M.Tech DEGREE COURSE

COMPUTER AIDED PROCESS DESIGN

(CHEMICAL ENGINEERING) Curricula, Scheme of Examinations and Syllabi

(With effect from 2015 admissions)
## SCHEME OF EXAMINATIONS

### Semester I

<table>
<thead>
<tr>
<th>Exam Slot</th>
<th>Course No.</th>
<th>Name</th>
<th>L-T-P</th>
<th>Internal Marks</th>
<th>End Semester Exam Marks</th>
<th>Duration (hrs)</th>
<th>Credits</th>
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<tbody>
<tr>
<td>A</td>
<td>09CH6111</td>
<td>Advanced Mathematics</td>
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### Elective I
1. 09CH6115  Process Optimization
2. 09CH6125  Process Safety Engineering
3. 09CH6135  Advanced heat and mass transfer
4. 09CH6145  Project engineering of process plants
### Semester II

<table>
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<th>Exam Slot</th>
<th>Course No.</th>
<th>Name</th>
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**Electives:II**
1. 09CH6116  Design and Analysis of Experiments  
2. 09CH6126  Environmental Engineering and Management  
3. 09CH6136  Transport Phenomena  
4. 09CH6146  Downstream Processing  

**Elective III**
1. 09CH6166  Modern Methods of Instrumentation and Analysis  
2. 09CH6176  Computational Fluid Dynamics  
3. 09CH6186  Industrial Pollution Control  
4. 09CH6196  Advanced Chemical Engineering Thermodynamics
Semester III

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Elective IV
1. 09CH7117 Process Integration
2. 09CH7127 Non-Conventional Energy Sources
3. 09CH7137 Advanced Bioprocess Engineering
4. 09CH7147 Mathematical Methods in Chemical Engineering

Elective V
1. 09CH7167 Advanced Process Control
2. 09CH7177 Nanomaterials & Nanotechnology
3. 09CH7187 Separation Processes
4. 09CH7197 Polymer Composites

Semester IV

<table>
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<tr>
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<th>Course No.</th>
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FIRST SEMESTER

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<th>Course Name</th>
<th>L-T-P-Credits</th>
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<tr>
<td>09CH6111</td>
<td>ADVANCED MATHEMATICS</td>
<td>3-1-0-4</td>
<td>2015</td>
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Course Objectives
This course is intended to impart knowledge in numerical methods and statistics, which are powerful tools in engineering and also have wide areas of application.

Syllabus
Direct and iterative methods for solving systems of equations; interpolation techniques; numerical integration and differentiation; numerical solutions of ODE and PDE, probability and statistics.

Expected Outcome
Students will be able to identify and apply appropriate methods for dealing with numerical data obtained from experimental outcomes. The statistical tools will help them to analyze the results and to make better conclusions.

Text Books
1. Froberg C.E., Introduction to Numerical Analysis, Addison Wesley
2. Richard A. Johnson – Probability and Statistics for engineers ( PHI )

Reference Books
1. Gerald C.F., Applied Numerical Analysis, Addison Wesley
2. Hildebrand F.B., Introduction to Numerical Analysis, T.M.H.
4. Erwin Kreysig – Advanced Engineering Mathematics ( Wiley Eastern )

Course Plan

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
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|    | Lagrange’s interpolation polynomial - divided differences 
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<thead>
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<th>Newton’s divided difference interpolation polynomial - error of interpolation - finite difference operators - Gregory – Newton forward and backward interpolations - Stirling’s interpolation formula - interpolation with a cubic spline</th>
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<tr>
<td>FIRST INTERNAL EXAM</td>
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<tr>
<td>II</td>
<td>Numerical differentiation - differential formulas in the case of equally spaced points - numerical integration - trapezoidal and Simpson’s rules - Gaussian integration - errors of integration formulas</td>
</tr>
<tr>
<td>III</td>
<td>Numerical solution of ordinary differential equations- The Taylor series method - Euler and modified Euler methods - Runge–Kutta methods (2\textsuperscript{nd} order and 4\textsuperscript{th} order only) - multistep methods - Milne’s predictor - corrector formulas - Adam-Bashforth &amp; Adam-Moulton formulas - solution of boundary value problems in ordinary differential equations - finite difference methods for solving two dimensional Laplace’s equation for a rectangular region - finite difference method of solving heat equation and wave equation with given initial and boundary conditions</td>
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<tr>
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|    | 7 |
|    | 13% |

|    | 6 |
|    | 12% |

|    | 13 |
|    | 25% |

<p>|    | 13 |
|    | 25% |</p>
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<td>09CH6121</td>
<td>CHEMICAL ENGINEERING DESIGN I</td>
<td>3-1-0-4</td>
<td>2015</td>
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</table>

**Course Objectives**
To study in detail mechanical design of process equipments and their accessories involved and to develop CAD modules for them.

**Syllabus**
Introduction of codes for pressure vessel design, classification of pressure vessels as per codes. Design of cylindrical and spherical shells under internal and external pressure, selection and design of closures. Design of shell for tall tower used at high wind and seismic conditions. Design of lug, skirt and saddle support including bearing plates and anchor bolts. Selection of gaskets, selection of standard flanges, optimum selection of bolts for flanges, design of flanges. Design of solid-liquid separators.

**Expected Outcome**
- Knowledge of IS codes
- Able to use software tool for the design of internal pressure vessels
- Able to design flanges
- Able to design vessels under external pressure
- Able to design tall vessels with heads and closures and their supports
- Able to design solid-liquid separator

**Text Books**

**References**
1. IS Codes

**Course Plan**

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
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<tr>
<td>I</td>
<td>Introduction to codes. CAD Modules for design of rectangular / cylindrical / spherical vessels under internal pressure with dished / conical heads / closures. Design of Flanges.</td>
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<tr>
<td>II</td>
<td>Design of Tall Vessels with heads / closures. Wind load / Seismic load. Design of Vessels under external pressure. Thick – walled Vessels.</td>
<td>17</td>
<td>30%</td>
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<td>III</td>
<td>Design of Supports for Short / Tall Vessels. Vertical Supports (Skirt supports, Lug supports), Horizontal Supports (Saddle Supports). Solid liquid separators: - Rotary Drum Filter. Grit chamber, Trickling filter, Cyclone separator</td>
<td>17</td>
<td>35%</td>
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<td><strong>END SEMESTER EXAM</strong></td>
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Course No | Course Name | L-T-P-Credits | Year of Introduction
---|---|---|---
09CH6131 | CHEMICAL ENGINEERING DESIGN II | 3-1-0-4 | 2015

Course Objectives
1. To develop the ability of students to demonstrate knowledge in fundamentals of chemical engineering
2. To develop the ability of students to identify, formulate, analyze and solve common chemical engineering problems including physical and chemical processes or units
3. To develop the ability of students to design units or components for heat transfer to meet specific needs while observing technical, economical and safety constraints
4. To develop the ability of students to utilize experimental data, software, empirical equations and rules of thumb in the design of chemical engineering units

Syllabus
General design consideration, Introduction to simulation software in chemical engineering systems.
Introduction to P&I diagram
Detailed process design of Heat exchangers- Double pipe, Shell and Tube and Finned Double Pipe Heat Exchangers, Shell and Tube Condensers

Expected Outcome
The students completing this course will be able to
1. Utilize physicochemical properties of pure and mixed fluids
2. Apply basic material and energy balances to analyze and solve problems for a unit, process or an entire flow sheet using sequential and/or process solutions by performing hand-calculations and/or using suitable computer simulation packages and software
3. Compute the implications and differences in flow regimes; quantify the effects of constrictions and pipe size on power requirements; utilize the properties of materials to select a suitable material for constructing pipes based on the flowing fluid properties
4. Utilize proper energy equations and codes & standards to calculate energy requirements for equipment, such as heat exchangers and condensers
5. Calculate heat transfer coefficients, performing steady state analysis related to different modes of heat transfer
6. Utilize empirical equations and rules of thumbs in the design of chemical engineering units

Text Books

Reference Books
5. Alexandre C Dimian, “Integrated design and Simulation of Processes”, Elsevier
<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
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</table>
| I      | General: General design consideration, Optimum design, Details of Property estimation and Material and Energy balance to special software for steady state and dynamic simulation of chemical engineering systems. Introduction to P&I diagram  
Design of Double Pipe Heat Exchangers: Hairpins in series, hairpins in series – parallel. Heat transfer Correlations, Pressure drop computations | 17    | 30%                    |
|        | **FIRST INTERNAL EXAM**                                                                                                                                                                                 |       |                        |
Design of Finned Double Pipe Heat Exchangers: Longitudinal fins. Fin efficiency. Heat transfer and pressure drop correlations | 17    | 35%                    |
|        | **SECOND INTERNAL EXAM**                                                                                                                                                                                 |       |                        |
| III    | Condensers (Shell and Tube): Vertical condensers, horizontal condensers. Heat transfer and pressure drop correlations for film condensation on vertical and horizontal tube bundles. Condenser – sub coolers. Split flow arrangement | 18    | 35%                    |

**END SEMESTER EXAM**
Course No | Course Name | L-T-P-Credits | Year of Introduction
---|---|---|---
09CH6141 | ADVANCED CHEMICAL REACTION ENGINEERING | 2-1-0-3 | 2015

**Course Objectives**
The students completing this course will develop
1. Ability to determine the kinetics of homogeneous and heterogeneous reactions.
2. Ability to develop models for ideal and non-ideal reactors.
3. Skill to choose a reactor from many available alternatives.
4. Skill to design of reactors for a specific application.

**Syllabus**

**Expected Outcomes**
The students will be able to
1. Analyze the chemical reactors and reaction systems.
2. Describe the important aspects of homogeneous and heterogeneous reactions.
3. Apply the concepts to resolve the problems in solid catalyzed reaction.
4. Design of chemical reactors for homogeneous and heterogeneous reactions by applying the concepts of non-isothermal and non-ideal situations.

