UNIVERSITY OF CALICUT

Abstract


GENERAL AND ACADEMIC BRANCH – IV ‘E’ SECTION

No.GAIIV/E1/1894/03 (sub file) Dated: Calicut University P.O., 02.02.2012.

3. Item No.7 of the minutes of the meeting of Board of Studies in Engineering (PG) held on 24.06.2011.
4. Minutes of the meeting of the Academic Council held on 03.12.2011 (Item No.1.17)

ORDER

As per paper read first above, the Principal, Government Engineering College, Kozhikode has informed that the college has obtained sanction from All India Council for Technical Education for commencing M.Tech course in Computer Aided Process Design (Chemical Engineering). The Principal had forwarded the syllabus of the said course, which was prepared by experts in the field and has requested for its approval

Vide paper read 2nd above, University has granted affiliation for starting M.Tech course in Computer Aided Process Design (Chemical Engineering) in Government Engineering College Kozhikode during the academic year 2011-2012.

As per paper read 3rd above, the meeting of Board of Studies in Engineering (PG) held on 24.06.2011, the members of the Board examined the syllabus and found that it is in accordance with the M.Tech Regulations – 2010. The Board vide item No.7 unanimously resolved to approve the syllabus of M.Tech course in Computer Aided Process Design (Chemical Engineering) and also fixed the eligible Degree for admission to the said course as “Degree in Chemical Engineering”.

Vide paper read 4th above, the meeting of the Academic Council held on 03.12.2011, vide item No.1.17, resolved to approve the above resolution of the Board of Studies in Engineering (PG) held on 24.06.2011.

Sanction has therefore been accorded for implementing the scheme and syllabus of the M.Tech course in Computer Aided Process Design (Chemical Engineering) with effect from 2011-2012 admission.

Orders are issued accordingly.

The syllabus is available in the University website.

Sd/-

ASSISTANT REGISTRAR (G&A-IV)
To
1. The Principal, Government Engineering College, Kozhikode
2. The Principals of all affiliated Engineering colleges offering M.Tech course.

Copy to: SA (with a request to upload in the University website)
PS to VC/ PA to Registrar/ PA to PVC/DR-M.Tech Sn/
PA to CE/Ex Section/ EG Section/Enquiry/
Chairman, Board of Studies in
Engineering (PG)/(UG)/SF/FC

Forwarded/By order

Sd/-
SECTION

OFFICER
UNIVERSITY OF CALICUT

M.Tech DEGREE COURSE
COMPUTER AIDED PROCESS DESIGN
(CHEMICAL ENGINEERING)

Curricula, Scheme of Examinations and Syllabi

(With effect from 2011 admissions)
## Scheme of Examinations

### Semester I

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Subject</th>
<th>Hours/week</th>
<th>Marks</th>
<th>Total marks</th>
<th>Sem-end exam duration - Hrs</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPD11 101</td>
<td>Advanced Mathematics</td>
<td>3 1 0</td>
<td>100 100</td>
<td>200</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>CPD 11 102</td>
<td>Mechanical Design of Process vessels-I</td>
<td>3 1 0</td>
<td>100 100</td>
<td>200</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>CPD 11 103</td>
<td>Process Equipment Design-II</td>
<td>3 1 0</td>
<td>100 100</td>
<td>200</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>CPD 11 104</td>
<td>Advanced Heat &amp; Mass Transfer</td>
<td>3 1 0</td>
<td>100 100</td>
<td>200</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>CPD 11 105</td>
<td>Elective I</td>
<td>3 1 0</td>
<td>100 100</td>
<td>200</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>CPD 11 106(P)</td>
<td>Computer Aided Design Lab/Mini Project</td>
<td>0 0 2</td>
<td>100 0</td>
<td>100</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>CPD 11 107(P)</td>
<td>Seminar</td>
<td>0 0 2</td>
<td>100 0</td>
<td>100</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>15 5 4</td>
<td>700 500</td>
<td>1200</td>
<td></td>
<td>24</td>
</tr>
</tbody>
</table>
### Elective I
- CPD 11 105 (A) Process Optimization
- CPD 11 105 (B) Process Safety Engineering
- CPD 11 105 (C) Project Engineering of process plants

### Semester – II

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Subject</th>
<th>Hours/week</th>
<th>Marks</th>
<th>Total</th>
<th>Sem-end exam duration - Hrs</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>T</td>
<td>P</td>
<td>Internal</td>
<td>Sem-end</td>
</tr>
<tr>
<td>CPD 11 201</td>
<td>Process modeling and Simulation</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>CPD 11 202</td>
<td>Process equipment Design -III</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>CPD 11 203</td>
<td>Process equipment Design -IV</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>CPD 11 204</td>
<td>Elective II</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>CPD 11 205</td>
<td>Elective III</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>CPD 11 206(P)</td>
<td>Design,Simulation &amp; Instrumental Analysis Lab/Mini Project</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>CPD 11 207(P)</td>
<td>Seminar</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

**TOTAL** | 15 | 5 | 4 | 700 | 500 | 1200 | 24 |

### Elective II
- CPD 11 204(A) Transport Phenomena
- CPD 11 204(B) Industrial Instrumentation
- CPD 11 204(C) Environmental Engineering and Management

