BHARATI VIDYAPEETH UNIVERSITY,
Pune.

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COURSE STRUCTURE & SYLLABUS

M. Tech. (Chemical) (Semester - I to IV)

COURSE STRUCTURE & SYLLABUS

BHARATI VIDYAPEETH UNIVERSITY, PUNE

M. Tech. (CHEMICAL) (Sem. I to IV)

HIGHLIGHTS

Bharati Vidyapeeth University College of Engineering (BVUCOE) is the largest Engineering College in Maharashtra with an intake of 700 students in each academic year. Imparting quality technical education from Under Graduate to Doctorate Level, BVUCOE is probably the only Engineering College in India with an accreditation from both NAAC as well as NBA. The faculty at BVUCOE boasts of highly qualified academicians, a quality that is further emphasized by the fact that 15 of them are presently pursuing their Ph.D. degree.

BVUCOE has been ranked 29th amongst the Top 50 Technical Schools of India in survey conducted by DATAQUEST-IDC. We have enjoyed a ranking in this list for the last 4 years. Research is of utmost importance in all our programs. A total of 113 research papers were published in the academic year 2007-2008.

Currently we have 12 ongoing research projects. The infrastructure of BVUCOE is state-of-the-art with 62 classrooms, 59 laboratories and a well-stocked library that currently holds 27,130 titles. The college has an international presence with MoUs signed with the North Carolina A&T State University (Greensboro, USA), University of Venice (Italy), Actel Corporation (USA).Corporate interaction is also inculcated in our programs through our association with Oracle India Ltd., Infosys Ltd. and Tata Consultancy Services.

DEPARTMENT OF CHEMICAL ENGINEERING

Department of Chemical Engineering is one of the oldest department in Pune region and known for its very valuable contribution in providing high caliber, outstanding professionals to the industry and R & D establishments.

Being our own university, the department has got freedom to design and adopt the change in the structure and content of the syllabus in consultation with the industrial experts and researchers to suit their requirement. The department of chemical engineering desires its students to excel in the changing trends in the global economy. The salient features of the present course designed are:

- Computer Education with advanced simulation softwares
- Industrial training after VIIth semester for the period of six weeks
- Wide range of advanced elective subjects
- Expert interaction on each subject by the experts from the various fields

The department also conducts a post graduate course in Chemical Engineering. The P. G. students perform their dissertation work in collaboration with National Chemical Laboratories (NCL), Pune.

The Department of Chemical Engineering has following well equipped laboratories:

- Mechanical Operations
- Heat Transfer
- Mass Transfer
- Chemical Reaction Engineering
- Process Dynamics Instrumentation and Control
- Instrumental Analysis
- Software Laboratory – CHEMCAD, MATLAB, FEMLAB, gPROMS, T. K. Solver

The faculty has constantly endeavored to improve the academic standards and pursue the R & D work, publishing the academic research papers in the National and International journals. Some of the faculty members have presented their research papers at various conferences/seminars and workshops. As a result of continuous efforts by the faculty, the department has received the following funds/grants from the AICTE, New Delhi.

- Young Career Award Research Project (10 Lakh)
- Research Promotion Scheme (RPS) Grant (5.75 Lakh)
- MODROB's for various chemical engineering laboratories (12 Lakh)

The department has the state of Art facilities of:

- Gas Chromatography (G. C.)
- High Pressure Liquid Chromatography (HPLC)
- U.V.- Visible Spectrophotometer
- Fluoride ion selective electrode meter

Department plans to provide low priced testing facility for Industry and research laboratories. Students' community actively involved in R & D experimentation can avail the same for affordable rates.

STRUCTURE & EXAMINATION PATTERN

M. Tech. - Chemical Engineering

Semester I

Total Duration : 20 Hrs/Week
Total Marks : 500

Subject Code	Subject	Teaching Scheme (Hrs.)		Examination Scheme (Marks)				Total (Marks)
		L	P	Theory	Unit Test	T.W.	Oral	
K10501	Numerical Methods in Chemical Engineering	04	02	70	30	25	25	150
K10502	Advanced Transport Phenomena	04	-	70	30	-	-	100
K10503	Applications of Thermodynamics to Chemical Engineering	04	-	70	30	–	–	100
K10504	Advanced Process Control	04	02	70	30	25	25	150
	Total	16	04	280	120	50	50	500

Teaching Scheme		Examination Scheme				Total
Lectures	Practical	Theory	Test	T. W.	Oral	
16	04	280	120	50	50	500

Semester II

Total Duration : 20 Hrs/Week
Total Marks : 500

Subject Code	Subject	Teaching Scheme (Hrs)		Examination Scheme (Marks)				Total (Marks)
		L	P	Theory	Unit Test	T.W.	Oral	
K10505	Modeling and Simulation of Chemical Processes	04	02	70	30	25	25	150
K10506	Chemical Reactor Analysis	04	–	70	30	–	–	100
K10507	Synthesis and Design of Chemical Processes	04	–	70	30	–	–	100
K10508	Advanced Mass Transfer	04	02	70	30	25	25	150
	Total	16	04	280	120	50	50	500

Teaching Scheme		Examination Scheme				Total
Lectures	Practical	Theory	Test	T. W.	Oral	
16	04	280	120	50	50	500

Total of Sem. I & II = 1000

STRUCTURE & EXAMINATION PATTERN

M. Tech. - Chemical Engineering

Semester III

Total Hours: 15Hrs/week

Subject Code	Subject	Teaching Scheme (Hrs.)		Examination Scheme (Marks)				Total (Marks)
		L	P	Theory	Unit Test	TW	Oral	
K10601	Elective I	04	02	70	30	25	25	150
K10602	Elective II	04	02	70	30	25	25	150
K10603	Seminar I	-	01	-	-	25	25	50
K10604	Dissertation Stage I	-	02	-	-	25	-	25
	Total	**08**	**07**	**140**	**60**	**100**	**75**	**375**

Teaching Scheme Hrs/Week		Examination Scheme (Marks)				Total
Lectures	Practical	Theory	Unit Test	T.W.	Or.	
08	07	140	60	100	75	375

Semester IV

Total Hours: 20Hrs/week

Subject Code	Subject	Teaching Scheme (Hrs.)		Examination Scheme (Marks)				Total (Marks)
		L	P	Theory	Unit Test	TW	Oral	
K10605	Dissertation Stage II	-	04	-	-	150	75	225
	Total	**-**	**04**	**-**	**-**	**150**	**75**	**225**

Teaching Scheme Hrs/Week		Examination Scheme (Marks)				Total
Lectures	Practical	Theory	Unit Test	Oral	T. W.	
-	04	-	-	75	150	225

Total of Sem. III & IV - 600
Grand Total - 1600

Elective – I

a. Air Pollution Control Engineering
b. Non-Conventional Energy Sources
c. Industrial Waste Water Treatment
d. Heterogeneous Catalysis
e. Catalyst Materials

Elective II

a. Membrane Separation
b. Bioprocess Engineering
c. Multicomponent Separation
d. Food Process Engineering
e. Fluidization Engineering

Dissertation Stage I :

This stage will include comprehensive report on literature survey, design and fabrication of experimental set up and/or development of model, relevant computer programs and the plan for stage II.