**Text Books**

**Reference Books**

**Course Plan**

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
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<td>Kinetics of single reactions in Ideal reactors</td>
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<td>Design of ideal reactors for single reactions</td>
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<td>Single and multiple reactor systems</td>
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<td>Basics of non-ideal flow.</td>
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<td>Convection model for laminar flow</td>
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<tr>
<td>Pore diffusion resistance combined with surface kinetics, effectiveness factor.</td>
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<td>Performance equation for reactors containing porous catalyst particles</td>
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<td>Packed bed catalytic reactors, fluidized reactors.</td>
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<td>Non-catalytic - Fluid–particle reactions- kinetics.</td>
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25%
Course No | Course Name | L-T-P- Credits | Year of Introduction
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09CH6115 | PROCESS OPTIMIZATION | 2-1-0-3 | 2015

Course Objectives
The students completing this course
1. Will develop in depth knowledge of different principles and methods of optimization.
2. Will develop a general approach for establishing the conditions for equilibrium and stability for complex systems.
3. Can analyze & solve practical chemical engineering optimization problems.
4. Can apply the knowledge of optimization to design problems.

Syllabus

Expected Outcome
1. Understand different principles and methods of optimization.
2. Formulate an optimization problem.
3. Analyze different levels of optimization problems (univariate & multivariate, unconstrained & constrained).
4. Apply the proper optimization methods to actual Chemical Engineering based problems.

Text Books
1. T. F. Edgar and DM Himmelblau, *Optimization of chemical processes*

Reference Books
2. Gilbert Strang, *Linear Algebra*

Course Plan

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<th>Contents</th>
<th>Hours</th>
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<td>Linear Algebra, Formulation of Optimization Problems in Chemical Engineering. Unconstrained optimization: necessary and sufficiency condition for local optimum, univariate optimization methods - bracketing techniques, Golden section and cubic interpolation.</td>
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<td>II</td>
<td>Multivariate Unconstrained Optimization -, Nelder-Head's method, Powell's method</td>
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<tr>
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<td>Steepest descent, Conjugate gradient, Newton and quasi-Newton methods</td>
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<td>III</td>
<td>Multivariate Constrained Optimization: Karush-Kuhn-Tucker conditions for local optimality, Linear Programming: Simplex, Duality</td>
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<tr>
<td>IV</td>
<td>Duality theory for nonlinear programming- Lagrangean Interpolation method- Quadratic programming- Active set method- Quadratic penalty method</td>
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<td>PROCESS SAFETY ENGINEERING</td>
<td>2-1-0-3</td>
<td>2015</td>
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**Course Objectives:**
To study the principles and practice of process safety.

**Syllabus:**

**Expected Outcome:**
1. To describe the needs of safety
2. Implement the safety in processes.
3. Analyze the chemical hazards in plants.
4. Analyze the Process Reliability and Human Errors.

**Text Books:**
2. V. C. Marshall- “Major Chemical Hazards” Ellis Harwood Ltd, Chicheser, UK 1987

**Reference Books:**

**Course Plan**

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
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<tbody>
<tr>
<td>I</td>
<td>Special Hazards of Chemicals – Toxicity, Flammability, Explosions</td>
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<td></td>
<td>Sources of Ignition, Ionising Radiation, Pressure and Temperature deviation, Runaway reactions.</td>
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<tr>
<td></td>
<td>Identification of Hazard - Inventory analysis, Dow Fire and Explosion Index.</td>
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<td>Mond Fire, Explosion and Toxicity Index.</td>
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<td></td>
<td>Major Industrial Hazards - Reasons, Flixborough and Bhopal disasters.</td>
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<td></td>
</tr>
<tr>
<td>II</td>
<td>Technique for Hazard Evaluation - Hazard and Operability, study</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preliminary Hazard Analysis</td>
<td>2</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>What if Analysis</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**FIRST INTERNAL EXAM**
Fault Tree Analysis, Event Tree Analysis
Failure Modes , Effects Analysis, Examples

2 13%
<p>| III | Consequence Analysis and Quantitative Risk Assessment- Consequence of Chemical accidents. | 1 |
|     | Models for Fire, Explosion and Toxic gas dispersion. | 2 |
|     | Individual and Societal Risk | 1 |
|     | F-N curves, Probit function. | 1 |
|     | Elements of Emergency Planning | 1 |
|     | Inherent Safety and Process Intensification-The concept of | 2 |
|     | Inherent Safety, Tools for Inherent Process Safety. | 1 |
|     | Inherent Safety Indices. | 1 |
|     | The concept of Process Intensification | 1 |
|     | <strong>SECOND INTERNAL EXAM</strong> | |
| IV  | Process Reliability and Human Error Analysis-Basic Principles of Reliability engineering. | 3 |
|     | Ways of improving process Reliability. | 2 |
|     | Reasons of Human Error | 2 |
|     | Technique for assessing Human error | 3 |
|     | <strong>END SEMESTER EXAM</strong> | |</p>
<table>
<thead>
<tr>
<th>Course No</th>
<th>Course Name</th>
<th>L-T-P- Credits</th>
<th>Year of Introduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>09CH6135</td>
<td>ADVANCED HEAT AND MASS TRANSFER</td>
<td>2-1-0-3</td>
<td>2015</td>
</tr>
</tbody>
</table>

**Course Objectives**

The students completing this course will develop

1. Deeper understanding on modes of heat transfer and their treatment in multi-dimensions.
2. The ability to analyze various engineering problems involving conduction, convection and radiation heat transfer.
3. The ability to develop and solve boundary layer equations for various cases of heat and mass transfer.
4. Knowledge to analyze and solve mass transfer cases involving multi-component diffusion.
5. Understanding of interphase mass transport involving multi component systems.
6. Apply the knowledge of heat and mass transfer to design problems.

**Syllabus**


**Expected Outcome**

Students will develop deeper understanding on advanced concepts of heat and mass transfer, analytical and problem solving skills on engineering problems involving the same and skill to apply the knowledge acquired in real design problems.

**Text Books**


**Reference Books**


**Course Plan**

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Review of conduction, convection, and thermal radiation fundamentals, steady state one- and two- dimensional conduction, transient conduction for various configurations and fins.</td>
<td>10</td>
<td>25%</td>
</tr>
<tr>
<td>II</td>
<td>Convection heat transfer – Heat transfer in laminar and turbulent flows, hydrodynamic and thermal boundary layer.</td>
<td>5</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td><strong>FIRST INTERNAL EXAM</strong></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Integral analysis of hydro dynamic boundary layer. Heat transfer to non-</td>
<td>5</td>
<td>12%</td>
</tr>
</tbody>
</table>
Newtonian fluids.

| III | Molecular diffusion – Steady state molecular diffusion, equations of change for multi component systems, use of equations of change in diffusion problems. Simultaneous diffusion and chemical reaction. Analogy between heat, mass and momentum transfer. | 10 | 25% |

**SECOND INTERNAL EXAM**

| IV | Interphase transport in multi component systems – Binary mass transfer coefficient in one phase, mass transfer coefficients for low and high mass transfer rates. Film theory, penetration theory and boundary layer theory of mass transfer. | 9 | 25% |

**END SEMESTER EXAM**
<table>
<thead>
<tr>
<th>Course No</th>
<th>Course Name</th>
<th>L-T-P- Credits</th>
<th>Year of Introduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>09CH6145</td>
<td>PROJECT ENGINEERING OF PROCESS PLANTS</td>
<td>2-1-0-3</td>
<td>2015</td>
</tr>
</tbody>
</table>

**Course Objectives**

*To impart the basic concepts of project management and design aspects of process plants*

**Syllabus**

Scope of project engineering - the role of project engineer - R & D - plant location and site selection - process engineering - Planning and scheduling of projects - procurement operations - office procedures - project financing - statutory sanctions - Details of engineering design and equipment selection I - Details of engineering design and equipment selection II - thermal insulation and buildings - safety in plant design - plant constructions, start up and commissioning

**Expected Outcome**

1. The student will acquire the knowledge to evaluate design aspects & design options of process plant.
2. The student will be able to evaluate the technical, economic, and financial feasibility of a process plant

**Reference Books**

- Rase & Barrow, Project Engineering of Process Plants, John Wiley
- Frederick B. Plummer, Project Engineering, BH

**Course Plan**

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Scope of project engineering - the role of project engineer - R &amp; D - TEFR - plant location and site selection - preliminary data for construction projects - process engineering - flow diagrams - plot plans - engineering design and drafting</td>
<td>9</td>
<td>25%</td>
</tr>
<tr>
<td>II</td>
<td>Planning and scheduling of projects - bar chart and network techniques</td>
<td>4</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>FIRST INTERNAL EXAM</td>
<td></td>
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<tr>
<td></td>
<td>procurement operations - office procedures - contracts and contractors - project financing - statutory sanctions</td>
<td>5</td>
<td>15%</td>
</tr>
<tr>
<td>III</td>
<td>Details of engineering design and equipment selection I - design calculations excluded - vessels - heat exchangers - process pumps - compressors and vacuum pumps - motors and turbines - other process equipment</td>
<td>10</td>
<td>25%</td>
</tr>
</tbody>
</table>

**SECOND INTERNAL EXAM**
| IV | Details of engineering design and equipment selection II - design calculations excluded - piping design - thermal insulation and buildings - safety in plant design - plant constructions, start up and commissioning | 10 | 25% |

**END SEMESTER EXAM**
Course No | Course Name | L-T-P-Credits | Year of Introduction
---|---|---|---
09CH6151 | RESEARCH METHODOLOGY | 1-1-0-2 | 2015

**Course Objectives**
Introduce the students to the field of research and give an idea on how to conceptualize their research design and how to publish their results in the knowledge database.