### Elective III
- CPD 11 205(A) Computational methods for Process Design
- CPD 11 205(B) Modern methods of instrumentation and analysis
- CPD 11 205(C) Process Integration
### Semester III

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Subject</th>
<th>Hours/week</th>
<th>Marks</th>
<th>Total</th>
<th>Sem-end exam duration - Hrs</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>T</td>
<td>P</td>
<td>Internal</td>
<td>Sem-end</td>
</tr>
<tr>
<td>CPD 11 301</td>
<td>Elective IV</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>CPD 11 302</td>
<td>Elective V</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>CPD 11 303(P)</td>
<td>Industrial Training</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>CPD 11 304(P)</td>
<td>Master Research Project (Phase -I)</td>
<td>0</td>
<td>0</td>
<td>22</td>
<td>Guide\ EC*</td>
<td>150</td>
</tr>
</tbody>
</table>

**TOTAL** 6 2 22 550 200 750 15

NB: The student has to undertake the departmental work assigned by HOD

*EC – Evaluation Committee

**Electives – IV**
- CPD 11 301(A) Computational Fluid Dynamics
- CPD 11 301(B) Separation Processes
- CPD 11 301(C) Advanced Process Control

**Electives – V**
- CPD 11 302 (A) Non-conventional Energy sources
- CPD 11 302 (B) Nanomaterials & Nanotechnology
- CPD 11 302 (C) Design and Analysis of Experiments

### Semester IV

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Subject</th>
<th>Hours per week</th>
<th>Internal Marks</th>
<th>Sem-end exam</th>
<th>Total marks</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPD 11 404(P)</td>
<td>Masters Research Project (Phase II)</td>
<td>-</td>
<td>-</td>
<td>30</td>
<td>150</td>
<td>150</td>
</tr>
</tbody>
</table>

**TOTAL** 30 150 150 150 150 600 12

NB: The student has to undertake the departmental work assigned by HOD
Teaching scheme
4
3 hours lecture & 1 hour tutorial per week

Objective
This course provides a brief description of the concepts in numerical methods and statistics which are powerful tools in engineering and also have wide areas of application.

Module I (13 Hours)


Module II (14 Hours)
Lagrange’s interpolation polynomial - divided differences 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 - numerical differentiation - differential formulas in the case of equally spaced points - numerical integration - trapezoidal and Simpson’s rules - gaussian integration - errors of integration formulas

Module III (13 Hours)
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 & 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

Module IV (13 Hours)

References
1. Froberg C.E., Introduction to Numerical Analysis, Addison Wesley
2. Gerald C.F., Applied Numerical Analysis, Addison Wesley
3. Hildebrand F.B., Introduction to Numerical Analysis, T.M.H.
5. Erwin Kreysig – Advanced Engineering Mathematics(Wiley Eastern)
Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks
Question pattern
Answer any 5 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1: 20 marks</td>
<td>Question 3: 20 marks</td>
<td>Question 5: 20 marks</td>
<td>Question 7: 20 marks</td>
</tr>
<tr>
<td>Question 2: 20 marks</td>
<td>Question 4: 20 marks</td>
<td>Question 6: 20 marks</td>
<td>Question 8: 20 marks</td>
</tr>
</tbody>
</table>

CPD 11 102 MECHANICAL DESIGN OF PROCESS VESSELS I

Teaching scheme
4  
3 hours lecture & 1 hour tutorial per week

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

Module I (18 hours)
Introduction to codes. CAD Modules for design of rectangular / cylindrical / spherical vessels under internal pressure with dished / conical heads / closures. Design of Flanges.

Module II (18 hours)

Module III (17 hours)
Design of Supports for Short / Tall Vessels. Vertical Supports (Skirt supports, Lug supports), Horizontal Supports (Saddle Supports). Design of Pipes / Tubes under internal / external pressure.

References
Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 4 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1: 25 marks</td>
<td>Question 3: 25 marks</td>
<td>Question 5: 25 marks</td>
</tr>
<tr>
<td>Question 2: 25 marks</td>
<td>Question 4: 25 marks</td>
<td>Question 6: 25 marks</td>
</tr>
</tbody>
</table>

CPD 11 103  PROCESS EQUIPMENT DESIGN -II

Teaching scheme

3 hours lecture & 1 hour tutorial per week

Credits: 4

Objectives

The students are exposed with in detail design of fluid flow and heat transfer equipments and the basics of various design softwares which are very integral in industry.

Module I (17 Hours)

General: General design consideration, Optimum design, Property estimation and Material and Energy balance introduction to special software for steadystate and dynamic simulation of chemical engineering systems. Introduction to P&I diagram.


