UNIVERSITY OF CALICUT
Abstract

Faculty of Engineering – scheme & syllabi of M.Tech course in Computer Aided Process Design (Chemical Engineering) – Sanctioned – implemented – with effect from 2011-2012 admission - Orders issued.

GENERAL AND ACADEMIC BRANCH – IV 'E' SECTION

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

Read: 1. Letter No.C1/1417/2011 dated 09.05.2011 from the Principal, Government Engineering College, Kozhikode.
2. U.O.No.GAI/D4/4104/2011 dated 07.09.2011.
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)

O R D E R

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)

For **REGISTRAR**

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

Course Code	Subject	Hours/week			Marks		Total marks	Sem-end exam duration - Hrs	Credits
		L	T	P/D	Internal	Sem-end			
CPD11 101	Advanced Mathematics	3	1	0	100	100	200	3	4
CPD 11 102	Mechanical Design of Process vessels-I	3	1	0	100	100	200	3	4
CPD 11 103	Process Equipment Design-II	3	1	0	100	100	200	3	4
CPD 11 104	Advanced Heat & Mass Transfer	3	1	0	100	100	200	3	4
CPD 11 105	Elective I	3	1	0	100	100	200	3	4
CPD 11 106 (P)	*Computer Aided Design Lab/Mini Project*	0	0	2	100	0	100	-	2
CPD 11 107(P)	*Seminar*	0	0	2	100	0	100	-	2
TOTAL		15	5	4	700	500	1200		24

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

Course Code	Subject	Hours/week			Marks		Total	Sem-end exam duration - Hrs	Credits
		L	T	P	Internal	Sem-end			
CPD 11 201	Process modeling and Simulation	3	1	0	100	100	200	3	4
CPD 11 202	Process equipment Design -III	3	1	0	100	100	200	3	4
CPD 11 203	Process equipment Design -IV	3	1	0	100	100	200	3	4
CPD11 204	Elective II	3	1	0	100	100	200	3	4
CPD 11 205	Elective III	3	1	0	100	100	200	3	4
CPD 11 206(P)	*Design,Simulation & Instrumental Analysis Lab /Mini Project*	0	0	2	100	0	100	-	2
CPD 11 207(P)	*Seminar*	0	0	2	100	0	100	-	2
TOTAL		15	5	4	700	500	1200		24

Elective II

CPD 11 204(A) Transport Phenomena
CPD11 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

Course Code	Subject	Hours/week			Marks		Total	Sem-end exam duration - Hrs	Credits
		L	T	P	Internal	Sem-end			
CPD 11 301	Elective IV	3	1	0	100	100	200	3	4
CPD 11 302	Elective V	3	1	0	100	100	200	3	4
CPD 11 303(P)	*Industrial Training*	0	0	0	50	-	50	-	1
CPD 11 304(P)	*Master Research Project (Phase -I)*	0	0	22	Guide: 150 / EC*: 150	-	300	-	6
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

Course Code	Subject	Hours per week			Internal Marks		Sem–end exam		Total marks	Credits
		L	T	P/D	Guide	Evaluation Comittee	Extl. Guide	Viva-Voce		
CPD 11 404(P)	*Masters Research Project (Phase II)*	-	-	30	150	150	150	150	600	12
TOTAL				30	150	150	150	150	600	12

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

FIRST SEMESTER

CPD 11 101 ADVANCED MATHEMATICS

Teaching scheme **Credits:** 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)

Systems of linear equations – Jacobi, Gauss Seidel, SOR methods, Thomas algorithm for tridiagonal systems; Systems of nonlinear equations - successive approximation method, methods for improved convergence, Newton Method and its variants, continuation methods for multiple solutions.

Numerical solution of ordinary differential equations: Ordinary differential equations: Runge-Kutta, Euler's and Milne's predictor corrector methods. Solution of boundary value problems.

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^{nd} order and 4^{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)

Probability and statistics - Probability distributions – Inferences concerning means – tests of hypotheses – Inferences concerning variances – Curve fitting – The method of least squares – Multiple regression - Correlation – Analysis of variance – Factorial experimentation-Stochastic Processes

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.
4. James M.L., Smith C.M. & Wolford J.C., Applied Numerical Methods for Digital Computation, Harper & Row
5. Erwin Kreysig – Advanced Engineering Mathematics(Wiley Eastern)
6. M.K.Venkitaraman – Higher Mathematics for Engineering and Science.