**Syllabus**
Introduction to Research methodology, Conceptualizing a research design, Application of mathematical modelling and simulation in research, Research writing and publishing

**Expected Outcome**
The student will be able to:

1. Formulate the research problem
2. Develop a research plan
3. Conduct the research
4. Analyze and interpret the data by various techniques
5. Publish their results

**Text Books**

**Reference Books**

**Course Plan**

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester Exam marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Research Methodology: An introduction Meaning of research, Objectives of research, Motivation in research, Applications of research, Definition of research, Characteristics of research, Types of research, Steps in research process Formulating a research problem: - Reviewing the literature,</td>
<td>7</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>Formulating a research problem, Identifying variables, Constructing hypothesis</td>
<td></td>
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</tbody>
</table>
| II | Conceptualizing a Research Design:-  
Definition of a research design, Need for research design, Functions of research design, Features of a good design  
Methods of Data Collection:-  
Collection of primary data, Observation method, Interview method, Collection of data through questionnaires, Collection of data through schedules. | 7 | 25% |
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<tr>
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</thead>
<tbody>
<tr>
<td>III</td>
<td>Mathematical modelling and simulation:— Concepts of modelling, Classification of mathematical models, Modelling with:— Ordinary differential equations, Difference equations, Partial differential equations, Graphs, Simulation, Process of formulation of model based on simulation.</td>
<td>6</td>
</tr>
</tbody>
</table>
| IV | Research writing in general:— Referencing, Writing a bibliography, Developing an outline, Writing about a variable, Interpretation of data and paper writing, Layout of a research paper, Journals in Chemical Engineering, Impact factor of Journals, When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism  
Software for paper formatting like LaTeX/ MS Office | 6 | 25% |
<table>
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<tbody>
<tr>
<td></td>
<td>FIRST INTERNAL EXAM</td>
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</tbody>
</table>
| II | Conceptualizing a Research Design:-  
Definition of a research design, Need for research design, Functions of research design, Features of a good design  
Methods of Data Collection:-  
Collection of primary data, Observation method, Interview method, Collection of data through questionnaires, Collection of data through schedules. | 7 | 25% |
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<tbody>
<tr>
<td>III</td>
<td>Mathematical modelling and simulation:— Concepts of modelling, Classification of mathematical models, Modelling with:— Ordinary differential equations, Difference equations, Partial differential equations, Graphs, Simulation, Process of formulation of model based on simulation.</td>
<td>6</td>
</tr>
</tbody>
</table>
| IV | Research writing in general:— Referencing, Writing a bibliography, Developing an outline, Writing about a variable, Interpretation of data and paper writing, Layout of a research paper, Journals in Chemical Engineering, Impact factor of Journals, When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism  
Software for paper formatting like LaTeX/ MS Office | 6 | 25% |
<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>SECOND INTERNAL EXAM</td>
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</tbody>
</table>
Course No | Course Name | L-T-P-Credits | Year of Introduction
---|---|---|---
09CH6161 | SEMINAR | 0-0-2-2 | 2015

Course Objectives
To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his/her ideas and thus creating self esteem and courage that are essential for an engineer.

Individual students are required to choose a topic of their interest from process design/design related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 45 minutes. A committee consisting of at least three faculty members shall assess the presentation of the seminar and award marks to the students based on merits of topic of presentation. Each student shall submit two copies of a write up of the seminar topic. One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Internal Continuous Assessment (*Maximum Marks-100*)

<table>
<thead>
<tr>
<th>Component</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relevance + Literature</td>
<td>10</td>
</tr>
<tr>
<td>Concept / Knowledge in the topic</td>
<td>20</td>
</tr>
<tr>
<td>Presentation</td>
<td>40</td>
</tr>
<tr>
<td>Report</td>
<td>30</td>
</tr>
<tr>
<td><strong>Total marks</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Expected Outcome
At the end of the course the student will be able to
1. Communicate with group of people on different topics
2. Prepare a Seminar report that includes consolidated information on a topic
<table>
<thead>
<tr>
<th>Course No</th>
<th>Course Name</th>
<th>L-T-P- Credits</th>
<th>Year of Introduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>09CH6171</td>
<td>COMPUTER AIDED DESIGN LAB</td>
<td>0-0-2-1</td>
<td>2015</td>
</tr>
</tbody>
</table>

**Course Objectives**
To study the design of process equipments using special softwares for chemical engineering systems.

Optimal design of the following equipments using softwares.

3. Condensers (Shell and Tube): Vertical condensers, horizontal condensers.
4. Reboilers & Vaporisers: Kettle type, Vertical Thermosyphon type.

**Internal Continuous Assessment** *(Maximum Marks - 100)*

- Regularity : 30 marks
- Record : 20 marks
- Tests, Viva : 50 marks
- **Total marks** : **100 marks**

**Expected Outcome**
At the end of the course the student will be able to

1. Solve complex chemical engineering problems by applying suitable numerical methods
2. Design the process equipment using design software
**SECOND SEMESTER**

<table>
<thead>
<tr>
<th>Course No</th>
<th>Course Name</th>
<th>L-T-P- Credits</th>
<th>Year of Introduction</th>
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</thead>
<tbody>
<tr>
<td>09CH6112</td>
<td>CHEMICAL ENGINEERING DESIGN III</td>
<td>2-1-0-3</td>
<td>2015</td>
</tr>
</tbody>
</table>

**Course Objectives**

To study in detail design of heat and mass transfer equipments and phase separation equipments which are very integral in industry

**Syllabus**


**Expected Outcome**

1. The course will provides basic concepts, industrial practices and theoretical relationships useful for the design of process equipment
2. The students will able to apply the principles of heat & mass transfer to engineering situations and the design of equipments involving both heat & mass transfer.

**Reference Books**

7. Nauman Bruce; Handbook of chemical reactor design, optimisation and scale up, McGraw Hill

**Course Plan**

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Reboilers &amp; Vaporisers: Kettle type, Vertical Thermosyphon type</td>
<td>10</td>
<td>30%</td>
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<td></td>
<td><strong>FIRST INTERNAL EXAM</strong></td>
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<td><strong>SECOND INTERNAL EXAM</strong></td>
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END SEMESTER EXAM
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<tr>
<th>Course No</th>
<th>Course Name</th>
<th>L-T-P-Credits</th>
<th>Year of Introduction</th>
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<tbody>
<tr>
<td>09CH6122</td>
<td>CHEMICAL ENGINEERING DESIGN IV</td>
<td>3-1-0-4</td>
<td>2015</td>
</tr>
</tbody>
</table>

**Course Objectives**

1. To develop the ability of students to demonstrate knowledge in fundamentals of chemical engineering
2. To develop the ability of students to demonstrate knowledge of physical processes encountered in chemical engineering practice including the various separation processes
3. To develop the ability of students to identify, formulate, analyze and solve common chemical engineering problems including physical and chemical processes or units
4. To develop the ability of students to design units or components for mass transfer to meet specific needs while observing technical, economical and safety constraints
5. To develop the ability of students to utilize experimental data, software, empirical equations and rules of thumb in the design of chemical engineering units

**Syllabus**

Detailed process design of equipment for Absorption, Distillation, Multi-component Distillation, Liquid-Liquid extraction

**Expected Outcome**

The students completing this course will be able to

1. Utilize physicochemical properties of pure and mixed fluids
2. Apply basic material and energy balances to analyze and solve problems for a unit, process or an entire flow sheet using sequential and/or process solutions by performing hand-calculations and/or using suitable computer simulation packages and software
3. Apply the fundamentals of stage operations using phase diagrams and phase equilibrium, and describe the main factors affecting them
4. Analyze stage-wise and continuous gas-liquid/ liquid-liquid separation processes by applying graphical and analytical methods for absorbers, distillation columns and extraction columns
5. Apply the basics of mass transfer operations in the design of units such as absorption, distillation columns and liquid-liquid extraction units.
6. Calculate mass transfer coefficients, performing steady state analysis
7. Utilize proper codes & standards, empirical equations and rules of thumbs in the design of chemical engineering units

**Text Books**


**Reference Books**

5. Alexandre C Dimian, “Integrated design and Simulation of Processes”, Elsevier
## Course plan

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Design of Packed Bed Absorption Column: Flooding and loading. Flooding Velocity Computation. Mass transfer correlations. HTU — NTU concept</td>
<td>16</td>
<td>30%</td>
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<tr>
<td>II</td>
<td>FIRST INTERNAL EXAM</td>
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<tr>
<td>III</td>
<td>SECOND INTERNAL EXAM</td>
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<tr>
<td></td>
<td>Computer Aided Design and Analysis of Multicomponent Distillation processes by FUG (Fenske — Underwood — Gilliland) Method. Liquid - liquid extraction columns, packed columns</td>
<td>18</td>
<td>35%</td>
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<tr>
<td></td>
<td>END SEMESTER EXAM</td>
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<tr>
<td>Course No</td>
<td>Course Name</td>
<td>L-T-P-Credits</td>
<td>Year of Introduction</td>
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</tr>
<tr>
<td>09CH6132</td>
<td>PROCESS MODELING AND SIMULATION</td>
<td>2-1-0-3</td>
<td>2015</td>
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</tbody>
</table>

### Course Objectives
1. To develop the ability in students to demonstrate the knowledge of physical and chemical processes encountered in chemical engineering practice
2. To make the students to develop the mathematical models for chemical engineering systems and solutions for those models

### Syllabus
Introduction-Models, Classification and Model building. Modeling and Simulation of Lumped parameter models (steady-state and unsteady-state), Distributed parameter models (steady-state and unsteady state)

### Expected Outcome
The students completing this course will be able to
1. Define, List and Explain the classification of mathematical models
2. List and Explain the steps involved in mathematical modeling
3. Describe the fundamental, the physical meaning and the equations governing the processes
4. Formulate and Validate models
5. Demonstrate the model solving ability for various processes/unit operations

### Text Books
2. Biquette W.B., Process Dynamics - Modeling Analysis and Simulation, Prentice Hall of India

### Reference Books
4. John Ingham et.al., Chemical Engineering Dynamics - Modelling with PC Simulation, VCH Publishers
<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Definitions of Modelling, Simulation-classification of modelling techniques-uses and applications of mathematical modelling-basic modelling principles-fundamental laws of chemical engineering: energy equations, continuity equation, equation of motion, transport equations, equations of state, equilibrium states and chemical kinetics-sufficiency and redundancy-boundary conditions Solution methods for algebraic equations: direct and indirect methods- Solution methods for initial value and boundary value problems: Euler’s method, R-K method.</td>
<td>9</td>
<td>25%</td>
</tr>
<tr>
<td>II</td>
<td>Mathematical models with simulation strategies for chemical engineering systems: continuous flow tanks-open and enclosed vessel- mixing vessel</td>
<td>4</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td><strong>FIRST INTERNAL EXAM</strong></td>
<td></td>
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<tr>
<td></td>
<td>Mixing with reaction - reversible reaction- steam jacketed vessel-isothermal constant and variable hold up CSTR in series- batch reactor - semi batch reactor.</td>
<td>6</td>
<td>15%</td>
</tr>
<tr>
<td>III</td>
<td>Mathematical models with simulation strategies for Boiling of single component liquid- open and closed vessel - continuous flow boiling - multicomponent boiling system - batch distillation-condensation- Multicomponent flash drum- ideal binary distillation column – multicomponent distillation column- Liquid extraction</td>
<td>11</td>
<td>25%</td>
</tr>
<tr>
<td>IV</td>
<td>Solution strategies for distributed parameter models-shooting method, finite difference methods. Mathematical models with simulation strategies for Distributed system: Double pipe liquid-liquid heat exchanger- tubular reactor with axial dispersion</td>
<td>9</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td><strong>SECOND INTERNAL EXAM</strong></td>
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<td></td>
<td><strong>END SEMESTER EXAM</strong></td>
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</tbody>
</table>
Course Objectives
This subject provides students with the knowledge to

1. Use statistics in experimentation;
2. Understand the important role of experimentation in new product design, manufacturing process development, and process improvement;
3. Analyze the results from such investigations to obtain conclusions;
4. Become familiar methodologies that can be used in conjunction with experimental designs for robustness and optimization.