Module II (18 Hours)


Module III (18 Hours)

Reboilers & Vaporisers: Kettle type, Vertical Thermosyphon type

References
6. Alexandre C Dimian, “Integrated design and Simulation of Processes”, Elsevier

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern
Answer any 4 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1: 25 marks</td>
<td>Question 3: 25 marks</td>
<td>Question 5: 25 marks</td>
</tr>
<tr>
<td>Question 2: 25 marks</td>
<td>Question 4: 25 marks</td>
<td>Question 6: 25 marks</td>
</tr>
</tbody>
</table>
CPD 11 104  ADVANCED HEAT AND MASS TRANSFER

Teaching scheme
3 hours lecture & 1 hour tutorial per week

Credits: 4

Objective
To enable the students to have a detailed understanding of advanced concepts of heat and mass transfer

Module I (13 Hours)
Review of conduction, convection, and thermal radiation fundamentals, steady state one- and two-dimensional conduction, transient conduction for various configurations and fins.

Module II (13 Hours)

Module III (14 Hours)
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.

Module IV (13 Hours)
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.

References

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks
Question pattern
Answer any 5 questions by choosing at least one question from each module.
<table>
<thead>
<tr>
<th>Question 1</th>
<th>Question 3</th>
<th>Question 5</th>
<th>Question 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 marks</td>
<td>20 marks</td>
<td>20 marks</td>
<td>20 marks</td>
</tr>
<tr>
<td>Question 2</td>
<td>Question 4</td>
<td>Question 6</td>
<td>Question 8</td>
</tr>
<tr>
<td>20 marks</td>
<td>20 marks</td>
<td>20 marks</td>
<td>20 marks</td>
</tr>
</tbody>
</table>
Teaching scheme
Credits: 4
3 hours lecture & 1 hour tutorial per week

Objectives
To give in depth knowledge of different principles and methods of optimization so that it can be applied to Chemical engineering based problems.

Module I (13 Hours)

Module II (13 Hours)

Module III (14 Hours)
Multivariate Constrained Optimization: Karush-Kuhn-Tucker conditions for local optimality, Linear Programming: Simplex, Duality

Module IV(13 Hours)
Quadratic programming: Active set method, Nonlinear programming: Penalty function methods, SQP (Successive quadratic programming), Wolfe's reduced gradient methods, Generalized reduced gradient

References
1. T. F. Edgar and DM Himmelblau, Optimization of chemical processes
3. S.S. Rao, Optimization Theory and Applications
5. Gilbert Strang, Linear Algebra

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks
Question pattern
Answer any 5 questions by choosing at least one question from each module

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1: 20 marks</td>
<td>Question 3: 20 marks</td>
<td>Question 5: 20 marks</td>
<td>Question 7: 20 marks</td>
</tr>
<tr>
<td>Question 2: 20 marks</td>
<td>Question 4: 20 marks</td>
<td>Question 6: 20 marks</td>
<td>Question 8: 20 marks</td>
</tr>
</tbody>
</table>
Teaching scheme

4
3 hours lecture & 1 hour tutorial per week

Objectives

This is a detailed study of the principles and practice of process safety is intended. Hazard Analysis of Chemical plants, Case studies, Safe Design, Risk Assessment, Reliability engineering

Module 1 (13 Hours)

Special Hazards of Chemicals – Toxicity, Flammability, Explosions, Sources of ignition, Ionising Radiation, Pressure and Temperature deviation, Runaway reactions. Identification of Hazards- Inventory analysis, Dow Fire and Explosion Index, Mond Fire, Explosion and Toxicity Index. Major Industrial Hazards- Reasons, Flixborough and Bhopal disasters.

Module II (13 Hours)

Technique for Hazard Evaluation- Hazard and Operability Study, Preliminary Hazard Analysis, What if Analysis, Fault Tree Analysis, Event Tree Analysis, Failure Modes and Effects Analysis, Examples

Module III (14 Hours)


Module IV (13 Hours)


References


Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1: 20 marks</td>
<td>Question 3: 20 marks</td>
<td>Question 5: 20 marks</td>
<td>Question 7: 20 marks</td>
</tr>
</tbody>
</table>
CPD 11 105(C) PROJECT ENGINEERING OF PROCESS PLANTS

Teaching scheme
4
3 hours lecture & 1 hour tutorial per week

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

Module 1 (13 Hours)
Scope of project engineering - the role of project engineer - R & D - TEFR - plant location and site selection - preliminary data for construction projects - process engineering - flow diagrams - plot plans - engineering design and drafting

Module II (13 Hours)
Planning and scheduling of projects - bar chart and network techniques - procurement operations - office procedures - contracts and contractors - project financing - statutory sanctions

Module III (14 Hours)
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

Module IV (13 Hours)
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

References:
1. Rase & Barrow, Project Engineering of Process Plants, John Wiley
2. Peter S. Max & Timmerhaus, Plant design and economics for chemical engineers.
7. Frederick B. Plummer, Project Engineering, BH

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks
Question pattern

Answer any 5 questions by choosing at least one question from each module.
CPD 11 106(P)COMPUTER AIDED DESIGN LAB/MINI PROJECT

Hours per week: 2  
Credits: 2

Objective

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.

Mini project: Student has to do a mini project on a topic approved by a 3 member committee and submit two copies of project report and an assessment will be conducted by the committee.