7. Richard A. Johnson – Probability and Statistics for engineers(PHI)
8. Athanasios Papoulis, S Unnikrishna Pillai - Probability, Random Variables and Stochastic Processes (McGraw Hill)
9. Jenson and Jeffreys - Mathematical Methods in Chemical Engineering(Academic Press)

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.

Module I	Module II	Module III	Module IV
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

CPD 11 102 MECHANICAL DESIGN OF PROCESS VESSELS I

Teaching scheme **Credits:** 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)

Design of Tall Vessels with heads / closures. Wind load / Seismic load.Design of Vessels under external pressure. Thick – walled Vessels.

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

1. Brownell & Young. Process Equipment Design- Vessel Design, Wiley Eastern.
2. B.C Bhattacharya, Introduction to Chemical Equipment Design, CBS Publishers & Distributors, New Delhi.
3. B.C. Bhattacharyya and C.M. Narayanan, “Computer Aided Design of Chemical Process Equipment", Ist Edn., New Central Book Agency (P) Ltd., New Delhi, 1992.
4. M.V Joshi & Mahajan V.V., Process Equipment Design, 3rd Edn, Mac-Milan & Co India.

5. IS Codes

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.

Module I	Module II	Module III
Question 1 : 25 marks Question 2 : 25 marks	Question 3 : 25marks Question 4: 25marks	Question 5 : 25marks Question 6: 25marks

CPD 11 103 PROCESS EQUIPMENT DESIGN -II

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

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.

Design of Double Pipe Heat Exchangers. Hairpins in series, hairpins in series – parallel. Heat transfer Correlations, Pressure drop computations.

Module II (18 Hours)

Shell and Heat Exchangers. Fixed tubesheet / floating head / U – tube constructions. Multipass construction. Tubesheet layout (square, triangular, rotated square layouts). Heat transfer correlations for tubeside and shellside heat transfer coefficients (Colburn's and Donohue's correlations). Correction factors for baffle configuration, baffle leakages, bundle bypass and unequal baffle spacing. No – tubes – in – baffle window construction. Pressure drop computations. Correction factors for pressure drop.

Design of Finned Double Pipe Heat Exchangers : Longitudinal fins. Fin efficiency. Heat transfer and pressure drop correlations.

Module III (18 Hours)

Condensers (Shell and Tube) : Vertical condensers, horizontal condensers. Heat transfer and pressure drop correlations for film condensation on vertical and horizontal tube bundles. Condenser – subcoolers . Split flow arrangement.

Reboilers & Vaporisers: Kettle type, Vertical Thermosyphon type

References

1. B.C. Bhattacharyya and C.M. Narayanan, “Computer Aided Design of Chemical Process Equipment", Ist Edn., New Central Book Agency (P) Ltd., New Delhi, 1992.
2. Ernest E. Ludwig**,** “Applied Process Design for Chemical and Petrochemical Plants**’’** Volume 1, 2, 3. Third Edition.
3. Narayanan,C.M. and B.C.Bhattacharya**,** Unit Operations and Unit Processes, Volume – I , CBS Publishers, New Delhi.
4. Harry Silla, “Chemical Process Engineering Design and Economics”, M Dekker
5. Douglas Erwin P E**,**“Industrial Chemical Process Design”, McGraw hill.
6. Alexandre C Dimian, “Integrated design and Simulation of Processes”, Elsevier
7. Perry’s Chemical Engineering HandBook, McGrawHill.
8. Kern D.Q., Process Heat Transfer.

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.

Module I	**Module II**	**Module III**
Question 1: 25 marks Question 2: 25 marks	Question 3 : 25marks Question 4: 25marks	Question 5 : 25marks Question 6: 25marks

CPD 11 104 ADVANCED HEAT AND MASS TRANSFER

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

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)

Convection heat transfer – Heat transfer in laminar and turbulent flows, hydrodynamic and thermal boundary layer, integral analysis of hydro dynamic boundary layer. Exact analysis of thermal boundary layer. Heat transfer to non-Newtonian fluids. Heat transfer in packed and fluidized beds.