Dissertation Stage II :

This is the final stage in the dissertation work. This stage will include comprehensive report on the work carried out at this stage and relevant portions from stage I , including experimental studies, analysis and/or verification of theoretical model, conclusions. The student is required to publish at least one national/international paper based on the dissertation work. The publication/ accepted paper for publication shall be included in the report.

Seminar I:

The students will be required to select a advanced research topics for the seminar and present the seminar during the semester. A detailed report should also be submitted and assessment will be based on the quality in terms of the research and development.

RULES FOR CONDUCTING TESTS

Mode of the test

- Three unit tests per subject shall be conducted in each semester. The schedule for the same will be declared in the academic calendar of each term.
- Each unit test shall carry 30 marks.
- University examination pattern has given weightage of 30 marks for unit tests and 70 marks for theory examination
- To calculate final marks of the unit test following procedure is followed:

  i) Out of the three unit tests conducted during the semester, the marks of only two unit tests in which the candidate has shown his/her best performance shall be considered, to decide the provisional marks in each subject

  ii) Average marks obtained in two unit tests in which students have performed well shall be considered as provisional marks obtained by the student.

  iii) If the candidate appears only for two unit tests conducted during the semester, he/she will not be given the benefit of the best performance in the tests.

  iv) If the candidate appears only for one unit test conducted during the semester, to calculate the marks obtained in the unit tests it will be considered that the candidate has got 0(zero) marks in other unit tests.

  v) There is separate passing in theory examination. A candidate has to secure minimum 28 marks(i.e.40%) out of 70 marks to declare him/her pass. Provisional marks obtained by the candidate in unit tests should reflect as proportional to the marks obtained in theory examination. In case of disparity of more than 15% it will be scaled down accordingly. These marks will be final marks obtained by the student. No scaling up is permitted.

  vi) Unit test marks will be added in theory examination marks only after passing of candidate in theory examination in respective subject.
- Paper pattern for the unit tests:
- All questions are compulsory with weightage as following:

  Question 1 - 10 marks
  Question 2 - 10 marks
  Question 3 - 10 marks
- For granting the term it is mandatory to appear for all the three unit tests conducted in each semester.
- Roll numbers allotted to the students shall be the examination numbers for the unit tests.

SEMESTER - I

K10501: NUMERICAL METHODS IN CHEMICAL ENGINEERING

TEACHING SCHEME

Lectures : 04 Hrs/week
Practical : 02 Hrs/week

EXAMINATION SCHEME

Theory	: 70 Marks
Duration	: 03 Hours
Unit Test	: 30 Marks
Term Work	: 25 Marks
Oral	: 25 Marks

Unit-I (08 Hours)

Introduction:

Approximation and round-off errors, accuracy and precision, error definition, truncation errors, Taylor series. Bisection method, false position method, Secant method, roots of polynomials, Mueller's method, Bairstow's method.

Unit-II (08 Hours)

Linear and Non-Linear Algebraic Equations:

Gauss elimination, Gauss Jordon, LU decomposition, matrix inversion, Gauss-Seidel method. System of nonlinear equations, Newton Raphsons method.

Unit-III (08 Hours)

Curve fitting

Least Square Regression:

Linear regression, nonlinear regression, polynomial regression.

Interpolation:

Newtons Divided difference interpolating polynomials, Lagrange interpolating polynomial, Inverse interpolation.

Unit-IV (08 Hours)

Numerical Differentiation and Integration:

Trapezoidal rule, Simpson's rule, integration with unequal segments, Newton-cots algorithm for equation, Ramberg integration, Gauss qudrature, numerical differentiation.

Unit-V (08 Hours)

Ordinary Differential Equation:

Eulers implicit and explicit method, predictor-corrector method, Runge-Kutta second and fourth order method, system of equations, boundary and eigen value problem.

Unit-VI (08 Hours)

Partial differential equations:

Finite difference method, elliptical and parabolic equations, Laplace equation, solution techniques, boundary conditions, explicit method, Crank-Nicholson method.

Oral:

Oral examination will consist of assessment of the termwork (duly certified by the teacher and HOD)and oral exam based on the term work/practical. The term work shall consist of the following:

- Minimum 6 practicals based on solving numerical methods mentioned in the syllabus using C, C++ language, or TK solver software, or any chemical Engineering Software.
- Assignments given by concerned subject teacher throughout the semester.

Text Books/ References

- Chapra S. C., R. P. Canale, "Numerical Methods for Engineers", Tata-McGraw Hill Publications
- Teukolsky S. A., W. H. Press, "Numerical Recipes in 'C' ", Cambridge University Press
- Constantinides A., "Applied Numerical Methods with Personal Computer", McGraw Hill publishers

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

K10502: ADVANCED TRANSPORT PHENOMENA

TEACHING SCHEME
Lectures : 04 Hrs/week

EXAMINATION SCHEME
Theory : 70 Marks
Duration : 03 Hours
Unit Test : 30 Marks

Unit-I (08 Hours)

Newtonian and non Newtonian fluids, Convective momentum transport, Shell momentum balance and boundry condition. Flow of two adjacent immiscible fluids. Creeping flow around sphere. The Equation of continuity, Motion and Mechanical energy. Flow near a wall suddenly set in motion, unsteady laminar flow near an oscillating plate.

Unit-II (08 Hours)

Time smoothed equation of change for incompressible fluids. Interphase Transport in Isothermal System: friction factors for flow arround spheres. Friction factors for packed columns. Trubulent flow in packed columns. Friction losses in various types of fittings. Macroscopic momentum balance.

Energy transport

Unit-III (08 Hours)

Fourier's law of heat conduction, Effective thermal conductivity of composit solids. Convective transport of energy, Shell energy balance, boundry conditions. Heat conduction in a cooling Fin. Forced convection, Free convection. The equation of change for non isothermal systems. The equation of energy. The Boussinesq equation of motion for forced and free convection. Tangential flow in an Annulus with viscous heat generation.

Unit-IV (08 Hours)

Unsteady Heat Conduction in Solids: Unsteady heat conduction near the wall with sinusoidal heat flux. Temperature distribution in turbulent flow: Time smoothed equation of change for incompressible non isothermal flow. Heat transfer coefficients for forced convection in tubes and through

packed beds. Energy transport by Radition. Planks distribution law ,Wiens Displacement law & Stefen–Boltzman law.

Unit-V (08 Hours)

Fick's law of binary Diffusion. Mass and Molar transport by convection. The Maxwell-Stefen equation for multi component Diffusion in gases at low density. Shell mass balance, boundry conditions Diffusion and chemical reaction inside a porous catalyst. Equation of change for Multi component systems: Use of equation of change for Mixtures, simultaneous Heat and Mass transport.

Unit-VI (08 Hours)

Unsteady Diffusion with first order Homogeneous reaction, Enhancement of mass transfer by first order reaction in turbulent flow. Mass transfer in creeping flow through packed beds. Combined heat and mass transfer by free convection, The macroscopic Mass, Momentum & Energy balance. Unsteady operation of packed column.

