UNIVERSITY OF CALICUT
(Abstract)

Faculty of Engineering – Regulations, scheme & Syllabi of M.Tech Courses – implemented with effect from 2010 admn onwards - Orders Issued.

GENERAL AND ACADEMIC BRANCH - IV 'E' Section

GAIV/E1/AC / 03.07.2010 Dated, Calicut University.P.O., 27-08-2010.

Read:- 1) U.O. No. GAI/D4/4085/2003 dated, 21.11.2009.
2) Minutes of the meeting of the BOS in Engineering (PG) held on 10.12.2009 and 28.01.2010.
3) Minutes of the meeting of the faculty of Engineering held on 28.01.2010.
4) Minutes of the meeting of the Academic Council held on 03.07.2010.

ORDER

As per paper read 1st, Provisional affiliation was granted to start a new course in M.Tech Machine Design in Nehru College of Engineering & Research Centre, Pampady.

As per the paper read 2nd, the Board of Studies in Engineering (PG) framed, formulated and approved the syllabi of M.Tech in Machine design for 2010-2011. The Board of Studies also framed the revised M.Tech regulations, scheme and Syllabi of the following M.Tech Courses for the year 2010-2011.

1) Environmental Engineering
2) Production Engineering
3) Thermal Systems
4) Power Systems
5) Chemical Process Control
6) Embedded Systems

As per the paper read 3rd, the meeting of the faculty of Engineering approved the decision of the Board of Studies held on 10.12.2009 and 28.01.2010 and approved the revised M.Tech regulations and scheme and syllabi of the above M.Tech Courses.

The faculty also recommended the following in the revised regulations of M.Tech in the case of self financing colleges that there should be sufficient qualified faculty members and sufficient infrastructure in self financing colleges as recommended by All India Council for Technical Education.

As per paper read 4th, the meeting of the Academic Council held on 03.07.2010, approved the decisions of the Board of Studies held on 10.12.2009 and 28.01.2010 and the minutes of the faculty of Engineering held on 28.01.2010 for implementing the regulations and scheme and syllabi of the above M.Tech courses with effect from 2010 admission.

Contd…..2

Sanction has therefore been accorded for implementing the revised M.Tech regulations and Scheme & Syllabi of the following M.Tech Courses with effect from 2010 admission onwards.

1) Environmental Engineering
2) Production Engineering
3) Thermal Systems
4) Power Systems
5) Chemical Process Control
6) Embedded Systems
7) Machine design

Orders are issued accordingly, (regulations, scheme & Syllabi appended)

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SECTION OFFICER

UNIVERSITY OF CALICUT

M.Tech. DEGREE COURSE
CHEMICAL PROCESS CONTROL
(CHEMICAL ENGINEERING)

Curricula, Scheme of Examinations and Syllabi
(With effect from 2010 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**			
CPC 10 101	Mathematics	3	1	0	100	100	200	3	4
CPC 10 102	Process Dynamics and Control – 1	3	1	0	100	100	200	3	4
CPC 10 103	Industrial Instrumentation	3	1	0	100	100	200	3	4
CPC 10 104	Modern Control Theory	3	1	0	100	100	200	3	4
CPC 10 105	Elective I	3	1	0	100	100	200	3	4
CPC 10 106 (P)	*Advanced Process Control lab / Mini project*	0	0	2	100	0	100	-	2
CPC 10 107(P)	*Seminar*	0	0	2	100	0	100	-	2
TOTAL		15	5	4	700	500	1200		24

Elective I

CPC 10 105(A) Process Optimization
CPC 10 105(B) Energy Engineering And Management
CPC 10 105(C) Separation Processes

Semester – II

Course Code	Subject	Hours/week			Marks		Total	Sem-end exam duration - Hrs	Credits
		L	T	P	Internal	Sem-end			
CPC 10 201	Process Dynamics and Control – II	3	1	0	100	100	200	3	4
CPC 10 202	Advanced Chemical Reaction Engineering	3	1	0	100	100	200	3	4
CPC 10 203	Advanced Heat and Mass Transfer	3	1	0	100	100	200	3	4
CPC 10 204	Elective II	3	1	0	100	100	200	3	4
CPC 10 205	Elective III	3	1	0	100	100	200	3	4
CPC 10 206 (P)	*Modelling, Design and Simulation Lab/Mini Project*	0	0	2	100	0	100	-	2
CPC 10 207(P)	*Seminar*	0	0	2	100	0	100	-	2
TOTAL		15	5	4	700	500	1200		24

