Master of Technology (Chemical Engineering)  
Program: CE  
Duration – 2 Years (Full time)

Paper Code: 14 for Dual Degree students  
95 for student admitted from other institute

Program Scheme and Syllabus  
(1\textsuperscript{st} to 4\textsuperscript{th} semester)
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UNIVERSITY SCHOOL OF CHEMICAL TECHNOLOGY
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FIRST SEMESTER EXAMINATION

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Note: Student can select two electives either offered by the department from the above list or from the list of intradepartmental electives.

ONE DIMENSIONAL TRANSPORT IN LAMINAR FLOW (SHELL BALANCE): Newtonian and non-Newtonian fluids, General method of shell balance approach to transfer problems; Choosing the shape of the shell; most common boundary conditions; momentum flux and velocity distribution for flow of Newtonian fluids in pipes, for flow of Newtonian fluids in planes, slits and annulus, heat flux and temperature distribution for heat sources such as electrical, nuclear, viscous and chemical; forced and free convection; mass flux and concentration profile for diffusion in stagnant gas, systems involving reaction and forced convection.

EQUATIONS OF CHANGE AND THEIR APPLICATIONS: Conversation laws and equations of change; development of equations of continuity, motion and energy in single component systems in rectangular coordinates and the forms in curvilinear coordinates; simplified forms of equations for special cases, solutions of momentum, mass and heat transfer problems discussed under shell balance by applications of equation of change.

TRANSPORT IN TURBULENT AND BOUNDARY LAYER FLOW: Introduction to turbulent flows, comparisons of laminar and turbulent flows in simple systems such as circular tube, flat plate. Concept of Boundary Layer Flow.

Books & Reference:

Rate-Based Models for Separation: Rate models, transport-rate expression, estimation of transport co-efficient.


Enhanced and Hybrid Distillation: Salt distillation, Pressure swing-distillation, Heterogenous azeotropic distillation, reactive distillation-theory and design consideration, hybride separation process module and design consideration.

Supercritical fluid extraction: Theory, Process and Process Design; Molecular Sieve separation.

Books & Reference:

5. Rautenbach, R. and Albrecht, R., Membrane Processes, John Wiley, 198
Introduction to process engineering and optimization, Formulation of various process optimization problems and their classification, Basic concepts of optimization – convex and concave function, necessary and sufficient conditions for stationary points, optimization of one dimensional problems. (05 Hrs)

Unconstrained multi variable optimization – direct search methods, indirect first and second order methods; linear programming and its application: Simplex, Big M & Two Phase methods. (8 Hrs)

Constrained multi level optimization – necessary and sufficient for constrained optimum, quadratic programming (Wolfe’s Method and Beale’s Method), Generalized Reduced gradient method, optimization of stage and discrete processes, Dynamics Programming, Integer and Mixed Integer Programming (Gomory’s algorithm and Branch & Bound technique) (10 Hrs)


Course Objectives:
Introduction to various optimization techniques fo linear and non-linear problems to the students.
Use of various emerging tools e.g. Neural Network in optimizing the problems in process industries.
To make students capable for developing programs using MATLAB for optimization techniques.

Books & Reference :
Design of Experiment and Analysis of Engineering Data


Books & Reference:
2. Stephan G.N., Ariela Sofer; Linear & nonlinear programming, McGraw Hill.
Ecology and Environment: Source of air, water and solid wastes.
Air pollution: Micrometeorology and dispersion of pollutants in environment. Fate of pollutants.
Treatment methods: Primary methods; setting, pH control, chemical treatment. Secondary methods; Biological treatment, Tertiary treatments; like ozonization, disinfection, etc.
Solid waste collection, treatment and disposal. Waste recovery system.