Text Books/ References

- Slattery John C, "Advanced transport phenomena", Cambridge University Press
- Stewart W. E., Lightfoot E. N., Bird R. B.,"Transport Phenomena", John Wiley & Sons
- J. G. Knudsen, D. L. Kaz, "Fluid Dynamics and Heat Transfer'', McGraw Hill, 1953

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

K10503: APPLICATION OF THERMODYNAMICS TO CHEMICAL ENGINEERING

TEACHING SCHEME
Lectures : 04 Hrs/week

EXAMINATION SCHEME
Theory : 70 Marks
Duration : 03 Hours
Unit Test : 30 Marks

Unit -I (08 Hours)

Chemical Reaction Equilibria:

Phase rule and Duhem's theorem for reacting systems, Single reaction equilibrium, Multiple reaction equilibria, Fuel cells.

Unit –II (08 Hours)

Application of Solution Thermodynamics:

Liquid phase properties from VLE data, Activity coefficients, Excess Gibbs energy, Local composition models, Enthalpy concentration diagrams, Reactions in heterogeneous systems.

Unit-III (08 Hours)

Topics in Phase Equilibria:

VLE from cubic equation of state, Liquid-Liquid equilibria, Solid - Liquid equilibria, Osmotic equilibrium and osmotic pressure.

Unit-IV (08 Hours)

Application of Thermodynamics to Biological Process:

Biopolymer stabilities, thermodynamic studies of protein stability, thermodynamics of two-state model, optical models and the Van't Hoff enthalpy calorimetric studies.

Unit-V (08 Hours)

Introduction to Molecular Thermodynamics:

Behavior of Excess Properties, Excess Enthalpy, Excess Entropy, VLE by molecular simulation.

Applications of thermodynamics to nonelectrolyte solutions:

Thermodynamic properties of ideal solutions.

Applications of thermodynamic to solutions containing electrolyte solutions:

Pitzer equations, Pitzer equations at elevated temperatures, the Pseudo phase model, the mass action model.

Unit-VI (08 Hours)

Stastical Thermodynamics

Role of stastical mechanism, Energy levels and degeneration of energy, Microscopic and Macroscopic states, Entropy from microscopic and probability point of view, Boltzman distribution law. Partition function, Transitional, Rotational and Vibration functions, Fermi-Dirac functions.

Text Books/ References

- Smith J. M., Vanness H. C.,"Introduction to Chemical Engineering Thermodynamics", McGraw Hill Publications
- Denbeigh K. G., "Chemical Engineering Thermodynamics", Cambridge Univ. Press
- Dodge B. F., "Chemical Engineering Thermodynamics", McGraw Hill Publications
- Daubart T. E., "Chemical Engineering Thermodynamics", McGraw Hill Publications
- Hougen O. A., Watson, Regatz, "Chemical Engineering Process", Principals – part-II, McGraw Hill Publications
- Nag P. K., "Engineering Thermodynamics", Tata McGraw Hill Publishers
- Potter and Craig, "Engineering Thermodynamics", Shaum's Out line Series, McGraw Hill Publications
- J. Bevan Ott, Juliana Boerio-Goates, "Chemical Thermodynamics: Advanced Applications", Academic Press – 2000. No. 99-68278

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

K10504: ADVANCED PROCESS CONTROL

TEACHING SCHEME		EXAMINATION SCHEME	
Lectures	: 04 Hrs/week	Theory	: 70 Marks
Practical	: 02 Hrs/week	Duration	: 03 Hours
		Unit Test	: 30 Marks
		Term Work	: 25 Marks
		Oral	: 25 Marks

Unit -I (08 Hours)

Response of Control Loop Components and Transfer Functions:

Open loop response, most useful forcing functions, step function, sinusoidal function and the pulse function, respective responses of the forcing functions. Response of a more complex system to forcing functions.

Unit –II (08 Hours)

Types of Controls:

Feed forward control: Advantages and drawbacks, typical examples. Feed back control: Advantages and drawbacks, typical examples.

Unit-III (08 Hours)

Adaptive and Inferential Control Systems:

Adaptive: Feed forward, feed back

Inferential: Need for a model

Examples for illustration.

Unit-IV (08 Hours)

Response Analysis:

Stability and Testing Step response analysis Frequency response analysis: Bode criterion, Nyquist Diagram, Root-Locus, Routh-Hertzwitz criterion. Pulse function: Laplace transforms, transfer function of various system.

Unit-V (08 Hours)

Dynamics of Various Systems:

Dead time, distance-velocity lag, inverse response systems, dynamic analysis, Qualitative characteristics, Distributed parameter systems.

Unit-VI (08 Hours)

Control Strategies for various unit operations and processes. Unit operations: Distillation, Drying, Absorption column, Stirred tanks. Processes: Process Design, Product quality control. Computer control: Direct Digital Control (DDC), Supervisory Digital Control, Economic justification for supervisory digital control.

List of Practical

Practical examination will consist of assessment of the term work (duly certified by the teacher and HOD) and the oral based on the term work/ practical)

The term work will consist of the following-

- Ability of the student to explain the theory and related course material.
- The process control modules are now extensively used in industry. The student should demonstrate their working principles and the utility citing at least 4 chemical industries.
- The controllers used in chemical industry need careful monitoring.
- Students should briefly describe the type of maintenance for controllers.
- Assignments given and the way they were tackled.

Text Books/ References

- George Stephanopoulos, "Chemical Process Control - An Introduction to Theory and Practice"
- Coulson and Richardson, "Chemical Engineering Vol 3"

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

SEMESTER - II

K10505: MODELING AND SIMULATION OF CHEMICAL PROCESSES

TEACHING SCHEME		EXAMINATION SCHEME	
Lectures	: 04 Hrs/week	Theory	: 70 Marks
Practical	: 02 Hrs/week	Duration	: 03 Hours
		Unit Test	: 30 Marks
		Term Work	: 25 Marks
		Oral	: 25 Marks

Unit -I (08 Hours)

Basic concepts:

Fundamental laws, general modeling procedure, simulation tools, model based on transport phenomena principle, deterministic versus probabilistic model, linear versus non-linear model, steady state versus unsteady state model, distributed versus lumped parameter model.

Basic Modeling:

Modeling principles, formulation of models for cases such as Simple hydraulic tank, Variable hydraulic tank, mixing Vessel, mixing with reaction, Steam jacked vessel, coffee percolator.

Unit –II (08 Hours)

Mass transfer :

Introduction, vapor-liquid equilibrium, bubble point of gas mixtures, dew point calculations, equilibrium flash calculations, tower sizing for valve trays, packed tower design, determination of plate in fractionating columns by Smiker equation, multi-component distillation column. Multi-component flash drum, batch distillation, batch distillation with holdup and countercurrent extraction, stage-wise absorption.

Unit-III (08 Hours)

Heat transfer :

Shell and tube heat exchanger, double pipe heat exchangers, air cooler, condensation, steady-state and unsteady-state heat exchanger, jacketed reactor, gas flow system, hydraulic transients.