Internal Continuous Assessment (Maximum Marks-100)

Regularity - 30 marks
Record - 20 marks
Tests, Viva - 50 marks

CPD 11 107(P) SEMINAR

Hours per week: 2 hours practical  
Credits: 2

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)

Presentation + Discussion : 60
Relevance + Literature : 10
Report : 20
SECOND SEMESTER
CPD 11 201 PROCESS MODELLING AND SIMULATION

Teaching scheme
3 hours lecture & 1 hour tutorial per week

Objective
To give student an understanding of Process Modelling and Simulation.

Module I (13 Hours)
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
Mathematical models for chemical engineering systems: continuous flow tanks-open and enclosed vessel

Module II (13 Hours)
Mathematical models for mixing vessel- mixing with reaction - reversible reaction- steam jacketed vessel-isothermal constant and variable hold up CSTR in series- Boiling of single component liquid-open and closed vessel - continuous flow boiling - multicomponent boiling system - batch distillation-condensation

Module III (14 Hours)
Multicomponent flash drum- - batch reactor – reactor with mass transfer- semi batch reactor-ideal binary distillation column – multicomponent distillation column
Distributed system: jacketed tubular reactor - laminar flow in a pipe - counter current liquid-liquid heat exchanger

Module IV (13 Hours)
Simulation of gravity flow tank- CSTR in series - non-isothermal CSTR- binary distillation column - batch reactor

References
3. John Ingham et.al., *Chemical Engineering Dynamics - Modelling with PC Simulation*, VCH Publishers

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks
Question pattern
Answer any 5 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1 20 marks</td>
<td>Question 3 20 marks</td>
<td>Question 5 20 marks</td>
<td>Question 7 20 marks</td>
</tr>
<tr>
<td>Question 2 20 marks</td>
<td>Question 4 20 marks</td>
<td>Question 6 20 marks</td>
<td>Question 8 20 marks</td>
</tr>
</tbody>
</table>
CPD 11 202 PROCESS EQUIPMENT DESIGN –III

Teaching scheme
3 hours lecture & 1 hour tutorial per week

Credits: 4

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

Module I (18 Hours)
Design of reactors - batch reactor- CSTR (single and two phase) - tubular- packed bed catalytic- Fluidised bed systems. Solid-liquid separators: Rotary drum filter.

Module II (17 Hours)

Module III (18 Hours)

References
7. Nauman Bruce;Handbook of chemical reactor design, optimisation and scale up, McGrawhill

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern
Answer any 4 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1 : 25 marks</td>
<td>Question 3 : 25 marks</td>
<td>Question 5 : 25 marks</td>
</tr>
<tr>
<td>Question 2 : 25 marks</td>
<td>Question 4 : 25 marks</td>
<td>Question 6 : 25 marks</td>
</tr>
</tbody>
</table>

CPD 11 203 PROCESS EQUIPMENT DESIGN –IV

Teaching scheme
3 hours lecture & 1 hour tutorial per week

Credits: 4

Objectives
To study in detail design of mass transfer equipments which are very integral in industry

**Module I (17 Hours)**

**Module II (18 Hours)**

**Module III (18 Hours)**

**References**
7. Nauman Bruce; Handbook of chemical reactor design, optimisation and scale up, McGrawhill

**Internal continuous assessment: 100 marks**
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

**End semester Examination: 100 marks**

**Question pattern**

Answer any 4 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1: 25 marks</td>
<td>Question 3: 25 marks</td>
<td>Question 5: 25 marks</td>
</tr>
<tr>
<td>Question 2: 25 marks</td>
<td>Question 4: 25 marks</td>
<td>Question 6: 25 marks</td>
</tr>
</tbody>
</table>

**CPD 11 204 (A) TRANSPORT PHENOMENA**

**Teaching scheme**
3 hours lecture & 1 hour tutorial per week

**Credits: 4**

**Objectives**
To impart the basic concepts of transport phenomena and develop understanding about momentum transport, heat transport and mass transport

**Module I (13 Hours)**
Introduction to general transport equations for momentum, heat and mass transfer in Cartesian, Cylindrical and Spherical coordinates, simplification of general equations to solve problems, boundary layer concept

**Module II (13 Hours)**
Equations of change in terms of substantial derivatives, Dimensional analysis of the equations of change. Time dependent flow of Newtonian fluids, flow near solid surfaces by boundary layer theory.

Velocity distributions in turbulent flow, comparison of laminar and turbulent flows in circular tubes and flat plates, time smoothed equations of change for incompressible fluid, time smoothed velocity profile near a wall, turbulent flow in ducts.


Module III (13 Hours)
Dimensionless groups in non-isothermal systems. Unsteady heat conduction in solids, steady heat conduction in laminar incompressible flow, boundary layer theory for non-isothermal flow. Turbulent flow- time smoothed equations of change for incompressible non-isothermal flow, time smoothed temperature profile near a wall and that for flow in tubes.

Interface transport in non-isothermal systems – definition of heat transfer coefficients, heat transfer coefficients for forced convection through tubes, flow around submerged objects, free convection and condensation of pure vapour on solid surfaces.

Macroscopic energy balance, use of macroscopic balances to solve steady state problems with flat velocity profile.

Module IV (14 Hours)
Equation of continuity for a multi component mixture, use of equations of change for mixtures, dimensional analysis of the equation of change for binary mixtures.

