 9**

ADDIE Model – Conceptualization – Content Collection – Storyboard–Script Authoring Metaphors – Testing – Report Writing – Documentation. Multimedia for the web and mobile platforms. Virtual Reality, Internet multimedia content distribution, Multimedia Information sharing – social media sharing, cloud computing for multimedia services, interactive cloud gaming. Multimedia information retrieval.

**Suggested Activities:**

1. External learning – Game consoles.
2. External learning – VRML scripting languages.

**Suggested Evaluation Methods:**

1. Demonstration of simple interactive games.
2. Tutorial – Simple VRML program.

**TOTAL : 45 PERIODS**

**COURSE OUTCOMES:**

**CO1:**Handle the multimedia elements effectively.
**CO2:**Articulate the concepts and techniques used in multimedia applications.
**CO3:**Develop effective strategies to deliver Quality of Experience in multimedia applications.
**CO4:**Design and implement algorithms and techniques applied to multimedia objects.
**CO5:**Design and develop multimedia applications following software engineering models.

**REFERENCES**:

1. Li, Ze-Nian, Drew, Mark, Liu, Jiangchuan, “Fundamentals of Multimedia”, Springer, Third Edition, 2021.
2. Prabhat K.Andleigh, Kiran Thakrar, “MULTIMEDIA SYSTEMS DESIGN”, Pearson Education, 2015.
3. Gerald Friedland, Ramesh Jain, “Multimedia Computing”, Cambridge University Press, 2018. (digital book)
4. Ranjan Parekh, “Principles of Multimedia”, Second Edition, McGraw-Hill Education, 2017

**DS4015 BIG DATA ANALYTICS L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To understand the basics of big data analytics
- To understand the search methods and visualization
- To learn mining data streams
- To learn frameworks
- To gain knowledge on R language

**UNIT I INTRODUCTION TO BIG DATA 9**

Introduction to Big Data Platform – Challenges of Conventional Systems - Intelligent data analysis –Nature of Data - Analytic Processes and Tools - Analysis Vs Reporting - Modern Data Analytic Tools- Statistical Concepts: Sampling Distributions - Re-Sampling - Statistical Inference - Prediction Error.

**UNIT II SEARCH METHODS AND VISUALIZATION 9**

Search by simulated Annealing – Stochastic, Adaptive search by Evaluation – Evaluation Strategies –Genetic Algorithm – Genetic Programming – Visualization – Classification of Visual Data Analysis Techniques – Data Types – Visualization Techniques – Interaction techniques – Specific Visual data analysis Techniques

**UNIT III MINING DATA STREAMS 9**

Introduction To Streams Concepts – Stream Data Model and Architecture - Stream Computing - Sampling Data in a Stream – Filtering Streams – Counting Distinct Elements in a Stream – Estimating Moments – Counting Oneness in a Window – Decaying Window - Real time Analytics Platform(RTAP) Applications - Case Studies - Real Time Sentiment Analysis, Stock Market Predictions

**UNIT IV FRAMEWORKS 9**

MapReduce – Hadoop, Hive, MapR – Sharding – NoSQL Databases - S3 - Hadoop Distributed File Systems – Case Study- Preventing Private Information Inference Attacks on Social Networks- Grand Challenge: Applying Regulatory Science and Big Data to Improve Medical Device Innovation

**UNIT V R LANGUAGE 9**

Overview, Programming structures: Control statements -Operators -Functions -Environment and scope issues -Recursion -Replacement functions, R data structures: Vectors -Matrices and arrays - Lists -Data frames -Classes, Input/output, String manipulations

**COURSE OUTCOMES:**

CO1:understand the basics of big data analytics

**CO2:** Ability to use Hadoop, Map Reduce Framework.

**CO3:** Ability to identify the areas for applying big data analytics for increasing the business outcome.

CO4:gain knowledge on R language

**CO5:** Contextually integrate and correlate large amounts of information to gain faster insights.

**TOTAL:45 PERIODS**

**REFERENCE:**


1. Michael Berthold, David J. Hand, Intelligent Data Analysis, Springer, 2007.
2. Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 3rd edition 2020.
3. Norman Matloff, The Art of R Programming: A Tour of Statistical Software Design, No Starch Press, USA, 2011.
4. Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, John Wiley & sons, 2012.
5. Glenn J. Myatt, Making Sense of Data, John Wiley & Sons, 2007.


**CO-PO Mapping**

| CO | POs | | | | | |
|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
| 1 | 3 | 3 | 3 | 3 | 2 | 1 |
| 2 | 3 | 3 | 3 | 3 | 2 | 1 |
| 3 | 3 | 3 | 3 | 3 | 2 | 1 |
| 4 | 3 | 3 | 3 | 3 | 2 | 1 |
| 5 | 3 | 3 | 3 | 3 | 2 | 1 |
| Avg | 3 | 3 | 3 | 3 | 2 | 1 |

**NC4201 INTERNET OF THINGS AND CLOUD** **L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To understand Smart Objects and IoT Architectures
- To learn about various IOT-related protocols
- To build simple IoT Systems using Arduino and Raspberry Pi.
- To understand data analytics and cloud in the context of IoT
- To develop IoT infrastructure for popular applications

**UNIT I FUNDAMENTALS OF IoT** **9**

Introduction to IoT – IoT definition – Characteristics – IoT Complete Architectural Stack – IoT enabling Technologies – IoT Challenges. Sensors and Hardware for IoT – Hardware Platforms – Arduino, Raspberry Pi, Node MCU. A Case study with any one of the boards and data acquisition from sensors.