Unit-IV (08 Hours)

Process Control :

Basic control configuration, first and second order transfer function, higher order response, pure time delay, time constant, Control Instrumentation, Controller tuning, Performance of controllers : on-off control, P, PI and PID controllers, Ziegler-Nichols method (ZN method)

Unit-V (08 Hours)

Advanced control Systems:

Ratio Control, Cascade Control, Computed variable control. Case studies of distillation column control, compressor control.

Fluid flow:

Gas flow system, hydraulic transients.

Unit-VI (08 Hours)

Reaction Engineering:

General Modeling scheme, liquid phase CSTR, radical kinetics, heterogeneous kinetics, particle age distribution in CSTR, tubular chemical reactor, reactor with axial dispersion. Modeling and simulation of batch reactor.

Oral:

Oral examination will consist of assessment of the termwork (duly certified by the teacher and HOD) and oral exam based on the term work/ practical.)

The term work shall consist of the following,

- Minimum 6 practicals based on Modeling of Chemical Processes mentioned in the syllabus. (Softwares such as CHEMCAD can be used for the same).
- Assignments given by concerned subject teacher throughout the semester.

Text Books/ References

- Franks R. E. G., "Modeling and Simulation in Chemical Engineering", Wiely Interscience, NY
- John Ingam, Irving J. Dunn, "Chemical Engineering Dynamic Modeling with PC Simulation", VCH Publishers
- William L. Luyben, "Process Modeling Simulation and Control for Chemical Engineers", McGraw Hill International Edition

- Kayode Coker A., " Chemical Process Design, Analysis and Simulation", Gulf Publishing Company
- Himmelblau D., K. B. Bischoff, " Process Analysis and Simulation", John Wiely & Sons
- Wayne Blackwell, "Chemical Process Design on a Programmable Calculator", McGraw Hill
- Wayne Bequette, " Process Dynamics, Modeling, Analysis and Simulation", Prentice Hall

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

K10506: CHEMICAL REACTOR ANALYSIS

TEACHING SCHEME
Lectures : 04Hrs/week

EXAMINATION SCHEME
Theory : 70 Marks
Duration : 03 Hours
Unit Test : 30 Marks

Unit -I (08 Hours)

Chemical factor affecting the choice of the reactor, fundamental mass, energy and momentum balance. Model for batch reactor.

Unit –II (08 Hours)

Model for a semi-batch reactor, optimum operation policies and control strategies, optimal batch operation time, optimal temperature policies, stability of operation and transient behavior for mixed flow reactor.

Unit-III (08 Hours)

Fixed Bed Catalytic Reactor:

The importance and scale of fixed bed catalytic processes, factors in preliminary design, modeling of fixed bed reactor. Pseudo-homogeneous model, the multi-bed adiabatic reactor, auto-thermal operation, non-steady-state model with axial mixing, two dimensional pseudo-homogeneous models, heterogeneous models, one dimensional and two dimensional model equation.

Unit-IV (08 Hours)

Multiphase Flow Reactor:

Types of multiphase flow reactors, packed columns, plate columns, empty columns, stirred vessel reactors.

Unit-V (08 Hours)

Design model for multiphase flow reactors, gas and liquid phase in completely mixed and plug flow, gas phase in plug flow and liquid phase in completely mixed flow, effective diffusion model, two zone model, specific design aspects, packed absorber, two-phase fixed bed reactor, plate column, spray tower, bubble reactor, stirred vessel reactor.

Unit-VI (08 Hours)

Temperature effects in reactor:

Introduction, well mixed system with steady feed, the stability and start-up of CSTR, limit cycles and oscillatory reactions, the plug flow reactors, tubular reactor, diffusion control, prorogation of reaction zone.

Text Books/ References

- Froment G. F. and K. B. Bischoff, " Chemical Reactor Analysis and Design", John Wiley & Sons
- Denbigh K. G. and J. C. Turner, " Chemical Reactor and Theory – An Introduction", 3rd edition Cambridge University Press
- Bruce Nauman, " Chemical Reactor Design", John Wiley & Sons
- Smith J. M., " Chemical Engineering Kinetics ", McGraw Hill, 1981
- Fogler H. S., "Elements of Chemical Reaction Engineering", Prentice - Hall, 1986

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

K10507: SYNTHESIS AND DESIGN OF CHEMICAL PROCESSES

TEACHING SCHEME
Lectures : 04Hrs/week

EXAMINATION SCHEME
Theory : 70 Marks
Duration : 03 Hours
Unit Test : 30 Marks

Unit -I (08 Hours)

Hierarchy of chemical process design: Hierarchy, approach to process design, Synthesis of reaction: Function of process recycle, vapor cycles and purges, vapor verses liquid cycles, batch processes, process yield, Choice of reactor: Reaction path, types of reaction systems, reactor performance.

Unit –II (08 Hours)

Preliminary Process Synthesis, Continuous or Batch Processing, Chemical state, Process Operations, Synthesis Steps, Synthesis Tree, Heuristics, Algorithmic Methods.

Unit-III (08 Hours)

Recycle structure, Recycle material balances, Reactor heat effects, Equilibrium limitations, Reactor design, Separation system, vapor recovery system, Liquid separation system, Distillation column sequencing, azeotropic systems, Residue Curves for Heterogeneous Systems.

Unit-IV (08 Hours)

Heat Exchanger Design, Heat Duty, Temperature driving force for Heat Transfer, Minimizing Utilities in Heat Integration, Minimum Number of heat exchangers ,The pinch design method, design of threshold problems, stream splitting, design of multiple pinches, network optimization.

Unit-V (08 Hours)

Safety and health considerations:

Fire, explosion, toxic release, intensification and attenuation of hazardous materials, minimization of waste, life cycle analysis, effluent treatment, incineration, treatment of solid particle emission, gaseous emission,

combustion product emission.

Unit-VI (08 Hours)

Computer–Aided Design programs-General structure of Computer –Aided Design Programs, Material balances Calculations, Complete Plant Simulation, and Detailed Case Studies.

Text Books/References

- Robin Smith, "Chemical Process Design", McGraw Hill
- Hartmann K., K. Kaplick, "Analysis and Synthesis of Chemical Process System", Elsevier, Amsterdam
- Jordan D. G., "Chemical Process Development – Part I", Robert K. Krieger Publishing Company
- James M. Douglas, "Conceptual Design of Chemical Processes" McGraw Hill
- Warren D. Seider, J. D. Seader, Daniel R. Lewin, "Process Design Principles Synthesis, Analysis and Evaluation," John Wiley & Sons Inc

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

K10508: ADVANCED MASS TRANSFER

TEACHING SCHEME		EXAMINATION SCHEME	
Lectures	: 04 Hrs/week	Theory	: 70 Marks
Practical	: 02 Hrs/week	Duration	: 03 Hours
		Unit Test	: 30 Marks
		Term Work	: 25 Marks
		Oral	: 25 Marks

Unit -I (08 Hours)

Estimation of Mass Transfer Models, Macroscopic Material Balance, General Material Balance, Simple diffusion Models, Steady State diffusion with heterogeneous chemical reaction, Steady state diffusion accompanied by homogeneous Chemical reaction Importance of dimensional analysis and analogies between mass, momentum and heat transfer.

Unit –II (08 Hours)

Multicomponent Absorption, Non isothermal absorption, Tray by Tray Calculation.