Elective II

CPC 10 204(A) Multivariable Feedback Control
CPC 10 204(B) System Identification
CPC 10 204(C) Environmental Engineering and Management

Elective III

CPC 10 205(A) Fuzzy Systems and Control
CPC 10 205(B) Biochemical Engineering
CPC 10 205(C) Applied Process Control

Semester III

Course Code	Subject	Hours/week			Marks		Total	Sem-end exam duration - Hrs	Credits
		L	T	P	Internal	Sem-end			
CPC 10 301	Elective IV	3	1	0	100	100	200	3	4
CPC 10 302	Elective V	3	1	0	100	100	200	3	4
CPC 10 303(P)	*Industrial Training*	0	0	0	50	-	50	-	1
CPC 10 304(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

CPC 10 301(A) Computational Flow Modelling
CPC 10 301(B) Process Safety Engineering
CPC 10 301(C) Research Methodology

Electives –V

CPC 10 302(A) Process Modelling And Simulation
CPC 10 302(B) Computational Methods For Process Design
CPC 10 302(C) Nanomaterial And Nanotechnology

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		
CPC 10 404(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

CPC 10 101 : MATHEMATICS

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

Objective:
This course provides further studies on linear algebra and statistics which are wealths of ideas and results with wide areas of application. Also it gives a brief description of the concepts and results in matrices and power series that may be useful in engineering.

Module I: (13 Hours)
Definition of Vector space – Linear Dependence, Basis and Dimensions – Vector subspace – Inner Product spaces – Orthogonal basis and Grahm-Schmidt process of Orthogonalization – Linear Simultaneous Equations – Rank and Nullity.

Module II: (13 Hours)
Eigen values and Eigen vectors of Square Matrix – Cayley-Hamilton Theorem – Diagonalization of Square Matrices – Eigen value problem problems for Hermitian matrices – Quadratic forms – Reduction to Canonical forms – Definiteness of Quadratic forms.

Module III: (14 Hours)
Solution of Differential Equations in power series – Frobenius method – Bessel's equation – Legendre's equation – Bessel's and Legendre's functions Orthogonality – Generating functions – Recurrence relations – Solutions of system of Linear differential equations – Elimination methods – Matrix methods – Laplace Transform method.

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.Erwin Kreysig – *Advanced Engineering Mathematics*(Wiley Eastern)
2.M.K.Venkitaraman – *Higher Mathematics for Engineering and Science*.
3.K.V.Dutta – *Matrix and Linear Algebra*(Prentice –Hall)
4.Richard A. Johnson – *Probability and Statistics for engineers*(PHI)
5.Athanasios Papoulis, S Unnikrishna Pillai - *Probability, Random Variables and Stochastic Processes* (McGraw Hill)
6.Gilbert Strang – *Linear Algebra and its Apllications*(Thomson Books)
7.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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

CPC 10 102: PROCESS DYNAMICS AND CONTROL – 1

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: (13 Hours)

Linear system stability – Frequency response techniques – Bode and Nyquist stability criteria. Non –linear system stability analysis – the Phase plane technique – iscoline method – the Describing function technique – treatment of simple non-linearities.

Module II: (13 Hours)

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 III:(14 Hours)

Advanced control strategies – Cascade control, Feed forward control, Ratio control, Internal model control. Model reference adaptive control, self tuning regulator. Dead time compensator – the Smith predictor.

Module IV: (13 Hours)

Sampled data systems – sampling, zero order hold, impulse modulated function, the Z- transform. Open loop and closed loop response. Stability analysis.

