Heat Transfer Operations

T.E. Sem. V [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical with Oral Exam.	–	25
Term Work	–	25

SYLLABUS

1. **Introduction**
   Applications of heat transfer, Mechanisms of heat flow, Basic considerations.

2. **Heat Transfer by Conduction**
   Fourier's Law; Comparism with Newton's Law of Viscosity; Thermal Conductivity; Steady state Conduction : Conduction through a flat slab; Compound Resistances in series; Conduction through a thick walled Cylinder; Critical Radius of insulation; Conduction through a spherical Shell and to a particle; Unsteady state conduction : Heating or cooling of a large Slab, an infinitely long cylinder or sphere; Semi–infinite solid; Heating of particles; Systems with negligible internal resistance; Systems with Varying Fluid temperature.

3. **Individual or Surface Heat Transfer Coefficient**
   Concept and Definitions; Temperature Gradients; Overall Heat Transfer Coefficients (U); Resistance Form of U; LMTD; Heat Transfer Between Fluids separated by a cylindrical Wall; Wilson Plot; Fouling Factors; Typical Heat Exchange Equipment : Shell and Tube Heat Exchanger, Double Pipe Heat Exchanger; Enthalpy Balances.

4. **Forced Convection**
   Thermal Boundary Layer and Flow Regimes; Dimensional Analysis : Principles and Applications; Various Empirical Correlations: Graetz, Dittus–Boelter, Sieder–Tate and Colburn Equations; Estimation of Wall Temperature; Cross Coefficients; Overall Coefficient; Enthalpy Balances for Single Effect Evaporators with negligible and appreciable Heat of Dilution; Multi–effect Evaporators; Methods of feeding, Capacity and Economy, Effect of Liquid Head and boiling point Elevation; Vapor Recompression.

References :

1. Perry's Chemical Engineers Handbook 6th Ed., *(Peryy, R.H. et.al)* McGraw –Hill, International Edition, 1984.
2. Unit Operations Handbook Vol 1 & 2, *(McKetta J.J. et.al.)* Marcel Dekker, 1992
3. Heat Transfer Design Methods *(McKetta J.J. et.al)* Marcel Dekker, 1992
4. Chemical Process Equipment Selection and Design*, (Walas S.M.)* Butterworths Heinemann, 1990.
5. Transport Processes and Unit Operations 3rd Ed.*(Gean Koplis, C.J.)* Prentice Hall of India, 1997.
6. Principles of Unit Operations *(Foust A.)* John Wiley & Sons (Asia), 2nd Ed., 1980.
7. Process Heat Transfer *(Hewitt, G.F. et.al)* CRC Press, New York, 1994
8. Chemical Engineering Vol.1, 4, 5, 6 Ed., *(Coulson, J.M. et al. Coulson & Richardsons)* Butterworth Heinmenn Ltd., 1996.
9. Unit Operations of Chemical Engineering, 5th Edition *(McCabe, W.L. Smith, J.C. Harriot P.)* McGraw Hill International Edition.
10. Process Heat Transfer *(Kern D.Q.)* Tata McGraw Hill Ed. 1997
11. Heat Transfer 7th Edition *(Holman J.P.)* McGraw Hill.
12. Engineering Heat Transfer *(N.V.Suryanarayana)* Penram International Publishing Pvt. Ltd.

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Chemical Engineering Thermodynamics–I

T.E. Sem. V [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical with Oral Exam.	–	–
Term Work	–	25

SYLLABUS

1. Introduction; Concepts of System, surrounding, process, cycle, state and path functions, heat and work interactions, reversible and irreversible process; Concept of internal energy and enthalpy; First law of thermodynamics. Application of the first law of thermodynamics to various types of process and cycle. Thermodynamic analysis of flow process.

2. Limitations of the first law of thermodynamics and the need for the second law. Concepts of heat engine, heat pump and refrigerator. Second law of thermodynamics. Carnot cycle and Carnot principle.

3. Clausius inequality; Concept of Entropy; Estimating entropy of reversible and irreversible process and cycles. Availability and lost work.