Time dependent diffusion, steady state transport in binary boundary layer.

Concentration distribution in turbulent flow- concentration fluctuation and the time smoothed concentration, time smoothing of the equation of continuity of a species.

Interphase transport- definition of mass transfer coefficients in one phase, correlation of binary transfer coefficients in one phase, mass transfer coefficients in two phases, mass transfer and chemical reactions. Macroscopic balances in multicomponent systems, use of macroscopic balances to solve steady state problems

References

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern
Answer any 5 questions by choosing at least one question from each module.
CPD 11 204 (B) INDUSTRIAL INSTRUMENTATION

Teaching scheme
3 hours lecture & 1 hour tutorial per week

Credits: 4

Objectives
To study about the different instruments and techniques used in chemical industry for measurement of various process variables and understand the theory behind them.

Module I (13 Hours)

Module II (13 Hours)

Module III (14 Hours)
Flow measurement – Electrical type flow meter, electromagnetic flow meter, ultrasound or acoustic velocity flow meter, Rotameter, hot wire anemometer. Flow measurement of solids. Level measurement in open vessels using bubbler system, strain measurement using strain gauge, humidity measurement using industrial dew point apparatus. Moisture content measurement using thermal method.

Module IV (13 Hours)

References

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks
Question pattern

Answer any 5 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1 : 20 marks</td>
<td>Question 3 : 20 marks</td>
<td>Question 5 : 20 marks</td>
<td>Question 7 : 20 marks</td>
</tr>
<tr>
<td>Question 2 : 20 marks</td>
<td>Question 4 : 20 marks</td>
<td>Question 6 : 20 marks</td>
<td>Question 8 : 20 marks</td>
</tr>
</tbody>
</table>

CPD 11 204(C) ENVIRONMENTAL ENGINEERING AND MANAGEMENT

Teaching scheme

3 hours lecture & 1 hour tutorial per week

Credits: 4

Objectives:

To enable the students for understanding and characterizing waste water, air pollution, solid waste management, design of systems for solid, liquid and air pollution control

Module I (13 Hours)


Module II (13 Hours)


Module III (14 Hours)

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.

Module IV (13 Hours)

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.

References:

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1: 20 marks</td>
<td>Question 3: 20marks</td>
<td>Question 5: 20marks</td>
<td>Question 7: 20marks</td>
</tr>
<tr>
<td>Question 2: 20 marks</td>
<td>Question 4: 20marks</td>
<td>Question 6: 20marks</td>
<td>Question 8: 20marks</td>
</tr>
</tbody>
</table>
Teaching scheme
3 hours lecture & 1 hour tutorial per week

Objective
To give the student an understanding of Computer aided steady state analysis, Flowsheeting, Methods of tearing, Simulation

Module I (13 Hours)
Mathematical methods used in flow sheeting and simulation, solution methods for linear and non-linear algebraic equations, solving one equation on one unknown, solution methods for linear equations, general approach for solving sets of non-linear equations, solving sets of sparse non-linear equations.

Module II (13 Hours)
Computerized physical property systems – physical property calculations, degrees of freedom in process design, degrees of freedom for a unit, degrees of freedom in a flow sheet, steady state flow sheeting and process design, approach to flow sheeting systems, introduction to sequential modular approach, simultaneous modular approach and equation solving approach, sequential modular approach to flow sheeting, examples. Tear streams, convergence of tear streams, partitioning and tearing of a flow sheet, partitioning and precedence ordering, tearing a group of units.

Module III (14 Hours)
Flow sheeting by equation solving methods based on tearing, modelling considerations, solution procedure, examples.

Module IV (13 Hours)
Simulation by linear methods, application to staged operations, absorption column, flash drum, simulation by quasi linear methods, simulation of flow in pipe networks, application to distillation and multiple reaction equilibrium

References
3. C.M. Crowe et al, Chemical plant simulation-an introduction to computer aided steady state analysis, Prentice Hall.
4. Anil Kumar, Chemical process synthesis and engineering design, TMH, 1981

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern
Answer any 5 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1: 20 marks</td>
<td>Question 3: 20 marks</td>
<td>Question 5: 20 marks</td>
<td>Question 7: 20 marks</td>
</tr>
<tr>
<td>Question 2: 20 marks</td>
<td>Question 4: 20 marks</td>
<td>Question 6: 20 marks</td>
<td>Question 8: 20 marks</td>
</tr>
</tbody>
</table>
Teaching scheme

3 hours lecture & 1 hour tutorial per week

Credits: 4

Objective
To familiarize the basic concepts of various modern instrumentation techniques used in chemical analysis

Module 1 (13 Hours)
Introduction to chemometrics- Classification of errors- accuracy- precision –how to reduce systematic errors- reliability of results- classification of instrumental techniques. Basic functions of instrumentation-factors affecting choice of analytical method- interferences- data handling

Module II (14 Hours)
Principles of chromatography, 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. HPLC instrumentation, mobile phase delivery system, sample introduction. Separations column-standard column, narrow bore column, short fast column, guard column and in-line filters, temperature control, detectors –UV visible photometers and spectrometers, electrochemical detectors. High pressure liquid chromatography- applications

Module III (13 Hours)
General feature of spectroscopy, interaction of radiation with matter, instrumentation of IR&FTIR spectroscopy, sample handling, quantitative analysis, NMR spectroscopy, basic principles, spectra and molecular structure, elucidation of NMR spectra, quantitative analysis. Mass spectroscopy- instrumentation ionization methods, mass analysis, correlation of mass spectra with molecular structure,Introduction to scanning electron microscopy, transform electron microscopy. Atomic force microscopy.