Syllabus
Introduction to the role of experimental design - Basic statistical concepts - Hypothesis testing - Analysis of variance (ANOVA) - Design of experiments - Regression analysis - Response surface methodology

Expected Outcomes
The students will be able to

1. Describe how to design experiments, carry them out, and analyze the data they yield.
2. Understand the process of designing an experiment including factorial and fractional factorial designs.
3. Investigate the logic of hypothesis testing, including analysis of variance and the detailed analysis of experimental data.
4. Learn the technique of regression analysis, and how it compares and contrasts with other techniques studied in the course.
5. Understand the role of response surface methodology and its basic underpinnings.

Text Books

Reference Books
2. “Introduction to Probability models” by Sheldon M. Ross, 10th Edn, Elsevier, USA.

Course Plan

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Introduction to the role of experimental design</td>
<td>2</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>Basic statistical concepts, sampling and sampling distribution</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hypothesis Testing</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Inference about the difference in means and variances</td>
<td>2</td>
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</tr>
<tr>
<td></td>
<td>Analysis of variance (ANOVA) - one-way classification</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Analysis of fixed effects model, Estimation of model parameters</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

**FIRST INTERNAL EXAM**

<table>
<thead>
<tr>
<th>I</th>
<th>Comparison among treatment means</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Random effects model; randomized designs and paired comparison designs, the randomized complete block design.</td>
<td>3</td>
</tr>
</tbody>
</table>

**SECOND INTERNAL EXAM**

<table>
<thead>
<tr>
<th>III</th>
<th>Factorial design of experiments; two-factor factorial design</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Analysis of fixed effects model</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>General factorial design</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Analysis of 2k and 3k factorial designs</td>
<td>3</td>
</tr>
</tbody>
</table>

**END SEMESTER EXAM**
Course No 09CH6126  Course Name ENVIRONMENTAL ENGINEERING AND MANAGEMENT  L-T-P-Credits 2-1-0-3  Year of Introduction 2015

Course Objectives
The students completing this course
1. Will be able to understand and characterize water & air pollutions and respective sources.
2. Enable for management, design of systems for solid, liquid and air pollution control

Syllabus

Expected Outcome
1. Understand different types of Air, water pollutions and respective sources.
2. Analyze the environmental aspects of pollution.
3. Characterize different sources of waste.
4. Manage solid & hazardous wastes.
5. Model and design water treatment system for any effluent treatment plant.

Text Books

Reference Books
2. H.S Peavey et al., Environmental engineering, McGraw Hill

Course Plan

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Waste water treatment Modelling and Design of Activated sludge system, Advanced waste water treatment, Sludge treatment and disposal. Characteristics of domestic waste, municipal waste water treatment systems</td>
<td>9</td>
<td>25%</td>
</tr>
<tr>
<td>II</td>
<td>Air pollution: Air pollution control of stationary</td>
<td>5</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td><strong>FIRST INTERNAL EXAM</strong></td>
<td>5</td>
<td>13%</td>
</tr>
<tr>
<td>III</td>
<td>Pollution control in industries: pollution control in petroleum refineries, fertilizer industries, pulp and paper industries, textile industries, rubber processing industries, chlor-alkali industries, tanning industries, breweries, dairy, phenol plants, electroplating and metal finishing industries and cement industries</td>
<td>10</td>
<td>25%</td>
</tr>
</tbody>
</table>

**SECOND INTERNAL EXAM**

| IV | Solid waste and hazardous waste management: characteristics of solid waste, disposal methods, Resource conservation and recovery. Definitions and classification of hazardous waste, waste minimization and recycling, treatment techniques. Handling and management of hospital wastes. General guidelines of environmental impact assessment (EIA), environmental management systems (EMS) and environmental audit. | 10 | 25% |

**END SEMESTER EXAM**
Course No  | Course Name       | L-T-P-Credits | Year of Introduction |
-----------|-------------------|---------------|----------------------|
09CH6136   | TRANSPORT PHENOMENA | 2-1-0-3       | 2015                 |

**Course Objectives**
To develop the ability to elaborate conceptual and mathematical models, from conservation principles, to systems involving simultaneous mass, momentum, and/or heat transfer processes as well as reactions or other sources/sinks of transport for multi-component mixtures.

**Syllabus**
Flux laws, shell balance equations- simplification and solution to problems, use of equations of change to solve fluid flow problems, comparison of laminar and turbulent flows in circular tubes and flat plates, interphase transport – friction factors, energy equation, use of equations of change to solve heat transfer problems, equation of continuity for a multi component mixture, use of equations of change to solve mass transfer problems, simultaneous heat and mass transfer, thermal diffusion and pressure diffusion.

**Expected Outcome**
The students completing this course will develop
1. Understanding of the principles of transport of momentum, heat and mass.
2. The ability to set up overall balances for conservation of momentum, energy and mass and apply flux laws in balances.
3. The ability to obtain profiles for velocity, temperature and concentration from shell balance equations.
4. The ability to reduce and solve appropriate equations of change to obtain desired profiles for velocity, temperature and concentration.
5. The ability to apply the principles of transport processes to practical situations.

**Text Books**

**Reference Books**
1. Frank M. White, Viscous fluid flow, McGraw Hill International
2. C.O.Bennett, J.E. Myers, Momentum, Heat and Mass Transfer, McGraw Hill

**Course Plan**

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Flux laws, shell balance equations for momentum, heat and mass transfer – simplification of equations in various coordinate systems to solve a few introductory problems-flow of a falling film, flow through a circular tube, heat conduction through composite walls, heat conduction with a chemical heat source, diffusion through stagnant gas film, diffusion with reaction.</td>
<td>9</td>
<td>25%</td>
</tr>
<tr>
<td>II</td>
<td>Equation of continuity, motion, substantial derivative,</td>
<td>6</td>
<td>13%</td>
</tr>
</tbody>
</table>
Navier – Stokes equation, Euler equation, use of equations of change to solve fluid flow problems- flow of falling film, steady flow in a long circular tube, shape of surface of a rotating liquid, operation of a couette viscometer.

<table>
<thead>
<tr>
<th>FIRST INTERNAL EXAM</th>
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</thead>
<tbody>
<tr>
<td>Comparisons of laminar and turbulent flows in circular tubes and flat plates, interphase transport- friction factors for flow in tubes</td>
<td>4</td>
</tr>
<tr>
<td>III</td>
<td>10</td>
</tr>
<tr>
<td>Equation of energy, use of equations of change to solve steady state problems involving heat transfer- steady flow forced convection heat transfer in laminar flow in a circular tube, tangential flow in an annulus with viscous heat generation, steady flow in a non-isothermal film, transpiration cooling.</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SECOND INTERNAL EXAM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Equation of continuity for a multi component mixture, diffusion, convection and chemical reaction, use of equations of change to solve problems involving mass transfer-simultaneous heat and mass transport, thermal diffusion and Clusius – Dickel column, pressure diffusion and ultracentrifuge</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>END SEMESTER EXAM</th>
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</thead>
</table>
Course Objectives
In this course the students are introduced to different downstream processing techniques and their principle, scale up, design application and importance in product separation and purification operations.

Syllabus
Overview of downstream process technology, Product identification techniques. Mechanisms, principle, scale up and design of thickener, precipitation units, filtration units, distillation column, extraction column, evaporator, crystallizer and driers.

Expected Outcome
The students completing this course will develop
- Ability to describe the principles and application of major unit operations used in downstream processing; for example homogenization, centrifugation and precipitation, chromatography and membrane separation units.
- Ability to analyze and perform basic scale-up calculations for major downstream unit operations such as sedimentation, filtration, extraction, adsorption etc
- Ability to design various equipments like thickener, filtration units, distillation column, extraction column, evaporator, crystallizer and driers.

Reference Books
1. Juan A. Asenjo (Ed), *Separation processes in biotechnology*, CRC