Unit-III (08 Hours)

Adsorption:

Principle of adsorption, Pressure swing adsorption, thermal swing adsorption, adsorption based on size and shape selectivity: pore diffusion model (zeolite), diffusion models, kinetic models (carbon molecular sieves) Chromatography, thin layer chromatography, ion-exchange chromatography.

Unit-IV (08 Hours)

Multicomponent Distillation, batch and continuous with minimum and total reflux condition fractionation, Calculation of number of stages by Lewis Sorrel Metheson method, Details of Ponchon Svarit Method, Comparison of short cut and tray by tray calculations.

Unit-V (08 Hours)

Introduction to Novel Separation techniques, application of Novel Separation techniques, changes made to conventional techniques

(factor/principle governing novel separation) Other techniques: supercritical fluid extraction (SCFE), reactive distillation, reactive extraction, separation based on thermal diffusion, zone melting.

Unit-VI (08 Hours)

Bioseparation, biodesulfurization, biodegradation, protein separation, separation based on surface science.

Oral:

Oral examination will consist of assessment of the term work (duly certified by the teacher and HOD) and oral exam based on the term work/practical.

The term work shall consist of the following,

- Minimum 6 practical should be done
- Assignments given by concerned subject teacher throughout the semester.

Text Books/References

- Antony L. Hines, Robert N. Maddex, "Mass Transfer Fundamentals and Applications", Prentice Hall, Englewood Cliffs, New Jersy 0763
- King, C. J., " Separation Processes ", Tata McGraw Hill Publishing Co., Ltd., 1982
- Schoew H. M., " New Chemical Engineering Separation Techniques ", Interscience Publishers, 1972
- Ronald W. Russell , " Handbook of Separation Process Technology ", John Wiley, New York, 1987
- J. M. Coulson, J. F. Richardson, "Chemical Engg", Volume Two, Pergamon Press Oxford, New York
- Welty J. R. ,C. E. Wicks and R. E. Wilson, "Fundamentals of Momentum, Heat and Mass Transfer", John Wiley and Sons, 1976

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

SEMESTER - III

K10601 ELECTIVE I:
AIR POLLUTION CONTROL ENGINEERING

TEACHING SCHEME

Lectures : 04 Hrs/week
Practical : 02 Hrs/week

EXAMINATION SCHEME

Theory	: 70 Marks
Duration	: 03 Hours
Unit Test	: 30 Marks
Termwork	: 25 Marks
Oral	: 25 Marks

Unit-I (08 Hours)

Introduction to air pollution control. Types of Emission sources, Environmental legislation. Air pollution control act, Air pollution sources, effect of Air Pollution on Man & Vegetation.

Unit-II (08 Hours)

Air Pollution Sampling & Measurements:

Ambient air sampling, collection of gaseous & particulate pollutants, stack sampling, isokinetic sampling. Analysis of Air Pollutant Such as SO_2, NO_2, CO & Hydrocarbons & Particulate matter.

Unit-III (08 Hours)

Air Pollution Concentration Models:

Introduction, Fixed-Box Model, Diffusion model. Plume Rise, Gaussian Plume Model Multiple Cell Models. Receptor Oriented and Source Oriented Air Pollution Models.

Unit-IV (08 Hours)

Air Pollution Control Methods & Equipment:

Design of Dry Collectors-Gravity settlers Tray Chambers, Centrifugal separators. Design of ESP. Design of Bog filters, Fabric filters. Design of Wet Scrubbers for Solids (adsorption).

Unit-V (08 Hours)

Control of Volatile Organic Components (VOCS):

Design aspects for control by adsorption, Control by Combustion, Control by Condensation.

Control of Sulphur Oxides:

Design aspect of absorber for gas absorption and stripping. Lime Stone Wet Scrubbers. Modification of fuel source.

Unit-VI (08 Hours)

Control of Nitrogen Oxide:

Chemistry of Nitrogen & Sulphur, NO & NO2 equilibrium, Nitrogen Oxide Control by Combustion, Modification of Design & Operating Conditions. Control of CO & Hydrocarbons. Air Pollutants & global climate.

Text Books/ References

- S. P. Mahajan, "Pollution Control in Process Industries", Tata Mc Graw-Hill Co.Ltd 1985
- C. S. Rao, "Environmental Pollution Control Engg.", Willey Estern Ltd. 1994
- Noel de Nevers, "Air Pollution Control Engg", Mc Graw-Hill, Inc, internationai Edition 1995

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

K10601 ELECTIVE I:
NON CONVENTIONAL ENERGY SOURCES

TEACHING SCHEME

Lectures : 04 Hrs/week
Practical : 02 Hrs/week

EXAMINATION SCHEME

Theory	: 70 Marks
Duration	: 03 Hours
Unit Test	: 30 Marks
Term Work	: 25 Marks
Oral	: 25 Marks

Unit-I (08 Hours)

Renewable Sources of Energy:

Solar energy: Thermodynamic and heat transfer aspects of solar collection. Energy storage. Solar distillation. Solar drying, Wind energy. Tidal, Wave and ocean thermal energy. Geothermal energy.

Unit-II (08 Hours)

Fuel Cells:

Definition. Types of fuel cells: phosphoric acid, molten salt, solid oxide and other types of fuel cells. Anodes and cathodes. Fuel cells as alternative energy source.

Unit-III (08 Hours)

Bio-Energy:

Biogas. Gasification and combustion. Alcohol from biomass. Economics of bio-mass energy systems.

Unit-IV (08 Hours)

Utilization of Wastes:

Utilization of fly ash, blast furnace slag in cement and concrete.

Unit-V (08 Hours)

Advanced Waste Water Treatment:

Need for advanced treatment. Advanced technologies. Granular-medium filtration, micro-screening. Biological nitrification and denitrification. Removal of phosphorus. Removal of toxic compounds and refractory organics.

Unit-VI (08 Hours)

Case studies on energy and environmental engineering obtained in the practice.

Practical

The practicals shall consist of analysis, synthesis, design and development, construction and fabrication, testing of product or system, generation of new concepts, idea and improvement in existing process related to the subject. The term work shall consist of a report based on the studies . In order to maintain the continuity, the term work report will incorporate the studies carried out in Term I (Elective I) also. The content of the report should be equivalent to a paper in national/international journal/seminar. The student should normally incorporate the publication in the report.

Text Books/References

- Rao C. S., "Environmental Pollution Control Engineering," Wiley Eastern
- Mahajan S. P., "Pollution Control in Process Industry", Tata McGraw Hill Publishers
- Douglas C., "Energy Technology Handbook", Tata McGraw Hill Publishers
- Majumdar B., "A Textbook of Energy Technology", APH Publications
- Metcalf and Eddy, "Waste Water Engineering", Tata McGraw Hill Publishers

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

K10601 ELECTIVE I:
INDUSTRIAL WASTE WATER TREATMENT

TEACHING SCHEME

Lectures : 04 Hrs/week
Practical : 02 Hrs/week

EXAMINATION SCHEME

Theory	: 70 Marks
Duration	: 03 Hours
Unit Test	: 30 Marks
Term Work	: 25 Marks
Oral	: 25 Marks

Unit -I (08 Hours)

Introduction, Source of Industrial waste water, Physical, Chemical & Biological characteristics Of Industrial Waste Water. Measurement of polluting strength of Ind.Waste water (physical, chemical & biological).