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

1. Bird et al., *Transport phenomena*, John Wiley & Sons.
2. Wetty J.R et al., *Fundamentals of momentum, heat and mass transfer*, John Wiley & Sons
3. Wetty J.R., *Engineering heat transfer*, John Wiley & Sons.
4. Foust A.S et al., *Principles of unit operations*, John Wiley & Sons.
5. Giedt, *Principles of engineering heat transfer*, Van Nostrand Co.

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.

Module I	Module II	Module III	Module IV

Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

CPD 11 105(A) PROCESS OPTIMIZATION

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)

Linear Algebra - Introduction to vector spaces and matrix algebra, Geometric concepts. 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.

Module II (13 Hours)

Multivariate Unconstrained Optimization -, Nelder-Head's method, Powell's method, Steepest descent, Conjugate gradient, Newton and quasi-Newton methods.

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*
2. M.C. Joshi and K. M. Moudgalya, *Optimization: Theory and Practice*, Narosa Publishing.
3. S.S. Rao, *Optimization Theory and Applications*
4. J. Nocedal and S. J. Wright, *Numerical Optimization*, Springer Verlag.
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

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

CPD 11 105(B) PROCESS SAFETY ENGINEERING

Teaching scheme **Credits:** 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)

Consequence Analysis and Quantitative Risk Assessment- Consequence of Chemical accidents.Models for Fire,Explosion and Toxic gas dispersion.Individual and Societal Risk,F-N curves,Probit function.Elements of Emergency Planning
Inherent Safety and Process Intensification-The concept of Inherent Safety,Tools for Inherent Process Safety.Inherent Safety Indices.The concept of Process Intensification.

Module IV (13 Hours)

Proess Reliability and Human Error Analysis-Basic Principles of Reliability engineering.Ways of improving process Reliability.Reasons of Human Error,Tehnique for assessing Human error

References

1. Lees F.P,,Loss *Prevention in Process Industries,Vol.1,2&3,Second Edn*,Butterworth-Heinemann.1996
2. *Guidelines for Hazard Evaluation Procedure.Centre for Chemical Process Safety*.AICHE,1992
3. Ralph King, *Safety in the Process Industries*,Butterworth-Heinemann
4. Wells.G.L,*Safety in Process Plant Design*,George Godwin Ltd,London

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.

Module I	Module II	Module III	Module IV
Question 1: 20 marks	Question 3 : 20marks	Question 5 : 20marks	Question 7 : 20marks

Question 2 : 20 marks	Question 4: 20marks	Question 6: 20marks	Question 8: 20marks

CPD 11 105(C) PROJECT ENGINEERING OF PROCESS PLANTS

Teaching scheme **Credits:** 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.
3. Mc Graw Hill (2002).
4. Srinath L. S., “PERT AND CPM.” affiliated east press pvt. Ltd., new york (1973)
5. Perry J. H.,”Chemical engineering handbook” 7th ed. Mc Graw Hill (1997).
6. Jellen F. C., “Cost and optimization in engineering”. Mc Graw Hill (1983).
7. Frederick B. Plummer, Project Engineering, BH
8. Ernest E. Ludwig, Applied project engineering and management, Gulf Pub. Co., (1988)

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.

Module I	Module II	Module III	Module IV

Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

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.

1. Shell and Tube heat exchangers , Plate type Heat Exchanger& Condensers.

2. Double Pipe Heat Exchangers, Finned Heat Exchangers.

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

Participation : 10
Total marks : 100

SECOND SEMESTER

CPD 11 201 PROCESS MODELLING AND SIMULATION

Teaching scheme **Credits:** 4

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

1. Luyben W.L., *Process Modelling, Simulation and Control for Chemical Engineers*, McGraw Hill International Edition
2. Franks R.G.E., *Mathematical Modelling in Chemical Engineering*, John Wiley
3. John Ingham et.al., *Chemical Engineering Dynamics - Modelling with PC Simulation*, VCH Publishers
4. Biquette W.B., *Process Dynamics - Modeling Analysis and Simulation*, Prentice Hall of India
5. Amiya K.Jana, *Computer Process Modelling and Computer Simulation*, Prentice Hall of India

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.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

CPD 11 202 PROCESS EQUIPMENT DESIGN –III

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

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)

Design of Multiple Effect Evaporators (MEE) : Classification of Evaporators. Types of feeding in Multiple Effect Evaporators (MEE). Mass and Heat Balances in MEE. BPR chart. Enthalpy – Concentration Diagrams. Solution for ***n*** effects using Gauss – Seidel / Crout' s method. Optimum number of effects.