References:

1. D.R.Coughanowr, *Process system analysis and control*, McGraw –Hill.

2. George Stephanopoulos, *Chemical Process Control, an introduction to theory and practice*, Prentice-Hall.
3. K.Ogata, *Model Control Engineering*, Prentice-Hall.
4. Peter Harriot, *Process Control*, Tata McGraw Hill.
5. D.D. Perlmutter, *Introduction to Chemical Process Control*.
6. W.L. Luyben, *Process modeling, Simulation and Control for Chemical Engineers*, 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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

CPC 10 103 : INDUSTRIAL INSTRUMENTATION

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objective :
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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3: 20 marks

Question 4: 20 marks

Module III

Question 5: 20 marks

Question 6: 20 marks

Module IV

Question 7: 20 marks

Question 8: 20 marks

CPC 10 104: MODERN CONTROL THEORY

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

Objectives:
The students are exposed to basic analysis of the system in state space, Stability analysis of linear and nonlinear systems, Controllability and observability of control systems.

Module I: (13 Hours)
Introduction to state space analysis-Definitions of state space, state variables and equilibrium points-representations of systems described by differential equations and transfer functions in state variable form-Bush form, Guilllemin's form, Foster's form, Jordans's form. Cayley-Hamilton theorem-Evaluation of Matrix polynomial, inverse of a matrix, state transition matrix . Quadratic forms and sign definiteness of quadratic forms.

Module II: (13 Hours)
State space analysis of control systems-Introduction to the state concept. State space representation of systems. Solution of the time invariant state equations-state transition matrix. Transfer matrix. Linear time varying systems. Discrete systems-state space representation and solution.

Module III: (14 Hours)
Liapunov stability analysis-Definition of stability, instability and asymptotic stability. Liapunov stability theorems. Stability analysis of simple linear systems. Stability analysis of non-linear systems-Krasovski's method and the Variable gradient method.

Module IV: (13 Hours)
Controllability and Observability- Definitions, controllability and observability of continuous and discrete time systems-Introduction to optimal control.
References:

1. Katsuhiko Ogata, *Modern control engineering*, Prentice- Hall of India
2. Chen,C.F and I.J Haas, *Elements of control system analysis*, Prentice – Hall
3. Katsuhiko Ogata, *State space analysis of control systems*, Prentice – hall
4. Kuo,B.C, *Analysis and synthesis of sampled data control systems*, Prentice -Hall

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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

CPC 10 105A: 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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

CPC 10 105B: Energy Engineering and Management

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objectives:

The students are given a comprehensive knowledge of different sources of renewable energy, solar energy tapping, biomass conversion, fuel cells, energy conservation and energy audit

Module I:(13 Hours)

Classification of energy, energy resources and energy consumption – world and Indian scene. Energy strategies for a sustainable world, the DEFENDUS scenario.

Concept of thermal efficiency, reversible and irreversible processes, thermal efficiency of a heat engine, coefficient of performance, irreversible process and loss of energy. Significance of heat at higher temperature, thermodynamic cycle and thermal power plants, heat pumps, gas turbines, combined cycle power plants. Fluidized bed combustion.

Module II: (13 Hours)

Solar energy, thermal and photo voltaic systems, flat plate and focusing collectors, solar water heating, solar distillation, solar cooking, solar refrigeration, power generation, energy plantations.

Module III: (14 Hours)

Biomass conversion technologies – thermo chemical and biochemical routes. Wind energy, wave energy. Magneto hydrodynamics, hydrogen energy, fuel cells, electric vehicles, energy storage routes, small hydropower.

Module IV: (13 Hours)

Energy audit and conservation in chemical industry, efficient generation and utilization of steam. Energy conservation in distillation columns, heat exchangers, dryers, furnaces, boilers. Thermal insulation, pinch technology, co-generation. Energy conservation in petroleum and petrochemical and steel industries. Electrical energy conservation in chemical plants.