Course Plan

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overview of downstream process technology: Need for downstream processing, criteria for choice of recovery processes. Cell disruption, Flocculation, Foam and bubble fractionation- Principle, operation and applications.</td>
<td>2</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>Gravity sedimentation: Mechanisms of sedimentation, Design of industrial equipments for gravity settling-thickeners, classifiers – applications in downstream processing.</td>
<td>2</td>
<td></td>
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<tr>
<td></td>
<td>Centrifugal separations: Theory of centrifugal settling, ultra centrifugation.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Filteration: Equipments for conventional filtration- filter media, pre-treatment methods, general filtration theory- Darcy’s law, compressible and incompressible filter cakes, filtration cycle, scale up and design of filtration systems.</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product identification techniques – Electrophoresis, Thin layer chromatography, High performance liquid chromatography.</td>
<td>1</td>
<td></td>
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<tr>
<td>Distillation – Types of distillation – batch, continuous, industrial fractionation, extractive distillation, steam and vacuum distillation.</td>
<td>3</td>
<td></td>
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</tr>
<tr>
<td>Extractive separations: General principles, analysis of batch and staged extraction - differential and fractional extraction-scale up and design of extractors - reciprocating plate extraction columns, centrifugal extractors- aqueous two phase extraction and supercritical fluid extraction – theoretical principles, process, equipment and applications.</td>
<td>15%</td>
<td></td>
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</tr>
<tr>
<td>Adsorption: Adsorption equilibrium, adsorbent types, equipment operation- adsorption column dynamics- fixed bed and agitated bed adsorption, scale up of adsorption processes- LUB method</td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaporation: Factors affecting evaporation, equipments – Number of effects, short tube, long tube, falling film evaporators.</td>
<td>2</td>
<td></td>
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</tr>
<tr>
<td>Precipitation: Methods of precipitation, precipitate formation, Factors influencing protein solubility, design of precipitation systems</td>
<td>25%</td>
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<td></td>
</tr>
<tr>
<td>Product crystallization: Basic principles- nucleation and crystal growth - Mier’s super saturation theory- kinetics of crystallization-analysis of dilution batch crystallization-commercial crystallizers- process crystallization of proteins, Recrystallization.</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product drying: Heat and mass transfer in drying- types of commercial dryers- vacuum dryers, freeze dryers, spray dryers- scale up and design of drying systems.</td>
<td>25%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chromatographic separations: Classification of techniques, elution chromatography- retention theory, band broadening effects, separation efficiency, resolution, yield and purity, discrete stage analysis, kinetic analysis- Gas and liquid chromatography- Bonded phase chromatography, Ion exchange chromatography, gel permeation chromatography, affinity chromatography-supercritical fluid chromatography - Chiral chromatography- expanded bed chromatography- simulated countercurrent chromatography- process scale up.</td>
<td>25%</td>
<td></td>
<td></td>
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<tr>
<td><strong>Electrokinetic separations</strong>: Electrophoresis – Principles and techniques.</td>
<td>1</td>
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<tr>
<td><strong>Membrane separation processes</strong>: Cross flow filtration – filter media- ultra filtration and microfiltration membranes, filter modules, modes of operation, concentration polarization and fouling.</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipments, principle and applications of reverse osmosis, dialysis, electrodialysis, pervaporation and perstraction.</td>
<td>1</td>
<td></td>
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</tbody>
</table>

**END SEMESTER EXAM**
<table>
<thead>
<tr>
<th>Course No</th>
<th>Course Name</th>
<th>L-T-P-Credits</th>
<th>Year of Introduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>09CH6166</td>
<td>MODERN METHODS OF INSTRUMENTATION AND ANALYSIS</td>
<td>2-1-0-3</td>
<td>2015</td>
</tr>
</tbody>
</table>

**Course Objectives**
To familiarize the basic concepts of various modern instrumentation techniques used in chemical analysis.

**Syllabus**
Working principle, components, areas of application of different types of Chromatography, spectroscopy, thermal analysis, microscopy and X-ray techniques.

**Expected Outcome**
The students completing this course will develop
- Acquaintance with modern instrumentation and analysis techniques
- Ability to describe the principles of analytical methods such as chromatography, spectroscopy, and thermal analysis, XRD, SEM, AFM and TEM
- Ability to use modern instrumentation and classical techniques, to design experiments, and to properly record the results of their experiment

**Reference Books**

**Course Plan**

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Introduction to chemometrics - classification of instrumental techniques.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basic functions of instrumentation - factors affecting choice of analytical method - interferences - data handling</td>
<td>3</td>
<td></td>
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<tr>
<td></td>
<td>Introduction to scanning electron microscopy, transform electron microscopy, Atomic force microscopy.</td>
<td>2</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>Introduction to differential scanning calorimetry (DSC), thermogravimetric analysis (TGA) and differential thermal analysis (DTA).</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Principles of chromatography.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instrumentation of Gas liquid chromatography, gas chromatography column, liquid phases and column selection, detectors - thermal conductivity detectors, flame ionization detectors, thermionic emission detector and electron capture detector.</td>
<td>4</td>
<td>12%</td>
</tr>
</tbody>
</table>

**FIRST INTERNAL EXAM**
HPLC instrumentation, mobile phase delivery system, sample introduction, Separation columns - standard column, narrow bore column, short fast column, guard | 5 | 13% |
column and in-line filters, temperature control, detectors — UV visible photometers and spectrometers, electrochemical detectors. High pressure liquid chromatography-applications

| III | General feature of spectroscopy, interaction of radiation with matter. | 1 |
| Instrumentation of IR&FTIR spectroscopy, sample handling, quantitative analysis | 4 |
| NMR spectroscopy—basic principles, spectra and molecular structure, elucidation of NMR spectra, quantitative analysis. | 3 |
| Mass spectroscopy—instrumentation ionization methods, mass analysis, correlation of mass spectra with molecular structure. | 2 |

| II | Introduction to XRD, production of X-ray and X-ray spectra. X-ray absorption methods | 2 |
| x-ray diffraction, and electron spectroscopy for chemical analysis | 3 |
| Surface area determination by BET method, particle size by light scattering method, zeta potential, colour etching spectrophotometer lavibond tintometer | 4 |

**END SEMESTER EXAM**
<table>
<thead>
<tr>
<th>Course No</th>
<th>Course Name</th>
<th>L-T-P-Credits</th>
<th>Year of Introduction</th>
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</thead>
<tbody>
<tr>
<td>09CH6176</td>
<td>COMPUTATIONAL FLUID DYNAMICS</td>
<td>2-1-0-3</td>
<td>2015</td>
</tr>
</tbody>
</table>

**Course Objectives**
To build expertise in detailed study of Computational Flow Modelling, Solution of model equations and application in reactive flows and multiphase flows.

**Syllabus**
Introduction to computational modeling, index notation of vectors and tensors, control volume, Reynold’s transport theorem, governing equations, phenomenological models, numerical methods for CFD, PDE’s, properties of numerical solutions, accuracy and error, application of numerical methods, detailed study of Navier – Stokes equation, implicit and explicit methods, turbulence modeling, reactive flows and combustion, multiphase flow, polymeric liquids, rheological models, circulation, Die swell, extensional flows, DEM-Lattice Boltzmann-Immersed Boundary-Boundary Elements.

**Expected Outcome**
After successfully completing this course, the student will be able to
1. Develop an understanding of the major theories, approaches and methodologies used in CFD
2. Apply knowledge of basic science and engineering fundamentals to solve practical problems
3. Numerically solve the governing equations for fluid flow.
5. Understand and apply turbulence models to engineering fluid flow problems.
6. Assess the quality of numerical results.
7. Understand the issues in multiphase flow modeling.

**Text Books**

**Reference Books**

<table>
<thead>
<tr>
<th>Course Plan</th>
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</thead>
<tbody>
<tr>
<td><strong>Module</strong></td>
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<tr>
<td>I</td>
</tr>
<tr>
<td>II</td>
</tr>
<tr>
<td><strong>FIRST INTERNAL EXAM</strong></td>
</tr>
<tr>
<td>III</td>
</tr>
<tr>
<td><strong>END SEMESTER EXAM</strong></td>
</tr>
</tbody>
</table>
Course No | Course Name | L-T-P- Credits | Year of Introduction
--- | --- | --- | ---
09CH6186 | INDUSTRIAL POLLUTION CONTROL | 2-1-0-3 | 2015

**Course Objectives:**

- To impart the basic concepts of industrial pollution control
- To develop understanding about water, air, Soil pollution control

**Syllabus:**

Water pollution laws and standards - industrial wastewater treatment, processes and equipment. Water pollution control in different Chemical industries, Air Pollution Laws, Air pollutants monitoring equipment and method of analysis, Air pollution control methods in industries, sludge treatment and disposal.

**Expected Outcome:**

1. To understand the needs of environmental pollution control.
2. Apply the Air, Water and Environmental (Protection) Act, Hazardous and Solid Waste (Management & Handling) rules for prevention and control of pollution.
3. Analyze the emission of pollutants from industries and its health effects.
4. Design proper control methods to prevent pollution through air, water and sand.
5. Design Effluent Treatment plant based on effluent characteristics.

**Text Books:**

2. Mahajan S.P., Pollution Control In Process Industries, Tata Mcgraw Hill
3. Mccaff & Eddy, Waste Water Treatment
4. Peavy, Environmental Engineering
5. Rao C.S., Environmental Pollution Control Engineering, New Age Int. Pub.
6. Gerard Kiely, Environmental Engineering, Mcgraw Hill

**Reference Books:**

3. Babbitt H.E, Sewage & Sewage Treatment, John Wiley
4. Abbasi S.A, & Ramasami E, Biotechnical Methods Of Pollution Control, Universities Press (India) Ltd.
5. S C. Bhatia, Handbook of industrial pollution control vol-1 and 2.

**Course Plan**

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Classification of industrial wastewater</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Types of pollutants and their effects</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitoring and analysis Methods</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water pollution laws and standards</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial wastewater treatment - processes</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial wastewater treatment -equipment.</td>
<td>2</td>
<td>25%</td>
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</tbody>
</table>
|   | Water pollution control in industries --
<table>
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<tr>
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<tbody>
<tr>
<td></td>
<td>Pulp and paper, Textile processing</td>
</tr>
<tr>
<td></td>
<td>Tannery wastes, Dairy wastes</td>
</tr>
<tr>
<td></td>
<td>Cannery wastes, Brewery</td>
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<tr>
<td></td>
<td>Distillery, Meat Packing, Food Processing Wastes</td>
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<tr>
<td></td>
<td>Pharmaceutical wastes, Chlor-Alkali Industries</td>
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</table>

### FIRST INTERNAL EXAM

<table>
<thead>
<tr>
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<th>Score</th>
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<tbody>
<tr>
<td>Fertilizer Industry</td>
<td>1</td>
</tr>
<tr>
<td>Petrochemical Industry</td>
<td>1</td>
</tr>
<tr>
<td>Rubber Processing Industry, Starch Industries</td>
<td>1</td>
</tr>
<tr>
<td>Metal Industries, Nuclear Power Plant Wastes</td>
<td>1</td>
</tr>
<tr>
<td>Thermal Power Plant Wastes.</td>
<td>1</td>
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</tbody>
</table>