Books & Reference:


**Book & Reference:**

2. Geankoplis “ Transport Processes and Unit Operations, Prantice Hall, India.
1. **Introduction to CPQRA (Chemical Process Quantitative Risk Analysis):** -
   - Techniques of CPQRA
   - Scope of CPQRA Studies
   - Management of incident lists
   - Application of CPQRA
   - Limitations of CPQRA

2. **Consequence Analysis:** -
   - Source Models
   - Explosion & Fires
   - Effect Models

3. **Event Probability and Failure Frequency Analysis:** -
   - Incident Frequencies from Historical Record
   - Frequency Modeling Techniques

4. **Measurement, Calculation & Presentation of Risk Estimates:** -
   - Risk Measures
   - Risk Presentation
   - Risk Calculations
   - Risk Uncertainty, Sensitivity & Importance

5. **Creation of CPQRA Data Base:** -
   - Historical Incident Data
   - Process & Plant Data
   - Chemical Data
   - Environmental Data
   - Equipment Reliability Data

6. **Case Studies:** -
   - Chlorine Rail Tank Car Loading Facility
   - Distillation Column

**Books &References**

1. Guidelines for Chemical Process Quantitative Risk Analysis, CCPS of AIChE
2. Risk Analysis for Process Plant, Pipelines & Transport; J.R. Taylor
UNIVERSITY SCHOOL OF CHEMICAL TECHNOLOGY
SCHEME OF EXAMINATION M.TECH (CHEMICAL ENGINEERING)

SECOND SEMESTER EXAMINATION

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Note: Student can select three electives either offered by the department from the above list or from the list of intradepartmental electives.
Process and cost models, Role & application of mathematical models in process design and optimization, Process synthesis, modelling and development. (8 Hrs)

Process flow sheeting. Dynamic modelling and simulation of chemical process with / without recycle structure. Use of generic software for steady unsteady state material, momentum & energy balance flow sheet simulation, software development for design of process equipment & flowsheet. (8 Hrs)

Introduction to design of Separation network, Reactor-Separator network, Flow sheet optimisation. (8 Hrs)

**Process design under uncertainty:** Accommodating to future developments; Anticipating the future, Accommodating to linear demand forecast, Non zero initial demand, sizing new chemical plants in a dynamic, economy, Accounting for uncertainty in Data; engineering on safe side, The propagation of uncertainty through designs, Failure tolerance; introduction, Catastrophic results from minor events, preliminary flow sheet review, theory of reliability & its application, Engineering around variation; variability, effects of storage on pulsed supply, analysis of queing theory, intersystem variation, economically optimal utilization, adapting to a variable power supply. (8 Hrs)

**Course Objectives :**
- Train students for various process design problems in industries using computer tools available like ASPENTECH.
- To make students capable for development of the software in process designing.

**Books & Reference:**
1. Alexander C. Dimian, Integrated Design and Simulation of Chemical Processes, Elsevier,
3. Rudd and Watson; strategy of process engineering, John wiley & sons, inc. Babu
Fundamentals of Statistical Thermodynamics: Quantum energy levels and degeneracy, Boltzmann statistics, Maxwell statistics and thermodynamics properties, Thermodynamics equilibrium of process, Molecular theory of ideal gases, Dense gases and liquids, Phase transitions and phase equilibrium.  

Irreversible Thermodynamics: Definition, Entropy production and flow, Thermodynamics forces, Onsager’s reciprocal relation and application to chemical processes.  

Molecular Simulation: Thermodynamics modeling and molecular simulation of equilibrium separation processes.  

Course Objectives:  
- To introduce the fundamentals of statistical thermodynamics and to give students a foundation for molecular simulation of chemical engineering processes.  
- To train students to apply this fundamental body of knowledge in thermodynamics to the solution of practical problems.  
- To understand the fundamentals concepts of chemical engineering thermodynamics and to explain these concepts to other chemical engineers. We will re-drive the essential conclusions of statistical thermodynamics so that students will comprehend the breadth as well as the limitations of thermodynamics.  

Books & Reference :  
4. J M Haile, Molecular Dynamics Simulations-Elementary Methods, J Wiley & Sons.  
Energy Scenario: Indian and global energy crisis, Classification of various energy sources, renewable and non-renewable energy sources, remedial measures to energy crisis.

Energy Conservation: Laws of energy efficiencies, Ways of conserving energy in chemical and allied industries, viz, better house keeping, scope of improvements in design of equipments, waste heat recovery, concept of multiple effect and recycling etc. Energy audit.

Bioenergy, bio-gas plants and their operation, biomass and its conversion routes to gaseous and liquid fuels, its potential and generation by wind mills

Nuclear energy: status, nuclear raw materials, nuclear reactors and their classification, generation of nuclear power, nuclear installation in India and their capacity generation, limitation of nuclear energy, reprocessing of spent nuclear fuel.