References:

1. Mittal.K.M, *Non-conventional energy systems*, Wheeler Publishing Co.
2. Rao.S and Parulekar, *Energy technology*, Khanna Publishers.
3 Bansal.N.K and Kleeman, *Renewable energy sources and conversion technologies*, Tata-McGraw Hill.
4. Sukhatme.S.P. *Solar energy*, Tata-McGraw Hill.
5. Reddy, A.K.N and Goldemberg, *Energy for a sustainable world*, 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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

CPC 10 105C: 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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4 : 20 marks

Module III

Question 5 : 20 marks

Question 6 : 20 marks

Module IV

Question 7 : 20 marks

Question 8 : 20 marks

CPC 10 106(P): Advanced Process Control Lab / Mini Project

Hours per week: 2

1.Study of control valve characteristics

2.Study of differential pressure transmitter

3.Study of current to pressure and pressure to current convertor

4.Conducting experiments in Flow Process Analyser to study the control of process flow tank using on – off, Proportional, Proportional integral, proportional derivative and proportional integral derivative controllers

5.Conducting experiments in Temperature Process Analyser to study the control of process tank using on – off, Proportional, Proportional integral, proportional derivative and proportional integral derivative controllers

6.Conducting experiments in Cascade controller trainer to study the control of integrated flow and level processes simultaneously using on – off, Proportional, Proportional integral, proportional derivative and proportional integral derivative controllers

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

CPC 10 107(P): Seminar

Hours per week: 2 hours practical **Credits:** 2

Objective:
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 control / process control 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

CPC 10 201: Process Dynamics and Control – II

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objective:

To enable the students to model, conduct dynamic study and control real process in chemical industry and
to have knowledge about distributed control systems and digital control

Module I: (13 Hours)

Theoretical analysis of complex processes – Control of a steam-jacketed kettle, dynamic response of a gas absorber. Distributed parameter systems – Heat conduction into a solid, transportation lag as a distributed parameter system, double pipe heat exchanger.

Module II: (13 Hours)

Dynamics and control of heat exchangers and distillation columns – Dynamics of steam heated exchangers and control schemes. Dynamic behaviour of distillation columns, control schemes for distillation columns.

Module III: (14 Hours)

Distributed control systems – Evolution, building blocks, functions of field control units, operator stations, data highways. DCS – tasks and configuration, communication in DCS, protocols. Case studies in DCS.

Module IV: (13 Hours)

Process control using digital computers – Transient response of closed-loop sampled data systems. Analysis and design of sampled–data controllers, minimal prototype algorithms, digital PI and PID controllers.

References:

1. D.R.Coughanowr, *Process system analysis and control*, McGraw –Hill.
2. George Stephanopoulos, *Chemical Process Control, an Introduction to theory and practice*, Prentice-Hall.
3. W.L. Luyben, *Process modeling, Simulation and Control for Chemical Engineers*, McGraw Hill
4. Krishna Kant, *Computer based industrial control*, Prentice Hall.
5. Deshpande P.B and R.H.Ash, *Elements of process control applications*, ISA Press.
6. Mckloni D.T, *Real time control networks*, ISA Press.
7. Shinskey F.G, *Distillation control*, 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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

CPC 10 202: Advanced Chemical Reaction Engineering

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objectives:

To study the kinetics of solid catalysed reactions, different types of reactors and their model equations. The student will be able to select and design the type of reactor for a particular application.

Module I: (13 Hours)

Kinetics of homogeneous reactions, interpretation of batch reactor data, ideal reactors, reactor design for single reactions and multiple reactions, single reactor and multiple reactor systems, recycle reactor, auto catalytic reactor, non-isothermal reactor design, reactor stability, multiple steady states.

Module II: (13 Hours)

Basics of non-ideal flow, compartment models, the axial dispersion model, the tanks-in-series model, the convection model for laminar flow, earliness of mixing, segregation and RTD

Module III: (14 Hours)

The kinetics of solid catalysed reactions, pore diffusion resistance combined with surface kinetics, effectiveness factor, performance equation for reactors containing porous catalyst particles, the packed bed catalytic reactor, the fluidized reactor, the bubbling fluidized bed, the K – L Model for bubbling fluidized bed, deactivating catalysts.

Module IV: (13 Hours)

Gas – liquid reactions on solid catalysts trickle beds, slurry reactors, three – phase fluidized beds, fluid – fluid reactions – kinetics and reactor design.

