Programmes: B. Tech

➢ Semester-III

Code	Course Title	L	T	S	C
MA331	Mathematics - 3	3	0	0	3
CH301	Industrial Stoichiometry	3	1	0	4
CH302	Fluid Mechanics	3	0	0	3
CY331	Chemistry - 2 (Inorganic & Organic)	3	0	0	3
ME331	Mechanical Engineering	3	0	0	3
CH351	Fluid Mechanics Laboratory	0	0	3	2
CY381	Chemistry Laboratory-2	0	0	3	2
WS381	Workshop Practice - 3	0	0	3	2

➢ Semester-IV

Course Title	L	T	S	C

Code	Course Title	L	T	S	C
CH401	Heat Transfer	3	1	0	4
CH402	Chemical Engg. Thermodynamics	3	0	0	3
CH403	Energy Sources & Utilization	3	0	0	3
CH404	Safety and Environmental Engineering	3	0	0	3
CY431	Chemistry - 3 (Physical & Electrochemical)	3	0	0	3
CH451	Heat Transfer Laboratory	0	0	3	2
CH452	Energy Laboratory	0	0	3	2
ME481	Mechanical Design of Equipments & Components Sessional	0	0	3	2

Code

Code	Course Title	L	T	S	C
CH501	Mathematical Modelling & Simulation	3	1	0	4
CH502	Chemical Reaction Engineering -1	3	0	0	3
CH503	Mass Transfer -1	3	0	0	3
CH504	Mechanical Operations	3	0	0	3
YY54*	Open Elective - 1	3	0	0	3
CH551	Mechanical Operations Laboratory	0	0	3	2
CH552	Computing Laboratory	0	0	3	2
CH553	Process Equipment Design - 1	0	0	3	2

Sem-VI

Code	Course Title	L	T	S	C
MS631	Principles of Management	3	0	0	3
CH601	Process Control & Instrumentation	3	1	0	4
CH602	Mass Transfer -2	3	0	0	3
CH603	Chemical Reaction Engineering - 2	3	0	0	3
CH604	Chemical Process Industries - 1	3	0	0	3
CH651	Modelling & Simulation Lab	0	0	3	2
CH652	Process Equipment Design - 2	0	0	3	2
HS681	Professional Communications	0	0	3	2

- ## Semester-V

- ## Semester-VII

CH701	Transport Phenomena	3	1	0	4
CH702	Chemical Process Industries- 2	3	0	0	3
CH710-729	Departmental Elective - 1	3	0	0	3
CH710-729	Departmental Elective - 2	3	0	0	3
CH751	Mass Transfer Laboratory	0	0	3	2
CH752	Process Equipment Design - 3	0	0	3	2
CH753	Seminar - 1	0	0	2	1
CH754	Project Work - 1	0	0	6	3
CH755	Vocational Training / Summer Internship	0	0	0	1

- **Semester-VIII**

Code	Course Title	L	T	S	C
CH 810-829	Departmental Elective – 3	3	0	0	3
CH 810-829	Departmental Elective – 4	3	0	0	3
YY84*	Open Elective – 2	3	0	0	3
CH 851	Reaction Engineering Laboratory	0	0	3	2
CH 852	Process Control & Instrumentation Lab	0	0	3	2
CH 853	Seminar – 2	0	0	2	1
CH 854	Project Work – 2	0	0	12	6
CH 855	Viva Voce	0	0	0	2

Departmental Electives

	Departmental Elective - 1 & 2				
CH 710	Petroleum Refining & Petrochemicals	3	0	0	3
CH 711	Non-conventional Energy Engineering	3	0	0	3
CH 712	Project Engineering	3	0	0	3
CH 713	CFD Applications in Chemical Engineering	3	0	0	3
CH 714	Biochemical Engineering	3	0	0	3
CH 715	Computer Aided Process Engineering	3	0	0	3
CH 716	Membrane Separation Processes	3	0	0	3
	Departmental Elective - 3 & 4				
CH 810	Multiphase Flow	3	0	0	3
CH 811	Safety & Disaster Management	3	0	0	3
CH 812	Bioprocess & Bioreactor Engineering	3	0	0	3
CH 813	Process Utilities & Materials	3	0	0	3
CH 814	Combustion Engineering	3	0	0	3
CH 815	Process Analysis and Optimisation	3	0	0	3
CH 816	Boiling Heat Transfer	3	0	0	3
	Open Electives - I				
CH 540	Fuels & Combustion	3	0	0	3
CH 541	Process Heat Transfer	3	0	0	3
	Open Electives - II				

CH 840	**Non-linear Dynamics**	**3**	**0**	**0**	**3**
CH 841	**Computer Aided Process Design**	**3**	**0**	**0**	**3**
CH 842	**Process Intensification**	**3**	**0**	**0**	**3**

Course	**Course Title**	**Credits**

		Lecture (L)	Tutorial (T)	Practical # (P)	Total Hours	
CH	**Semester - III**					
Code	**Subject**	**L**	**T**	**S**		**C**
CH 331	Process Calculations	3	0	0	3	3
CH	**Semester - IV**					
CH 431	Unit Operations of Chemical Engineering I					
CH 481	Unit Operations of Chemical Engineering Lab I					
CH	**Semester - V**					
CH 531	Unit Operations of Chemical Engineering II					
CH 581	Unit Operations of Chemical Engineering Lab II					
CH	**Semester - VI**					
CH 631	Process Control and Instrumentation					

<u>For Department of Bi-Technology</u>

THIRD SEMESTER

INDUSTRIAL STOICHIOMETRY (CH 301) (3-1-0)

(Teachers involved: JPS, GNH)

Course Overview: The course covers basic knowledge on units & dimensions, types of equations based on laws and equations generated through dimensional analysis of complex physical problems & use of different types of plots used in chemical engineering. Numerical problems on mass balance using ideal gas and its related laws. It also covers the concept of different laws & equation on vapor pressures for solving numerical problems. The course also covers humidity concept, various humidity and temperature terms, psychometric chart and related mass balance problems. It also covers the enthalpy balance on chemical engineering processes/systems with & without chemical reaction based on the fundamentals of Physical and Thermo chemistry.

Course objectives:

- To create a fundamental understanding of units and dimensions and equations to enable the students to identify the nature of the equations frequently used in the field of chemical engineering.
- To enable to solve simple numerical problems on mass balance, using, different gas laws, vapor pressure laws and humidity concept and psychometric charts
- To introduce the enthalpy balance concept needed for solution of energy balance of different chemical engineering processes in industries.

Syllabus:

Module - I (10 L)

- Units and Dimensions:, Conversion of Equations, Systems of Units, Dimensional Homogeneity and Dimensionless Quantities, Buckingham Pi-theorem for Dimensional Analysis Mathematical Requisites: Use of log-log and semi-log graph paper, Triangular Diagram. **6 hrs**
- Introduction to Chemical Engineering Calculations: Basis, Mole Fraction and Mole Percent, Mass Fraction and Mass Percent, Concentration of different forms, Conversion from one form to another **4 hrs**

Module – II (10 L)

- Ideal gas laws and its significance, Molar concept, Concept of partial pressure & partial volume, Dalton's law and Amagat's law and Numerical problems on their applications. **4 hrs**
- Fundamental concept of vapor pressure & boiling point, Clausius-Clapeyron equation, Antoine equation and numerical problems on their applications, Numerical problems on Duhring & Cox plots **4 hrs.**
- Ideal & non-ideal solutions, Rault's law, Henry's law and their applications in numerical problems. **2 hrs.**

Module – III (10 L)

- Humidity and its significance, various humidity/saturation terms like, molar, absolute, relative & percentage saturations, sample numerical problems using the humidity terms. **4 hrs**
- Fundamental concept and significance of dry-bulb, wet-bulb, adiabatic saturation temperatures and dew point. Psychometric/humidity chart and its application on solving numerical problems. **6 hrs**

Module – IV (10 L)

- Energy Balance: Enthalpy calculation for systems without Chemical Reaction, Estimation of Heat Capacities of solids, liquids and gases. Heat of fusion and vaporization, **3 hrs**
- Enthalpy calculation for systems with Chemical Reaction, Thermo-chemistry, Calculations of heat of reaction, heat of combustions, heat of formation and heat of neutralization, Effect of Temperature and Pressure on Heat of Reaction, Hess's Law, Adiabatic Flame Temperature, Theoretical Flame Temperature. Application of Material and Energy balance to problems of various chemical processes **7 hrs.**

Text Books:

Unit Operations – Chemical Process Principles – Part-I - Haugen, Watson & Ragatz (CBS)

Basic Principles and Calculations in Chemical Engineering – Himmelblau ((Prentice Hall of India)

FLUID MECHANICS (CH 302) (3-0-0)

(Teachers involved: PPG, TM)

Course Overview: The course covers fluid statics, kinematics and kinetics. Details of flows of Newtonian and non-Newtonian fluids through closed conduits, flow metering devices, flow past solid surfaces and fluid machines are included.

Course objectives:

- To create a fundamental understanding of fluid statics, kinematics and kinetics
- To solve problems on flows of Newtonian and non-Newtonian fluids through closed conduits
- To introduce drag and fluidization; flow measuring devices:
- To create detailed understanding of fluid machineries
- VI. Solve pipeline problems of different difficulty levels through tutorials
- VII. Process design of a pipeline network through assignment / group task

Syllabus:

Module - I

- Fluids and fluid properties, continuum concept. 1 hr
- Fluid statics: Pressure and pressure measuring devices. 2 hrs
- Fluid kinematics, different flow regimes, equation of continuity. Boundary layer 2 hrs
- Skin and form friction. 1 hr

Module - II

- Bernoulli's equation, Hagen-Poiseuille equation, Fanning's equation and their applications. 5 hrs.
- Pipes, fittings and valves. Pressure losses due to sudden expansion, contraction and fittings. 4 hrs.
- Navier-Stoke's equation and total energy balance equation. 3 hrs
- Turbulent flow, Reynold's stress, universal velocity profile. 2 hrs

Module - III

- Flow past solid surface, drag, flow through packed bed, fluidization, pneumatic conveying. 3 hrs.
- Flow of compressible fluids, flow through convergent-divergent nozzles. 2 hrs
- Non-Newtonian fluids: Their characteristics and calculation of pressure drop due to their flow through pipes. 2 hrs
- Flow measuring devices: Orificemeter, venturimeter, rotameter, weirs, anemometer, pitot tubes, etc. 3 hrs

Module - IV

- Fluid machines: Pumps, blowers and compressors. 10 hrs.

Text Books:

Unit Operations – McCabe and Smith (McGraw Hill)

Transport Processes and Unit Operations – Geankoplis (Prentice Hall)

Principle of Unit Operations – Foust (Wiley)

FLUID MECHANICS LABORATORY (CH-351) (0-0-3-2)

(Teachers involve: PPG, KCG, TM)

Course Overview: The course covers experimentation verification of various laws and equations in fluid mechanics and determination of different coefficients and factors involved in fluid flow.

Course objectives:

- To prove experimentally laws/equations like Bernoulli's equation, Fanning's equation, etc learnt in the theory courses
- To determine different coefficients and factors involved in fluid flow

Syllabus:

- To study the transition from laminar to turbulent flow regimes.
- To determine the coefficient of discharge in venturimeter and orificemeter and study the effect of Reynolds' number on this
- To determine K factor of pipe fittings and valves
- To draw characteristic curves of pump
- To determine the velocity profiles using pitot tube
- To determine the flowrate through an open channel by weirs
- To determine the friction factor in a flow through packed bed
- To prove experimentally laws/equations like Bernoulli's equation, Fanning's equation, etc.

Text book: Transport Processes and Unit Operations - C. J. Geankoplis

FOURTH SEMESTER

HEAT TRANFER (CH 401) (3-1-0-4)

(Teachers involve: SH, SD)

Course Objectives:

1. To conceive the idea of different modes of heat transfer
2. To formulate the equations for calculating heat flux for conduction, convection, radiation, boiling, condensation
3. To construct the governing equations for designing and analyzing heat transfer equipment

Course Outcome

I. Learn fundamentals of heat transfer

II. Identify principles of different modes of heat transfer

III. Design and analyze heat transfer equipment

IV. Compare performances and select type of heat transfer equipment

V. Learn industrial applications of heat exchangers

VI. Solve heat transfer problems of different difficulty levels through tutorials

VII. Complete design of a heat exchanger through assignments/ group task

Course Syllabus:

Module 1

Mechanism of heat transmission: Conduction, Convection and Radiation. Conduction: Fourier's law; Steady-state heat transfer through composite slabs, cylinders and spheres; Optimum thickness of insulation; Unsteady-state heat transfer - use of Gurnie-Lurie chart, one and two-dimensional conduction in different geometry.

(10 hrs.)

Module 2

Convection: Forced convection; Heat transfer coefficients; Overall Heat Transfer Coefficients; Log-mean temperature difference; Dimensional analysis of heat transfer; Equivalent diameter; General equation for forced convection; Thermal boundary layer; Analogy between heat and momentum transfer. (10 hrs)

Module 3

Natural convection: Empirical equations; Condensation: Film Condensation, Derivation of heat transfer coefficient, Empirical equations; Boiling of liquids: Concept of excess temperature, Pool boiling, Forced convection boiling; Radiation: Black body and Gray body; Laws of radiation; View factor; Radiant heat exchange between surfaces; (10 hrs)

Module 4

Heat exchangers: Type of different heat exchangers and their design - Double pipe, Shell and tube, Finned tube and Compact heat exchangers; Condensers and reboilers. (5 Hrs.)

Evaporation: Type of evaporators with accessories; Capacity and Steam economy; Boiling point rise/elevation; Multiple effect evaporators; Design of single and multiple effect evaporators. (5 Hrs.)