Module IV (13 Hours)
Introduction to differential scanning calorimetry(DSC), thermogravimetric analysis (TGA) and differential thermal analysis(DTA). Introduction to XRD, production of X-ray and X–ray spectra. X-ray absorption methods, x-ray diffraction, and electron spectroscopy for chemical analysis. Surface area determination by BET method, particle size by light scattering method, zeta potential, colour etching spectrophotometer lavibond tintometer

References

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.
End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1: 20 marks</td>
<td>Question 3: 20 marks</td>
<td>Question 5: 20 marks</td>
<td>Question 7: 20 marks</td>
</tr>
<tr>
<td>Question 2: 20 marks</td>
<td>Question 4: 20 marks</td>
<td>Question 6: 20 marks</td>
<td>Question 8: 20 marks</td>
</tr>
</tbody>
</table>

CPD 11 205(C) PROCESS INTEGRATION

Teaching scheme

3 hours lecture & 1 hour tutorial per week

Credits: 4

Objective

Energy requirement of a chemical plant can be considerably reduced by process integration. This course will provide an insight to a systematic method for the process energy integration.

Module 1 (13 Hours)
Introduction to Process Integration- Importance of Process Integration and applications in Chemical Industries. Overview of Process Integration.

Module II (13 Hours)

Module III (14 Hours)
Distillation Integration-Distillation sequencing, Heat Integration characteristics of Distillation column, appropriate placement of distillation column, various configurations for heat integration of distillation column.

Module IV (13 Hours)

References
Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern
Answer any 5 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1: 20 marks</td>
<td>Question 3: 20 marks</td>
<td>Question 5: 20 marks</td>
<td>Question 7: 20 marks</td>
</tr>
<tr>
<td>Question 2: 20 marks</td>
<td>Question 4: 20 marks</td>
<td>Question 6: 20 marks</td>
<td>Question 8: 20 marks</td>
</tr>
</tbody>
</table>

CPD 11 206(P) DESIGN, SIMULATION AND INSTRUMENTAL-ANALYSIS LAB/MINI PROJECT

Hours per week: Practical 2 hours

Credits: 2

Objective: 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)*:

- Regularity - 30 marks
- Record - 20 marks
- Tests, Viva - 50 marks

MINI PROJECT

**Teaching scheme:** 2 hours per week

**Credits:** 2

**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.

Individual students 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.

Mini Project will have internal marks 50 and Semester-end examination marks 50.

**Internal marks** will be awarded by respective guides as per the stipulations given below.

<table>
<thead>
<tr>
<th>Attendance, regularity of student</th>
<th>20 marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual evaluation through viva voce / test</td>
<td>30 marks</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>50 marks</strong></td>
</tr>
</tbody>
</table>

Semester End examination 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.

| Report | 25 marks |
| Concept/knowledge in the topic | 15 marks |
| Presentation | 10 marks |
| **Total** | **50 marks** |

CPD 11 207 (P) SEMINAR

**Teaching scheme:** 2 hours per week

**Credits:** 2
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 ideas and thus creating in him/herself esteem and courage that are essential for an engineer.

- All 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 30 minutes. A committee consisting of at least three faculty members shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his/her 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: 100 marks

Evaluation shall be based on the following pattern:

<table>
<thead>
<tr>
<th>Component</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report</td>
<td>50</td>
</tr>
<tr>
<td>Concept/knowledge in the topic</td>
<td>20</td>
</tr>
<tr>
<td>Presentation</td>
<td>30</td>
</tr>
<tr>
<td>Total marks</td>
<td>100</td>
</tr>
</tbody>
</table>

THIRD SEMESTER

The student has to credit 2 theory subjects from the two groups of electives listed. The student has to undergo an industrial training of duration one month during the semester break after the semester II and complete that within 15 calendar days from the start of semester III.

CPD 11 301(A) COMPUTATIONAL FLUID DYNAMICS

Teaching scheme
3 hours lecture & 1 hour tutorial per week

Credits: 4

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

Module I (13 Hours)
Introduction to Computational Modeling of Flows - significance with special emphasis on chemical engineering applications. – Index notation of vectors and tensors-Control volume-Reynolds Transport Theorem-Governing equations- Non dimensional forms-Phenomenological models-boundary conditions-classification

Module II (13 Hours)
Numerical methods for CFD-classification of PDE’s-Basic discretisation methods-Mesh-solution, and convergence-iterative methods-Properties of numerical solutions-accuracy and errors-Application of numerical methods to selected model equations such as wave equations-heat equation .Laplaces equation-Burgers equation-First and Second order methods such as upwind, Lax Wendroff, MacCormack methods etc.