Module III (18 Hours)

Design of dryers: Rotary dryer, Tray dryer. Cooling Towers : Water cooling by air. Psychrometric equations. Minimum (L/G) ratio. HTU – NTU concept.

References

1. Narayanan,C.M. and B.C.Bhattacharya, Unit Operations and Unit Processes, Volume – I , CBS Publishers, New Delhi
2. Richardson, J.M., Coulson J.F. and Sinnot R. K.: Chemical Engineering Vol . 6.
3. Harry Silla, "Chemical Process Engineering Design and Economics", M Dekker
4. Douglas Erwin P E,"Industrial Chemical Process Design", McGraw hill.
5. Kunni D., Levenspial D.: Fluidization Engineering. Wiley.
6. Perry's Chemical Engineering HandBook, McGrawHill.
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.

Module I	Module II	Module IV
Question 1 : 25 marks Question 2 : 25 marks	Question 3 : 25marks Question 4: 25marks	Question 5 : 25marks Question 6: 25marks

CPD 11 203 PROCESS EQUIPMENT DESIGN –IV

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objectives

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

Module I (17 Hours)

Design of Packed Bed Absorption Column : Flooding and loading. Flooding Velocity Computation. Mass transfer correlations. HTU – NTU concept. Design of Absorber with chemical reaction.

Module II (18 Hours)

Sieve Plate and Bubble Cap Columns (Absorption / Distillation columns): Flooding Velocity Computation. Tray spacing. Active plate area. Minimum weeping velocity. Correction for entrainment. Plate stability. Lquid gradient across the tray. Total pressure drop through perforations, riser – cap assembly, through aerated mass. Downcomer hydraulics. Residence time in downcomer.

Module III (18 Hours)

Computer Aided Design and Analysis of Multicomponent Distillation processes by FUG (Fenske – Underwood – Gilliland) Method. Liquid –liquid extraction columns: mixer-settler, packed columns.

References

1.Narayanan,C.M. and B.C.Bhattacharya, Unit Operations and Unit Processes, Volume – I , CBS Publishers, New Delhi

2. Richardson, J.M., Coulson J.F. and Sinnot R. K.: Chemical Engineering Vol . 6.

3. Harry Silla, "Chemical Process Engineering Design and Economics", M Dekker

4. Douglas Erwin P E,"Industrial Chemical Process Design", McGraw hill.

5. Kunni D., Levenspial D.: Fluidization Engineering. Wiley.

6. Perry's Chemical Engineering HandBook, McGrawHill.

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.

Module I	Module II	Module IV
Question 1 : 25 marks Question 2 : 25 marks	Question 3 : 25marks Question 4: 25marks	Question 5 : 25marks Question 6: 25marks

CPD 11 204 (A) TRANSPORT PHENOMENA

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

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.
Interphase transport in isothermal systems – friction factors for flow in tubes, flow around spheres. Macroscopic balance for isothermal systems- macroscopic mass balance, momentum balance, mechanical energy balance, use of macroscopic balances to set up steady flow problems.

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
1. Bird R.B, Stewart W.E & Lightfoot E.N, Transport Phenomena, John Wiley Publishers.
2. Welty J.R, Wicks C.E& Wilson.K.E., Fundementals of Momentum, Heat and Mass Transfer, John Wiley Publishers.
3. Frank.M.White, Viscous fluid flow, McGraw Hill International.

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.

Module I	Module II	Module III	Module IV
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

CPD 11 204 (B) INDUSTRIAL INSTRUMENTATION

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

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)
Different types of applications of measurement instrumentation, functional description of measuring instruments, performance characteristics of instruments – static and dynamic characteristics. Dynamic response of first-order type and second-order type instruments. Dynamic accuracy of an instrument.

Module II (13 Hours)
Pressure measurement – Passive and active electrical pressure transducers. Principles of piezo electric manometers. Measurement of low pressure using Ionization gauge, McLeod gauge, and radioactive vacuum gauge. High- pressure measurement using air-pressure balance method. Dynamic accuracy of pressure measuring systems.
Temperature measurement – Thermal expansion methods, thermoelectric sensors, electrical resistance sensors, digital thermometer, radiation thermometer. Dynamic response of temperature sensors.