Text Books:

1. Process Heat Transfer – D.Q.Kern (McGraw-Hill)
2. Heat Transfer : Principles and Applications – Binay K. Dutta (Prentice-Hall India)

Reference Books:

1. Heat Transmission – Mc Adams (McGraw-Hill)

<u>CHEMICAL ENGINEERING THERMODYNAMICS (CH 402)</u> (3-0-0-3)

(Teachers involve: PPG, GNH)

Course Overview: The course covers the laws of thermodynamics and their applications; thermodynamic relations, Solution thermodynamics and phase equilibrium and chemical reaction equilibrium

Course objectives:

- To learn in details the laws of thermodynamics and their applications; thermodynamic relations
- To learn in details solution thermodynamics and phase equilibrium; to generate VLE data; to check the consistency of experimental VLE data; to calculate bubble and dew points
- To learn chemical reaction equilibrium; to calculate equilibrium conversion for homogeneous and heterogeneous reactions

Module - I

- Scope of thermodynamics and fundamental concepts. Microscopic and macroscopic view. 1 hrs.
- First law of thermodynamics: Applications to batch and flow systems. 2 hrs.
- Second and third laws of thermodynamics: Reversibility and irreversibility, Carnot cycle, entropy, free energies, exergy. 2 hrs.

Module - II

- Real gases: Equations of state, compressibility charts, departure functions. 3 hrs.
- Thermodynamics of flow processes: Single and multi-stage compression, expansion through nozzles. 2 hrs.
- Refrigeration and liquefaction of gases: Vapour compression, cascade, absorption and gas refrigeration cycles, Choice of refrigerants, Linde and Claude processes of liquefaction of gases. 4 hrs.

Module - III

- Thermodynamic property relations: Maxwell's relations and thermodynamic functions of pure substances. Residual properties, fugacity. 6 hrs.

Module - IV

- Solution thermodynamics and phase equilibrium: Multi-component gaseous systems and solution. Partial molal properties and thermodynamic potential, criteria for equilibrium, thermodynamic properties of solutions, Gibbs-Duhem equation and consistency of thermodynamic data. Activity and activity coefficient, estimation of activity coefficient- Margules and Van laar equations, ASOG and UNIFAC methods. Generation of VLE data. Calculation of bubble and dew points of ideal and non-ideal solutions. Azeotropes. Miscible and immiscible systems. Phase equilibrium at elevated pressure.
12 hrs.

Module - V

- Chemical reaction equilibrium: Estimation of equilibrium constant. Homogeneous reactions. Heterogeneous reactions.
8 hrs.

Text Books:

Chemical Engineering Thermodynamics – J. M. Smith & H. C. Van Ness and M. M. Abbott (Tata McGraw Hill)

Chemical & Engineering Thermodynamics – S. I. Sandler (Wiley)

ENERGY SOURCES AND UTILISATION (CH 403) (3-0-0-3)

(Teachers involve: SH, MKM)

Course objectives:

This course focuses on current and potential future energy systems, covering resources, extraction, conversion, and end-uses. This will enable the students to gain understanding of general engineering knowledge and how these may be applicable to the alternative energy systems

Course Outcomes:

I. Learn different sources of energy and basic terminology

II. Identify characteristic properties of fuels

III. Design and analyze fuel processing equipment

IV. Compare performances and select type of fuel processing equipment

V. Learn industrial applications of fuel processing equipments

VI. Solve mathematical problems of different difficulty levels through tutorials

VII. Complete design of a fuel processing equipment through assignments/ group task

Syllabus

- Introduction: Survey of different sources of energy and their utilisation. 2 hrs.
- Fossil fuels: Coal, Petroleum and gaseous fuels. 1 hrs.
- Coal: Origin and formation of coal . Petrographic constituents of coal, Properties and testing. Classifition of coal, Coal preparation- washing and blending, Metallurgical and other uses. Carbonisation of coal, coke ovens and recovery of by-products. 12 hrs.
- Petroleum : Constitution of petroleum, Origin and Occurrence of crude, Evaluation of crude, Properties, testing and specifications of petroleum products- Octane no.; Reid vapor pressure; Flash point; Fire point; Smoke point; Pour point; Cloud point; Aniline point and Diesel index; Cetane no. , Processing of Crude Petroleum
10 hrs.
- Gaseous fuels: Classification. Manufacture of producer and water gas. 5 hrs.
- Combustion and furnace: Combustion characteristics, Combustion appliances--furnaces, waste heat recovery system, burners. 6 hrs.
- Non-conventional energy sources: Solar energy Nuclear Energy from biomass, Geothermal, Wind, Tidal
4 hrs.

Text books:

1. Modern Petroleum Refining: B. K. B. Rao

2. Fuels & Combustion: Samir Sarkar

Reference books:

1. Petroleum Refining Engineering: W. L. Nelson
2. Petroleum Refining Technology & Economics: J.H. Gary & G.E. Handwerk
3. The elements of fuel technology: G. W. Himus

<u>SAFETY AND ENVIRONMENTAL ENGINEERING (CH-404)</u> (3-0-0-3)

(Teachers involve: PP, JS)

Course Overview:

Course objectives: Operation of the fossil fuel based power plants, coke manufacturing plants, steel industries, cement, fertilizer and allied process industries leads to environmental pollution in varied scale depending on their applied technology. Amidst stringent environmental regulations, all industrial operations that continue to cause environmental pollution will eventually have to close down unless they seriously addresses the issues of environmental pollution. Quality manpower is the need of the hour who can develop green process plants and innovate new routes for environmentally benign production and clean the waste streams effectively before discharge to the environment. This course has been designed keeping in view requirement of quality manpower in green production regime. The course intends to make the students aware of the sources of environmental pollution, their associated health hazards, remedial measures, currently practiced treatment technologies, design and operation of the treatment plants, their trouble shooting, assessing their strengths and weaknesses and above all to ignite the passion of the students towards innovation that would foster growth in sustainable environment.

<u>Module-1</u>

- Domains of Environmental Pollution- Air, Water, Noise pollution.
- Root cause analysis of Environmental Pollution 2 Hrs

<u>Module-2</u>

Water pollution:

- Sources and distribution of water , surface and groundwater contamination
- Drinking water standards , wastewater characteristics; testing for drinking water parameters and wastewater characteristics 2 Hrs

<u>Module-3</u>

Abatement:

- Physico-chemical treatment of water and wastewater:
- Filtration, coagulation, flocculation and settling 2 Hrs
- Design problems (Tutorial): 2 Hrs

<u>Module-4</u>

- Biological Treatment:
- Activated Sludge Process 2 Hrs
- Design Problems(tutorial) 1 Hr
- Trickling Filter 2 Hrs
- Design Problems(Tutorial) 1 Hr
- Aerated Lagoons 2Hrs
- Design Problems (Tutorial) 1 Hr

<u>Module-5</u>

- Advanced Treatment:
- Submerged Aerated Filter 1 Hr

- Upward Flow Anaerobic Sludge
- Blanket System 1 Hr
- Reed bed Treatment 1 Hr
- Membrane separation 2 Hrs

Module-6

- Polishing Treatment
- Ion-exchange : 1 Hr
- Disinfection : 1 Hr

Module-7

- Solid waste management 2 Hrs
- Hazardous waste management 2Hrs
- Sludge Disposal 1 Hr

Module-8

AIR POLLUTION

- Air Pollution - Sources, Health Hazards, global warming & climate change
- Role of Atmosphere in dispersion , Plume behavior 2 Hrs
- Dispersion problems and Stack Design(Tutorial): 1 Hr
- Control devices –ESP, Venturi scrubber, gravity separator, filters 2 hrs
- Design Problems (Tutorial) 2 Hr
- Abatement of gaseous pollutants & VOCs 1 Hr

Module-9

- Environmental Impact Assessment, Environmental ethics 2 Hrs
- Safety codes, basics of plant safety, hazards analysis, accident prevention and investigation 2 Hrs
- Fire hazards, explosives 1 Hr

References:

(1) Basic Environmental Technology- Jerry A. Nathanson

(2) Environmental Pollution Control Engineering – C.S. Rao

(3) Water Quality and Treatment – Fredrick W. Pontius Ed.(AWWA)

(4) Wastewater Engineering Treatment, Disposal, Reuse: Metcalf & Eddy, INC.

(**5**) Wastewater treatment for Pollution control: S.J. Arceivala

(**6**) Safety in the Chemical Industry : O.P.Kharbanda & E.A. Stallworthy

(7) Groundwater Arsenic Remediation: Treatment Technology & Scale Up: P.Pal, Elsevier Science

HEAT TRANFER LABORATORY (CH 451) (0-0-3-2)

(Teachers involve: JPS, PP, MKM, JS)

Course objectives

Hands on training of the budding chemical engineers on important heat transfer devices are the focus of the course. Motivation to team work in a miniature process plant environment using steam and the other process utilities is the other major objective of the course. The course intends to develop skill of the budding chemical engineers in safe handling of major heat transfer equipment/devices, in close observation of their operation, in developing analytical ability in correlating the performance of the devices with their operational conditions.

Course Outcome

I. Understanding fundamentals of some major Heat transfer operations

II. Development of design processes

III. Application of design principles for heat transfer devices

IV. Learning operations of various heat transfer systems

V. Building foundation for process intensification

VI. Motivation towards innovations for novel systems of heat transfer

VI. Learning to work in group in innovative design

Syllabus:

- Thermal Conductivity of Metal Rod
- Parallel flow/counter flow heat exchanger
- Shell & Tube Heat Exchanger
- Film wise and drop wise condensation Apparatus
- Heat Transfer in forced Convection
- Emissivity Measurement Apparatus
- Stefan Boltzmann's Apparatus
- Single Effect Evaporator

Text books:

- Laboratory manual

Reference books:

- Process Heat Transfer: D Q Kern
- Heat Transfer: Principles and Applications: B. K Dutta

<u>ENERGY LABORATORY (CH 452)</u> (0-0-3-2)

(Teacher involves: CMN, GNH, SD)

Course Objectives:

1. To list the specifications required for each type of fuel
2. To be familiar with all the equipment used for characterizing solid, liquid fuels
3. To learn the theoretical knowledge behind each experiment and principle of operation of each equipment

Course Outcome:

I. Learn the characteristic properties of solid, liquid and gaseous fuels

II. Identify the equipment for characterization of fuels

III. Learn principles of operations of experiments

IV. Calculate the characteristic parameters through group tasks

V. Identify the difficulties associated with experimental set through group tasks

VI. Analyze the performance of equipment through group tasks

Syllabus:

1. Proximate Analysis of coal
2. Ultimate Analysis of coal and estimation of combustor efficiency based on Orsat Analysis of flue gases
3. Determination of washability characteristics of coal
4. Determination of swelling and caking index of coal
5. Determination of shattering index of blast furnace coke
6. Determination of kinematic viscosity of petroleum oils using Redwood Viscometer
7. Experiment of ASTM distillation of sample oil
8. Determination of flash point of fuel oils using Abel's Flash Point Apparatus and determination of flash and fire point using Pensky-Marten apparatus
9. Determination of Aniline point and Diesel Index
10. Determination of Reid Vapour pressure
11. Determination of Carbon Residue using Conradson apparatus
12. Determination of Calorific value of solid and liquid fuels by Bomb Calorimeter
13. Determination of moisture content by Dean and Stark Apparatus
14. Preparation and analysis of biodiesel(from vegetable oil)
15. Testing and Analysis of water heating flat plate solar collector.

Module I: Experiments on coal analysis and utilisation:

16. Proximate Analysis of coal
17. Ultimate Analysis of coal and estimation of combustor efficiency based on Orsat Analysis of flue gases
18. Determination of washability characteristics of coal
19. Determination of swelling index of coal
20. Determination of caking index of coking coal
21. Determination of shattering index of blast furnace coke

Module II: Experiments on Petroleum

1. Determination of kinematic viscosity of petroleum oils using Redwood Viscometer
2. Determination of flash point of fuel oils using Abel's Flash Point Apparatus

Module III: Experiments on alternate liquid fuels:

1. Preparation and analysis of biodiesel(from vegetable oil)
2. Testing of biodiesel using Abel's Flash Point Apparatus and Redwood Viscometer.

Module IV: Experiments on Renewable Energy Sources:

1. Testing and Analysis of water heating flat plate solar collector.
2. * Testing and Analysis of solar concentrating collector
3. Analysis of Biogas using Junker's Gas Calorimeter

* Being installed

NOTE: Each experiment is of 3hr duration

Text books:

3. Modern Petroleum Refining: B. K. B. Rao
4. Fuels & Combustion: Samir Sarkar

Reference books:

4. Petroleum Refining Engineering: W. L. Nelson
5. Petroleum Refining Technology & Economics: J.H. Gary & G.E. Handwerk

FIFTH SEMESTER

MATHEMATICAL MODELLING AND SIMULATION (CH 501) (3-1-0-4)

(Class Teachers - AKS)

Course Overview:

Course Objectives: This course explores the basic concepts and steady state equations of simple systems in chemical process industries. It deals with the techniques for derivation of system model equations, data analysis and visualization. The basic objective is to develop the tools to analyze the system and to visualize the effect of various process inputs on system performance and state variables. The course aims to present the basic idea and concept on process model with detailed analysis and solution of model equations for steady and unsteady operation.