4. Ideal gas and real gas behaviour. Equations of state (EOS); Van Der Waals, Berthelot, Dietrici, Redlich–Kwong, Redlich–Kwong Redlich–Kwong Soave, Virial, Peng Robinson. Applications of the above mentioned equations of state to a pure gas. As well as to a mixture of gases.

5. Definition of Helmholtz energy and Gibbs energy. Maxwll's relations; Various thermodynamic relations; Joule Thompson effect and estimation of Joule Thompson coefficient For gases.

6. Residual properties. Residual enthalpy and entropy. Thermodynamic charts, diagrams and its use. Fugacity and fugacity coefficient.

References:

1. Chemical Engineering Thermodynamics *(Sandler S.L.)* John Wiley, 1989
2. Chemical Engineering Thermodynamics *(Daubert T.E.)* McGraw Hill, International edition, 1994.
3. Thermodynamics for Chemists *(Glasstone)* Van Nostrand East–West Press, 1964.
4. Phase Equilibria *(Walas J.W)* Prentice Hall N.J.
5. Introduction to Chemical Engineering Thermodynamics *(Smith J.M. and Van Ness H.C)* McGraw Hill, 1994.
6. Chemical Engineering Thermodynamics *(Rao Y.V.C.)* University Press, 1997.

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Process Equipment Design & Drawing –I

T.E. Sem.V [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical with Oral Exam.	–	–
Term Work	–	25

SYLLABUS

1. Introduction to Chemical Process Equipment Design. Nature of process equipment design, Standards, codes & their significance, equipment design, Standards, codes & their significance, equipment classification & selection, Review of stresses due to compression & tension : bending; torsion; temperature effects; principal stresses & theories of failure, materials of construction for chemical process equipments, Design pressure, Design temperature, design stress & design loads, Significance of factor of safety, Review of fabrication techniques, Economic & Environmental considerations in the design process.

2. Design of Unfired Pressure Vessels :

Types of pressure vessels, codes & standards for pressure vessels (IS : 2825 : 1969), material of Construction, Selection of Corrosion Allowance & weld joint efficiency purging of vessels.

PART A : Pressure Vessel Subjected to Internal Pressure.
Complete Design as per IS : 2825 : 1969 involving
Shells : Cylindrical, spherical & conical.
Study, selection & design of various heads such as Flat, hemispherical, torrispherical, elliptical & conical.
Openings/nozzles, oblique nozzles & manholes etc.
Fanged joints :
Gasket : Types, selection & design.
Bolt design & selection
Flange dimensions & optimization for bolt spacing.

PART B : Pressure Vessel Subjected to External Pressure.
Design of shell, heads, nozzles, flanged joints & stiffening rings design of column supports for the brackets.
Design of saddle supports, Ring stiffeners, Assembly and detailed design with sketches of supports (not to scale).

Inspection, Testing & Quality Management :
Inspection of equipment, Testing of equipment by using non–destructive tests like Pressure tests. Hydraulic and pneumatic Tests & application of various NDT methods which wee covered in the subject Fabrication Techniques of Sem III, Concepts of ISO and Quality Management for process plant.

References :