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)
Composition analysis – Gas analysis using infra red gas analyzer. Paramagnetic oxygen analyzer. Thermal conductivity bridge method for flue gas analysis. Chromatography for gas analysis. The automatic hydrogen gas analyzer. Determination of particulate in stack gases. Smoke and dust detection – ionization smoke detector, smoke meter for dust measurement. Concept of signal conditioning and data transmission. Indicating, recording and display systems. Computer data systems.

References
1.Ernest O Doeblin, *Measurement systems, Application and Design*, McGraw –Hill.
2.Jain .R.K, *Mechanical and Industrial measurements*, Khanna publishers.
3.Patranabis.D, *Principles of Industrial Instrumentation*, Tata- McGraw Hill.

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.

Module I	Module II	Module III	Module IV
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

CPD 11 204(C) ENVIRONMENTAL ENGINEERING AND MANAGEMENT

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

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)

Waste water treatment: unit operations of pre treatment and primary treatment, unit processes of secondary treatment, disinfection, advanced waste water treatment, sludge treatment and disposal. Characteristics of domestic waste, municipal waste water treatment systems. Concept of common effluent treatment plant (CETP). Zero discharge systems.

Module II (13 Hours)

Air pollution: effect of air pollutants on health, vegetation and materials, global effect of air pollutants, factors affecting dispersion of air pollutants, dispersion modeling. Air pollution control of stationary sources: gaseous pollutants and particulate pollutants. Air pollution control of mobile sources: automobile emissions. Noise pollution: effect of noise pollution on people, community noise-sources and criteria, noise control.

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:

1. Metcalf and Eddy, *Waste water engineering, treatment, disposal, reuse*, Tata-McGraw Hill.
2. Mahajan.S.P, *Pollution control in process industries*, Tata-McGraw Hill.
3. Rao.C.S, *Environmental pollution control engineering*, New age international (P) ltd.
4. Rao.M.N and H.V.N. Rao, *Air pollution*, Tata McGraw Hill

5. H.S Peavey et al., *Environmental engineering*, McGraw Hill

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.

Module I	Module II	Module III	Module IV
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

CPD 11 205(A) COMPUTATIONAL METHODS FOR PROCESS DESIGN

Teaching scheme **Credits:** 4

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

1. A.W. Westerberg et al, process flow sheeting, Cambridge University Press.
2. Lorenz T Biegler et al, Systematic method of Chemical Process Design, Prentice Hall
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.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

CPD 11 205(B) MODERN METHODS OF INSTRUMENTATION AND ANALYSIS

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

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

1. J. Mendham, J.D. Barnes, R.C. Denny& M.J.K.Thomas, Vogel's Textbook of Quantitative Analysis.

2. Gurdeep.R Chatwal ,Sham Anand ,Instrumental Methods of Chemical Analysis,Himalaya Publishing.

3. Hobart.H.Williard,Lynne.L.Merritt,John.A.Dan,Frank.A.Settle,Instrumental Methods of Analysis,CBS Publishers& Distributors.

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.

Module I	Module II	Module III	Module IV
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

CPD 11 205(C) PROCESS INTEGRATION

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

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.

Heat Exchanger Networking-Hot Composite Curve, Cold Composite Curve, Problem Table Algorithm, Grand Composite Curve, Area Targeting by Uniform Bath formula and Unit Targeting by Eulers' formula, Heuristics for Pinch Design, Maximum Energy Recovery Design, Evolution of Network.

Module II (13 Hours)

Reactor Integration-Choice of Idealized reactor model and reactor performance. Reactor configurations: Temperature Control, Gas-Liquid and Liquid-Liquid Reactors, Choice of Reactors. Heat Integration characteristics of reactors, Appropriate placements of reactors. Use of GCC for Heat Integration of reactors.

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)

Mass Exchanger Network Synthesis-Mass Exchanger Network, Minimum Mass Separating Agents (MSA), Mass exchange networks for minimum external MSA. Minimum Number of Mass Exchangers.