Module – 1 **(20 hours)**

- **Introduction to Mathematical Model and its Necessity:**

  Empirical relationship, experimentation, data interpretation, correlation and mathematical modeling using example **2 hr**

- **Model Development Principles and Classification of Models:**

  Dimensional Analysis, Synthesis of sub-models, Experimental facts, Hypothesis, Scaleup concept

  Steady state, unsteady state model, dynamic response, Constitutive relationships

  Deterministic and Stochastic – Macroscopic diffusion equation, Random walk

  Lumped and Distributed Parameter - Stirred tank and plug flow models

  Linear and non-linear models **2hrs**

- **Conservation principlesof mass and energy and momentum balance equations and Modelling of few simple systems**

  (a) Gravity flow tank

  (b) Flash drum

  (c) Distillation column

  (d) Double pipe heat exchanger

  (e) Gas-liquid absorption column

  (f) Batch reactor

  (g) Plug flow reactor. **16 hrs**

Module – 2 **10 hrs**

- **Development of dynamic model**

  Input output model vs state model, system parameters, numerical integration,

  Linear models and deviation variables, linearization of non-linear models,

  System with one state variables, one state one input. State space model

  Heated mixing tank, Isothermal CSTR, Non-isothermal CSTR with 2nd order chemical reaction, linearizied model for the system and state space representation, Stability analysis and eigen values. **6 hrs**

- **Case studies**

  Pyrolysis, Combustion, Gasification process of coal and biomass and comprehensive modelling in TGDA, Isothermal mass loss Apparatus, Drop tube furnace and Fluidized bed reactor. **4 hrs**

Module – 3 **15 hrs**

- **Specialized Modeling and Simulation Techniques:**

The general conservation equation and interpretation of individual terms, The Distributed parameter system and model equations, Detail derivation of Finite volume method and its application to steady state diffusive, convective and convective-diffusive problem. Extensions of the same for unsteady state operation. Presence of non-linear reaction terms, radiation term and linearization technique. Solution o few Numerical problems. 15 hrs

Books:

1.**Lyuben**, W.L, **Process Modelling**, Simulation and Control, McGraw-Hill, N.Y. 1990.

2. Franks, **R. G. E.**, "Mathematical Modelling in Chemical Engineering", John Wiley, 1967.

3. Franks, **R. G. E.**, "Modeling and Simulation in Chemical Engineering", John Wiley,

4. Babu B. V., Process Plant simulation, Oxford University Press.

5. Patankar, S. V., 'Numerical fluid flow and heat transfer', 1980, Hemisphere

6. Current literature on relevant topics.

Course Assessment method: As per institute norms.

<u>CHEMICAL REACTION ENGINEERING - I (CH 502)</u> (3-0-0-3)

(Teachers involved- CMN, PPG)

Course Overview: The course covers interpretation of rate data for homogeneous reactions, design of isothermal reactors for single and multiple reactions, design of non-isothermal reactors; biochemical reactions; modeling of non-ideal reactors

Course objectives:

- To determine the rate mechanism
- Determination of rate kinetics
- Design of isothermal reactors for single and multiple reactions
- Design and analysis of nonisothermal reactors;
- Study of biochemical reactions; design of biochemical reactors
- Modeling of non-ideal reactors

Module - I

- Review of elements of reaction kinetics: The rate expression, mechanism of reactions, thermodynamic formulation of rates, collision and activated complex theories, Arrhenius' equation. 3 hrs.
- Interpretation of rate data: Constant volume and variable volume batch reactors, continuous reactors and effect of temperature. 7 hrs.

Module - II

- Single homogeneous reaction: Design equations for batch, plug flow and back-mix reactors for isothermal, adiabatic and heat-regulated reactions. Thermal stability of reactors, multiple-steady states. 10 hrs.
- Multiple reactions: Independent, parallel and series reactions. Mixed reactions, autocatalytic reactions. Choice of reactors for simple and complex reactions and multiple reactor systems. 5 hrs.

Module - III

Biochemical reactions: Enzyme-catalyzed and biomass growth reaction kinetics, design of bioreactors.
8 hrs.

Module - IV

- Non-ideal flow in reactors: Residence time distribution of fluid in vessels, RTD in ideal and non-ideal reactors, modelling of non-ideal reactors. 7 hrs.

Text Books:

Chemical Reaction Engineering – Octave Levenspiel (Wiley Eastern)

Elements of Chemical Reaction Engineering – H. Scott Fogler (Prentice hall of India)

<u>MASS TRANSFER – 1 (CH - 503)</u> (3-0-0-3)

(Teachers involve: JPS, SD)

Course Objectives:

1. To conceive the different laws for mass transfer operation
2. To apply the fundamental laws to formulate governing equations for mass transfer operations
3. To design mass transfer equipment and analyze the difficulties

Course Outcome:

I. Learn fundamentals of mass transfer

II. Identify principles of mass transfer operation

III. Design and analyze mass transfer equipments

IV. Compare performances and select type of mass transfer equipment

V. Learn industrial applications of mass transfer equipments

VI. Solve mass transfer problems of different difficulty levels through tutorials

VII. Complete design of a mass transfer equipment through assignments/ group task

Course Syllabus

Module I

Mass transfer operation and principles. General principles of diffusion process. Molecular and eddy diffusion in fluids. Diffusion in solids and measurement of diffusivity. Multi-component diffusion. Diffusion through a variable area. Knudsen diffusion, surface diffusion and self diffusion. 5 hrs

Module II

Convective mass transfer and mass transfer coefficients: Introduction. Dimensionless groups in mass transfer and correlations for the convective mass transfer coefficient. Theories of mass transfer. Analogy between Momentum, Heat and Mass Transfer. Inter-phase mass transfer and Basic laws. Two-film theory, overall mass transfer coefficient. Material balance in contacting equipment – the operating line and Mass transfer in stage-wise contact of two phases.7 hrs

Module III

Gas absorption and stripping: Introduction. Design of a packed tower: Design method based on individual mass transfer coefficients. Design method based on the overall mass transfer coefficient. Determination of the number of stages in a tray tower. HETP, Tray efficiency.

Gas-liquid contacting equipment, tray or plate column. Operational features of tray column: Hydraulic gradient and multi-pass trays, weeping and dumping, entrainment, flooding, turndown ratio and estimation of diameter of tray. 8 hrs

Module IV

Elementary idea about multi-component absorption and adsorption with chemical reactions.Extraction: Liquid-liquid extraction, Equilibrium data, Use of triangular diagrams, selectivity and choice of solvent, Single and multi stage calculation in liquid-liquid extraction. Extraction efficiency, Principles of leaching and stage calculation methods. 10 hrs

Text books:

1. R. E. Treybal, Mass Transfer Operations, 3rd Edition, Mc Graw-Hill
2. B. K. Dutta, Principles of Mass Transfer and Separation Processes, PHI

Reference Book:

1. A. P. Sinha and P. De, Mass Transfer Principles and Operations, PHI

MECHANICAL OPERATIONS (CH-504) **(3-0-0-3)**

(Teachers involve: SH, JS)

Course Objectives:

1. To conceive the different laws for Mechanical operations
2. To conceive the different size separation equipments
3. To apply the fundamental laws to formulate governing equations for size reduction operations
4. To design size separation equipment and analyze the difficulties

Course Outcome:

I. Learn fundamentals of Mechanical Operations

II. Identify principles of separation of liquid-solid, gas-solid, and solid-solid

III. Design and analyze mechanical operation equipments

IV. Compare performances and select type of size separation, solid-liquid separation and size reduction equipment

V. Learn industrial applications of size separation, solid-liquid separation, size reduction equipments

VI. Solve mechanical operations problems of different difficulty levels through tutorials

VII. Complete design for efficiency calculation through assignments/ group task

Module

- Particle size analysis:

Determination of mean particle size (1 Hr)

Sieve analysis (2 Hrs)

Industrial screens (2 Hrs)

Effectiveness of screens (2 Hrs)

- Size reduction:

Principles of crushing and grinding (1 Hr)

Equipment – selection (1 Hr)

Operating principles of

a) Coarse crushing equipment (2 Hrs)
b) Intermediate & Grinding equipment (2 Hrs)

Laws of crushing and grinding – limitation and applicability (2 Hrs)

- Size enlargement: Granulation and other size enlargement operations. (2 Hrs)
- Fluid – particles separation: Terminal settling velocity, free and hindered settling, equal settling velocity and sedimentation; Classifiers and clarifiers; Settling chambers, thickener, tabling, jigging, floatation, centrifugal separators, cyclone separators, electro-static precipitator, magnetic separator, etc. (17 Hrs)
- Filtration : Introduction; Types of filtration; Filtration equations; batch and continuous filtration equipment – Bed, Plate and Frame, Leaf and Rotary Drum Vacuum Filters; Filter Aid and Filter Medium; Washing (10 Hrs)
- Mixing and agitation: Types of equipment and power requirement. (2 Hrs)
- Storage and transport of solid:
  Bins, silo and hoppers (1 Hr)
  Conveyors and elevators, Hydraulic and pneumatic transport (1 Hr)

Text Books:

1. Unit Operations-Brown (CBS Publishers & Distribution)
2. Introduction to Chemical Engineering-Badger and Banchero (McGraw-Hill)
3. Transport Processes and Unit Operation-Geankoplis (Prentice-Hall India)
4. Principles of Unit Operation-Foust (John Wiley & Sons)
5. Mechanical Operations for Chemical Engineers-C.M. Narayanan, B.C. Bhattacharyya (Khanna Publishers)

6. Unit Operations Of Chemical Engineering-Mc. Cabe Smith & Harriot (TMH)
7. Unit Operation-C.J. King
8. Coulson & Richardson's Chemical Engineering Volume.2

MECHANICAL OPERATIONS LABORATORY (CH- 551) (0-0-3)

(Teachers involve: SH, SD, JS)

Course objectives:

1. To learn the fundamental principle of operation of equipment
2. To be able to run the equipment used in industry for physical operation
3. To be familiar with the difficulties and shortcomings of the equipment

Course Outcome

I. Learn fundamentals of mechanical operations

II. Identify the equipments for various mechanical operations

III. Learn principles of operations of experiments

IV. Calculate the characteristic parameters through group tasks

V. Identify the difficulties associated with experimental set through group tasks

VI. Analyze the performance of equipments through group tasks

Course Syllabus

- To find out the particle size distribution by sieve analysis.
- To study the effectiveness of double-deck vibrating screen.
- To study crushing efficiency of crushing and grinding in Jaw crusher, Ball Mill, and crushing rolls.
- To study constant pressure filtration and washing of cake in a plate and frame filter press
- To study mixing characteristics in marine type propeller.
- To determine Mixing Index of Kneader Mixer
- To study the operation of a Cyclone separator.

COMPUTING LABORATORY (CH- 552) (0-0-3)

(Teachers involve: AKS, SP)

Objective: This course aims to provide the basic of computer programming using c and FORTRAN. It deals with the techniques to understand the concept of variables, data type, mathematical and logical expression, loops and conditional loop. The basic principles of one and two dimensional array, concept of matrices and its operation will be shown by problem solving method. The students will be familiarize with the programming and will use a computational tool for solving the chemical Engineering problem. The specific assignments will be solved in tandem with the theory courses already taught in the various classes of earlier semester.

Module I **9 hr**

1. Familiarization of programming environment and execution of sample programs

2. Expression evaluation

3. Conditionals and branching

4. Iteration

5. Functions

6. Arrays

Module II **9 hr**

Solution of liner and non-liner algebraic equations

System of linear and non-liner algebraic equations

Module III **9 hr**

Initial value ODES using Euler explicit and implicit technique. Non-linear ODEs

System of Linear ODEs

System of non-liner and Stiff ODEs.

Module IV **9 hr**

The problems related to chemical engineering are given as laboratory assignments. Most of the problems deals with the various numerical methods taught in the Mathematics course. The problems on Phase Equilibrium, Equation of State, Determination of Bubble point and Dew Point calculation.

References

1. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India.

2. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill.

3. Byron Gottfried, Schaum s Outline of Programming with C, McGraw-Hill.

4. Computational Methods in "Chemical Engineering," Prentice Hall, 1975.

<u>PROCESS EQUIPMENT DESIGN – 1 (CH-553</u>) (0-0-3-2)

(Teachers involve: MKM)

Course Objectives:

The objective of this course is to acquire basic understanding of design parameter, complete knowledge of design procedures for commonly used process equipment and their attachments (e.g. internal and external pressure vessels, tall vessels, high pressure vessels, supports etc.), and different types of equipment testing methods.

Course outcomes

- Knowledge of basics of process equipment design and important parameters of equipment design
- Ability to design internal pressure vessels and external pressure vessels
- Ability to design special vessels (e.g. tall vessels) and various parts of vessels (e.g. heads)
- Knowledge of equipment fabrication and testing methods

Syllabus

- Introduction to the basic principles and criteria of pressure vessel design. 6 hrs
- Unfired pressure vessels with internal and external and external pressure. 2 hrs
- Introduction to standards, codes and regulations. 3 hrs
- Selection of material and design of various parts of vessel 8 hrs
- Design of storage vessels. Tall vessels and their design. 6 hrs
- Design of supports for vertical and horizontal towers. 3 hrs
- Pipe joints and fittings, gaskets. 3 hrs
- Sketching and drawing of gate, globe and needle valve, steam trap, safety valve 3 hrs
- Numerical solutions for vessel design 6 hrs

Text books:

- Process Equipment Design by Lloyd E. Brownell & Edwin H. Young
- Process Equipment Design by M. V. Joshi

Reference books:

- Introduction to Chemical Equipment Design: Mechanical Aspects by B. C. Bhattacharya
- Plant Design and Economics for Chemical Engineers by M.S. Peters and K.D. Timmerhaus
- Chemical Process Equipment: Selection and Design by James R. Couper

SIXTH SEMESTER

PROCESS CONTROL & INSTRUMENTATION (CH 601) (3-1-0-4)

(Teachers involve: AKS, SD, JS)

Course Overview:

The course covers linear system dynamics, block diagrams, feedback control, process identification, Stability and Tuning. A systematic introduction to dynamic behavior and automatic control of chemical processes will be discussed. The classical linear approaches will be adopted for controller design.