Unit –II (08 Hours)

Physical Unit Operations:

Sedimentation & Design of Settling Chambers. Filtration & Design of Filters. Coagulation, Flocculators, Froth Flotation.

Unit-III (08 Hours)

Conventional Waste Water Treatment:

Primary Treatment (Physical).Design Principles of Grit chambers & screens. Principles of Aeration .Secondary treatments (Biological), Kinetics of Growth & Food utilization, Design Principles of A.S.P. Trickling Filters, oxidation ponds, stabilization ponds, Aerobic, anaerobic Lagoons.

Unit-IV (08 Hours)

Sludge Treatment & Disposal:

Anaerobic digestion, Aerobic Digestion, Sludge disposal, composting.

Unit-V (08 Hours)

Advanced Waste Water Treatment:-

Carbon adsorption, Ion exchange, membrane processes. Nitrogen removal, Phosphorous removal, Chemical oxidation, Recovery of materials from process effluents.

Unit-VI (08 Hours)

Solid Waste Management:

Characterstics, Solid waste collection & transport, Solid Waste Processing & recovery, Disposal of Solid waste. Hazardous waste management & Risk assessment. Types of hazardous waste, health Effects, Treatment methods & Final disposal.

Text Books/ References

- Metcalf & Eddy, "Waste Water Engineering" Treatment & Reuse, Tata Mc Graw-Hill. Fourth Edition 2003
- C.S.Rao., "Environmental Pollution Control Engineering",Wiley Eastern Ltd. New Age International, Second print 1994
- A. P. Sincero, G. A. Sincero, "Environmental Engg.", A design approach, Prentice Hall of India Pvt. Ltd. New Delhi 1996

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

K10601 ELECTIVE I: HETEROGENOUS CATALYSIS

TEACHING SCHEME

Lectures : 04 Hrs/week
Practical : 02 Hrs/week

EXAMINATION SCHEME

Theory	: 70 Marks
Duration	: 03 Hours
Unit Test	: 30 Marks
T. W.	: 25 Marks
Or.	: 25 Marks

Unit -I (08 Hours)

Adsorption, Desorption:

Definition, rates of adsorption and desorption, surface areas for physical adsorption. Experimental aspects of adsorption and allied phenomena on catalyst surfaces.

Unit –II (08 Hours)

Significance of Pore Structure and Surface Area in Heterogeneous Catalysis:

Importance of pore structure and surface area, experimental methods to determine surface area, methods of assertening pore volume and diameter. Kelvin equation, pore size distribution by gas adsorption, pressure porosimeter, density measurement. Pore structure of adsorbents and catalysts: Hysterisis and shape of capillaries, surface area from hysterisis loops, modes for characterizing pore structures. Reaction rates in pores catalysts: Mass transfer, concentration profiles, reaction rates, pressure and temperature gradients, catalyst deactivation.

Unit-III (08 Hours)

Role of Lattice Imperfections in Heterogeneous Catalysis:

Classification of lattice imperfections, role of point dislocations and point defects, lattice imperfections and polymerization catalysts, role of geometric and electronic factors in catalytic activity.

Unit-IV (08 Hours)

Dynamics of Selective and Poly-functional Catalysis:

Catalyst selectivity, selective formation of intermediate products, effect of pore size on selectivity, mass transport of intermediate product in non-trivial poly-step reactions, selectivity of poly-functional catalysts.

Zeolites in catalysis: Structural aspects and synthesis of zeolites, modification of zeolites, diffusion in zeolites, applications.

Unit-V (08 Hours)

Fischer-Tropsch synthesis: Synthesis and Decomposition of Ammonia

Catalyst cracking: catalyst composition and chemical properties, mechanism of cracking reactions. Catalysis of electrode reactions.Kinetics of catalytic reactions: Rate of chemical reaction, overall reaction rate, mass transfer through gas phase, mass transfer in pores.

Unit-VI (08 Hours)

Mass and heat transfer in solid catalyst beds.

Design calculations: Isothermal conditions, adiabatic conditions, non-adiabatic conditions. Thermal selectivity of packed bed reactors. Fluidized bed reactors. Optimum design: Continuous variation of parameter along the reaction path, temperature profiles for reversible and consecutive reactions, optimum catalyst concentration in bi-functional catalyst systems.

List of Practical

Practical examination will consist of assessment of the term work (duly certified by the teacher and HOD) and the oral/seminar based on the term work/practical.

The term work shall consist of the following

- Research survey, literature review and analysis, synthesis, design and development, experimental work, testing on the product or system, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. The student is required to choose the topic in consultation with the subject teacher. The student is expected to submit a report on the work carried out throughout the semester.
- Assignments given by concerned subject teacher throughout the semester.

Text Books/References

- Thomas J. M., Thomas W. J., "Introduction to The Principles of Heterogeneous catalysis", Academic Press

- Srivastav R. D., "Heterogeneous catalytic Science", CRC Press
- Thomas S. J., Webb G., "Heterogeneous Catalysis", Oliver & Boyd Ltd.

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

K10601 ELECTIVE I: CATALYST MATERIALS

TEACHING SCHEME
Lectures : 04 Hrs/week
Practical : 02 Hrs/week

EXAMINATION SCHEME
Theory : 70 Marks
Duration : 03 Hours
Unit Test : 30 Marks
Term Work : 25 Marks
Oral : 25 Marks

Unit-I (08 Hours)

Bimetallic Catalysts:

Introduction, nature, method of preparation and characterization, catalytic properties of bimetallic systems. Supported bimetallic catalyst, chemical nature, factors affecting efficiency and uniformity of co clustering, structure, surface composition, catalytic properties.

Unit –II (08 Hours)

Perovskite Related Oxides:

Solid state properties, Zeolite, crystal structure, non-stoichiometry, magnetic and electrical properties, ferro electric and acoustic properties, applications. Crystal chemistry and catalytic properties of oxides with scheelite structure, crystal chemistry, olefin oxidation, and mechanism. Catalytic properties of synthetic layered silicates and alumino silicate, synthetic mica-montmorillonite and nickel reducibility, layered metal silicate catalyst.

Unit-III (08 Hours)

Biological Catalyst:

Enzymes, incentives for using enzymes, methodology,chemical and physical properties, activity, pH-activity behavior, stability, application.

Unit-IV (08 Hours)

Catalyst Design:

Optimization of catalyst distribution in a single pellet, the case of single and multiple reaction, isothermal and non-isothermal conditions, complex reaction system, factors affecting catalytic dispersion, optimal distribution of catalytic loading.

Unit-V (08 Hours)

Optimization of Catalyst Distribution in a Reactor:

Single reaction and multiple reaction, isothermal and non-isothermal conditions. Catalytic deactivation, non-selective and selective poisoning.

Unit-VI (08 Hours)

Membrane Reactor:

Membrane reactor with non-uniform catalytic distribution, optimal catalyst distribution in pellets for an inert membrane reactor and catalytic membrane reactor, preparation of catalytic membrane.