### SECOND INTERNAL EXAM

<table>
<thead>
<tr>
<th></th>
<th>Score</th>
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</thead>
<tbody>
<tr>
<td>Air pollution control in industries: source and classification of industrial air pollutant</td>
<td></td>
</tr>
<tr>
<td>Monitoring equipment and method of analysis</td>
<td>1</td>
</tr>
<tr>
<td>Damages to health, vegetation and Materials</td>
<td>1</td>
</tr>
<tr>
<td>Air pollution laws and standards</td>
<td>1</td>
</tr>
<tr>
<td><strong>Treatment method in specific industries</strong> - thermal power plants - cement</td>
<td>2</td>
</tr>
<tr>
<td>Fertilizers - Petroleum Refineries</td>
<td>1</td>
</tr>
<tr>
<td>Iron and steel - chlor-alkali</td>
<td>1</td>
</tr>
<tr>
<td>Pulp and paper.</td>
<td>1</td>
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### END SEMESTER EXAM

<table>
<thead>
<tr>
<th></th>
<th>Score</th>
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<tbody>
<tr>
<td>Industrial odour control - sources and solutions - odour control by adsorption and wet scrubbing</td>
<td></td>
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<tr>
<td>Industrial noise control methods</td>
<td>2</td>
</tr>
<tr>
<td>Sludge treatment and disposal</td>
<td>1</td>
</tr>
<tr>
<td>Industrial hazardous waste management, Waste minimization.</td>
<td>1</td>
</tr>
<tr>
<td>Environmental Impact Assessment and risk assessment-Environmental Audit and Environmental management system</td>
<td>2</td>
</tr>
<tr>
<td>Concept of common effluent treatment plants.</td>
<td>2</td>
</tr>
</tbody>
</table>
Course No | Course Name | L-T-P-Credits | Year of Introduction
--- | --- | --- | ---
09CH6196 | ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS | 2-1-0-3 | 2015

Course Objectives
The students completing this course will develop
1. The ability to apply energy and entropy balance to practical situations
2. In-depth understanding of phase and reaction equilibria.
3. A general approach for establishing the conditions for equilibrium and stability for complex systems
4. The capability of working with multi-phase pure materials and mixtures.
5. The skill to solve problems involving phase equilibrium of single and multi component systems
6. The ability to apply the knowledge of thermodynamics to design problems.

Syllabus
Basic concepts of thermodynamics, thermodynamic properties of fluids, properties of solutions, phase equilibria for single component and multi component systems, reaction equilibrium.

Expected Outcome
Students will be able to
1. Understand the importance and relevance of thermodynamics in life processes
2. Analyze various situations and apply the concepts of thermodynamics to problem solving.
3. Work with single and multiphase systems of pure materials and mixtures.
4. Apply the knowledge of thermodynamics to design problems.

Text Books

Reference Books
1. Kyle B.G., Chemical and Process Thermodynamics, Prentice-Hall of India
2. Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press

Course Plan

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Basic concepts – internal energy, enthalpy, entropy, work, ideal and real gas laws. Thermodynamic properties of pure fluids - Gibbs free energy, work function - Maxwell’s equations - Clapeyron equation, Joule-Thomson coefficient - Gibbs - Helmholtz equation.</td>
<td>3</td>
<td>25%</td>
</tr>
<tr>
<td>Topic</td>
<td>Weight</td>
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<td>----------------------------------------------------------------------</td>
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<tr>
<td>Fugacity and activity of pure fluids - effect of temperature and</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pressure on fugacity and activity.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Properties of solutions, partial molar properties, chemical</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>potential, fugacity in solutions, Lewis-Randall rule</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Henry’s law, ideal solutions - Raoult’s law, activity in solutions,</td>
<td>4</td>
<td></td>
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<tr>
<td>Gibbs-Duhem equations, excess properties.</td>
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**FIRST INTERNAL EXAM**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase equilibria in single component and multi component systems,</td>
<td>3</td>
</tr>
<tr>
<td>phase rule for non-reacting systems - Duhem’s theorem</td>
<td></td>
</tr>
<tr>
<td>VLE in ideal solutions - non-ideal solutions - positive and</td>
<td>3</td>
</tr>
<tr>
<td>negative deviation - azeotropes</td>
<td></td>
</tr>
<tr>
<td>VLE at low pressures - Wohl’s equation - van Laar equation - Wilson</td>
<td>2</td>
</tr>
<tr>
<td>equation - application of activity coefficient equations in</td>
<td></td>
</tr>
<tr>
<td>equilibrium calculations - basic idea on NRTL, UNIQUAC and UNIFAC</td>
<td></td>
</tr>
<tr>
<td>methods</td>
<td></td>
</tr>
<tr>
<td>Phase equilibrium - vapour-liquid equilibrium at high pressures,</td>
<td>2</td>
</tr>
<tr>
<td>bubble point, dew point and flash calculations in multi component</td>
<td></td>
</tr>
<tr>
<td>systems - computer programs for these calculations</td>
<td></td>
</tr>
<tr>
<td>Consistency tests for equilibrium data, calculation of activity</td>
<td>2</td>
</tr>
<tr>
<td>coefficients using Gibbs - Duhem equations</td>
<td></td>
</tr>
<tr>
<td>Vapour-liquid equilibrium in partially miscible and immiscible</td>
<td>2</td>
</tr>
<tr>
<td>systems, phase diagrams - liquid-liquid equilibrium - binary and</td>
<td></td>
</tr>
<tr>
<td>ternary equilibrium diagrams.</td>
<td></td>
</tr>
</tbody>
</table>

**SECOND INTERNAL EXAM**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical reaction equilibria - criteria of chemical equilibrium -</td>
<td>5</td>
</tr>
<tr>
<td>equilibrium constant, Feasibility of reaction, factors affecting</td>
<td></td>
</tr>
<tr>
<td>equilibrium conversion</td>
<td></td>
</tr>
<tr>
<td>Phase-rule for reacting systems. Heterogeneous chemical reactions,</td>
<td>4</td>
</tr>
<tr>
<td>combined chemical and phase equilibrium.</td>
<td></td>
</tr>
</tbody>
</table>

**END SEMESTER EXAM**
<table>
<thead>
<tr>
<th>Course No</th>
<th>Course Name</th>
<th>L-T-P- Credits</th>
<th>Year of Introduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>09CH6162</td>
<td>MINIPROJECT</td>
<td>0-0-4.2</td>
<td>2015</td>
</tr>
</tbody>
</table>

**Course Objectives**

- To practice the steps involved for the selection, execution, and reporting of the project.
- To train the students for group activities to accomplish an engineering task.

Student group consist of maximum of 2 members are required to choose a topic of their interest. The subject content of the mini project shall be from emerging / thrust areas, topics of current relevance having research aspects or shall be based on industrial visits. At the end of the semester, the students should submit a report duly authenticated by the respective guide, to the head of the department.

Evaluation will be conducted by a committee consisting of three faculty members. The students are required to bring the report completed in all respects duly authenticated by the respective guide and head of the department, before the committee. Students individually will present their work before the committee. The committee will evaluate the students individually and marks shall be awarded as follows.

Mini Project will have internal marks100.

<table>
<thead>
<tr>
<th>Attendance &amp; Regularity</th>
<th>10+10 marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluation I</td>
<td>30 marks</td>
</tr>
<tr>
<td>Evaluation II</td>
<td>30 marks</td>
</tr>
<tr>
<td>Assessment by Guide</td>
<td>20 marks</td>
</tr>
</tbody>
</table>

**Expected Outcome**

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

1. Implement the methods/techniques identified
2. Analyse and interpret the results obtained.
3. Prepare a report that includes information on a topic.
Course No    | Course Name                                | L-T-P-Credits | Year of Introduction |
-------------|--------------------------------------------|---------------|----------------------|
09CH6172     | DESIGN, SIMULATION AND INSTRUMENTAL - ANALYSIS LAB | 0-0-2-1       | 2015                 |

**Course Objectives**

To provide the students with the fundamental knowledge of

- Programming and computation in MATLAB.
- Design of processes and equipments and their simulation using softwares.
- Measurement and analysis of process variables by using modern instruments.

Optimal design of the following.

1. Distillation column for binary mixture: plate & packed columns, Multi-component distillation. Absorption tower both plate as well as packed type.


3. Multiple Effect Evaporators.

**List of experiments in Instrumental Analysis Lab**

1. UV-Visible spectrophotometer
2. Infrared spectrophotometer
3. Atomic absorption spectrophotometer.
4. Flame photometer
5. Thermo gravimetric analyzer
6. Differential scanning calorimeter
7. Differential thermal analyzer
8. Gas chromatograph.
9. High performance liquid chromatograph

**Internal Continuous Assessment (Maximum Marks-100):**

<table>
<thead>
<tr>
<th>Component</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regularity</td>
<td>30</td>
</tr>
<tr>
<td>Record</td>
<td>20</td>
</tr>
<tr>
<td>Tests, Viva</td>
<td>50</td>
</tr>
</tbody>
</table>

**Expected Outcome**

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

1. Solve complex chemical engineering problems by applying suitable numerical methods.
2. Design the process equipment using software.
3. Analyse different parameters using Modern instruments.
THIRD SEMESTER

<table>
<thead>
<tr>
<th>Course No</th>
<th>Course Name</th>
<th>L-T-P-Credits</th>
<th>Year of Introduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>09CH7117</td>
<td>PROCESS INTEGRATION</td>
<td>2-1-0-3</td>
<td>2015</td>
</tr>
</tbody>
</table>

**Course Objectives**
The students completing this course will develop
1. The ability to analyse heat exchanger networks
2. The ability to find out the energy requirement for a process using composite and grand composite curves
3. The ability to do Thermodynamic analysis (Pinch analysis), design and optimization of energy efficient industrial processes
4. The ability to modify processes for minimisation of raw material and waste generation

**Syllabus**

**Expected Outcome**
The students completing this course will develop the skills
1. To design heat exchanger with minimum external heating/cooling with fewest number of units and lowest possible total area in the heat exchanger
2. To suggest energy optimal integration solutions for distillation columns, evaporators heat and power systems
3. To do mathematical optimization within process design

**Text Books**

**Reference Books**

**Course Plan**

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
</tr>
</thead>
</table>
Network.