Course objectives:

1. To enable the students to design and conduct laboratory experiments, as well as to analyze and interpret data, in particular to determine the efficacy of control designs
2. To enable the students to understand the dynamic behavior of the processes and its significance in real-time processes
3. To develop ability in the students to design a control system to meet desired needs for a given process

Module I: Process Dynamics & Transfer function 10hrs

Process Dynamics & Model: I/O model-first-order and second-order process, Linearization and concept of deviation variable, Laplace Transform, Block Diagram, Different forcing function: step, pulse, impulse, ramp, and sinusoid. Lumped and distributed parameter system

Transfer function: SISO & MIMO systems, Transient response of first, second and higher order systems, Transportation lag; Pade approximation, Control valve: Characteristics curves and transfer function. Open loop transfer

Module II: Closed loop systems and Stability 10hrs

Closed loop systems and its components: Measuring device, Controller, Final Control Element (FCE), transmission line; Block diagram, Servo and Regulator control, closed loop response, Different type of analog controller: P, PI, PD, PID, On-Off.

Concept of Stability: BIBO, characteristics equation, Routh– Hurwitz method, root locus method.

Module III: Frequency Response and Controller Tuning **10hrs**

Frequency Response Analysis and Controller Tuning: Amplitude Ratio and Phase Lag calculation for: General, first, second and higher order systems, Dead time, P, PI, PD, PID controllers and their respective Bode plot & Nyquist plot; Bode & Nyquist stability criteria; Controller design: Empirical tuning criteria: one quarter decay ratio, ISE, IAE, ITAE. Controller tuning: Cohen-Coon, Zeigler-Nichols method;

Elementary idea of feed forward, cascade, ratio, adaptive and digital computer control. Model-based control –Internal model controller

Module IV: Introduction to Instrumentation 10hrs

Measurement of High temperature, Measurement of Moderate to Low Temperature, Measurement of High Pressure, Measurement of Moderate to Low Pressure, Measurement of gas and liquid flow, Measurement of multiphase flow, Measurement of liquid level

Text Book/ References:

1. Process Systems Analysis and Control, Donald Coughanowr McGraw-Hill Science/Engineering/Math; 2 edition (March 1, 1991)
2. Chemical Process control, G. Stephanopoulos, PHI, 2008
3. Essentials of Process Control, Luyben et al. McGraw-Hill Companies (August 1, 1996)
4. Process control, Thomas Marlin, McGraw-Hill Education; 2nd International edition (July 1, 2000)

MASS TRANSFER -II (CH 602) (3-0-0-3)

(Teachers involve: PP, MKM)

Course objectives: Mass transfer is a subject unique to the chemical engineers. Units involved in mass transfer operations forms the hearts of many chemical process industries particularly for separation and purification of the products. Successful operation of the mass transfer devices/equipment is absolutely essential to the business success dealing with chemical manufacturing or allied sectors. The objective of this course is to impart knowledge to the undergraduate students on the basic principles of operation of the major mass transfer equipment/devises, their design and operation under optimum conditions. The course has been designed to build the foundation of the budding chemical engineers in mass transfer equipment/devices and their efficient operation. The course covers both the traditional as well as the emerging new techniques of mass transfer operations/devises/tools.

Course Outcome

I. Understanding fundamentals of some major Mass transfer operations

II. Development of design processes

III. Application of design principles for mass transfer devices

IV. Learning operations of various mass transfer systems

V. Building foundation for process intensification

VI. Motivation towards innovations for novel systems of mass transfer

VI. Learning to work in group in innovative design

Syllabus

- Humidification & Dehumidification Operations: 2hrs
- Wet & dry bulb thermometry, Construction and use of humidity charts. Principles of Humidification & Dehumidification; characteristics of saturated and unsaturated vapor- gas mixtures- 4hrs
- Design problems (tutorial) : 1hr
- Fundamentals of gas-liquid contact operations, design & operation of cooling towers : 3hrs
- Spray chambers, principles of air conditioning 2hrs

- Design problems (tutorial) 1hr
- Drying: theory and mechanism of drying. Steady and unsteady state drying, classification and selection of industrial dryers. Estimation of drying rates. Drying characteristics of materials. Performance and design of batch and continuous dryers. 5hrs
- Design problems (tutorial) 2hrs
- Distillation processes: Vapor- liquid equilibrium, relative volatility, azeotropism 2hrs
- Equilibrium and flash distillation, types of distillation columns and construction 2hrs
- Rectification of binary systems, enthalpy diagram and construction 2hrs
- Rectification column design methods: Lewis-Sorel & Ponchon –Savarit 2hrs
- McCabe-Thiele method 2hrs
- Design problems(tutorial) 2hrs
- Special distillation processes: molecular, extractive, catalytic &other types 2hrs
- Multicomponent Distillation & introduction to ASPEN PLUS 2hrs
- Theory of crystallization, Nucleation and crystal growth 2hrs
- Batch and continuous crystallizers. 1hr
- Design calculations for crystallizers 2hrs
- Membrane separation basics, classification & transport mechanisms 2hrs
- Membrane modules and design problems on micro, ultra, nano & reverse osmosis: 2hrs

Text books

- Mass Transfer: R.E.Treybal
- Unit operations of chemical engineering: W.L. McCabe & J.C.Smith

Reference books:

- Principles of Mass Transfer & Separation Processes: B. K. Dutta
- Introduction to chemical engineering: W.L.Badger & J.T.Banchero
- Membrane Science & Technology, Osada & Nakagawa

CHEMICAL REACTION ENGINEERING – 2 (CH-603) (3-0-0-3)

(Teachers involve: PPG, KCG)

Course Overview:

To learn the fundamentals of heterogeneous reactions and design and analysis of non-catalytic and catalytic fluid-solid reactors including multi-phase reactors

Course objectives:

- To learn fundamentals of heterogeneous reactions
- To learn reaction models of fluid-solid non-catalytic and catalytic reactions
- To design & analyze fluid-solid non-catalytic and catalytic reactors
- To compare performances of various heterogeneous reactors
- To learn industrial applications of reactors including multiphase reactors
- To solve reactor problems of different difficulty levels through tutorials
- Complete process design of a reactor through assignment / group task

Syllabus

MODULE I **(8 hrs.)**

Introduction to heterogeneous reacting systems. Non-catalytic solid-fluid reactions: Sharp interface and volume reaction models, determination of rate-controlling steps and application to design of reactors.

MODULE II **(12 hrs.)**

Solid-fluid catalyzed reactions: Catalysis, porous catalyst, steps in catalytic reactions, surface kinetics, pore diffusion resistance, performance equations, interaction of physical and chemical rate processes, effectiveness factor, selectivity, product distribution in multiple reactions, effect of pore distribution, experimental methods

MODULE III **(8 hrs.)**

Fluid-fluid reactions: Overall rate equations, application to reactor design.

MODULE IV **(12 hrs.)**

Analysis of reactors: Packed, moving and fluidised-bed reactors, slurry and trickle bed reactors, Stability analysis of reactors.

Texts / References:

1. H. S. Fogler, **Elements of Chemical Reaction Engineering**, Prentice Hall India

2. O. Levenspiel, **Chemical Reaction Engineering**, Wiley Eastern

CHEMICAL PROCESS INDUSTRIES – 1 (CH-604) (3-0-0-3)

(Teachers involve: MKM, BD)

Course objectives

Chemical industry is unique in being its single best customer. As chemical engineers, this course will be helpful to understand the processes technologies of various organic and inorganic process industries for manufacturing chemicals and associated troubleshoot. This will give powerful approach in designing new process and product development.

Course Outcome

- Ability to understand the manufacturing of various inorganic and organic chemicals
- Ability to understand the process flow diagram and various process parameters
- Ability to identify and solve engineering problems during production

Syllabus

- Basic philosophy of a process flow diagram (PFD). Elements of a PFD. General discussion on Influence of various parameters on deciding process for a product and method of drawing PFD.
  1 hr
- Water-sources and it's economic use. Water conditioning processes. Industrial waste water treatment - different processes.
  4 hrs

- Industrial production of oxygen and nitrogen-cryogenic and non-cryogenic processes. Hydrogen manufacture from different source-steam reforming and partial oxidation processes.
3 hrs
- Ammonia, Nitric acid and it's important salts. 5 hrs
- Sulphur, sulphuric acid and it's important salts 3 hrs
- Phosphorus, phosphoric acid nd it's important salts 3 hrs
- Fertilisers - ammonium sulphate, amonium phosphates, superphosphates, urea, ammonium nitrate. Mixed & NPK fertilisers. 5 hrs
- Caustic chlorine industry - mercury, membrane and diaphragm cells. Hydrochloric acid and important chlorine compounds.
4 hrs
- Soda ash, sodium bicarbonate. 2 hrs
- Lime, cement and plasters 6 hrs
- Glass & ceramic industries 2 hrs
- Miscellaneous inorganic chemicals. Nuclear materials. 2 hrs

Text books

- Dryden, C. E., and Rao, M.G. (Ed.), Outlines of Chemical Technology Affiliated East West Press.
- Austins, G.T., Sherve's Chemical Process Industries, MGH 5th Edn.

Reference books:

- Venkateswarlu, S. (Ed.) Chemtech (II) Chemical Engineering Development Centre, IIT, Madras.
- S. K. Ghoshal, S. K. Sanyal and S. Datta, Introduction to Chemical Engineering, Tata McGraw Hill, New Delhi.
- Kirk & Othmer (Ed.), Encyclopedia of Chemical Technology

MODELLING AND SIMULATION LABORATORY (CH-651) (3-0-0-3)

(Teachers involve: SP, AKS)

Objective: The course aims to provide the basics programming using Matlab. The students will understand Matlab data type, mathematical and logical expression, loops and conditional loop. The basic concept of matrices and its operation will be shown by problem solving method. The students will be familiarize with the Matlab programming and will use Matlab as a computational tool for solving the chemical Engineering problem. Students will be able to solve the specific assignments that has been formulated in the theory class in earlier semester.

I. To demonstrate how modeling and simulations techniques help us troubleshoot chemical processes

II. To do a deeper analysis of a problem mathematically in order to enhance process performance

III. To forecast process information (where experimental data are not available) that help designing a process

IV. To improve process control and safety

Module I 6 **hrs**

1. Familiarization of Matlab command window and programming environment

2. Expression evaluation

3. Conditionals, branching and iteration

4. Functions in Matlab

Module II **6 hrs**

Solution of liner and non-liner algebraic equations

System of linear and non-liner algebraic equations, Effect of recycle ratio and residence time on conversion in a series of CSTRs , Finding optimal contact of a series reaction in a CSTR, Effect of downstream pressure on multicomponent flash drum, Temperature profile of a Co-axial heat exchanger, Simulation of distillation column using Aspen/Hysis

Module III **6 hrs**

Initial value ODES using Euler explicit and implicit technique. Non-linear ODEs

System of Linear ODEs

System of non-liner and Stiff ODEs.

To apply modeling techniques to simulate the behavior of CSTR

Module IV **18 hrs**

Solution of simple PDEs by writing own Matlab code (Finite Volume technique) The problems on Phase Equilibrium, Determination of Bubble point and Dew Point, Differential Distillation- Minimum Reflux Ratio Calculations, Numerical Integration for CSTR and plug flow reactor problem, Problem on single component vaporization, multi-component flush drum under steady and unsteady operation, problem on mass transfer Rayleigh's Equation, calculation of NTU in Absorption, Determination of Drying time from batch drying data, Determination of reactor size and Heat generation problems with chemical reaction.

Text Book

1. Lindfield, George and John Penny, "Numerical Methods Using MATLAB", Prentice-Hall, 2000.

2. Kamal and Al-Malah, MATLAB Numerical Methods with Chemical Engineering Applications, McGraw-Hill Education, New Delhi.

References

1. Computational Methods in "Chemical Engineering, Prentice Hall, 1975.

2. Kirani Singh. Y, and Chaudhuri B.B., MATLAB programming, Prentice Hall

PROCESS EQUIPMENT DESIGN – II (CH-652) (0-0-3-2)

(Teachers involve: SH, JS)

Course Objectives:

The objective of this course is to acquire basic understanding of design parameter, complete knowledge of design procedures for commonly used process equipment in Heat Transfer

Course outcomes

- Knowledge of basics of process equipment design and important parameters of equipment design
- Ability to design Evaporator
- Ability to design Shell and Tube Heat Exchager
- Knowledge of equipment fabrication and testing methods

Syllabus

- Introduction to the basic principles and criteria of different type of Evaporators. 6 hrs
- Design of Multiple effect Evaporator. 2 hrs
- Introduction to standards, codes and regulations. 3 hrs
- Selection of material and design of various parts of Evaporator 8 hrs
- Design of Shell and tube heat exchanger 6 hrs
-

Text books:

- Process Equipment Design by Lloyd E. Brownell & Edwin H. Young
- Process Equipment Design by M. V. Joshi

Reference books:

- Introduction to Chemical Equipment Design: Mechanical Aspects by B. C. Bhattacharya
- Plant Design and Economics for Chemical Engineers by M.S. Peters and K.D. Timmerhaus
- Chemical Process Equipment: Selection and Design by James R. Couper

SEVENTH SEMESTER

CH 701 TRANSPORT PHENOMENA

(Teachers involve: KCG, TM)

Course Objectives:

- Concept development on Momentum, Energy and Mass transport.
- Students will be able to solve the problems on Momentum, Energy and Mass transfer
- Mathematical presentation of any physical system based on Momentum, Energy and component transport
- Students will be capable to develop Model Equation for prototype system to scale up

Course Outcome

I. To create fundamental understanding on transport processes and their relation, transport properties, measurement of properties, boundary conditions etc.