Module III (14 Hours)
Detailed study of Navier stokes equation-Solution of the Navier Stokes equations-Discretization of convective, viscous, pressure and body force terms-conservation properties-grid arrangement-colocated and staggerd-pressure equation and its solutions-implicit and explicit methods-implicit pressure correction methods-Fractional Step method-SIMPLE algorithm for a colocated Variable arrangement
Turbulence Modelling -The Turbulence Problem-Algebraic and Differential Models,k- models, Other Models

Module IV (13 Hours)

References

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination:100 marks

Question pattern
Answer any 5 questions by choosing at least one question from each module.
CPD 11 301(B) SEPARATION PROCESSES

Teaching scheme
3 hours lecture & 1 hour tutorial per week

Credits: 4

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.

Module I (13 Hours)
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. Foam and bubble fractionation processes, foam-column theory, limiting equations, foam drainage and overflow, adductive crystallization and zone melting – ultra and zonal centrifugation.

Module II (13 Hours)
Diffusional separation processes – gaseous diffusion, mechanism, process description, design considerations, basic principles, application, equipment for thermal diffusion and pressure diffusion. Separation by action in a field – theory of electrical separation, electrophoresis, continuous flow electrophoresis, electro dialysis, ion selective membranes, design aspects, operating parameters, applications.

Module III (14 Hours)
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.

Module IV (13 Hours)
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, absorption with chemical reaction, effect of chemical reaction in gas absorption, theory of diffusion and reaction near an interface, film, surface renewal and penetration theory for a first order reaction, the reaction of NO\textsubscript{x} with water and aqueous solutions, reaction of CO\textsubscript{2} with alkaline solutions.

**References**


**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

**End semester Examination: 100 marks**

**Question pattern**

Answer any 5 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1 : 20 marks</td>
<td>Question 3 : 20 marks</td>
<td>Question 5 : 20 marks</td>
<td>Question 7 : 20 marks</td>
</tr>
<tr>
<td>Question 2 : 20 marks</td>
<td>Question 4 : 20 marks</td>
<td>Question 6 : 20 marks</td>
<td>Question 8 : 20 marks</td>
</tr>
</tbody>
</table>
3 hours lecture & 1 hour tutorial per week

Objectives
To familiarize the students with various advanced theories in process control, different types of controllers and control strategies in real time systems and z transforms for digital signal processing.

Module I (14 Hours)

Module II (13 Hours)

Module III (13 Hours)
Special Control Techniques: Advanced control techniques, cascade, ratio, feed forward, adaptive control, selective controls, computing relays, simple alarms, Smith predictor, internal model control.

Module IV (13 Hours)

References

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern
Answer any 5 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1: 20 marks</td>
<td>Question 3: 20 marks</td>
<td>Question 5: 20 marks</td>
<td>Question 7: 20 marks</td>
</tr>
<tr>
<td>Question 2: 20 marks</td>
<td>Question 4: 20 marks</td>
<td>Question 6: 20 marks</td>
<td>Question 8: 20 marks</td>
</tr>
</tbody>
</table>

**CPD 11 302(A) NON-CONVENIONAL ENERGY SOURCES**

**Teaching scheme**

3 hours lecture & 1 hour tutorial per week

**Credits:** 4

**Objectives**

*To familiarize the students with various non-conventional energy sources, and to develop understanding about energy harnessing methodology for sustainable development.*

**Module 1 (13 hours)**


**Module 1I (14 hours)**


- Salt gradient solar ponds: construction, operation, technical problems.

- Solar drying and dehumidification: Solar cabinet dryers, convective dryers.

**Module 1II (13 hours)**

- Energy from Ocean, Wind, Tides and geothermal sources:

- OTEC power plants (closed cycle, open cycle, hybrid 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.

**Module 1V (13 hours)**

- Energy from biomass :

- Biomass utilisation : pyrolysis, gasification, anaerobic digestion(biogas production).

- Biodiesels : Manufacture and characteristics.

- Gasohol : Characteristics and manufacture , use of pervaporation technology.

- Synthetic liquid fuels from coal : F – T Process, Coal hydrogenation, MTOG process.

**References**
5. Venkataswarlu D., Chemical Technology, I, S. Chand

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

**End semester Examination: 100 marks**

**Question pattern**

Answer any 5 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1 : 20 marks</td>
<td>Question 3 : 20 marks</td>
<td>Question 5 : 20 marks</td>
<td>Question 7 : 20 marks</td>
</tr>
<tr>
<td>Question 2 : 20 marks</td>
<td>Question 4 : 20 marks</td>
<td>Question 6 : 20 marks</td>
<td>Question 8 : 20 marks</td>
</tr>
</tbody>
</table>

**CPD 11 302(B) NANOMATERIAL AND NANOTECHNOLOGY**

**Teaching scheme**

3 hours lecture & 1 hour tutorial per week

**Credits: 4**

**Objectives**

*To impart the basic concepts of nanotechnology and to develop understanding about application of nanomaterials.*

**Module I (13 Hours)**

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.