List of Practical

Practical examination will consist of assessment of the termwork (duly certified by the teacher and HOD) and the oral/seminar based on the term work/practical.

The term work shall consist of the following,

- Research survey, literature review and analysis, synthesis, design and development, experimental work, testing on the product or system, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. The student is required to choose the topic in consultation with the subject teacher. The student is expected to submit a report on the work carried out throughout the semester.
- Assignments given by concerned subject teacher throughout the semester.

Text Books/ References

- Burton J. J. and Garton R. L., "Advanced materials in catalysis", Academic press, London, 1977
- Morbidelli M., Gavriilidis A. and Varma A., " Catalyst design: Optimal distribution of catalyst in pellets, reactorts and membrane", Cambridge university press, Cambridge, 2001.

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

K10602 ELECTIVE II: MEMBRANE SEPERATION

TEACHING SCHEME		EXAMINATION SCHEME	
Lectures	: 04 Hrs/week	Theory	: 70 Marks
Practical	: 02 Hrs/week	Duration	: 03 Hours
		Unit Test	: 30 Marks
		Term Work	: 25 Marks
		Oral	: 25 Marks

Unit -I (08 Hours)

Introduction

Separation Processes, Introduction to membrane processes, Definition of Membrane Merits of the Processes. Classification of the membrane separation process.

Unit –II (08 Hours)

Materials & Materials Properties

Membrane Polymers, Molecular weight, Porous & Porous membrane, Thermal, Chemical & Mechanical Properties of Inorganic membranes, Biological membranes. Retention & rejection co-efficient. Factor affecting the separation processes. Effect of polymeric structure on Tg Glass transition temperature depression.

Unit-III (08 Hours)

Preparation of Synthetic Membranes

Phase inversion membranes, Preparation by evaporation, Precipitation from the vapour phase. Precipitation by controlled evaporation, Thermal & immersion precipitation. Flat membranes, Tubular membranes, Zeolite membranes, Dense membrane. Preparation Technique for Composite Membrane, Inorganic Membranes.

Unit-IV (08 Hours)

Characteristics of porous membrane, Bubble Point Method, Mercury intrusion method, Permeability Method, Ultrafiltration, Gas-adsorption desorption, Characterisation of ionic membranes, characterisation of non-porous membrane.

Unit-V (08 Hours)

Transport in membrane, Knudsen flow, Friction Model, Transport through non-porous membrane. Determination of diffusion co-efficient & solubility co-efficient. Transport in ion exchange membranes.

Unit-VI (08 Hours)

Membrane Processes, M.F, U.F, R.O, Nano filtration Dialysis, Electrodialysis, Piezodialysis, Diffusion Dialysis, Membrane reactors & membrane bioreactors, Polarization & Fouling Phenomena in Membranes, C.P in electro dialysis, Temperature Polarization, Membrane Fouling, Method to reduce Fouling.

Text Books/ References

- Osada Yoshohito, Nakagawa T., "Membrane Science and Technology", Marcel Dekker Inc.
- Marcel Mulder,"Basic Principles of Membrane Technology",Kluwer Academic Publishers, Netherlands, 1998
- C.J.King,"Separation Processes", Tata Mc Graw-Hill

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

K10602 ELECTIVE II: BIOPROCESS ENGINEERING

TEACHING SCHEME

Lectures : 04 Hrs/week
Practical : 02 Hrs/week

EXAMINATION SCHEME

Theory	: 70 Marks
Duration	: 03 Hours
Unit Test	: 30 Marks
Term Work	: 25 Marks
Oral	: 25 Marks

Unit -I (08 Hours)

Introduction, Biotechnology & Bioprocess Engineering types & structure of cells, Growth Kinetics, Growth Cycle Phase, effect of Substrate conc., Cell Conc. & death rate on growth of M.O

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Unit –II (08 Hours)

Simple Enzyme Kinetics, Michaelis-Menten Kinetics, evaluation of M.M equation parameters, line-weaver, Burk plot, Eadie-Hofstee plot. Factors influencing enzyme activity, immobilized enzyme technology, immobilized kinetics.

Unit-III (08 Hours)

Selection, Scale-up & Control of Bioreactors

Ideal, on-ideal Bioreactors, Fed Batch reactor, sterilization reactor, Aeration & Agitation & mass transport in cellular system. Scale up difficulties, Bioreactor instrumentation & control.

Unit-IV (08 Hours)

Recovery & Purification of Product

Separation of insoluble products. Cell disruption, separation of soluble products, finishing steps for purification, integration of reaction & separation.

Unit-V (08 Hours)

Industrial Production of Chemicals

Ethanol, Acetic acid, Citric acid, Gluconic acid. Solvents such as Glycerol, acetone, butanol. Anti-biotics such as penicilline, streptomycine,

tetracycline. Production of High Fructose Corn Syrup (HFCS), Production of Bakers Yeast Single Cell Protein.

Unit-VI (08 Hours)

Medical & other applications of Bioprocess Engg. introduction, Tissue Engineering, Gene Therapy, Stem cell, Use of microbes in mineral beneficiation & oil recovery, Biofertilizers & Biopesticides, Biopolymer, Biological treatment of Industrial Waste.

Text Books/References

- Michael L. Shuler, F. Kargi, "Bioprocess Engineering Basic Concept", Prentice Hall, India, 2nd Edition, 2002
- Bailey, James Ollis, Davis F,"Biochemical Engg." Mc Graw-Hill, Publications
- Aiba A, Humphry A. E, "Biochemical Engg"
- Wingard L. B., "Enzyme Engg."
- Paulinemdoran, "Bioprocess Engg. Principles", Elsevier Publications

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

K10602 ELECTIVE II: MULTICOMPONENT SEPERATION

TEACHING SCHEME

Lectures : 04 Hrs/week
Practical : 02 Hrs/week

EXAMINATION SCHEME

Theory	: 70 Marks
Duration	: 03 Hours
Unit Test	: 30 Marks
Term Work	: 25 Marks
Oral	: 25 Marks

Unit -I (08 Hours)

Characteristics and selection of separation process: Importance and variety of separation, economic significance, characteristics, inherent separation factor, selection, factors influencing the choice of separation process, solvent selection, selection of equipment.

Unit –II (08 Hours)

Multicomponent separation: General short-cut equation, Edmister method, distillation, absorption, extraction, alternate short-cut method, Fenske and Underwood equation.

Unit-III (08 Hours)

Multicomponent separation: Distillation, Rigorous method, Lewis-Matheson method, Thiele-Geddes method, Amundson-Pontinen method.

Unit-IV (08 Hours)

Azeotropic and extractive distillation: Activity coefficient, equilibrium relationship, binary and ternary azeotropes, selection of solvent, calculations.

Unit-V (08 Hours)

Multicomponent separation: Extraction, Rigorous method, stripping factor equation, material balance, single and cross-current multiple contact, calculations.

Unit-VI (08 Hours)

Multicomponent separation: Absorption, Rigorous method for absorption, calculations.

List of Practical

Practical examination will consist of assessment of the termwork (duly certified by the teacher and HOD) and the oral/seminar based on the term work/practical.