II. To create an understanding on shell balance technique, NSE and their application in rectangular, cylindrical and spherical coordinate systems

III. To solve problems on momentum transport using shell balance technique and basic transport equations

IV. To solve problems on energy transport using shell balance techniques and basic transport equations

V. To develop understanding on momentum transport in thin films, parallel plates, couette flow, rotating surface flow and radial flow, flow near a wall suddenly set in motion

VI. To develop understanding on energy transport in fixed bed catalytic reactors, cooling fins, forced convection in circular tubes, natural convection from a heated plate

VII To develop understanding on mass transport in different coordinate systems e.g. diffusion in porous catalyst, diffusion in falling liquid film by using shell balance and continuity equation

VIII To solve problems on steady and unsteady state systems

IX To give an understanding on turbulent mass flux, interphase mass transport

•Transport Phenomena: Basic concepts, fundamental transport Processes and their relation, transport properties, measurement of properties, boundary conditions etc. 5 hrs.

•Momentum transport phenomena: Shell balance technique, Derivations of momentum, velocity, shear force etc. in rectangular, cylindrical and spherical coordinate systems by using shell balance, Equation of continuity and change (mass, momentum & energy), Navier stokes equation (NSE), Euler equation, application of NSEin rectangular, cylindrical and spherical coordinate systems. 8 hrs.

•Flow of fluids in thin films, parallel plates, circular tubes and annulus, adjacent flow of two immiscible fluids, couette flow, rotating surface flow and radial flow, flow near a wall suddenly set in motion. 8 hrs.

•Energy transport: Basic energy transport equations, derivation using elementary volume concept and conservation theorems in different coordinate system, analysis of energy transport using shell balance techniques and basic transport equations. 6 hrs.

•Conduction with energy sources in fixed bed catalytic reactors and in cooling fins, forced convection in circular tubes, natural convection from a heated plate and unsteady state conduction of finite slab. 8 hrs.

•Mass transport : Types of fluxes and their relation, continuity equation for a binary mixture, boundary conditions , analysis of mass transport using shell balance techniques and equation of continuity for different coordinate systems, steady and unsteady state systems, diffusion in porous catalyst with and without chemical reaction, diffusion in falling liquid film, turbulent mass flux, interphase mass transport 10hrs.

<u>CHEMICAL PROCESS INDUSTRIES – 2 (CH 702)</u> (3-0-0-3)

(Teachers involve: SH, BD)

Course Objective:

To study process technologies of various organic and inorganic process industries.

Course Outcome:

Ability to understand the manufacturing of various inorganic and organic chemicals • Ability to understand the process flow diagram and various process parameters • Ability to identify and solve engineering problems during production

Course content:

Module I: **10 hrs**

Oils & Fats: Methods of extracting vegetable oils (Process Description and Flow sheet). Hydrogenation of oils (Process description & flow sheet), major engineering problems and improved technology.

Soaps, Detergents & Glycerin: Classification of cleansing compounds, uses, Methods of soap production, Methods of detergent manufacture, Methods of production of Glycerin. Process description & flow sheet of each process.

Module II: **10 hrs**

Sugar and starch industries: Manufacturing process with flow diagram, Sugar refining, manufacturing process of starch and their different by-products; Glucose, Sorbitol & Polyols.

Pulp and paper Industries, technology and manufacturing methods, world market

Explosive: Military explosives – Nitrocellulose compound, TNT, Black Powder, Nitro-glycerin and Dynamite

Module III: **10 hrs**

Fermentation industries: Industrial Alcohol, Absolute Alcohol; their production process with flow diagram.

Agrichemical industries: Elementary ideas on Pesticides, Insecticides, Fungicides, Herbicides, DDT manufacturing process with flow sheet.

Module IV: **10 hrs**

Leather Technology : Molecular Biology of Collagen: Introduction of collagen, proteoglycan network, level of orders in collagen, primary, secondary, tertiary and quaternary structure of collagen, world market, production, different tanning methods,

Gelatin and Glue manufacturing and uses.

Text Book/ Reference Books:

1. Shreve's Chemical Process Industries, George T. Austin, Fifth Edison, McGraw-Hill International Editions
2. Dryden's Outlines Of Chemical Technology-for the 21st century, M. Gopala Rao, Marshall Sittig,, 3rd Edition, East West Press.
3. Manual of Chemical Technology, 1st and 2nd volume Edited by D. Venkateswarlu and K. R. Upadrashita, Chemical Engineering Education Development Centre, IIT Madras
4. Dutta, S.S. (2000), An introduction to the principles of leather manufacture, 4th Edn. Indian Leather Technologists Association, Calcutta.

PETROLEUM REFINING & PETROCHEMICALS CH-710 (3-1-0)

(Teachers involve: PP, MKM)

Course objectives:

Petroleum sector plays the most vital role for keeping the wheels of economic development rolling and the Chemical engineers mainly run the petroleum industry. Knowing the sources of crude petroleum, extraction of the crude petroleum, its refining to the useful petro-products and efficient transport to the end users through network are important tasks to the petroleum or chemical engineers. This course intends to form the foundation of the chemical engineers on all the above mentioned basic fields of petroleum from extraction to the safe end use where refining is the most challenging. The course puts major thrust on all the techniques/processes of petroleum refining encompassing selection of the mass/heat transfer devices, their operation and basic design. The course also covers the feed stocks of petrochemical industries and manufacture important petrochemicals.

Course Outcomes:

I. Understanding the role of petroleum as energy source amidst world energy scenario

II. Learning design and operation of petro refineries and petrochemical complexes

III. Learning safe practices in operations of refineries and petrochemical complexes

IV. Identifying challenges, energy security issues and environmental issues

V. Techno-economic analysis & trouble shooting

VI. Building foundation for process intensification

VII. Motivation towards innovations

Syllabus

- Petroleum - Origin and Occurrence, Exploration, Estimation and recovery 5hrs
- Evaluation of crude, Properties, testing and specifications of petroleum products 5hrs
- Problems & Prospectus of petroleum refining in India 2hrs
- Processing of Crude Petroleum - Atmospheric and Vacuum distillation, column control schemes 3hrs
- Cracking, Reforming, Visbreaking, Delayed Coking 3hrs
- Alkylation, Isomerization 2hrs
- Production of finished petroleum goods like, LPG, Kerosene, Petrol, Diesel, Lubricating Oil, Bitumen, Hydroprocessing : 10 hrs
- Petrochemicals- feedstocks, classification of petrochemicals, Cracking of raw feed stock for intermediate feed stock production, manufacture of PVC, PE, POLY STYRENE, BTX. etc. 10 hrs

Text books

- Petroleum Refining Engineering: W.L. Nelson
- Petrochemicals Technology: B.K.B. Rao

Reference books:

1. Advanced Petroleum Refining: G.M. Sarkar
2. Environmental Control in Petroleum Refining: J.C. Reis
3. Petroleum Refining Technology & Economics: J.H. Gary & G.E. Handwork

NON-CONVENTIONAL ENERGY ENGINEERING CH-711

(Teachers involve: BD, TM, and CMN)

Course objective:

1. To make the students understand the different non-conventional energy source advancement and their application in worldwide.
2. To develop the ability to design energy application systems
3. To gain knowledge on environmental problems due use of conventional energy sources.

Course outcome:

I. Learn about energy technology of different conventional and non-conventional energy resource.

II. Recent worldwide energy market scenario and recent trend of using different non-conventional energy resource

III. Learn different types on renewable energy resources like solar energy, Wind energy, Geo-thermal energy, nuclear energy and bio energy and its applications.

IV. Design &analyze of different renewable energy collectors and renewable energy thermal power plants

V. Learn industrial and domestic applications of different renewable energy sources.

VI. Solve energy technology problems of different difficulty levels through tutorials

VII. Complete process design of an energy system through assignment / group task

Course content:

Module 1 : **10 hrs**

Introduction to energy science and technology, law of conservation of energy, energy calculations, energy demand, various resources of non-conventional energy; introduction to wind energy forms and energy conversion systems; applications of wind turbine generator units, horizontal axis propeller type wind turbine generator units, three blends, horizontal axis wind turbine (WAWT), vertical axis wind turbines,

Module 2 : **10 hrs**

Solar energy - historical review and future prospects, fundamentals and applications, Solar thermal energy conversion systems, solar collectors, solar thermal power plants, solar photovoltaic cells, V-I characteristics of a solar cell, efficiency of a solar cell; Construction and performance analysis of solar flat plate collectors. Heat losses from FPC by radiation and natural convection, overall heat loss coefficient, collector efficiency factor, tilt factors, collector heat removal factor, Hottel-Willier-Bliss equation. Solar concentrating collectors: CPC, PTC, spherical paraboloids, modes of tracking, performance analysis. Salt gradient solar ponds: construction, operation, technical problems. Solar drying and dehumidification: Solar cabinet dryers, convective dryers

Module 3 : **10 hrs**

Geo-thermal energy – history of resources and applications, hydrothermal (convective) resources, geothermal electrical power plants, vapor dominated (stream) geothermal electrical power plants, liquid dominated (hot-water) geothermal electrical power plants, liquid dominated slashed steam geothermal electrical power plant, binary cycle liquid dominated geothermal power plants, comparison of various liquid dominated geothermal systems; Other Non-conventional Energy sources - introduction and brief idea about ocean energy, tidal energy and nuclear energy systems.

Module 4 **10 hrs**

Bio-mass energy - introduction, various resources and applications, processes, thermo-chemical-bio-chemical and hybrid-bio-gas-plant; Bio ethanol, Bio diesel, H_2 production and algal biofuel. Fuel Cells - introduction, types of fuel cells, working principles, electrolyte, membrane, catalyst, use etc.; Fuel from waste materials

Waste : Solid, liquid, gas and their effects. Treatment technologies: Physical, Chemical, Advanced and Integrated treatment systems.

Reference Book:

1. Non-conventional Energy Sources by G.D. Rai
2. Non-Conventional Energy Resources by B Khan
3. S.P.SUKHATME : Solar Energy

PROJECT ENGINEERING CH-712

(Teachers involve: SP)

Course Objectives:

This course will generally will discuss how various projects related to chemical process design and manufacturing are implemented with due consideration of economic aspects.

Course Outcome

I. Understanding the fundamental features of different types of projects

II. Determining project feasibility and project implementation time

III. Learning how to do project planning

IV. Learning how to implement a project

V. Preparing a project report – conceptualization to implementation & conclusion

Module I: **Introduction (4)**

Definition of project and project engineering–responsibilities of project engineers and project managers – examples of projects-process needs-project requirement specification (PRS)

Module II: **Project life cycle (8)**

Various stages of a project – managing the various stages of project – various approaches of managing the projects-case study-a design project

Module III: **Process Design Projects (10)**

Process design principles-process selection-DOF-design variable-mass balance and energy balance-PFD–optimization and sizing of equipment-P&ID-basic engineering package (BEP)

Module IV: **Process feasibility (5)**

Estimation of cost and profit - taxes & depreciation-rate of return (ROI)-case studies

Module V: **Project planning and scheduling (8)**

Various scheduling methods-application of heuristics-critical path method- case studies

Module VI**: Case studies of various projects (10)**

Course Assessment Method: The theory performance of students are evaluated.

TEXT BOOK/REFERNCE BOOK

1. Max S. Peters, K. D. Timmerhaus, Plant Design and Economics For Chemical Engineers 5th Edition, McGraw Hill Inc
2. Gavin Towler, R K Sinnott, Chemical Engineering Design, Second Edition: Principles, Practice and Economics of Plant and Process Design. Butterworth-Heinemann

CFD APPLICATIONS IN CHEMICAL ENGINEERING CH-713

(Teachers involve: PPG)

Course Overview: It covers the introduction to different techniques of computation fluid dynamics and elaborate on the use of Finite Volume Method to solve CFD problems.

Course objectives:

- To introduce different techniques of solving CFD problems
- To focus on Finite Volume Method and ensure that a student is able to solve CFD problems using FVM upto a reasonable level of complexity.

Syllabus

Module I: Introduction

- Introduction to Computational Fluid Dynamics 2
- Conservation Equations 2
- Discretization. Different Numerical methods and their comparison; Finite Difference Method, Finite Volume Method, Finite Element Method, etc. 5
- Source terms and their linearization 1
- Solution of discretized equations 2

Module II: Solution of mass and energy equations

- Solution of diffusive problems: Steady 1D, Steady 2D and Steady 3D problems. Unsteady 1D, 2D unsteady and 3D unsteady problems 9

- Solution of convective-diffusion problems: Steady and unsteady problems; Different schemes 9

Module III: Solution of momentum equations

- SIMPLE, SIMPLER, SIMPLEC algorithms 15

BIOCHEMICAL ENGINEERING CH-714

(Teachers involve: TM, SD)

Course Objectives:

1) To define the basic concept of the meaning of the word 'Bioreaction'.
2) To illustrate the mechanism of biochemical reactions
3) To describe the reaction engineering behavior occurring in the molecular level
4) To find the difference between classical microbiological reaction and recombinant cell reaction.
5) To assess biochemical processes for industrial application and evaluate the project performance.