**Module II (14 Hours)**

Nanomaterials, preparation of nanomaterials like gold, silver, different types of nano-oxides, Al₂O₃, TiO₂, ZnO etc. Sol-gel methods, chemical vapour deposition, ball milling etc. Carbon nanotubes, preparation properties and applications like field emission displays. Different types of characterization techniques like SEM, AFM, TEM & STM.

**Module III (13 Hours)**

Nanocomposites, nanofillers, high performance materials, polymer nanocomposites, nanoclays, nanowires, nanotubes, nanoclusters etc. Smart materials, self assembly of materials, safety issues with nanoscale powders.
Module IV (13 Hours)
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.

References
1. Nanocomposite science and technology, Pulikel M. Ajayan, Wiley-VCH 2005
2. Nanolithography and patterning techniques in microelectronics, David G. Bucknall, Woodhead publishing 2005
5. Micro and Nanofabrication, Zheng Cui, Springer 2005

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern
Answer any 5 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1: 20 marks</td>
<td>Question 3: 20 marks</td>
<td>Question 5: 20 marks</td>
<td>Question 7: 20 marks</td>
</tr>
<tr>
<td>Question 2: 20 marks</td>
<td>Question 4: 20 marks</td>
<td>Question 6: 20 marks</td>
<td>Question 8: 20 marks</td>
</tr>
</tbody>
</table>
CPD 11 302(C) DESIGN AND ANALYSIS OF EXPERIMENTS

Teaching scheme
3 hours lecture & 1 hour tutorial per week

Credits: 4

Objectives
The course objective is to learn how to plan, design and conduct experiments efficiently and effectively, and analyze the resulting data to obtain objective conclusions.

Module I (13 Hours)
Introduction to the role of experimental design; basic statistical concepts; sampling and sampling distribution; Testing of hypotheses about differences in means- randomized designs and paired comparison designs; testing of hypotheses about variances

Module II (13 Hours)
Analysis of variance (ANOVA) –one-way classification ANOVA; analysis of fixed effects model; comparison of individual treatment means; the random effects model; the randomized complete block design

Module III (13 Hours)
Factorial design of experiments; two-factor factorial design-fixed effects and random effects model, General factorial design; analysis of 2k and 3k factorial designs

Module IV (14 Hours)
Regression analysis- Simple and multiple linear regression and hypothesis testing; response surface methodology-the method of steepness ascent : response surface designs for first-order and second-order models.

Reference

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern
Answer any 5 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Module II</th>
<th>Module III</th>
<th>Module IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1: 20 marks</td>
<td>Question 3: 20 marks</td>
<td>Question 5: 20 marks</td>
<td>Question 7: 20 marks</td>
</tr>
<tr>
<td>Question 2: 20 marks</td>
<td>Question 4: 20 marks</td>
<td>Question 6: 20 marks</td>
<td>Question 8: 20 marks</td>
</tr>
</tbody>
</table>

CPD 11 303 INDUSTRIAL TRAINING

Teaching scheme: 1 hour per week

Credits: 1

The students have to undergo an industrial training of minimum two weeks in a Chemical industry during the semester break after second semester and complete within 15 calendar days from the start of third semester. The students have to submit a report of the training undergone and present the contents of the report before the evaluation committee.
constituted by the department. An internal evaluation will be conducted for examining the quality and authenticity of contents of the report and award the marks at the end of the semester.

**Internal continuous assessment: Marks 50**

**CPD 11 304 MASTERS RESEARCH PROJECT (PHASE – I)**

**Teaching scheme:** 22 hours per week  
**Credits:** 6

**Objective:**
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 masters research project phase-I during the third semester and the same is continued in the 4th semester (Phase-II). 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. Second review evaluates the progress of the work, preliminary report and scope of the work which is to be completed in the 4th semester.

**Internal Continuous assessment:**

**First Review:**

<table>
<thead>
<tr>
<th></th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guide</td>
<td>50</td>
</tr>
<tr>
<td>Evaluation Committee</td>
<td>50</td>
</tr>
</tbody>
</table>

**Second review:**

<table>
<thead>
<tr>
<th></th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guide</td>
<td>100</td>
</tr>
<tr>
<td>Evaluation Committee</td>
<td>100</td>
</tr>
</tbody>
</table>

**Total** 300 marks
FOURTH SEMESTER

CPD11 401(P) MASTERS RESEARCH PROJECT PHASE - II

Teaching scheme: 30 hours per week

Credits: 12

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.

Masters Research project phase-II is a continuation of project phase-I started in the third semester. Before the end of the fourth semester, there will be two reviews, one at middle of the fourth semester and other towards the end. In the first review, progress of the project work done is to be assessed. In the second review, the complete assessment (quality, quantum and authenticity) of the Thesis is to be evaluated. Both the reviews should be conducted by guide and Evaluation committee. This would be a pre qualifying exercise for the students for getting approval for the submission of the thesis. At least one technical paper is to be prepared for possible publication in journal or conferences. The technical paper is to be submitted along with the thesis. The final evaluation of the project will be external evaluation.

Internal Continuous assessment:

First review:

Guide 50 marks
Evaluation committee 50 marks

Second review:

Guide 100 marks
Evaluation committee 100 marks

End semester Examination: 300 marks

External Guide 150 marks
Vivavoce 150 marks