The term work shall consist of the following,

- Research survey, literature review and analysis, synthesis, design and development, experimental work, testing on the product or system, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. The student is required to choose the topic in consultation with the subject teacher. The student is expected to submit a report on the work carried out throughout the semester.
- Assignments given by concerned subject teacher throughout the semester.

Text Books/References

- Smith B. D., "Design of Equilibrium Stage Processes", McGraw Hill Book Company Ltd.
- King C. J., "Separation Processes", McGraw Hill Book Company Ltd.
- Treybal R. E., "Mass Transfer Operation", McGraw Hill
- Treybal R. E., "Liquid Extraction", McGraw Hill Book Company Ltd.
- Phillip C. Wankat, "Equilibrium Staged Separations", Prentice Hall

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

K10602 ELECTIVE II: FOOD PROCESSING ENGINEERING

TEACHING SCHEME

Lectures : 04 Hrs/week
Practical : 02 Hrs/week

EXAMINATION SCHEME

Theory	: 70 Marks
Duration	: 03 Hours
Unit Test	: 30 Marks
Term Work	: 25 Marks
Oral	: 25 Marks

Unit -I (08 Hours)

Introduction:

Characteristics and nutritional properties of food texture, taste, flavour and aroma. Geometric, physical and functional properties of food material. Preparation for food processing, energy conservation, material and energy balance.

Unit –II (08 Hours)

Processing Method

Heating : Balancing and pasteurization, freezing, dehydration, canning, additives. Fermentation: Extrusion cooking, hydrostatic pressure cooking. Dielectric heating microwave processing and aspetic processing, infrared radiation processing, concept and equipment used.

Unit-III (08 Hours)

Drying

Moisture content: Definition, method of determination, direct and indirect methods. Equilibrium moisture content: Hysterisis Effect. Psychometric properties of air-watervapourmixture. Drying mechanism: Constant rate period and falling rate period. Method and Equipments used, factor effecting rate of drying.

Unit-IV (08 Hours)

Food Conservation Operation

Sieve reduction, fibrous foods, dry foods and liquid foods. Theory and equipment, membrane.

Unit-V (08 Hours)

Material Handling

Material handling, types of candling and conveying system food products and their design, belt conveyors, screw conveyors, bucket elevator and pneumatic conveyor.

Unit-VI (08 Hours)

Preservation of Food Material

Preservation by drying, preservation by low temperature, chemical preservation .Thermal death time curve .

Text Books/ References

- Shivshankar B., "Food Processing and Preservation", Prentice Hall of India Pvt. Ltd., New Delhi 110001, 2002
- Sahay and Singh, "Unit Operation in Agricultural Processing"
- Dennis R. H., " Food Process Engineering"
- Rao M. A. & Rizvi S. S. H, " Engineering Properties of Food"

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

K10602 ELECTIVE II: FLUIDIZATION ENGINEERING

TEACHING SCHEME

Lectures : 04 Hrs/week
Practical : 02 Hrs/week

EXAMINATION SCHEME

Theory	: 70 Marks
Duration	: 03 Hours
Unit Test	: 30 Marks
Term Work	: 25 Marks
Oral	: 25 Marks

Unit -I (08 Hours)

Introduction and Application :Phenomenon of Fluidisation, Liquid like behavior of a fluidized bed, comparison with other methods , Advantages and Disadvantages, Types of Fluidisation. Gas behavior Of Fluidised bed :Fixed beds, minimum fuidisation velocity, Terminal velocity, and pressure drop, importance of distributor, voidage, TDH, viscosity and fluidity of fluidized beds.

Unit –II (08 Hours)

Bubbles and Emulsion phase in Dense bubbling beds: Single rising bubble, Stream of bubbles from single source, Ordinary Bubbling bed. Exprimental findings. Bubbling bed model for Emulsion phase.

Unit-III (08 Hours)

Flow pattern of gas through fluidized bed: Experimental findings ,Bubbling bed model for gas interchange. Evaluation of inter change coefficient. Radial and Axial diapersion of gas. Mass and heat transfer b/w fluid and solid.

Unit-IV (08 Hours)

Conversion of gas in bubbling beds: Two region model, Model using distribution. Catalytic conversion, reaction rate, contacting efficiency, application to successive reactions, control of bubble size, baffling and scale-up.

Unit-V (08 Hours)

Entrainment and Elutriation : Entrainment at or above TDH, Entrainment

below TDH. Model for entrainment from dense fluidized bed and its applications.

Unit-VI (08 Hours)

Application in physical operations: Synthesis reactions, cracking and reforming of hydrocarbons, carbonization and gasification. Gas solid reactions.

Text Books/ References

- Daizo Kunni and Octave Levenspiel, "Fluidisation Engineering", John Wiley & Sons
- Davidson and Harrison, "Fluidisation", Academic Press

Syllabus for Unit Test

Unit Test 1	Unit I & II
Unit Test 2	Unit III & IV
Unit Test 3	Unit V & VI

RULES REGARDING ATKT, CONTINUOUS ASSESSMENT AND AWARD OF CLASS

A. T. K. T.

- A candidate who is granted term for M.Tech Semester-I will be allowed to keep term for his/her M.Tech. Semester-II examination even if he/she appears and fails or does not appear at M.Tech. Semester-I examination.
- A candidate who is granted term for M.Tech Semester-III will be allowed to keep term for his/her M.Tech. Semester-IV examination even if he/she appears and fails or does not appear at M.Tech. Semester-III examination.
- A student shall be allowed to keep term for M.Tech Semester-III even if he/she has a backlog of all Heads of passing in theory examination held at M.Tech Semester I & II taken together.
- A student has to secure 40% marks in theory and 50% marks in TW & oral as a condition of pass class. The overall percentage of marks of all semesters taken together should be more than 50% to declare the student to be passed.

CONTINUOUS ASSESSMENT

- The term work assessment will be based on the practical/assignment as described in the syllabus.
- Final assessment of termwork shall be done by pair of internal and external examiners jointly during the oral/practical examination schedule declared by the university. The teacher conducting practicals/assignments during the term shall maintain a record of continuous assessment. Every practical/term work/assignment shall be assessed continuously on the scale of 20 marks and weightage of 20 marks shall be distributed as follows:

Sr. No.	Activity	Marks
1	Timely Submission	04
2	Presentation	06
3	Understanding	10

This record of continuous assessment shall be made available to the examiners during Term work and oral examination. Examiner shall use this record for overall assessment of the performance of the student.

- Assessment of the seminar work and dissertation work shall be done continuously.

• Record of this assessment shall be made available during examination. The student should submit the dissertation stage-I report along with the dissertation stage-II report at the time of final submission.

CLASS

• The class should be awarded to the student on the basis of aggregate marks obtained together in both the semesters of the respective year by him/her. The award of class shall be as follows.

A	Aggregate 66% or more marks	First Class with Distinction
B	Aggregate 60% or more marks but less than 66%	First Class
C	Aggregate 55% or more marks but less than 60%	Higher Second Class
D	Aggregate 50% or more marks but less than 55%	Second Class
E	Aggregate 40% or more marks but less than 50%	Pass Class