Cogeneration of fuel and power, Energy from tidal and ocean thermal sources.

Books & Reference:

Various process utilities, their role and importance in chemical plants.

**Water sources:** sources of water, their characteristics, storage and distribution of water, water for boiler use, cooling purposes, drinking and process water treatment reuse and conservation of water, water resources management.

**Steam:** Steam generation and its application in chemical process plants, distribution and utilization, design of efficient steam heating systems, steam economy, condensate utilization, steam traps, their characteristics, selection and application, waste heat utilization.

**Compressors and Vacuum Pumps:** Types of compressors and vacuum pumps and their performance characteristics. Methods of vacuum development and their limitations, materials handling under vacuum, piping systems, lubrication and oil removal in compressors in pumps.

**Refrigeration Systems:** Refrigeration system and their characteristics, load calculation and load calculation and humidification and de humidification equipments, drying and cooling tower, air blending, exhaust, ventilation, cryogenics, their characteristics and production of liquid N₂ and O₂.

**Insulation:** Importance of insulation for meeting for the process equipment, insulation material and their effect on various materials of equipment piping, fitting and valves, insulation for high, intermediate, low and sub zero temperatures including cryogenic insulation, determination of optimum insulation thickness.

**INERT GASES:** Introduction, properties of inert gases & their use, sources and methods of generation, comparison of nitro generation routes, general arrangement for inverting system, operational, maintenance and safety aspects.

**Books & Reference:**

1. Jack Broughton; Process utility systems; Institution of Chem. Engineers U.K.
3. S.C.Aroa & S.Domkumdwar; A course in refrigeration and air conditioning; Dhanpat Rai & Co.(P) ltd.
Catalysis and catalytic process, catalyst formation, adsorption on solid surfaces, physical-chemical adsorption model, multiplayer adsorption theory; catalytic reaction kinetic model, real and ideal surface models; various models for data analysis, adsorption enhancement, multi step rate control, significances of dual rate – determining step and non equilibrium kinetic model, catalyst deactivation, catalyst classification.

Fixed bed catalytic reactor; reactor and reaction parameter, chemical and physical dimensionless parameters, radial peclet, aspect and biot numbers, velocity variance, adiabatic and non adiabatic fixed bed reactor, design and modeling of fixed bed reactors

Fluidized bed catalytic reactor; character and quality of fluidization, fluid bed reactor modeling; Davidson Harrison model, Kunii-Levenspiel model, anatomy of overall rate coefficient, Olsons’s fluid bed reactor analysis. Introduction and performance of catalytic gaze reactor, trickle bed reactor, catalyst deactivation in fixed bed, batch fluid bed, moving bed and continuous fluid bed reactors, comparison of fixed moving and fluid beds; reactor poisoning in terms of spm, thermal waves in fixed bed regeneration, optimization of regeneration cycles.

Books & References:

5. R.E.Hayes; Introduction to Chemical Reactor Analysis”, Gordan and Breach science publishers.
Membrane development, preparation and characterization for RO, UF, NF and microfiltration, design of membrane support structure, membrane modules for industrial applications.

Membrane polymer/preparation: polymer selection, phase inversion membranes, thermodynamics; interfacial polymerization and membrane morphology

Catalytic membranes; non porous and porous inorganic membranes, design and use of membrane reactors for industrial applications.

Bio functional membranes: immobilized enzymes, covalent attachment methods, affinity chromatography, transport models, functionalized membranes, membrane based sensors.

Books & Reference:

1. Ho and Sirkar, Membrane Handbook, Chapman Hall, 1992

Reactor Dynamics: Dynamics model, Stability

Reactors with non-ideal mixing: Mixing time in agitated tanks, Resident time distributions, Models for no-ideal reactors, Mixing-Bio reaction interactions.

Sterilization Reactors: Batch Sterilization, Continuous Sterilization

Immobilized Bio Catalysts: Formulation and characterization of immobilized cell bio catalysts, Application of immobilized cell bio catalysts

Multiphase Bio reactors: Conversion of heterogeneous substrates, Packed bed reactors, Bubble column Bio-reactors, Fluidised bed Bio-reactors, Trickle bed reactors

Fermentation Technology: Medium formulation, Design and operation of a typical aseptic, arobic fermentation process, Alternate bio reactor configuration.