<table>
<thead>
<tr>
<th></th>
<th>Reactor Integration-Choice of Idealized reactor model and reactor performance. Reactor configurations: Temperature Control, Gas-Liquid and Liquid-Liquid Reactors</th>
<th></th>
<th>5</th>
<th>13%</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td><strong>FIRST INTERNAL EXAM</strong></td>
<td></td>
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<tr>
<td></td>
<td>Heat Integration characteristics of reactors, Appropriate placements of reactors. Use of GCC for Heat Integration of reactors.</td>
<td></td>
<td>5</td>
<td>12%</td>
</tr>
<tr>
<td>III</td>
<td><strong>SECOND INTERNAL EXAM</strong></td>
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<tr>
<td></td>
<td>Distillation Integration-Distillation sequencing, Heat Integration characteristics of Distillation column, appropriate placement of distillation column, various configurations for heat integration of distillation column.</td>
<td></td>
<td>10</td>
<td>25%</td>
</tr>
<tr>
<td>IV</td>
<td><strong>END SEMESTER EXAM</strong></td>
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<tr>
<td>Course No</td>
<td>Course Name</td>
<td>L-T-P-Credits</td>
<td>Year of Introduction</td>
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<tr>
<td>09CH7127</td>
<td>NON-CONVENTIONAL ENERGY SOURCES</td>
<td>2-1-0-3</td>
<td>2015</td>
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</tbody>
</table>

**Syllabus**
Non—conventional energy sources, Nuclear Energy, Solar Energy Utilisation (Thermal), Energy from Ocean, Wind, Tides and geothermal sources, Energy from biomass

**Expected Outcome**
Understand of nuclear energy and nuclear fission principles
Understand solar Energy sources
Understand wind Energy conversion systems
Understand energy from biomass biomass utilization

**Text Books**

**Reference Books**
1. Venkataswarlu D., Chemical Technology, I. S. Chand

**Course Plan**

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Nuclear Energy: Nuclear fission principles, types of nuclear reactors (BWR, PWR, PHWR, LMCR, GCR, FFR). Nuclear reactor analysis: four factor formula, resonance absorption, reactor buckling, multiplication factor, thermal utilisation coefficient, reflector saving, fast fission factor, optimum moderator to fuel ratio. Radioactive waste disposal.</td>
<td>9</td>
<td>25%</td>
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<tr>
<td></td>
<td><strong>FIRST INTERNAL EXAM</strong></td>
<td></td>
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<tr>
<td></td>
<td><strong>III</strong> Energy from Ocean, Wind, Tides and geothermal sources: OTEC power plants (closed cycle, open cycle, hybrid</td>
<td>10</td>
<td>25%</td>
</tr>
</tbody>
</table>
cycle), operation and technical problems, environmental impact. Tidal power, salinity power plants. Wind energy: Design and analysis of wind turbines. Geothermal systems: Hot water and dry steam systems, energy extraction principles.

<table>
<thead>
<tr>
<th>SECOND INTERNAL EXAM</th>
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<tbody>
<tr>
<td>IV</td>
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<td>10</td>
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<th>END SEMESTER EXAM</th>
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<tbody>
<tr>
<td>Course No</td>
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<tr>
<td>09CH7137</td>
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</tbody>
</table>

Course Objectives
To familiarize the students with various advanced theories in bioprocess engineering and kinetic parameters.

Syllabus
Introduction to fermentation process, Stoichiometry of microbial growth and product formation, Classification of microbial products, Material balance and energy balance of bioprocesses, Mass transfer in bioprocessing systems, Scale up and scale down of bioprocess systems, Design of novel bioreactors

Expected Outcome
The course will enable the student to:

1. Build mathematical models of microbial growth and product formation
2. Design a biological product and the desired bioprocess
3. Select or design appropriate bioreactor model based on the bioproduct and microbial strain
4. Develop suitable bioproduct separation techniques
5. Design proper bioprocess waste treatment methods

Text Books

Reference Books

Course Plan

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Introduction: Fermentation processes, General requirements of fermentation processes, An overview of aerobic and anaerobic fermentation processes and their application in industry, Medium requirements for fermentation processes - examples of simple and complex media, Stoichiometry of microbial growth and product formation: Growth stoichiometry and elemental balances, Respiratory</td>
<td>9</td>
<td>25%</td>
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</tr>
<tr>
<td><strong>II</strong></td>
<td>Classification of microbial products - Growth associated, Non-growth associated and Mixed growth associated product formation. Material balance and energy balance: Material balance for industrial fermentation, Downstream processing and waste treatment processes- problems.</td>
<td>5</td>
<td>13%</td>
</tr>
</tbody>
</table>

**FIRST INTERNAL EXAM**

|   | Energy balance for fermentation and downstream processing, Thermodynamics of microbial growth, Heat generation in microbial cultures-problems | 5 | 12% |

**III**

|   | Mass transfer in bioprocessing systems: Oxygen transfer mechanism, Assessment of $K_La$- chemical method, dynamic differential gassing out method, dynamic integral gassing out method, oxygen balance method, enzymatic method- merits and demerits of each method. Scale up and scale down of bioprocess systems: Need for scale up and scale down, Operating boundaries for aerated and agitated fermenters, Scale up criteria for microbial cell processes- constant power input per unit volume, constant $K_La$, constant mixing quality, constant momentum factor, constant impeller tip speed, constant mixing rate number, Scale down procedure | 10 | 25% |

**SECOND INTERNAL EXAM**

|   | Design of novel bioreactors- Packed bed bioreactors, Bubble-column bioreactors, Fluidized bed bioreactors, Trickle bed bioreactors, Airlift loop bioreactors, Photobioreactors. Thermal death kinetics of cells and spores: Survival curve, Decimal reduction factor, Extinction probability, Sterilization of culture medium, Batch and continuous sterilization- design aspects, Air sterilization, Design of fibrous type filters. | 10 | 25% |

**END SEMESTER EXAM**
**Course No**: 09CH7147  
**Course Name**: MATHEMATICAL METHODS IN CHEMICAL ENGINEERING  
**L-T-P-Credits**: 2-1-0-3  
**Year of Introduction**: 2015

**Course Objectives**  
The students completing this course will be able to  
1. To solve problems of algebraic, differential, simultaneous and partial differential equations  
2. Formulate mathematical model using single and multivariable calculus to enable engineering solutions to practical problem  
3. Apply pure mathematics content to problems related to practical Chemical Engineering  
4. Assess reasonableness of solutions and select appropriate levels of solution sophistication

**Syllabus**  
Mathematical formulation of the physical problems- Analytical solution of ordinary differential equations encountered in chemical engineering problems- The difference operator- Application of statistical methods

**Expected Outcome**  
The students completing this course will be able to evaluate a mathematical solution in terms of the original path

**Text Books**  
2. S. Pushpavanam, Mathematical Methods in Chemical Engineering, PHI.

**Reference Books**  

**Course Plan**

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Mathematical formulation of the physical problems - application of the law of conservation of mass, salt accumulation in stirred tank, starting equilibrium still, solvent extraction in two stages, diffusion with chemical reaction, application of the law of conservation of energy, radial heat transfer through cylindrical conductors, heating a closed kettle, flow of heat from a fin.</td>
<td>9</td>
<td>25%</td>
</tr>
<tr>
<td>II</td>
<td>Analytical (explicit) solution of ordinary differential equations encountered in chemical engineering problems first order differential equations, method of separation of variables,</td>
<td>3</td>
<td>8%</td>
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<tr>
<td></td>
<td><strong>FIRST INTERNAL EXAM</strong></td>
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</tr>
<tr>
<td></td>
<td>Equations solved by integration factors Examples involving mass and energy balances and reaction kinetics, second order differential equations, non-linear equations, linear equations, simultaneous diffusions and chemical</td>
<td>7</td>
<td>17%</td>
</tr>
</tbody>
</table>
reaction in a tubular reactor. Formulation of partial differential equations, unsteady state heat conduction in one dimension, mass transfer with axial symmetry.

| III | The difference operator, properties of the difference operator, difference tables and other difference operators, linear finite difference equations, the complimentary solution of the particular solution, simultaneous linear differential equations, non-linear finite difference equations, analytical solution. Solution of the following type of problems by finite difference method - calculation of the number of plates required for absorption column, calculation of the number of theoretical plates required for distillation column, number of steps required for a countercurrent extraction and leaching operations. | 10 | 25% |

**SECOND INTERNAL EXAM**

| IV | Application of statistical methods - propagation of errors of experimental data, parameter estimation of algebraic equations encountered in heat and mass transfer, kinetics and thermodynamics by: the method of averages, linear least squares and weighted line | 10 | 25% |

**END SEMESTER EXAM**
Course No: 09CH7167  
Course Name: ADVANCED PROCESS CONTROL  
L-T-P-Credits: 2-1-0-3  
Year of Introduction: 2015

**Course Objectives**
The students completing this course will learn:
1. The concepts of linear feedback control theory
2. Recent developments in control theory
3. Selection and applicability of different modes of controllers
4. To analyze the stability of systems and design controllers for robustness
5. Digital control
6. To simulate control systems using software

**Syllabus**
Basics of linear open loop and closed loop systems, different modes of controllers, performance criteria, stability analysis, advanced control strategies, sampled data control systems.

**Text Books**

**Reference Books**

**Course Plan**

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Introduction to linear open and closed loop</td>
<td>2</td>
<td></td>
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<tr>
<td></td>
<td>Different modes of controllers- P, PI, PID.</td>
<td>2</td>
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<tr>
<td></td>
<td>Performance criteria of controllers — the error performance indexes</td>
<td>2</td>
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<tr>
<td></td>
<td>Systems Control valves — characteristics, sizing and valve positioners</td>
<td>2</td>
<td></td>
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<tr>
<td></td>
<td>Introduction to PLC, SCADA, DCS systems</td>
<td>2</td>
<td>25%</td>
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<tr>
<td>II</td>
<td>Stability Analysis: Frequency response analysis, Bode plots</td>
<td>3</td>
<td>12%</td>
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<tr>
<td></td>
<td>Nyquist plots</td>
<td>1</td>
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<td></td>
<td><strong>FIRST INTERNAL EXAM</strong></td>
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<tr>
<td></td>
<td>Process identification.</td>
<td>1</td>
<td></td>
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<tr>
<td></td>
<td>Controller tuning - Zigler-Nichols and Cohen-Coon tuning methods</td>
<td>3</td>
<td>13%</td>
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<tr>
<td></td>
<td>Relay tuning.</td>
<td>1</td>
<td></td>
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<td></td>
<td><strong>III</strong> Special Control Techniques: Advanced control techniques, cascade, ratio, feed forward controls</td>
<td>3</td>
<td>25%</td>
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<tr>
<td></td>
<td>Adaptive control, selective controls</td>
<td>2</td>
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<td></td>
<td>Computing relays, simple alarms</td>
<td>1</td>
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<td></td>
<td>Smith predictor</td>
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<tr>
<td></td>
<td>Internal model control.</td>
<td>3</td>
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<tr>
<td></td>
<td><strong>SECOND INTERNAL EXAM</strong></td>
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<tr>
<td></td>
<td>Sample Data Controllers: Basic review of Z transforms</td>
<td>3</td>
<td></td>
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<tr>
<td></td>
<td>Response of discrete systems to various inputs. Open and closed loop response to step, impulse inputs,</td>
<td>4</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>Closed loop response of discrete systems.</td>
<td>3</td>
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<tr>
<td></td>
<td><strong>END SEMESTER EXAM</strong></td>
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</tbody>
</table>
Course Objectives
The students completing this course will develop
1. Understanding on nanotechnology and different types of nanomaterials.
2. Knowledge of synthesis and characterization of various nanomaterials such as nanoparticles, nanocomposites, etc.
3. Familiarity with the sophisticated analytical tools used for imaging, characterization and manipulation of nanomaterials.