References

1. Chemical Process Design and Integration Robin Smith, John Wiley and Sons. Ltd., New Delhi,
2005.
2. Product & Process Design Principles Warren D. Seider, J. D. Seader and Daniel R. Lewin, Wiley
Publication.
3. Heat Exchanger Network Synthesis U. V. Shenoy, Gulf Publication.

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.

Module I	Module II	Module III	Module IV
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

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.
2. Liquid –liquid extraction columns: mixer-settler, packed columns. Design of dryers: Rotary dryer, Tray dryer.
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.

Attendence, regularity of student	20 marks
Individual evaluation through viva voce / test	30 marks
Total	**50 marks**

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:

Report	=	50 marks
Concept/knowledge in the topic	=	20 marks
Presentation	=	30 marks
Total marks	=	100 marks

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 **Credits:** 4

3 hours lecture & 1 hour tutorial per week

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)

Reactive Flows and Combustion-Reactor Modelling (RTD Studies)-Polymerisation-Combustion Modelling-Multiphase Flow-Fluid/Fluid (bubbles/drops)-Fluid/Solid (fluidised beds, pneumatic conveying, settling) -Polymeric Liquids-Rheological models-Special cases: Circulation, Die-swell, Extensional flows-Brief Introduction to Other Approaches -CFD-DEM-Lattice Boltzmann-Immersed Boundary-Boundary Elements.

References

1. Anderson, John David, *Computational Fluid Dynamics: The Basics with Applicattions*, McGraw Hill, 1995.
2. Anderson, D. A;Tanneheil, J. C; Pletcher, R. H., *Computational Fluid Mechanics and Heat transfer*, Hemispher, New York, 1984.
3. Ferziger, J. H and Peric, M.,*Computational methods for Fluid Mechanics*, Springer, New York, 2002.
4. Bird, R. B; Stewart, W. E and Lightfoot, E. N, *Transport Phenomena*, John Wiley, New Delhi, 2002.
5. Ranade, V., *Computational Flow Modelling for Chemical Reaction Engineering*, Academic Press, 2002.
6. Peyret, R.,Taylor, T. D. Computational Methods for Fluid Flow, Springer Verlag, 1983.
7. Smith, G. D., *Numerical Solution of Partial Differential Equations: Finite Difference Methods*, Claderon Press, Oxford.
7. Patankar, Suhas, V., *Numerical Heat Transfer and Fluid Flow*, McGraw Hill, Washington,1980.
8. Bird, R. B., Armstrong, R. C., Hassagar,O. Hassagar, *Dynamics of Polymeric Liquids*, John Wiley, New York, 1987.
10. Barnes, H. A. ; Hutton, J. F. and K. Walters. *An Introduction to Rheology* Elsevier, 1993.
11. Crowe, Clayton T. (Ed.) Multiphase flow handbook CRC Taylor & Francis, 2006
12. Goodwin, J W and Huges R W, *Rheology for Chemists, 2nd Ed*, RSC Publishing 2008.
13. Tanner, Roger I, *Engineering Rheology, Second Edition*, Oxford University Press, 2002.

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.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

CPD 11 301(B) SEPARATION PROCESSES

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

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_x with water and aqueous solutions, reaction of CO_2 with alkaline solutions.

References

1. Seader,Henly , *Separation process principles*,John Wiley
2. Shoen K.M, *New chemical engineering separation techniques*, Inter Science (1962).
3. Loeb.S, *Industrial membrane separation processes*.
4. Perry.J.H and C.E.Chilto, *Chemical engineer's handbook*, McGraw Hill
5. McCabe W.L, J.C.Smith and P.Harriot, *Unit operations in chemical engineering*, McGraw Hill.
6. Rousseau R.W, *Handbook of separation process technology*, John Wiley (1987).
7. Winkle M.W, *Distillation*, McGraw Hill.
8. Sherwood T.K, R.L Pigford and C.R Wilke, *Mass transfer*, McGraw Hill

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.

Module I	Module II	Module III	Module IV
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4 : 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8 : 20marks

CPD 11 301(C) ADVANCED PROCESS CONTROL

Teaching scheme **Credits:** 4

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)

Review of Systems: Review of first and higher order systems, closed and open loop response. Response to step, impulse and sinusoidal disturbances.Different types of controllers – Pneumatic and electronic types. Control valves – characteristics, sizing and valve positioners. Performance criteria of controllers – the error performance indexes. Controller tuning.