Course Outcome:

I. Learn fundamentals of biochemical reactions

II. Identify reaction mechanism

III. Design and analyze various reactors

Course Syllabus:

Module 1

Principles of chemical reaction kinetics; enzymatic reaction kinetics, Michaelis-menten, Monod and Hill equation for kinetic study. Briggs-Haldane relationship, the determination and significance of kinetic constants. Lineweaver- burk and Eadie-Hofstee plot. kinetics of substrate utilization

(11 hr)

Module 2

Microbial growth and product formation. Microbial Kinetics; Biotechnology applied to raw minerals processing; Biogeochemical Reactions: Chemical mechanisms and controlling factors, microbial interventions, nature and characteristics of Biogeochemically. Stoichiometry of cellular reactions, ATP balances and energetics.

(11 hr)

Module 3

Classification of bioreactors. Free and immobilized enzyme system; fermenttion processes; pretreatment of raw materials; Design of fermentation air-filters; medium sterilization; physical separation processes, equilibrium process

(11 hr)

Module 4

Biological waste treatment processes.

(7 hr)

Text Book:

1. J. E. Bailey, D. F. Ollis, Biochemical Engineering Fundamentals, Second Edition, Mc. Graw Hill Inc., Singapore, 1986.

Reference Book:

1. J. Nielsen, J. Villadsen, G. Liden, Bioreaction Engineering, Second Edition, Springer, 2007.

2. N. C. Price and L. Stevens, Fundamentals of Enzymology: The cell and Molecular Biology of Catalytic Proteins, Third Edition,

Oxford University Press, Oxford, 2006.

2. D. G. Rao, Introduction to Biochemical Engineering, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2008.

COMPUTER AIDED PROCESS ENGINEERING CHE-715

(Teachers involve: CMN)

Objective: To familiarize students with computer aided design of Industrial processes / equipment and make them acquainted with development of CAD (software) packages.

Outcome: Students are groomed to become confident design engineers / process simulators. They are also made conversant with all aspects of chemical engineering science, since development of CAD packages demands proficiency in all unit operations and unit processes.

Module 1: Computer Aided Design of Pressure Vessels. CAD of cylindrical / spherical vessels under internal / external pressure, CAD of heads and closures, CAD of flanges, CAD of tall vessels / high pressure vessels, CAD of pipes, tubes. CAD of storage vessels, CAD of vertical / horizontal supports.

08 hrs

Module 2: Computer Aided Design of Heat Transfer Equipment. CAD of heat exchangers (shell and tube, double pipe, plate exchangers, finned exchangers). CAD of condensers, evaporators, multiple effect evaporators.

10 hrs

Module 3: Computer Aided Design of Mass Transfer Equipment. CAD of absorbers (packed columns, falling film absorbers), absorption with chemical reaction, CAD of extractors (liquid – liquid), CAD of leaching equipment.

08 hrs

Module 4: Computer Aided Design of Heat and Mass Transfer Equipment. CAD of continuous fractionators (sieve plate, bubble – cap fractionators), CAD of muti-component distillation systems, CAD of industrial dryers (batch, continuous, direct and indirect dryers), CAD of cooling towers.

12 hrs

Module 5: Computer Aided Design of Energy Systems. CAD of flat plate solar collectors (water heating, air heating), CAD of parabolic trough solar concentrators, CAD of regenerators and heat recovery systems.

10 hrs

Module 6: Computer Aided Design of Reacting Systems. CAD of packed bed, fluidized bed, semi – fluidized bed and inverse fluidized bed reactors. CAD of slurry reactors. CAD of bioreactors. Non-ideal reactor modelling and development of simulation packages.

12 hrs

Text Book:

1. Narayanan, C. M. and Bhattacharya, B.C., Computer Aided Design of Chemical Process Equipment, New Central Book Agency, Calcutta, 1992

2. Narayanan, C. M. and Bhattacharya, B.C., Unit Operations and Unit Processes - Vol. I & II, CBS Publishers, New Delhi, Revised Edition, 2005

MEMBRANE SEPARATION PROCESSES CH-716

(Teachers involve: JS, MKM)

Course objectives:

This course intends to form the foundation of the budding chemical engineers in this emerging technology domain. The course focuses on the back ground of rapid emergence of process intensification as a subject essential to sustainable operations of the process industries and the role of novel separation and purification technology in such process intensification. The course covers the avenues of process intensification with major thrust on emergence of membrane based novel hybrid plants, analysis of degree of process intensification as a result of implementation of membrane based new and green technologies. The critical aspects of dynamic modelling of the complicated transport phenomena will be particularly focused along with modelling and simulation of the novel processes with promising profit margin without affecting the mother earth. As sustainable technologies are expected through product and process innovations, this course attempts to ignite passion of the students towards innovation that shows light at the end of the tunnel.

Course Outcomes:

I. Learn fundamentals of membrane separation processes and current market scenario

II. Classify and characterize membrane separation processes

III. Principles and methodologies of separation and transport of molecules through membrane

IV. Learn latest development in both theory and applications

V. Working out solutions to exercise problems through tutorials

VI. Complete process design of separation through assignment / group task

Syllabus

- **Membrane Separation Processes:** Types of membranes and membrane characterization, Membrane modules and motion of molecules through membrane, Classification & characterization of Membrane Separation Processes. 6hrs
- **Reserve Osmosis (RO):** Fundamentals, Osmotic Pressure, Models of Solvent and solute Transport through membrane – Fluxes, Rejection and Separation factor, Mechanism of salt rejection by CA membrane, Concentration Polarization, applications 6 hrs
- **Nano-filtration (NF):** Fundamentals of NF, Models and Types of transport mechanism in NF membranes, Applications of NF 3 hrs
- **Ultra-filtration (UF):** Models and Types of transport in UF membranes, Membranes for UF – Fouling and concentration Polarization in UF, Separation schemes using UF, Dia-filtration – process design – batch, continuous, multistage 6 hrs
- **Micro-filtration (MF):** Membranes for MF – transport mechanism 3 hrs
- **Dialysis:** Solute transport in dialyzer – analysis of dialysis operation, Mode of dialysis, Hemo-dialysis – dialysis equipment – applications 3 hrs
- **Electro –dialysis (ED):** Types of ED – ion transport fundamentals, Resistances and voltages in ED cells – power requirement, ED membranes and cells, Problems of ED operation, Plant design and process cost 3 hrs
- **Liquid membrane**: Nature and types of available liquid membranes, Liquid membranes on solid membranes (facilitated transport) 2 hrs
- **Pervaporation (PV):** Theory of PV – parameter study, Classification of PV – air heated PV, Osmotic distillation, thermo-pervaporation, Advantages and disadvantages of PV, Application of PV 4 hrs
- **Gas Separation:** Membrane gas separation, Industrial applications 2 hrs
- Membrane distillation, membrane contactor 2 hrs

Text books

- Separation Processes – C. J. King
- Synthetic membranes – P. M. Bungay, H. K. Lonsdale, M. N. de Pinho

Reference books:

- Membrane Separation Processes – Kaushik Nath
- Membrane Hand Book – W. Ho and K. K. Sirkar
- Industrial Processing with membranes – R. E. Lacey & S Loeb
- Reverse Osmosis – S. Sourirajan
- Ultrafiltration Handbook – M. Cheryan
- Principles of Mass Transfer and Separation Processes – B. K. Dutta

CH 751 MASS TRANSFER LABORATORY

Course Objectives:

- To introduce concept of heat and mass transfer in mechanical contrivance for application in chemical industries

- To develop the idea for computation of overall heat transfer coefficients of chemical process equipment such as evaporator, heat exchanger.
- To understand the working principles of mass transfer equipment.

Course Outcomes:

- To demonstrate an understanding of heat and mass transfer modes and models
- To formulate the idea of the different types of interface reactions
- To apply principles of heat and mass transfer phenomena to chemical process industries s
- To enable solving the problems on process and materials related combined heat and mass transfer phenomena.

Syllabus:

1. Determination of overall heat transfer coefficient in a counter-current & parallel flow double pipe heat exchanger.
2. Studies on heat transfer and estimation of overall heat transfer coefficient of open pan evaporator.
3. Studies on estimation of hold-up volume under steady state condition and evaluate the overall performance of a rotary dryer.
4. Estimation of rate of drying of specific biomass under steady state condition in a atmospheric tray dryer.
5. Experimental test rig on drop-wise and film-wise condensation for assessing the performance.
6. Performance studies on continuous fractionating distillation column in terms of distillate, bottom product and reflux quantities, % loss, % recovery, energy consumption etc.

Text books

- Mass Transfer: R.E.Treybal
- Unit operations of chemical engineering: W.L. McCabe & J.C.Smith

Reference books:

- Principles of Mass Transfer & Separation Processes: B. K. Dutta
- Introduction to chemical engineering: W.L.Badger & J.T.Banchero
- Membrane Science & Technology, Osada & Nakagawa

CH 752 PROCESS EQUIPMENT DESIGN-3

Course Objectives:

The objective of this course is to acquire basic understanding of design parameter, complete knowledge of design procedures for commonly used process equipment and their attachments (e.g. internal and external Distillation column, tall vessels, high pressure vessels, supports etc.), and different types of equipment testing methods.

Course outcomes

• Knowledge of basics of process equipment design and important parameters of equipment design

• Ability to design distillation column

• Ability to design distillation column with its process design and mechanical design and various parts of column and drawing of internals of distillation column.

• Knowledge of equipment fabrication and testing methods

Course content:

- Introduction to the basic principles distillation process and its applications 6 hrs
- Design of distillation column with its process design and mechanical design and various parts of column and drawing of internals of distillation column 15 hrs
- Design of supports for vertical and horizontal towers. 5 hrs
- Mechanical drawing of Distillation column 4 hrs

Text and Reference Books:

- L. E. Brownell, E. H. Youg, "Process Equipment Design" John Wiley & Sons Publications, 2004.
- J.M. Coulson and J. Richardson, "Chemical Engineering", Vol. 6, Asian Books Printers Ltd.
- Indian Standard Specifications IS-803, 1962; IS-4072, 1967; IS-2825, 1969. Indian Standards Institution, New Delhi.
- R.H. Perry, "Chemical Engineers' Handbook", McGraw-Hill.
- W.L. McCabe, J.C. Smith and P. Harriot, "Unit Operation of Chemical Engineering", McGraw-Hill, 2001.
- B. C. Bhattacharyya, "Introduction to Chemical Equipment Design, CBS Publishers & Distributors, New Delhi, 2003

CH 753 SEMINAR-I

Objective: To be acquainted with the oral communication and learn how to present the technical information related to the field of chemical engineering in processes, equipment, research and consultancy projects.

Outcome: Students are made conversant with the present advancement and trend of technology in process industry adaptation of processes / phenomena developed in academic institutions and research laboratories.

Module 1: Presentation of seminar by each student. To enhance the presentation quality and give stress on the technical content, effective presentation and confidence in addressing questions from the audience.
30 hrs

Module 2: Preparation of technical report by each student. Assessment based on technical content, quality of technical writing, literature surveyed and cited.
10 hrs

CH 755 VOCATIONAL TRAINING

Objective: To acquaint students with real – life industrial processes, equipment, research and consultancy projects.

Outcome: Students are made conversant with industrial adaptation of processes / phenomena developed in academic institutions and research laboratories.

Module 1: Presentation of seminar by each student. Assessment based on technical content, effective presentation and confidence in addressing questions from the audience.
30 hrs

Module 2: Preparation of technical report by each student. Assessment based on technical content, quality of technical writing, literature surveyed and cited. 10 hrs

EIGHTTH SEMESTER

Multiphase flow CH 810 (3-1-0)

Course Objective: The course will give a general introduction to the underlying concepts of multiphase flows and different approaches to model such flows under different conditions. The course opens with real life examples of such flow and its importance in process industries with multiphase contactors.

Course Outcome:

I. To learn fundamental of multiphase flow, different flow patterns and flow pattern maps.

II. To learn transport mechanism of multiphase flow and industrial application of multiphase flow.

III. To learn different flow models in multiphase flow.

IV. Design & stability analyze of different types of multiphase flow.

V. Learn measurement techniques for multiphase flow.

VI. Solve multiphase flow problems of different difficulty levels through tutorials

VII. Complete process design of multiphase flow system through assignment / group task

Course content:

Module I:

Two phase flow: Gas/Liquid and Liquid/liquid systems: Flow patterns in pipes, analysis of two phase flow situations, Prediction of holdup and pressure drop or volume fraction, Bubble size in pipe flow, Lockchart-Martinelli parameters, Bubble column and its design aspects, Minimum carryover velocity. Holdup ratios, pressure drop and transport velocities and their prediction. 10 hrs

Module II:

Flow patterns - identification and classification - flow pattern maps and transition - momentum and energy balance - homogeneous and separated flow models -correlations for use with homogeneous and separated flow models - void fraction and slip ratio correlations - influence of pressure gradient - empirical treatment of two phase flow - drift flux model - correlations for bubble, slug and annular flows Introduction to three phase flow.
10 hrs

Module III:

Dynamics of gas-solid liquid contactors (agitated vessels, packed bed, fluidized bed, pneumatic conveying, bubble column, trickle beds), Flow regimes, pressure drop, holdup, distributions, mass and heat transfer, reactions, Applications of these contactors. 10 hrs

Module IV:

Measurement techniques in multiphase flow: Conventional and novel measurement techniques for multiphase systems (Laser Doppler anemometry, Particle Image Velocimetry). 10 hrs

TEXT BOOKS/REFERENCES:

1. Clift, R., Weber, M.E. and Grace, J.R., Bubbles, Drops, and Particles, Academic Press, New York, 1978.

2. Y. T. Shah, Gas-Liquid-Solid reactors design, McGraw Hill Inc, 1979

3. Fan, L. S. and Zhu, C., Principles of Gas-solid Flows, Cambridge University Press, 1998

4. Govier, G. W. and Aziz. K., "The Flow of Complex Mixture in Pipes", Van Nostrand Reinhold, New York, 1972.

5. Wallis, G.B., "One Dimensional Two Phase Flow", McGraw Hill Book Co., New York, 1969.

6. Crowe, C. T., Sommerfeld, M. and Tsuji, Y., Multiphase Flows with Droplets and Particles, CRC Press, 1998

7. Kleinstreuer, C., Two-phase Flow: Theory and Applications, Taylor & Francis, 2003 Rhodes, M., Introduction to Particle Technology, John Wiley & Sons, New York. 1998.