References:

1. Levenspiel. O, *Chemical Reaction Engineering*, John Wiley & sons.
2. Carberry. J.J, *Chemical and Catalytic Reaction Engineering*, Mc Graw Hill.
3. Smith, J. M., *Chemical Kinetics*, Mc Graw Hill.
4. Fogler, S. H., *Elements of Chemical Reaction Engineering*, Prentice Hall.
5. Walas, S. M., *Chemical Reaction Engineering Handbook of Solved Problems*, Oxford Sciences.
6. Davis, M.E. and Davis, R.J, *Fundamentals of Chemical Reaction Engineering*, Mc Graw 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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4 : 20 marks

Module III

Question 5 : 20 marks

Question 6 : 20 marks

Module IV

Question 7 : 20 marks

Question 8 : 20 marks

CPC 10 203: Advanced Heat and Mass transfer

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objectives:

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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4 : 20 marks

Module III

Question 5 : 20 marks

Question 6 : 20 marks

Module IV

Question 7 : 20 marks

Question 8 : 20 marks

CPC 10 204A: Multivariable Feedback Control

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

Objectives:
To give the students a basic understanding of multivariable feedback control

Module I: (13 Hours)
Introduction to classical feedback control: open loop and closed loop transfer functions, state space models, sensitivity and complementary sensitivity functions, closed loop stability, time domain and frequency domain closed loop performance.

Module II: (13 Hours)
Introduction to multivariable control: transfer functions for MIMO systems, transmission zeros, scaling, directional sensitivity and operability, condition number and RGA, decoupling. Elements of linear system theory: state controllability and state observability, internal stability of feedback systems, H_2 and H_∞ norms.

Module III: (14 Hours)
Limitations on performance in SISO and MIMO systems: limitations introduced by time delays, RHP zeros, RHP poles, input constraints and uncertainty. Input output controllability, SISO robust stability and robust performance.

Module IV: (13 Hours)
The structured singular value analysis for MIMO systems, μ synthesis and DK interaction. H_2, LQG and H_∞ controllers, basics of MPC.

References:

1. Sigurd Skogestad and Ian Postlethwaite, *Multivariable feedback control- Analysis and Design*, John Wiley & Sons, 1998.
2. B. Wayne Bequette, Process *Control Modeling Design and Simulation*, Prentice Hall of India, 2004.
3. P. Albertose and A. Sala, *Multivariable control systems an engineering approach*, Springer, 2004.
4. Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp,' *Process Dynamics and Control*, Willey India, 2006.

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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4 : 20 marks

Module III

Question 5 : 20 marks

Question 6 : 20 marks

Module IV

Question 7 : 20 marks

Question 8 : 20 marks

CPC 10 204B: System Identification

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

Objectives:
To give advanced concepts on process control system analysis and identification

Module I: (13 Hours)
Classification of models, transfer function and state space models for continuous time and discrete time systems, linear regression analysis – method of least squares.

Module II: (13 Hours)
Introduction to time-series models, auto covariance and cross covariance, least squares problem in covariance domain, estimation of dynamic input-output AR, MA models, ACF and PACF.

Module III: (14 Hours)
Impulse response, convolution, Fourier transforms, power spectrum, ETFE, prediction of stochastic processes – one step and k step ahead prediction.

Module IV: (13 Hours)
Estimation of ARMA, ARX, ARMAX, OE, BJ models, plant model and noise model.

References:

1. Lennart Ljung, *System Identification Theory for the user* , Prentice Hall,PTR ,1999.
2. Enso Ikonen and Kaddour Najim, *Advanced Process Identification and Control*, Marcel Dekker, Inc., 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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4 : 20 marks

Module III

Question 5 : 20 marks

Question 6 : 20 marks

Module IV

Question 7 : 20 marks

Question 8 : 20 marks

CPC 10 204C: 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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4 : 20 marks

Module III

Question 5 : 20 marks

Question 6 : 20 marks

Module IV

Question 7 : 20 marks

Question 8 : 20 marks

CPC 10 205A: Fuzzy Systems and Control

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objectives

Introduction to neural networks, ,fuzzy systems, fuzzy controllers, case studies

Module I: (13 Hours)

Introduction to artificial intelligence, implications of artificial intelligence applied to problems in chemical engineering analysis and design. Basics of neuroscience and artificial neuron models.