Animal & Plant Cell Reactor Technology: Environmental requirements for animal cell cultivation, Reactor for large-scale production using animal cells, Plant cell cultivation.

Books & References:
2. Bioprocess Engineering by Shuler & Kargi, Prentice Hall
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The student should select an existing experimental rig from U.G. Labs. Analyze the existing experiment being performed. Suggest modification for better performance. If required, update the existing manual. Suggest new experiment that may be carried out an existing or modified set up or entirely new set up.
**THIRD SEMESTER EXAMINATION**

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*NUES*

Note: Student can select two electives either offered by the department from the above list or from the list of intradepartmental electives.

Catalytic Conversion Processes: Fluid Bed and Orthoflow Catalytic Cracking, Catalytic Hydrocracking: Two stage and H-oil hydrocracker, Different type of catalysts used.

Reforming-type of catalysts, hydrotreating processes, hydrodesulphurization, Alkylation, Polymerization and isomerization

Supporting processes: solvent Extraction processes for deasphalting of Gasoline, Kerosene and Diesel oil. Wax separation and preparation as a finished product.

Course Objectives:
- A brief knowledge about chemical composition, characterization and evaluation of Crude Oil.
- To introduce the various processes of refinery and get familiarized with various type of refining processes to obtain finished petroleum products.

Books & References:

2. The chemistry and Technology of Petroleum, J.G. Speight, Marcel Dekker, 1991
General: Different water quality requirements of various industries for different pressure boiler feed waters, cooling water and process water. Waste generation and characterization from different industries like paper and pulp, breweries and distilleries, tanneries, textile, dairy, fertilizer, sugar mill, steel, oil refinery, petrochemical and pharmaceutical industries.


Air pollutants – generation, characterization - stack height - dispersal mechanisms. Control methods, particulate emission control methods such as gravitational settling chambers, cyclone separators, fabric filters, electrostatic precipitators, wet scrubbers, control of gaseous emissions by adsorption on solids, and by absorption in liquids, combustion.

Generation and treatment of sludge and solid wastes - identification of hazardous wastes - disposal methods.

Waste minimization and Life Cycle Analysis of a pollutant.

Books & References:

2. Environmental Pollution Control, C.S. Rao, 1993, Wiley Eastern Ltd.


**UNIVERSITY SCHOOL OF CHEMICAL TECHNOLOGY**

**SCHEME OF EXAMINATION M.TECH (CHEMICAL ENGINEERING)**

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**Introduction to Nanotechnology** – History of nano-revolution, nano scale materials and their applications, Carbon nano tubes, organic and inorganic nano structures. Future of the nanotechnology.

**Materials used in Nanotechnology** – An overview of the physical (mechanical, electrical) and chemical properties of different classes of solid materials such as metals, semiconductors, insulators and polymers. Examples of size effects of properties observed in thin films, colloids and nanocrystals.

**Conventional Fabrication Techniques** – Topdown and bottom up process, techniques used in conventional microfabrication including thin film deposition (e.g. CVD, PVD, lithography, chemical etching and electrodeposition.

**Analytical Techniques** – Analytical techniques such as Electron Microscopy, Electron and X-ray Diffraction, Ellipsometry, Photoelectron, Optical and Ion spectroscopy and Probe Microscopy.

**Applications** – Examples of applications in Micro and Nano technology including, Micro fluidics, Micro Electron Mechanical Systems (MEMS) membrane technology, and catayalyst and coatings

**Books & Reference :**

2. M. Meyyappan; Carbon Nanotubes, Science and application; CRC Press, 2005
3. Alexei Nabok; Organic and Inorganic Nanostructures; Publisher Artech House, London, 2005
The student should select any one of the topics offered from the department or select one on his own duly approved from the department. As part of the project work, candidate should give oral presentation of the work atleast one in a semester (CT - 651). The candidate is required to submit the detailed synopsis of the work that he would complete in the part-II (CT - 652) along with the report of the work already completed.
FOURTH SEMESTER EXAMINATION

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Students has to continue the work of CT-651, Major Project Part-I, and complete the work and submit the thesis for evaluation after giving Project Seminar (CT - 654).