Course Assessment Method: The theory performance of students are evaluated.

SAFETY & DISASTER MANAGEMENT CH- 811

(Teachers involve: JS)

Course Objectives: The course is intended to provide a general concept in the dimensions of disasters caused by nature beyond the human control as well as the disasters and environmental hazards induced by human activities with emphasis on disaster preparedness, response and recovery.

Course Outcome:

- To learn the different safety aspects in industrial application and daily life
- To learn safety procedure followed in industries
- To know the procedure for risk analysis
- To know different type of disaster
- To know procedure for damage assessment

Module:1 12 hr

Safety Management - Concept of Safety, Applicable areas, unsafe actions &Conditions.Responsibility of Safety - Society, Govt., Management, Union & employees.

Safety Officer - Appointment, Qualification, Duties of safety officer.Safety Committee - Membership, Functions & Scope of Safety committee.Motivation & Training of employees for safety in Industrial operations.

Introduction on Disaster Different Types of Disaster :

A) Natural Disaster: such as Flood, Cyclone, Earthquakes, Landslides etc

B) Man-made Disaster: such as Fire, Industrial Pollution,

Nuclear Disaster,

Biological Disasters,

Accidents (Air, Sea, Rail & Road), Structural failures(Building and Bridge),

War & Terrorism etc. Causes, effects and practical examples for all disasters.

Module:2 6 hr

Risk and Vulnerability Analysis

1. Risk : Its concept and analysis

2. Risk Reduction

3. Vulnerability : Its concept and analysis

4. Strategic Development for Vulnerability Reduction

Module:3 8 hr

Disaster Preparedness and Response Preparedness-

1. Disaster Preparedness: Concept and Nature

2. Disaster Preparedness Plan

3. Prediction, Early Warnings and Safety Measures of Disaster.

4. Role of Information, Education, Communication, and Training,

5. Role of Government, International and NGO Bodies.

6. Role of IT in Disaster Preparedness

7. Role of Engineers on Disaster Management. Response-

1. Disaster Response : Introduction

2. Disaster Response Plan

3. Communication, Participation, and Activation of Emergency Preparedness Plan

4. Search, Rescue, Evacuation and Logistic Management

5. Role of Government, International and NGO Bodies

6. Psychological Response and Management (Trauma, Stress, Rumor and Panic)

7. Relief and Recovery

8. Medical Health Response to Different Disasters

Module:4 10 hr

Rehabilitation, Reconstruction and Recovery

1. Reconstruction and Rehabilitation as a Means of Development.

2. Damage Assessment

3. Post Disaster effects and Remedial Measures.

4. Creation of Long-term Job Opportunities and Livelihood Options,

5. Disaster Resistant House Construction 6. Sanitation and Hygiene

7. Education and Awareness,

8. Dealing with Victims' Psychology,

9. Long-term Counter Disaster Planning

10. Role of Educational Institute.

References:

Dr. Mrinalini Pandey, Disaster Management, Wiley India Pvt. Ltd.

Tushar Bhattacharya , Disaster Science and Management, McGraw Hill Education (India) Pvt. Ltd.

Jagbir Singh, Disaster Management : Future Challenges and Opportunities , K W Publishers Pvt. Ltd.

BIOPROCESS & BIOREACTOR ENGINEERING CH-812

Course Objective:

1) To identify the difference in reaction engineering behavior between enzymes catalyzed reaction and life cell catalyzed reaction

2) To illustrate the mechanism of enzyme catalyzed reaction in both free and immobilized form and to recognize different factors affecting the rates.

3) To analyze biochemical rate laws in global perspectives.

4) To analyze parametric sensitivity, instability etc.

5) To design industrial bioreactor and develop scale-up and control strategies.

Course outcome:

I. Learn fundamentals of bioprocess and biochemical reactions

II. Identify reaction mechanism

III. Design and analyze various reactors

IV. Compare performances and select type of reactor and reactor assembly

V. Learn industrial applications of reactors

VI. Solve reactor problems of different difficulty levels through tutorials

VII. Complete process design of a reactor through assignment / group task

Course Syllabus:

Module I:

Introduction to the kinetics of Bioprocess; Enzyme kinetics; Cell growth kinetics; Kinetics of metabolic product synthesis by cells; Introduction of segregated and non-segregated models; Kinetics of immobilized enzymes and cells.

(10 hrs)

Module II:

Background of bioreactors, Type of bioreactors – Airlift bioreactors, Airlift pressure cycle bioreactors, Loop bioreactor, Stirred tank bioreactors, Fluidized bed bioreactors, Trickle bed bioreactor, Bubble column fermenter, Design equations for CSTR fermenter, Two stage reactors, Reactors with non ideal mixing, Parametric sensitivity, Multiplicity in Biosystems, Global and local stability analyses of Bioreactors.

(10 hrs)

Module III:

Bioreactor controlling probes, Characteristics of bioreactor sensors, Temperature measurement and control, DO measurement and control, pH/redox measurement and control, Detection and prevention of the foam, Biosensors.

(10 hrs)

Module IV:

Downstream processing in bioprocesses; Industrial application of bioprocesses. Bioprocess considerations in using animal cell cultures and plant cell cultures.

(10 hrs)

Text books:

1. J. E. Bailey, D. F. Ollis, Biochemical Engineering Fundamentals, Second Edition, Mc. Graw Hill Inc., Singapore, 1986.
2. H. W. Blanch, D. S. Clark, Biochemical Engineering, Special Indian Edition, Marcel Dekker Inc. New York, 2007.
3. M. L. Shuler, F. Kargi, Bioprocess Engineering - Basic Concepts, Second Edition, Prentice Hall of India Private Ltd., New Delhi, 2002.

Reference books:

4. P. M. Doran, Bioprocess Engineering Principles, Academic Press, California, 2009.

5. J. Nielsen, J. Villadsen, G. Liden, Bioreaction Engineering, Second Edition, Springer, 2007.

6. N. C. Price and L. Stevens, Fundamentals of Enzymology: The cell and Molecular Biology of Catalytic Proteins, Third Edition, Oxford University Press, Oxford, 2006.

7. D. G. Rao, Introduction to Biochemical Engineering, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2008.

PROCESS UTILITIES & MATERIALS CH813

Course Overview: The course highlights the basic understanding of various process utilities viz. water, steam, compressor, vacuum pumps, valves, insulator, pipes, fittings, accessories, their role and importance in chemical process industries and allied operations. Different methods of treatment of polluted and contaminated water through conventional processes. Applications of pumps, valves and joints in pipelines. Installations of refrigeration and cooling unit in specified segments of process plants. Problems to work out on energy efficiency of pump, power input, discharge volume, pressure drop etc.

Course objectives:

- To create a fundamental understanding of importance of water, water sources, storage, consumption pattern, reuse and treatment methods.
- To enable to solve simple numerical problems on steam economy, steam effectiveness and condenser duty of an evaporator.
- To introduce the concept of refrigeration and heat pumps and their application in process industries; solve the problems on COP, work input and cooling effect produced of refrigeration system.
- To introduce the concept of insulation system in heat transfer device, thermal contact resistance and work out the problems on conductive, convective and radiative heat transmission.

Syllabus:

Module - I (12 L)

Water: Importance of water: for human life, agriculture purposes, industrial purposes; sources of water: Lakes, reservoirs, rivers, groundwater, 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.
6 hrs
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. **6 hrs**

Module - II (8 L)
Compressors and Vacuum Pumps: Types of compressors: single stage and multistage, 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. **8 hrs**

Module - III (8 L)

Refrigeration Systems: Working principle of refrigeration system and their characteristics, Coefficient of Performance, work and heat load calculation, different refrigerants, their desirable characteristics, negative impact on the environment and humidification and de humidification equipment, drying.
4 hrs
Cooling tower, air blending, exhaust, ventilation, cryogenics, their characteristics and production of liquid N_2 and O_2.
4 hrs

Module - IV (12 L)

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.
6 hrs
Inert Gases: Introduction, properties of inert gases & their use, sources and methods of generation, comparison of nitro generation routes, general arrangement for inerting system, operational, maintenance and safety aspects.
6 hrs

Books & Reference:

1. Jack Broughton; Process utility systems; Institution of Chem. Engineers U.K.
2. Unit Operations–Chemical Process Principles – Part-I - Haugen, Wartson & Ragatz (CBS)
3. Reid, Prausnitz poling; The properties of gases & liquids, IV ed. McGraw Hill

international ed.
4. S. C. Arora & S. Domkumdwar; A course in refrigeration and air conditioning; Dhanpat Rai & Co.(P) ltd.

COMBUSTION ENGINEERING CH-814 (3-0-0)

(Teachers involve: AKS, GNH)

Objective: This course explores the basic concepts of properties and combustion mechanism of solid liquid and gaseous fuel. It deals with the techniques for coal gasification and clean coal technologies. It covers the principles of conservation of mass, and energy for simulation, data analysis. It also emphasis on measuring instruments for combustion gases. The theory of diffusion flame and premixed flame is elaborated for the design of industrial burners. The fluidized bed combustion of solid fuel in bubbling bed and circulating bed is addressed in order to design the industrial BFB and CFB. Many numerical problems are solved to understand the theory.

Module – 1 **12 hrs**

- **Properties of solid liquid and gaseous fuels-**
  Classification, Composition, Calorific Values, Lower and higher heating values, ASTM test techniques of solid, liquid and gaseous fuels. **2hrs**

- **Gasification of coal –**
  Coal gasification technologies, chemical reactions, process conditions, design of gasification equipments. Underground coal gasification technology, process routes
  5hrs

- **Clean coal Technologies:**
  What is clean coal technology? Principle and objectives.

  Oxyfuel combustion, Biochar, Carbon capture and storage, Carbon sequestration, Kyoto Protocol, Mitigation of global warming, Refined coal **5 hrs**

Module – 2 **10 hrs**

- **Stoichiometry of combustion -**

Chemical equations, Mass and energy balance of solid liquid and gaseous fuel combustion, problems on Fuel efficiency, excess air ratio and draft.

Gas analyzers- orsat and modern gas analyzes 5hrs

- **Combustion of liquid and gaseous fuels**

Theory of diffusion flame, length of diffusion flame, chemical properties of diffusion flame & Premixed flame and its nature
3 hrs

- **Burner design for liquid and gaseous fuel**

Types of Burners, design parameters and problems **2 hrs**

Module – 3 **(14 hours)**

- **Combustion of solid fuels**
  Stages of combustion- drying, de-volatilization, volatile combustion char combustion.

  Pulverized coal combustion, burner design

  Combustion in fluidized bed system, burning rate in fluidized bed, factors affecting combustion efficiency.

Combustion in bubbling fluidized bed boilers-

Combustion mechanism dense phase and lean phase concept and mass and energy balance, Recirculation of fly ash, effect of design parameters on combustion efficiency.

Combustion in circulating fluidized bed boilers-

Combustion and reaction mechanism, Cyclone design and its effect on combustion efficiency

Design procedure for bubbling and circulating fluidized beds

Different types of distributor plates in fluidized bed, distributor grids bubbling bed and CFB beds.

Text : 1. Combustion and Fuel Technolog, A.K. Shaha

2. Combustion and gasification in Fluidized bed, Prabir Basu, Taylor & Francis

PROCESS ANALYSIS AND OPTIMISATION CH-815

(Teachers involve: SP,KCG, BD)

Course overview:

Mathematical modeling of physical and chemical processes related to chemical engineering often leads to a system of complex model equations. Attempts have been made to solve these equations with analytical methods and numerical methods. Numerical methods have substantiated to arrive at solutions of the model equations, which are very difficult to solve using analytical methods. The methods are exercised to perform chemical process calculations and chemical process simulations.

Course objectives:

1. To formulate chemical engineering problems in mathematical terms by employing the appropriate microscopic and macroscopic balances.

2. To determine and apply the appropriate methods used to solve the resulting governing equations, namely linear and nonlinear algebraic equations, ordinary differential equations, and partial differential equations.

3. To assess when numerical methods are needed for the solution of governing equations

4. To solve them accordingly using mathematical software packages.

5. To identify and interpret the differences between model predictions and experimental results

Module ContentsHrs.

I Cramer’s rule, Inverse of matrix, Gauss elimination, Gauss Jordan method, LU decomposition, Gauss Seidel method, error analysis, Linear regression 9

II Bisection method, successive substitution method, Newton-Raphson method, Secant method 6

III Eigen values, Eigen vectors and its application in solving differential equations 5

IV Multi-variable optimization algorithms: Unidirectional search, Direct search methods, Gradient based methods.