Module II: (13 Hours)

Artificial neural networks: feed forward networks, computational capabilities, learning rules, adaptive multi-layer neural networks, symmetric and asymmetric recurrent networks, competitive and self organizing networks.

Module III: (14 Hours)

Introductions to fuzzy systems: fuzzy sets and systems, universe as a fuzzy set, basic notions, fuzzy relation calculations, fuzzy numbers, indices of fuzziness, membership function.

Module IV: (13 Hours)

Fuzzy controllers, basic construction, analysis of static and dynamic properties of fuzzy controllers, case studies.

References:

1. Bart Kosko, *Neural networks and fuzzy systems*, Prentice Hall.
2. Timothy J Ross, *Fuzzy logic with engineering applications*, McGraw Hill.
3. Yegnanarayana B, *Artificial neural networks*, Prentice Hall.
4. Bose N. K. and P. Liang, *Neural network fundamentals with graphs algorithms and applications*, McGraw Hill
5. Nie J and D. Linkens, *Fuzzy- neural control: principles, algorithms and applications*, Prentice Hall.

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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4 : 20 marks

Module III

Question 5 : 20 marks

Question 6 : 20 marks

Module IV

Question 7 : 20 marks

Question 8 : 20 marks

CPC 10 205B: Biochemical Engineering

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objectives:

To give advanced concepts in m*olecular genetics, kinetics of enzymes, bioreactors, biosensors and downstream processing.*

Module I: (13 Hours)

Introduction to microbiology and chemicals of life. Metabolic pathways in respiration like Embden- Meyerhof- Parnas pathway(glycolysis), TCA cycle(Krebs cycle). An understanding of biochemical processes like photosynthesis,biosynthesis,carbon catabolism,biosorption,bioleaching,and bioremediation.

Molecular genetics, process of gene expression, DNA replication and mutation , recombinant DNA technology, enzymes for manipulating DNA, cloning of DNA, expression of eukaryotic proteins in E.Coli, genetic engineering using other host organisms.

Module II: (13 Hours)

Kinetics of enzymes – catalyzed reactions, Michaelis-Menten kinetics for different types of enzyme catalysed reactions.. Solution of problems on above reactions for estimating step constants of Michaelis-Menten equation. Substrate activation and inhibition,Enzyme activation and inhibition, modulation and regulation of enzyme activity. Influence of pH, temperature, fluid forces, chemical agents and irradiation on enzyme activity-derivation.

Immobilized – enzyme technology, methods of immobilization, immobilized enzyme kinetics –derivation, mass transfer resistance due to immobilized enzymes. Industrial, medical, analytical applications of immobilized enzymes.

Module III: (14 Hours)

Growth of cells in a batch process-phases of growth.Monod growth kinetics. Ideal batch reactors- fed-batch reactor, CSTR, PFR, Non-ideal reactors. Multi-phase bioreactors –packed bed type, bubble column bioreactor,fluidized bed type, trickle bed type Mixing patterns and RTD in non-ideal bioreactors.

Fermentation technology, medium formulation, design and operation of a typical aseptic, aerobic fermentation process. Different configurations for fermentors. Animal and plant cell reactor technology.

Module IV: (13 Hours)

Concept of biosensors. Physical and chemical sensors,gas analysis sensors, online and offline sensors.Cell composition analysis.

Upstream and downstream processing, product recovery operations-filtration, centrifugation, sedimentation, solvent extraction, extraction using two-phase systems, sorption andprecipitation.

Purification processes like reverse osmosis, ultra filtration, electrophoresis, dialysis.