**UNIT II PROTOCOLS FOR IoT** **9**

Infrastructure protocol (IPV4/V6/RPL), Identification (URIs), Transport (Wifi, Lifi, BLE), Discovery, Data Protocols, Device Management Protocols. – A Case Study with MQTT/CoAP usage-IoT privacy, security and vulnerability solutions.

**UNIT III CASE STUDIES/INDUSTRIAL APPLICATIONS** **9**

Case studies with architectural analysis: IoT applications – Smart City – Smart Water – Smart Agriculture – Smart Energy – Smart Healthcare – Smart Transportation – Smart Retail – Smart waste management.

**UNIT IV CLOUD COMPUTING INTRODUCTION** **9**

Introduction to Cloud Computing - Service Model – Deployment Model- Virtualization Concepts – Cloud Platforms – Amazon AWS – Microsoft Azure – Google APIs.

**UNIT V IoT AND CLOUD** **9**

IoT and the Cloud - Role of Cloud Computing in IoT - AWS Components - S3 – Lambda - AWS IoT Core -Connecting a web application to AWS IoT using MQTT- AWS IoT Examples. Security Concerns, Risk Issues, and Legal Aspects of Cloud Computing- Cloud Data Security

**TOTAL:45 PERIODS**

**COURSE OUTCOMES:**

**At the end of the course, the student will be able to:**

**CO1:** Understand the various concept of the IoT and their technologies..
**CO2:** Develop IoT application using different hardware platforms
**CO3**: Implement the various IoT Protocols
**CO4**: Understand the basic principles of cloud computing.
**CO5:** Develop and deploy the IoT application into cloud environment

**REFERENCES**

1. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman ,CRC Press, 2017
2. Adrian McEwen, Designing the Internet of Things, Wiley,2013.
3. EMC Education Services, “Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data”, Wiley publishers, 2015.
4. Simon Walkowiak, “Big Data Analytics with R” PackT Publishers, 2016
5. Bart Baesens, “Analytics in a Big Data World: The Essential Guide to Data Science and its Applications”, Wiley Publishers, 2015.

**MX4073** **MEDICAL ROBOTICS** **L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To explain the basic concepts of robots and types of robots
- To discuss the designing procedure of manipulators, actuators and grippers
- To impart knowledge on various types of sensors and power sources
- To explore various applications of Robots in Medicine
- To impart knowledge on wearable robots

**UNIT I INTRODUCTION TO ROBOTICS 9**

Introduction to Robotics, Overview of robot subsystems, Degrees of freedom, configurations and concept of workspace, Dynamic Stabilization

**Sensors and Actuators**

Sensors and controllers, Internal and external sensors, position, velocity and acceleration sensors, Proximity sensors, force sensors Pneumatic and hydraulic actuators, Stepper motor control circuits, End effectors, Various types of Grippers, PD and PID feedback actuator models

**UNIT II MANIPULATORS & BASIC KINEMATICS 9**

Construction of Manipulators, Manipulator Dynamic and Force Control, Electronic and pneumatic manipulator, Forward Kinematic Problems, Inverse Kinematic Problems, Solutions of Inverse Kinematic problems

**Navigation and Treatment Planning**

Variable speed arrangements, Path determination – Machinery vision, Ranging – Laser – Acoustic, Magnetic, fiber optic and Tactile sensor

**UNIT III SURGICAL ROBOTS 9**

Da Vinci Surgical System, Image guided robotic systems for focal ultrasound based surgical applications, System concept for robotic Tele-surgical system for off-pump, CABG surgery, Urologic applications, Cardiac surgery, Neuro-surgery, Pediatric and General Surgery, Gynecologic Surgery, General Surgery and Nanorobotics. Case Study

**UNIT IV REHABILITATION AND ASSISTIVE ROBOTS 9**

Pediatric Rehabilitation, Robotic Therapy for the Upper Extremity and Walking, Clinical-Based Gait Rehabilitation Robots, Motion Correlation and Tracking, Motion Prediction, Motion Replication. Portable Robot for Tele rehabilitation, Robotic Exoskeletons – Design considerations, Hybrid assistive limb. Case Study

**UNIT V WEARABLE ROBOTS 9**

Augmented Reality, Kinematics and Dynamics for Wearable Robots, Wearable Robot technology, Sensors, Actuators, Portable Energy Storage, Human–robot cognitive interaction (cHRI), Human–robot physical interaction (pHRI), Wearable Robotic Communication - case study