Constrained optimization algorithms: Kuhn-Tucker conditions, Transformation methods 8

V Sensitivity analysis, Direct search for constrained minimization, Linearized search techniques, Feasible direction method, Generalized reduced gradient method, Gradient projection method 6

VI ODE- Initial Value Problem, Boundary Value Problem

Specialized algorithms: Integer programming, Geometric programming

Nontraditional optimization algorithms: Genetic algorithms, simulated annealing, Global optimization. 6

Total 40

Text Book and references

1. S. K. Gupta, "Numerical Techniques for Engineers", New Age International Publishers, 3rd edition, 2015

2. Deb K., Optimization for engineering design, Algorithms and examples, Prentice Hall of India, New Delhi, 2005.

3. Mathematical Methods in Chemical & Environmental Engineering: Ajay K.Ray, Thomson Learning, 2000.

Boiling Heat Transfer CH 816 (3-1-0)

(Teachers involve: SP)

Course Objective

This course covers mechanism of several classes of boiling phenomena and related flow boiling regimes

Course Outcome

I. Concept of a vapor bubbles

II. Understanding micro-convection of heat

III. Computing boiling regimes and heat transfer coefficients

IV. Switching of boiling regimes and thermal oscillations

V. Differentiating pool boiling and flow boiling

Module I: Concept of a vapor bubbles (10)

Boiling; Bubbles; growth mechanisms

Module II: boiling regimes and heat transfer coefficients (15)

Various boiling regimes; determination of heat transfer coefficients; subcooled boiling; saturated/bulk boiling;

Module III: Boiling flow Instabilities (15)

Types of instabilities; their mechanisms; consequences

Module IV: Condensation (10)

Collapse of vapor bubbles; their mechanism;

Course Assessment Method: The theory performance of students are evaluated

Text Book

1. John G. Collier, John R. Thome, Convective Boiling and Condensation, Clarendon Press, 1994

2. L S Tong , Y S Tang, Boiling Heat Transfer And Two-Phase Flow, CRC Press, 1997
3. R.T. Lahey, Boiling Heat Transfer, ELSEVIER, 1992

OPEN ELECTIVES-1

Fuels and Combustion CH 540

Course objectives:

This is a bridge course for non chemical engineering background students. It deals with an idea about different solid, liquid, gaseous fuels, their origin, composition, classification, combustion & conversion processes and applications.

Course Outcomes:

I. Learn classification of fuels and basic terminology

II. Identify sources and characteristic properties of fuels

III. Design and analyze fuel processing equipment

IV. Compare performances and select type of fuel processing equipment

V. Learn industrial applications of fuel processing equipments

VI. Solve mathematical problems of different difficulty levels through tutorials

VII. Complete design of a fuel processing equipment through assignments/ group task

Syllabus

- Introduction: Survey of different sources of energy and their utilization. 2 hrs.
- Fossil fuels: Coal, Petroleum and gaseous fuels. 4 hrs.
- Coal: origin and formation of coal, Petrographic constituents of coal, Characteristics of Indian coal deposits, Reserve of metallurgical coal, Properties and testing. Classification of coal, Coal preparation-washing and blending, carbonization of coal -LTC and HTC. Testing and properties of coke. 12 hrs.
- Petroleum: Origin and processing of crude petroleum, properties and testing of petroleum products and their applications. 8 hrs.
- Gaseous fuels: Classification. Manufacture of producer and water gas. 6 hrs.
- Principles of combustion: Combustion characteristics and stoichiometric calculations. Combustion appliances-Furnaces, waste heat recovery systems and burners and their design. 8 hrs.

Text books:

5. Modern Petroleum Refining: B. K. B. Rao
6. Fuels & Combustion: Samir Sarkar

Reference books:

6. Petroleum Refining Engineering: W. L. Nelson
7. Petroleum Refining Technology & Economics: J.H. Gary & G.E. Handwork

HEAT TRANSFER CH-541

Course Overview: The course covers theory and problems on conduction, convection and radiation. • Detail design and analysis of performance of heat exchangers and evaporators. It covers design and analysis of reactor heating and cooling systems.

Course objectives: To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.

Module I

- Mechanism of heat transmission: Conduction, Convection and Radiation. (2 Hrs.)

Conduction: Fourier’s law; Steady-state heat transfer through composite slabs, cylinders and spheres; Optimum thickness of insulation; Unsteady-state heat transfer - use of Gurnie-Lurie chart, one and two-dimensional conduction in different geometry. (12 Hrs.)

Module II

- Convection: Forced convection; Thermal boundary layer; Analogy between heat and momentum transfer; Dimensional analysis of heat transfer; Heat transfer coefficients; Log-mean temperature difference; General equation for forced convection; Equivalent diameter; Natural convection; Condensation; Boiling of liquids.
  (10 Hrs.)

Module III

- Radiation: Black body and Gray body; Laws of radiation; View factor; Radiant heat exchange between surfaces; Radiation from flame, gases and vapors. (7 Hrs.)

Module IV

- Heat exchangers: Type of different heat exchangers and their design - Double pipe, Shell and tube, finned tube and Compact heat exchangers; Condensers and reboilers.

  (9 Hrs.)

- Evaporation: Type of evaporators with accessories; Capacity and Steam economy; Boiling point rise/elevation; multiple effect evaporators; Design of single and multiple effect evaporators.
  (8 Hrs.)

Text Books:

3. Process Heat Transfer – D.Q.Kern (McGraw-Hill)
4. Heat Transmission – Mc Adams (McGraw-Hill)
5. Heat Transfer : Principles and Applications – Binay K. Dutta (Prentice-Hall India)

OPEN ELECTIVES-II

NON-LINEAR DYNAMICS CH 840

Course objectives: This course will cover the elementary concepts of the dynamical behavior of chemical, biochemical systems and mechanical systems.

Course outcomes: The students will be able to do the followings:

1. To understand steady-state multiplicities
2. To determine chaotic and periodic behaviors of the systems using bifurcations, limit cycle, bifurcation diagrams, power spectrum, phase-plane plots, period doubling, time-series plots, Lyapunov exponents and Lyapunov functions

Module I: Theories of ODEs

First-order ordinary differential equations, basic ideas. Definitions of stability and elements of linear algebra. Stability of homogeneous linear systems, fundamental stability theorem for nonlinear systems. Uniqueness Conditions for Linear and Nonlinear Systems
10 Hrs

Module II: Periodic solutions and Bifurcations:

Phase portraits; Hopf bifurcations; period doubling; Poncare maps; Ruelle Takens scenario; Floquet matrices and stability. Maps; Reduction of flows to maps; Reconstruction of phase space from one-dimensional signals. 10 Hrs

Module III: Quantitative analysis of strange attractors

Liouville's theorem and conservation of areas in phase space; Sensitivity to initial conditions; Stretching and folding;.
Lyaponov exponents; Fractal dimension; power spectrum, Lyapunov exponents and Lyapunov functions
10 Hrs

Module IV: Case studies

Logistic equation, Lotka-Volterra predator-prey mechanism, Oscillating Chemical Reactions: Brusselator and Oregonator, Lorenz and Rössler attractors, adiabatic and nonadiabatic CSTRs, fermenters, boiling flows, etc.

10 Hrs

1. Pushpavanam, S., Mathematical Methods in Chemical Engineering, PHI Learning
2. Strogatz, S. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry and Engineering by

COMPUTER AIDED PROCESS DESIGN CH 841

Objective: To familiarize students with computer aided design of Industrial processes / equipment and make them acquainted with development of CAD (software) packages.

Outcome: Students are groomed to become confident design engineers / process simulators. They are also made conversant with all aspects of chemical engineering science, since development of CAD packages demands proficiency in all unit operations and unit processes.

Module 1: Computer Aided Design of Pressure Vessels. CAD of cylindrical / spherical vessels under internal / external pressure, CAD of heads and closures, CAD of flanges, CAD of tall vessels / high pressure vessels, CAD of pipes, tubes. CAD of storage vessels, CAD of vertical / horizontal supports.

08 hrs

Module 2: Computer Aided Design of Heat Transfer Equipment. CAD of heat exchangers (shell and tube, double pipe, plate exchangers, finned exchangers). CAD of condensers, evaporators, multiple effect evaporators.

10 hrs

Module 3: Computer Aided Design of Mass Transfer Equipment. CAD of absorbers (packed columns, falling film absorbers), absorption with chemical reaction, CAD of extractors (liquid – liquid), CAD of leaching equipment.

08 hrs

Module 4: Computer Aided Design of Heat and Mass Transfer Equipment. CAD of continuous fractionators (sieve plate, bubble – cap fractionators), CAD of muti-component distillation systems, CAD of industrial dryers (batch, continuous, direct and indirect dryers), CAD of cooling towers.

12 hrs

Module 5: Computer Aided Design of Energy Systems. CAD of flat plate solar collectors (water heating, air heating), CAD of parabolic trough solar concentrators, CAD of regenerators and heat recovery systems.

10 hrs

Module 6: Computer Aided Design of Reacting Systems. CAD of packed bed, fluidised bed, semi – fluidised bed and inverse fluidised bed reactors. CAD of slurry reactors. CAD of bioreactors. Nonideal reactor modelling and development of simulation packages. 12 hrs

Text

1. Narayanan, C. M. and Bhattacharya, B.C., Computer Aided Design of Chemical Process Equipment, New Central Book Agency, Calcutta, 1992

2. Narayanan, C. M. and Bhattacharya, B.C., Unit Operations and Unit Processes - Vol. I & II, CBS Publisdhers, New Delhi, Revised Edition, 2005

Process Intensification (CH 842)

Course objective

Amidst stringent environmental regulations, process intensification is the only route for sustainable business operations of the chemical and allied process industries. This course intends to form the foundation of the budding chemical engineers in this emerging technology domain. The course focuses on the back ground of rapid emergence of process intensification as a subject essential to sustainable operations of the process industries. The course covers the avenues of process intensification with major thrust on emergence of membrane based novel hybrid plants, analysis of degree of process intensification as a result of implementation of membrane based new and green technologies. The critical aspects of dynamic modelling of the complicated transport phenomena will be particularly focused along with modelling and simulation of the novel processes with promising profit margin without affecting the mother earth. As sustainable technologies are expected through product and process innovations, this course attempts to ignite passion of the students towards innovation that shows light at the end of the tunnel.

Syllabus in the form of lesson plan

Definition of process intensification, relevance and background of rapid emergence -2 h

Overview of the possible avenues of process intensification: 2h

Green chemistry in process intensification: 2h

Process intensification through innovative chemical reactors: 2h

Process intensification through monolith reactors: 2h

Process intensification through membrane integration with reactors- 4h

Process intensification through reactive distillation; 2h

Process Intensification through: Reactive Extractive Technology; 2h

Process intensification through Absorption technology: 2h

Process intensification in waste treatment plants through membrane integration: 4 h

Process intensification in groundwater treatment through membrane based treatment: 4h

General transport modelling approaches: 2h

Dynamic modelling and simulation of nanomembrane based process plants: 4h

Dynamic modelling and simulation of nanomembrane based water treatment plants for industrial wastewater: 4h

Dynamic modelling and simulation of membrane based groundwater treatment plants: 4

Membrane distillation in process intensification: 4h

Case studies of process intensification: Chlor alkali industry, organic acid plants. 4h

Challenges in building scale up confidence, dynamism in implementation: 2

References:

1. Groundwater Arsenic remediation: Treatment Technology & Scale Up: P.Pal, pub: Elsevier Science

2. Membrane Science & Technology in Industrial wastewater Recovery and Reise: Simon Judd and Bruce Jefferson, Elsevier Sc.

3. Introduction to Membrane Science and Technology, Henrich Strathmann, Wiley

4. Reactive Distillation status and future directions: K.Sundmacher and A.Kienle, Wiley-VCH: Weinheim 2003.

5. Re-engineering the Chemical Processing Plants, A. Stankiewicz and J.A. Moulijn (Ed.), Marcel Dekker, 2004.

CH 851 REACTION ENGINEERING LABORATORY

Objective:

- Students can get hand on experience in prototype system.
- The students are learning the gap between the theoretical and practical phenomena in terms of outcome [results].
- Students also learn the safety in handling pilot scale instruments.
- Student's knowledge in Prototype system will help them to idea of commercialization.
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List of Experiments in reaction Engg Laboratory:

1. Study of dye removal using Fenton oxidation process and evaluation of its Kinetic data.
2. Study of non – catalytic homogeneous saponification reaction in a Continuous stirred tank reactor and to interpret the kinetic data of the given reaction in the form of a rate equation.
3. Study of non – catalytic homogeneous saponification reaction in a tubular flow reactor and to interpret the kinetic data of the given reaction in the form of a rate equation.
4. Residence distribution (RTD) Studies in CSTR.
5. To Study of non – catalytic homogeneous saponification reaction in a Isothermal Batch reactor and to interpret the kinetic data of the given reaction in the form of a rate equation.

CH 852 PROCESS CONTROL AND INSTRUMENTATION LAB

Course Outcome

I. To measure the steady state response and dynamic response of a process system

II. To compare the responses with those obtained from the mathematical model

III. To validate the methods for closed-loop stability analysis in context to a practical controller

IV. To validate the controller tuning methods in context to a practical controller

Experiments

1. Determination of Time constant of temperature sensor
2. Determination of Time constant of pressure sensor
3. Determination of Damping coefficient of a Manometer
4. Determination of Control valve characteristics
5. Response of interacting and non-interacting system
6. Online tuning of Level controller (H/W) and trainer (S/W)

CH 853 SEMINAR-2

Objective: To be acquainted with the oral communication and learn how to present the technical information related to the field of chemical engineering in processes, equipment, research and consultancy projects.

Outcome: Students are made conversant with the present advancement and trend of technology in process industry adaptation of processes / phenomena developed in academic institutions and research laboratories.

Module 1: Presentation of seminar by each student. To enhance the presentation quality and give stress on the technical content, effective presentation and confidence in addressing questions from the audience.

30 hrs

Module 2: Preparation of technical report by each student. Assessment based on technical content, quality of technical writing, literature surveyed and cited.

10 hrs