References:

1. Bailey and Ollis, Biochemical engineering fundamentals, 2nd Edition, McGraw Hill international
2. Aiba, Humphrey, Millis, *Biochemical engineering*, 2nd Edn., Academic Press.
3. Ghose.T.K., *Process computations in biotechnology*, Tata McGraw Hill
4. Levenspiel O, *chemical reaction engineering, 3rd Edn*., Wiley Eastern
5. Shuler and Kargi, *Bioprocess Engineering, first edn*,Pearson education
6. Donald Wise, *Bioinstrumentation and Biosensors*, Pearson education

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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

CPC 10 205C: Applied Process Control

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objectives:

The students are given concepts of, stability analysis, process identification, interaction between control loops, application to evaporator.

Module I: (13 Hours)

Introduction to system models: state equation models, the discrete state equation, input-output models. The difference operator. Stability studies based on state matrix. The forced circulation evaporator model – the non-linear model and the linear model. Computer simulation of the models.

Module II: (13 Hours)
Process identification techniques: general principles, parameter identification using step test. Time series analysis and its application to the evaporator.

Module III: (14 Hours)
The single loop control: single-input single-output control loops, controller tuning. Multiloop interactions, Bristol's relative gain array. Feed forward control – the feed forward compensator design, its application to the evaporator

Module IV: (13 Hours)
Interaction between control loops – effects of interaction, decoupling of control loops, design of a decoupling compensator. Decoupler for the evaporator. The multi-input multi-output controller. Dead time compensation – the smith predictor, its design. Application of dead time compensator to the evaporator.

References:

1. Newell R.B and P.L Lee, *Applied process control-a case study*, Prentice-Hall.
2. Astrom K.J and B.Wittenmark, *Computer controlled systems*: Theory and Design, Prentice-Hall.
3. W.L. Luyben, *Process modeling, Simulation and Control for Chemical Engineer*s, McGraw Hill
4. Ramirez W.F, *Process control and identification*, Academic Press.
5. Peter Young, *Recursive estimation and time series analysis-an introduction*.

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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4 : 20 marks

Module III

Question 5 : 20 marks

Question 6 : 20 marks

Module IV

Question 7 : 20 marks

Question 8 : 20 marks

CPC 10 206(P): Modeling, Design and Simulation Lab/Mini Project

Hours per week: Practical 2 hours **Credits: 2**

Objective:

- *Programming and computation in MATLAB/SCILAB.*
- *Model development using SIMULINK/SCICOS.*
- *Design of control systems and their simulation using ASPEN, CHEMCAD and HYSIS.*

References:

1. B. Wayne Bequette, *Process Control Modelling Design and Simulation*, Prentice Hall of India, 2004.
2. L. Ljung, *System Identification Theory for the user* – Prentice Hall PTR ,1999.
3. Ashish Tewari, *Modern Control Design with MATLAB and SIMULINK*, John Wiley and Sons Ltd.
4. Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp,' *Process Dynamics and control*

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 marks = 50 marks

CPC 10 207 (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.

- Individual students are required to choose a topic of their interest from Process Control 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 calender days from the start of semester III.

CPC 10 301A: Computational Flow Modelling

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 Fkuid Flow, Springer Verlag, 1983.
7. Smith, G. D., *Numerical Solution of Partial Differential Equations: Finite Difference Methods*, Claderon Press, Oxford.
8. Patankar, Suhas, V., *Numerical Heat Transfer and Fluid Flow*, McGraw Hill, Washington,
1980
9. 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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4 : 20 marks

Module III

Question 5 : 20 marks

Question 6 : 20 marks

Module IV

Question 7 : 20 marks

Question 8 : 20 marks

CPC 10 301B: 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:

8. Lees F.P,,Loss *Prevention in Process Industries,Vol.1,2&3,Second Edn*,Butterworth-Heinemann.1996
9. *Guidelines for Hazard Evaluation Procedure.Centre for Chemical Process Safety*.AICHE,1992
10. Ralph King, *Safety in the Process Industries*,Butterworth-Heinemann
11. 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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4 : 20 marks

Module III

Question 5 : 20 marks

Question 6 : 20 marks

Module IV

Question 7 : 20 marks

Question 8 : 20 marks

CPC 10 301 C: Research Methodology

Teaching scheme

Credits:4

3 hours lecture & 1 hour tutorial per week

ModuleI: (13 Hours)

Research Concepts – concepts – meaning – objectives – motivation. Types of research – descriptive research – conceptual research – theoretical research – applied research – experimental research. Research process – Criteria for good research – Problems encountered by Indian researchers.