Module II (13 Hours)

Transient response. Block diagrams. Stability Analysis: Frequency response, design of control system, controller tuning and process identification. Zigler-Nichols and Cohen-Coon tuning methods, Bode-Nyquist Plots.

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)

Sample Data Controllers: Basic review of Z transforms, Response of discrete systems tovarious inputs. Open and closed loop response to step, impulse and sinusoidal inputs, closed loop response of discrete systems. Design of digital controllers.

References

1. D.R. Coughanour 'Process Systems analysis and Control', , McGraw-Hill, 2nd Edition,1991.
2. Stephanopoulous, 'Chemical Process Control – Theory and Practice', Prentice Hall of India Ltd.,1984.
3. C.A. Smith and A.B. Corripio 'Principle and Practice of Automatic Process Control', 3rd ed., John Wiley and Sons, 2005.
4. W.L .Luyben 'Process Modelling Simulation and Control for ChemicalEngineers,McGraw Hill, 2nd Edition,1990.
5. E. Seborg, T.F. Edger, and D.A. Millichamp 'Process Dynamics and Control',John Wiley and Sons, 2nd Edition, 2004.

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.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

CPD 11 302(A) NON-CONVENIONAL ENERGY SOURCES

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

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)

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.

Module 1I (14 hours)

Solar Energy Utilisation(Thermal): Construction and performance analysis of solar flat plate collectors. Heat losses from FPC by radiation and natural convection, overall heat loss coefficient, collector efficiency factor, tilt factors, collector heat removal factor, Hottel-Willier-Bliss equation. Solar concentrating collectors : CPC, PTC, spherical paraboloids , modes of tracking, performance analysis.

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

1. Goldmberg J., Johansson, Reddy A.K.N. & Williams R.H., Energy for a Sustainable
World, John Wiley
2. Bansal N.K., Kleeman M. & Meliss M., Renewable Energy Sources & Conversion Tech.,
Tata McGraw Hill
3. Sukhatme S.P., Solar Energy, Tata McGraw Hill
4. Mittal K.M., Non-Conventional Energy Systems, Wheeler Pub.
5. Venkataswarlu D., Chemical Technology, I, S. Chand
6. Pandey G.N., A Text Book on Energy System and Engineering, Vikas Pub.
7. Rao S. & Parulekar B.B., Energy Technology, Khanna Pub.
8. Rai G.D., Non-Conventional Energy Sources, Khanna Pub.

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.

Module I	Module II	Module III	Module IV
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4 : 20marks	Question 5 : 20marks Question 6 : 20marks	Question 7 : 20marks Question 8 : 20marks

CPD 11 302(B) NANOMATERIAL AND NANOTECHNOLOGY

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

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, Al_2O_3, TiO_2, 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, Wood head publishing 2005
3. Transport in Nanostructures, D.K. Ferry and S.M. Goodmick, Cambridge university press 1997.
4. Optical properties of solids, F. Wooten, Academic press 1972
5. Micro and Nanofabrication, Zheng Cui, Springer 2005
6. Nanostructured materials, Jackie Y. Ying, Academic press 2001
7. Nanotechnology and nanoelectronics, W.R, Fahrner, Springer 2005
8. Nanoengineering of structural, functional and smart materials, Mark J. Schulz, Taylor & Francis 2006.
9. Hand book of Nanoscience, Engineering, and Technology, William A. Goddard, CRC press 2003.
10. Nanoelectronics and Information Technology, Rainer Waser, Wiley-VCH 2003.
11. The MEMS Handbook Frank Kreith, CRC press 2002.

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.

Module I	Module II	Module III	Module IV
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4 : 20marks	Question 5 : 20marks Question 6 : 20marks	Question 7 : 20marks Question 8 : 20marks

CPD 11 302(C) DESIGN AND ANALYSIS OF EXPERIMENTS

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

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
1. "Design and analysis of experiments" by D.C. Montgomery, 7th edition John Wiley and sons, New York (1984).

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.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

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 4^{th} 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 4^{th} semester.

Internal Continuous assessment:

First Review:

Guide	50 marks
Evaluation Committee	50 marks

Second review:

Guide	100 marks
Evaluation Committee	100 marks
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