**TOTAL:45 PERIODS**

**COURSE OUTCOMES:**

**CO1:** Describe the configuration, applications of robots and the concept of grippers and actuators
**CO2:** Explain the functions of manipulators and basic kinematics
**CO3:** Describe the application of robots in various surgeries
**CO4:** Design and analyze the robotic systems for rehabilitation
**CO5:** Design the wearable robots

**REFERENCES**

1. Nagrath and Mittal, “Robotics and Control”, Tata McGraw Hill, First edition, 2003
2. Spong and Vidhyasagar, “Robot Dynamics and Control”, John Wiley and Sons, First edition, 2008
3. Fu.K.S, Gonzalez. R.C., Lee, C.S.G, “Robotics, control”, sensing, Vision and Intelligence, Tata McGraw Hill International, First edition, 2008

4. Bruno Siciliano, Oussama Khatib, Springer Handbook of Robotics, 1st Edition, Springer, 2008
5. Shane (S.Q.) Xie, Advanced Robotics for Medical Rehabilitation - Current State of the Art and Recent Advances, Springer, 2016
6. Sashi S Kommu, Rehabilitation Robotics, I-Tech Education and Publishing, 2007
7. Jose L. Pons, Wearable Robots: Biomechatronic Exoskeletons, John Wiley & Sons Ltd, England, 2008
8. Howie Choset, Kevin Lynch, Seth Hutchinson, "Principles of Robot Motion: Theory, Algorithms, and Implementations", Prentice Hall of India, First edition, 2005
9. Philippe Coiffet, Michel Chirouze, "An Introduction to Robot Technology", Tata McGraw Hill, First Edition, 1983
10. Jacob Rosen, Blake Hannaford & Richard M Satava, "Surgical Robotics: System Applications & Visions", Springer 2011
11. Jocelyn Troccaz, Medical Robotics, Wiley, 2012
12. Achim Schweikard, Floris Ernst, Medical Robotics, Springer, 2015

**VE4202 EMBEDDED AUTOMATION L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To learn about the process involved in the design and development of real-time embedded system
- To develop the embedded C programming skills on 8-bit microcontroller
- To study about the interfacing mechanism of peripheral devices with 8-bit microcontrollers
- To learn about the tools, firmware related to microcontroller programming
- To build a home automation system

**UNIT - I INTRODUCTION TO EMBEDDED C PROGRAMMING 9**

C Overview and Program Structure - C Types, Operators and Expressions - C Control Flow - C Functions and Program Structures - C Pointers And Arrays - FIFO and LIFO - C Structures - Development Tools

**UNIT - II AVR MICROCONTROLLER 9**

ATMEGA 16 Architecture - Nonvolatile and Data Memories - Port System - Peripheral Features : Time Base, Timing Subsystem, Pulse Width Modulation, USART, SPI, Two Wire Serial Interface, ADC, Interrupts - Physical and Operating Parameters

**UNIT – III HARDWARE AND SOFTWARE INTERFACING WITH 8-BIT SERIES CONTROLLERS 9**

Lights and Switches - Stack Operation - Implementing Combinational Logic - Expanding I/O - Interfacing Analog To Digital Convertors - Interfacing Digital To Analog Convertors - LED Displays : Seven Segment Displays, Dot Matrix Displays - LCD Displays - Driving Relays - Stepper Motor Interface - Serial EEPROM - Real Time Clock - Accessing Constants Table - Arbitrary Waveform Generation - Communication Links - System Development Tools

**UNIT – IV VISION SYSTEM 9**

Fundamentals of Image Processing - Filtering - Morphological Operations - Feature Detection and Matching - Blurring and Sharpening - Segmentation - Thresholding - Contours - Advanced Contour Properties - Gradient - Canny Edge Detector - Object Detection - Background Subtraction

**UNIT – V HOME AUTOMATION 9**

Home Automation - Requirements - Water Level Notifier - Electric Guard Dog - Tweeting Bird Feeder - Package Delivery Detector - Web Enabled Light Switch - Curtain Automation - Android Door Lock - Voice Controlled Home Automation - Smart Lighting - Smart Mailbox - Electricity Usage Monitor -Proximity Garage Door Opener - Vision Based Authentic Entry System

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

On successful completion of this course, students will be able to

**CO1:** analyze the 8-bit series microcontroller architecture, features and pin details

**CO2:** write embedded C programs for embedded system application

**CO3**: design and develop real time systems using AVR microcontrollers

**CO4**: design and develop the systems based on vision mechanism

**CO5**: design and develop a real time home automation system

**REFERENCES:**


1. Dhananjay V. Gadre, "Programming and Customizing the AVR Microcontroller", McGraw-Hill, 2001.
2. Joe Pardue, "C Programming for Microcontrollers ", Smiley Micros, 2005.
3. Steven F. Barrett, Daniel J. Pack, "ATMEL AVR Microcontroller Primer : Programming and Interfacing", Morgan & Claypool Publishers, 2012
4. Mike Riley, "Programming Your Home - Automate With Arduino, Android and Your Computer", the Pragmatic Programmers, Llc, 2012.
5. Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer, 2011.
6. Kevin P. Murphy, "Machine Learning - a Probabilistic Perspective", the MIT Press Cambridge, Massachusetts, London, 2012.