ModuleII: (13 Hours)

Formulation of Research Task – Literature Review – Importance & Methods – Sources – Quantification of Cause Effect Relations – Discussions – Field Study – Critical Analysis of Generated Facts – Hypothetical proposals for future development and testing, selection of Research task

ModuleIII: (14 Hours)

Mathematical modelling and simulation – Concepts of modelling – Classification of mathematical models – Modelling with – Ordinary differential equations – Difference equations – Partial differential equations – Graphs – Simulation – Process of formulation of model based on simulation.

ModuleIV: (13 Hours)

Interpretation and report writing – Techniques of interpretation – Precautions in interpretation – Significance of report writing – Different steps in report writing – Layout of research report – Mechanics of writing research report – Layout and format – Style of writing – Typing – References – Tables – Figures – Conclusion – Appendices.

References:

1. J.W Bames, Statistical Analysis for Engineers and Scientists, McGraw Hill, N.York
2. Schank Fr., Theories of Engineering Experiments, Tata Mc Graw Hill Publication.
3. C. R. Kothari, Research Methodology, New Age Publishers.
4. Willktnsion K. L, Bhandarkar P. L, Formulation of Hypothesis, Himalaya 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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4 : 20 marks

Module III

Question 5 : 20 marks

Question 6 : 20 marks

Module IV

Question 7 : 20 marks

Question 8 : 20 marks

CPC 10 302 A: Process Modelling and Simulation

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objectives:

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 holdup CSTR in series- Boiling of single conponent 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-semibatch reactor-ideal binary distillation column – multicomponent distillation column
Distributed system: jacketed tubular reactor - laminar flow in a pipe - countercurrent 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:
8.Luyben W.L., *Process Modeling, Simulation and Control for Chemical Engineers*, McGrawHill International Edition
9.Franks R.G.E., *Mathematical Modeling in Chemical Engineering*, John Wiley
10.John Ingham et.al., *Chemical Engineering Dynamics - Modeling with PC Simulation*, VCH Publishers
11.Biquette W.B., *Process Dynamics - Modeling Analysis and Simulation*, Prentice Hall of India
12.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 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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4 : 20 marks

Module III

Question 5 : 20 marks

Question 6 : 20 marks

Module IV

Question 7 : 20 marks

Question 8 : 20 marks

CPC 10 302B: Computational Methods for Process Design

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

***Objectives**:*
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 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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4 : 20 marks

Module III

Question 5 : 20 marks

Question 6 : 20 marks

Module IV

Question 7 : 20 marks

Question 8 : 20 marks

CPC 10 302C: Nanomaterial and Nanotechnology

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objectives:

To impart the basic concepts of nanotechnology,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 : **(13 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 : (14 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. Pulikel M. Ajayan, *Nanocomposite science and technology*, Wiley-VCH 2005

2. David G. Bucknall, *Nanolithography and patterning techniques in microelectronics*,Wood head publishing 2005

3. D.K. Ferry and S.M. Goodmick, *Transport in Nanostructures*, Cambridge university press 1997.

4. F. Wooten, *Optical properties of solids*, Academic press 1972

5. Zheng Cui, *Micro and Nanofabrication*, Springer 2005

6. Jackie Y. Ying, *Nanostructured materials*, Academic press 2001

7. W.R, Fahrner, *Nanotechnology and nanoelectronics*, Springer 2005

8. Mark J. Schulz,*Nanoengineering of structural, functional and smart materials*, Taylor & Francis 2006.
9. William A. Goddard, *Hand book of Nanoscience, Engineering, and Technology*, CRC press 2003.
10. Rainer Waser, *Nanoelectronics and Information Technology*, Wiley-VCH 2003.
11. Frank Kreith, *The MEMS Handbook* ,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 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

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

CPC 10 303: 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

CPC 10 303(P): 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 / 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 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**

CPC10 401(P) : MASTERS RESEARCH PROJECT PHASE 2

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