1. Process equipment design–vessel *(Lloyd E. Brownell and Edwin H. Young)* John Wiley, New York 1963.
2. Chemical Engineering Volume – 6 *(J.M. Coulson, J.F. Richardson and R.K. Sinnott)* Pergamon press International Edition 1989.
3. Introduction to Chemical equipment design – Mechanical Aspects *(B.C. Bhattacharya)* CBS Publications.
4. Process Equipment Design *(M.V. Joshi)* Macmillan India.
5. Pressure Vessel Hand Book *(Eugene F. Megyesy)* Pressure Vessel Company USA.
6. Design of machine elements *(V.B.Bhandari)* McGraw hill.
7. Appropriate ISI Specifications and codes for unfired pressure vessels, viz.IS:2825, IS:803, IS:1182, IS:4853, IS:3658, IS:3703, IS:3664, IS:4260, IS:4072, IS:5403, IS:4049, IS:4864, IS:4870, IS:3133, IS:1239, IS:6392, IS:6418, IS:2062, IS:1730, IS800, IS:808, IS:1972, IS:3132, IS:1363, IS:2585, IS:3138, IS:2693, IS:3653, IS:3503, IS:5428.
8. ASME CODE division VIII Section 1 &2.
9. Equipment Design Handbook for refineries and chemical plant vol. 1 & 2 *(Evans F.L.)* Gulf Publishing 1980.
10. Structural analysis and design of equipment by *(Jawad M.H., Farr J.R.)* John Wiley 1984.
11. Mixing theories and practices *(Uhl V.W. and Grey J.B.)* Academic press New York 1967.
12. AutoDesk 'Manual & Guide on AutoCAD 2000 & Mechanical Desktop / Inventor.
13. ISO–9000 series of quality standards.

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Solid Fluid Mechanical Operations

T.E. Sem.V [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical with Oral Exam.	–	25
Term Work	–	25

SYLLABUS

1. Introduction: Scope and application of Solid Fluid operation
Particulate System and Characterization
Introduction to sub micron to mm range. Particle size, measurement methods, shape factore and its measurement, application, particle size distribution, their measurement and representations, by cumulative and differential analysis.

2. Size Reduction of solids
Characterization of comminuted solids. Criteria for combination. Energy and power requirements in combination (crushing laws), size reduction equipments and operations of the equipments (major equipments)
Screening Efficiency of the screens, ideal and actual screens, screening
Equipments, capacity and effectiveness of screens

3. Storage and handling of bulk solids
Relevant properties of particulate masses such as Angle of repose/ internal friction etc. Vertical / lateral pressure calculations. Storage in bins and hoppers. Flow from bins and hopper. Equipments for solids conveying conveyors, elevators and feeders.
Pneumatic and Hydraulic conveying principles, equipments for vertical / horizontal transport (No Numerical).

4. Solid liquid separation

- Sedimentation Principles (gravity). Batch sedimentation phenomena of fine and ciarse sikuds, methods to find out the area of thickener and the total depth. Equipment for gravity thickening.
- Centrifugal Sedimentation principles, sigma theory, equipments for centrifugal sedimentation.
- Flocculation–Electrical phenomena at interfaces, interactions between particles, coagulation phenomena, coagulation kinetics, effect of flocculation on sedimentation. Froth flotation, principle equipments.
- Jigging, Tabling, Scrubbing etc.

5. Filtration, Filtration Theory and principles (batch Filtration) constant rate, Constant pressure filtration, effect of cake compressibility, Filtration cycles, filtration equipments (batch and continuous types of filtration and theory equipment)
Hydrocyclone construction / sizing / operation principles, introduction to microfiltration.

6. Gas solid separation (Gas cleaning) Solid separation, construction / operation / specification of cyclone separators / its design variations, fabric filters, Dust collectors, Electrostatic precipitator.
Size enlargement Mechanics of Agglomeration / construction / operation / selection / specification of some equipment. Equipment like pressure compaction, pan granulators, Prilling, Drum granulators etc. (No Numericals)
Mixing of solids – solid mixing equipments construction Oeration selection for free flowing solids and for cohesive solids.

References :

1. Perry's Chemical Engg. Hand Book *(Perry R. II, Green D.)* McGraw Hill, 6th Edition 1984.
2. Chemical Process Equipment, Selection and Design *(Walas S.M.)* Butterworth Henemann 1990.
3. Seperation Processes *(King C.J.)* Tata McGraw Hill, 1974
4. Principles of Unit operations 2nd Edition *(Foust A.S. et al.)* John Wiley & Sons. 1980.
5. Introduction to Chemical Engg. *(Badger and Banchero)*
6. Unit Operations of Chemical Engg 5th Edition *(MaCabe W.L., Smith J.C.Harriot P.P.)* McGraw Hill International 1993.
7. Coulson and Richardson's Chemical Engg. 4th Edition Vol 1, 2 *(Coulson J.M. Richardson J.E. Backhurst I.R. Harker J.H.)* Pergamon Press, 1990.
8. Coulson and Richardson's Chemical Engg. 2nd Edition, Vol 6. *(Coulson J.M., Richardson J.F. Sinnot R.K.)* Pergamon Press, 1993