Syllabus

Expected Outcome
Students should get familiarized with aspects of nanotechnology, their applications and the ongoing research in this area.

Course Plan

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Introduction to nanotechnology, nanoscale, electromagnetic spectrum, top down and bottom up approach, particle size, chemistry and physics of nanomaterials, electronic phenomenon in nanostructures, optical absorption in solids, quantum effects.</td>
<td>9</td>
<td>25%</td>
</tr>
<tr>
<td>II</td>
<td>Nanomaterials, preparation of nanomaterials like gold, silver, different types of nano-oxides, A1203, TiO2, ZnO etc. Sol-gel methods, cherrrical vapour deposition, ball milling etc.</td>
<td>5</td>
<td>13%</td>
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<tr>
<td></td>
<td><strong>FIRST INTERNAL EXAM</strong></td>
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<tr>
<td></td>
<td>Carbon nanotubes, preparation properties and applications like field emission displays. Different types of characterization techniques like SEM, AFM, TEM &amp; STM.</td>
<td>5</td>
<td>12%</td>
</tr>
<tr>
<td>III</td>
<td>Nanocomposites, nanofillers, high performance materials, polymer nanocomposites, nanoclays, nanowires, nanotubes, nanoclusters etc. Smart materials, self assembly of materials, safety issues with nanoscale powders.</td>
<td>10</td>
<td>25%</td>
</tr>
<tr>
<td>IV</td>
<td>Nanomanipulation, Micro and nanofabrication techniques, Photolithography, E-beam, FIB etc. Nanolithography, softlithography, photoresist materials. Introduction to MEMS, NEMS and nanoelectronics. Introduction to bionanotechnology and nanomedicines.</td>
<td>10</td>
<td>25%</td>
</tr>
</tbody>
</table>

END SEMESTER EXAM
Course Objectives

The students are familiarized with the concepts of advanced separation processes like Membrane separation processes, diffusional separation process, multicomponent absorption, azeotropic and extractive distillation.

Syllabus

Fundamentals of Separation Processes; basic definitions of relevant terms. Membrane based separation processes; fundamentals and various terms; classifications. Diffusional separation processes; gaseous diffusion, mechanism, process description, design considerations, basic principles. Introduction to multicomponent absorption, azeotropic distillation, extractive distillation.

Expected Outcome

• Knowledge of various chemical engineering separation processes
• Ability to select appropriate separation technique for intended problem
• Ability to analyze the separation system for multi-component mixtures
  • Ability to design separation system for the effective solution of intended problem

Text Books

1. Seader, Henly, Separation process principles, John Wiley

Reference Books


Course Plan

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Membrane separation processes — fundamentals, mechanism and equilibrium relationships, types and structure of membranes, membrane permeation of liquids and gases, effects of concentration, pressure and temperature, dialysis: mechanism, basic idea on dialyser design, industrial application, reverse osmosis, definitions and theory, design considerations, applications, ultra filtration.</td>
<td>10</td>
<td>25%</td>
</tr>
<tr>
<td>II</td>
<td>Diffusional separation processes — gaseous diffusion, mechanism, process description, design considerations, basic principles.</td>
<td>5</td>
<td>13%</td>
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</tbody>
</table>

FIRST INTERNAL EXAM

Diffusional separation processes- application, equipment 4 12%
for thermal diffusion and pressure diffusion.

| III | Azeotropic and extractive fractional distillation — separation of homogeneous azeotropes, separation of heterogeneous azeotropes, quantitative treatment of separation of binary heterogeneous azeotropes, selection of addition agents, selectivity, factors affecting selectivity, methods for prediction, mechanism of relative volatility change, choice of entrainer or solvent, design of an azeotropic distillation process, design of an extractive distillation process, methods of solvent recovery. | 10 | 25% |

| IV | Absorption of gases — non isothermal operation, adiabatic absorption and stripping in packed columns, multicomponent absorption, graphical and algebraic method for multistage operation, multicomponent mass transfer effects in the design of packed columns. | 10 | 25% |

**SECOND INTERNAL EXAM**

**END SEMESTER EXAM**
<table>
<thead>
<tr>
<th>Course No</th>
<th>Course Name</th>
<th>L-T-P- Credits</th>
<th>Year of Introduction</th>
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</thead>
<tbody>
<tr>
<td>09CH7197</td>
<td>POLYMER COMPOSITES</td>
<td>2-1-0-3</td>
<td>2015</td>
</tr>
</tbody>
</table>

**Syllabus**
Introduction to composite materials, Manufacturing of advanced composites, Theory of reinforcement, Testing of composites

**Expected Outcome**
- Be familiar with a range of composite types, their production and commercial applications of composites.
- Understand mechanical behaviour of composites and the theoretical background.
- Understand the underlying principals of polymer structure-properties relationships.
- Understand design principles for the manufacture of polymer-based products.
- Understand testing of composite material and quality control methods

**Text Books**
2. Composite Materials – K.K.Chawla

**Reference Books**

**Course Plan**

<table>
<thead>
<tr>
<th>Module</th>
<th>Contents</th>
<th>Hours</th>
<th>Semester exam marks %</th>
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<tbody>
<tr>
<td></td>
<td>Manufacturing of advanced composites: Polymer matrix composites: Preparation of Moulding compounds and prepregs – hand lay up method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding- vacuum bag moulding centrifugal casting-pultrusion-machinery, operation, advantages and disadvantages -</td>
<td>5</td>
<td>13%</td>
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<tr>
<td>FIRST INTERNAL EXAM</td>
<td>Fibre Reinforced Thermoplastics(FRTP) preparation-brief description of coating process melt compounding process and dry blending process-injection moulding, rotational moulding and cold forming of reinforced thermoplastics.</td>
<td>5</td>
<td>12%</td>
</tr>
<tr>
<td>SECOND INTERNAL EXAM</td>
<td>Testing of composites materials and products for quality control- Brief outlines of testing of glass fibre, testing of resins-testing of products. General design considerations-design values factor of safety-working stress approach – service ability design-warning of danger-design process-shape design &amp; selection of materials and processing methods-application of composite of materials in various fields-chemical industries- electrical and electronic industries- aerospace, marine, and transport applications-application in buildings.</td>
<td>10</td>
<td>25%</td>
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<tr>
<td>END SEMESTER EXAM</td>
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</tbody>
</table>
Course No  | Course Name | L-T-P-Credits | Year of Introduction  
--- | --- | --- | ---  
09CH7163 | SEMINAR | 0-0-2-2 | 2015  

**Course Objectives**

To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his/her ideas and thus creating self esteem and courage that are essential for an engineer.

Individual students are required to choose a topic of their interest from process design/design related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 45 minutes. A committee consisting of at least three faculty members shall assess the presentation of the seminar and award marks to the students based on merits of topic of presentation. Each student shall submit two copies of a write up of the seminar topic. One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

**Internal Continuous Assessment (Maximum Marks-100)**

- Relevance + Literature : 10 marks
- Concept / Knowledge in the topic : 20 marks
- Presentation : 40 marks
- Report : 30 marks
- **Total marks** : **100 marks**

**Expected Outcome**

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

3. Communicate with group of people on different topics
4. Prepare a Seminar report that includes consolidated information on a topic
Course No 09CH7183  Course Name PROJECT (PHASE - I)  L-T-P Credits 0-0-12-6  Year of Introduction 2015

Course Objectives
To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

The project work can be a design project which contains design of part of the plant| experimental project and or computer simulation project on chemical engineering or any of the topics related with chemical engineering stream. The project work is allotted individually on different topics. The students shall be encouraged to do their project work in the parent institute itself. If it is found essential, they may be permitted to continue their project outside the parent institute subject to the conditions in clause 10 of M.Tech regulations. Department will constitute an Evaluation Committee to review the project work. The Evaluation committee consists of at least three faculty members of which internal guide and another expert in the specified area of the project shall be two essential members.

The student is required to undertake the project phase-I during the third semester. Phase-I consists of preliminary thesis work, two reviews of the work and the submission of preliminary report. First review would highlight the topic, objectives, methodology and expected results.

| Supervisor | 20 marks |
| Committee | 30 marks |
| **Total** | **50 marks** |

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

1. Implement the methods/techniques identified
2. Analyse and interpret the results obtained.
3. Compare the result obtained with literature
4. Demonstrate the original contribution to knowledge
### FOURTH SEMESTER

<table>
<thead>
<tr>
<th>Course No</th>
<th>Course Name</th>
<th>L-T-P-Credits</th>
<th>Year of Introduction</th>
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<tr>
<td>09CH7184</td>
<td>PROJECT (PHASE - II)</td>
<td>0-0-21-12</td>
<td>2015</td>
</tr>
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#### Course Objectives
To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

The third semester project is continued in the 4th semester (Phase—II). Second review evaluates the progress of the work, preliminary report and scope of the work which is to be completed in the 4th semester.

- Supervisor : 30 marks
- External : 30 marks
- Committee : 40 marks
- **Total** : 100 marks

#### Expected Outcome
At the end of the course the student will be able to

1. Implement the methods/techniques identified
2. Analyse and interpret the results obtained.
3. Compare the result obtained with literature
4. Demonstrate the original contribution to knowledge