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Mass Transfer Operations – I

T.E. Sem.V [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical with Oral Exam	–	25
Term Work	–	25

SYLLABUS

1. Diffusion in Liquids and gasses: Fick's Law of Diffusion, Definition of various fluxes and relation between them

Diffusivity – definitions and method of estimations, binary and multi component situations

Special case of binary mass transfer – equimolar counter diffusion and diffusion of one component through non diffusing second component, numerical examples.

Diffusion in solids, types of solid diffusion, numerical examples.

2. Mass transfer coefficient definition and evaluation in Laminar flow Turbulent flow

Theories of evaluation of mass transfer coefficient

Evaluation of mass transfer coefficient through analogy with heat and momentum transfer, numerical examples.

Effect of mass transfer on heat transfer

3. Inter phase mass transfer : Equilibrium

Mass transfer coefficient in individual phases

Overall mass transfer coefficient and relation between local and overall coefficient. Concept of phase with major resistance to mass transfer, numerical examples.

Methods of contacting phases: stage wise and continuous contact. Co–current, counter – current and cross current operations. Example of operation.

Equilibrium stage definition and concept, steady state, equilibrium stage operation: material balance, concept of operating line and equilibrium line, theoretical stage, point and sage efficiencies, overall efficiencies.

Continuous contacting, concept of NTU, HTU, HETP etc.

4. Equipment for gas liquid contacting : Construction, sizing and operation

(Mass transfer operations, efficiencies, general characteristic, dimensions and operating characteristics, numerical examples.)

Gas dispersed gas continuous – sparged vessels, tray tower and mechanical agitated vessels.

Liquid dispersed in continuous gas phase – venture scrubber, spray chambers, wetted wall column etc.

Packed towers.

Comparison of stage wise and continuous contacting equipment.

5. Gas Absorption

Equilibrium (solubility of gasses in liquids), effect of temperature and pressure, reference substance plots, ideal and non–ideal solution, Heat of solution, factor affecting choice of solvent.

Single component isothermal gas absorptions : stage wise and continuous contact. Co–current, counter current and cross current operations, concentrated and dilute solutions, Relation between overall and individual phase HTUs, numerical examples.

Single component adiabatic gas absorption: Equations and method of calculations (numerical examples not included

Multi component isothermal gas absorption: Equations and method of calculations (numerical examples not included

Absorption with chemical reaction: Examples with mass transfer controlling, equation and numerical examples Equipment description

6. Humidification and de–humidification operation:

Vapor liquid equilibrium and enthalpy, numerical examples

Vapor–gas mixtures : Definitions, Saturated and unsaturated mixture characteristic, Review of Psycrometric charts, Adiabatic saturation and wet bulb temperature, Lewis Relation, Numerical Examples.

Adiabatic Operation: (Air water systems) Water coolers, cooling towers, design of cooling towers, Numerical Examples.

Non–adiabatic operations: Evaporative cooling, Numerical Examples.

Equipment description

Drying:

Moisture Definitions and equilibrium

Drying operation – batch and continuous

Batch Drying – Mechanism, rate of drying curve, equipment and operation, Numerical Examples.

Continuous drying – equipment and operation

Design of rotary drum dryer, Numerical Examples.

References :

1. Diffusion: Mass Transfer in Fluid Systems, 2nd Edition, *(Cussler E.L.*) Cambridge University Press, 1998
2. Perry's Chemical Engineering Hand Book, 6th *(Perry J.H. and Chilton)* McGraw Hill, 1984.
3. Mass Transfer *(Sherwood T.K., Pigford R.L., and Wilke C.R.)* McGrall Hill, 1975.
4. Gas Separation By Absorption Process, *(Yang R.T.)* Butterworth, London, 1987
5. Handbook for Separation Technique Foe Chemical Engineer, *(Schweitze P.A.)*, McGraw Hill, New York, 1998.
6. Chemical Process Equipment : Selection and Design *(Walas S.M.)* Butterworth, London, 1989.
7. Handbook of industrial Drying *(Mujumdar A.S Ed)* Marcel–Decker, London, 1987
8. Transport Phenomena *(Bird R.B. and Stewart W.E. and Lightfoot E.N.)* Wiley, New York, 1960.

9 Transfer Operations 3rd Edition, *(Treybal R.E.)* McGraw Hill New York, 1980

10. Unit Operation in Chemical Engineering 5th Edition *(McCabe W.L. and Smith J.C.)* McGraw Hill, New York, 1993.
11. Transport Processes and Unit Operations *(Geankoplis C.J.)* Prentice Hall, New Delhi, 1997
12. Coulson and Richardson Chemical Engineering, Vol.1, *(Coulson J.M., Richardson J.F.Backhurst J.R. and Harker J.H.)* Butterworth Heinman, New –Delhi, 2000
13. Coulson and Richardson Chemical Engineering, Vol. 2 *(Coulson J.M., Richardson J.F., Backhurst J.R. and Harker J.H.)* Ashian Book Pvt. Ltd., New Delhi, 2000
14. Coulson and Richardson Chemical Engineering Vol–6, *(R.K. Sinnot)* Butterworth Heinman, New Delhi–2000

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Chemical Engineering Economics

T.E. Sem.V [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical with Oral Exam.	–	–
Term Work	–	–

SYLLABUS

1. **Basic principals of economics**
   - Importance of Economics to Chemical Engineer
   - Concepts of needs, cost and price etc.
   - Demand supply analysis
   - Economics of production
   - Markets and pricing
   - Introduction to economics of growth

2. **Interest and Investment Costs**
   - Types of Interest
     Simple Interest, Compound Interest
   - Nominal and effective interest rates, continuous interest
   - Present Worth and Discount
   - Annuities
   - Perpetuities and Capitalized Cost
   - Cash Flow in Chemical Project
   - Taxes and Insurance

3. **Cost Estimation**
   - Cash flow for Industrial Operation, Cumulative Cash Position
   - Types of capital cost estimates.
   - Factors affecting investment and production cost.
   - Constituents, capital – fixed, working
   - Estimation of capital investment and cost of product
   - Cost Indices
   - Break Even Analysis

4. **Depreciation**
   - Introduction to concepts of value, depletion, cost maintenance and repairs, service life, salvage value, scrap value, present value, book value, market value, replacement value
   - Methods for determining depreciation
     Straight–Line method
     Declining balance method
     Sum of years digits method
     Sinking Fund method
     Accelerated Cost Recovery system

5. **Profitability, Alternative Investments and Replacements**
   Mathematical methods for Profitability evaluation
   - Rate of return method
   - Discounted Cash Flow

- Net Present Worth
- Capitalized Cost
- Pay Out Period

Alternative Investments with small investment increments Replacements

6. Cost Accounting

- Concepts and definitions of financial ratios
- Balance sheets, profit and loss accounting
- Cost accounting and reporting

References :

1. Plant Design and economics for chemical engineers, 4th ed., *(Peters, M.S. and Timmerhaus, K.D.)* McGraw Hill, New York, 1995.
2. Capital cost estimating for process industries *(Kharbanda, O.P. and Stallworthy E.A.)* Butterworths, London, 1988
3. Jellens cost and optimization engineering, 3rd ed. *(Humphreys K.K.)* McGraw Hill, 1991.
4. Modern Economic Theory, 21st Edition, *(K.K.Dewett and Adarsh Chand)* S. Chand and Company.
5. Industrial Engineering and Management *(O.P. Khanna)*, Dhantpat Rai Publications (P) Ltd., 1992.

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Chemical Processes –I

T.E. Sem.VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical with Oral Exam.	–	–
Term Work	–	25

SYLLABUS

1. Introduction

1.1 Historical Development Of Chemical Industry In India
1.2 Material Resources And Shortcomings
Challenges Faced By Chemical Industry In India
Future Trends
1.3 Unit Operations And Processes concepts Used In Chemical Industries.
1.4 General principles applied in studying and industry.

2. 2.1 Nitrogen Industries : Manufacture Of Ammonia, Ammonium Sulphate, Urea And Nitric Acid.
2.2 Chlor–Alkali Industries: Manufacture Of Caustic Soda, Chlorine, Hydrochloric Acid And Hydrogen, Manufacture Of Soda Ash (Solvay And Dual Process).

3. 3.1 Manufacture Of Sulphur By Frasch Process, By Iron Pyrites Burning, manufacture of Sulphuric Acid By Dcda Process (Different Configurations Of Catalyst And Absorber Units)

4. 4.1 Phosphorous Industries Including The Manufacture Of Phosphorous (Electric Furnace Method), Phosphoric Acid (Wet And Electrolytic) And Manufacture Of Single And Triple Super Phosphates.

5. 5.1 Electrolytic Industries: Manufacture Of Aluminium, Manufacture Of Sodium Metal, Manufacture Of Sodium Chlorate

6. 6.1 Industrial Gases
Air Liquefaction And Fractionation To Manufacture Oxygen, Nitrogen.
6.2 Manufacture Of Acetylene
6.3 Manufacture Of Synthesis Gases, Carbon Dioxide, hydrogen, Carbon Monoxide By Steam Reforming, By Steam Reforming, By Partial Combustion Of Hydrocarbons.

References :

1. An introduction to industrial chemistry, *(Heaton C.A.)* Leonard Hill, 1984
2. The chemical industry *(Ibid)* ibid, 1986
3. Modern inorganic chemicals industries *(Thomson R.)* Royal Society of Chemistry 2nd ed.1994
4. Encyclopaedia of chemical technology *(Kirk–Othmer's)* John Wiley and sons Inc., 4th ed. 1990.
5. Encyclopaeia of Industrial Chemistry *(Ullmann's)* VCH, 1985
6. Encyclopaedia of chemical processing and design, *(McKetta's)* Marcel Dekker, 1999.
7. Industrial Electrochemistry *(Pletcher D and Walsh F.C.)* Chapman & Hall 1990.
8. Shreve's Chemical Process Industries 5th Ed., *(Austin G.T.)* McGraw Hill, International Edition.
9. A text Book of Chemical Technology Vol.I and II *(Pandey, G.N.)* Vikas Publications, 1984
10. Dryden's Outlines of Chemical Technology for 21st Century, East West Press, 3rd Edition, *(Rao. G.N. and Sitting M.)*

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Chemical Engineering Thermodynamics –II

T.E. Sem.VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical with Oral Exam.	–	–
Term Work	–	25

SYLLABUS

1. 1.1 Fundamentals property relation for open and closed systems.
1.2 Criteria of equilibrium in terms of intensive and extensive properties.
1.3 Chemical potential as criteria for phase equilibria.

2. 2.1 Properties of ideal mixture and solutions.
2.2 Review of Raoult's law, Henry's law, non–idealities of solutions and mixtures.
2.3 Electrolytes and non–electrolytes.
2.4 Molar and partial molar properties
2.5 Gibbs– Duhem equation.

3. 3.1 Fugacity and fugacity coefficients.
3.2 Estimation and determination of activity coefficients for prediction of thermodynamic equilibria.
3.3 Empirical and semi–empirical methods.
3.4 Group contribution methods.

4. 4.1 Phase equilibria at low and moderate pressures.
4.2 High pressure gas liquid and vapour liquid equilibria.
4.3 Liquid–liquid and solid–liquid equilibria.
4.4 Application of these methods to simple cases.
4.5 Computer methods of prediction of equilibria.

5. 5.1 Homogenous and heterogenous reaction systems.
5.2 Equilibrium constant and compositions in simple reactions.
5.3 Multiphase and multireactions equilibria.

6. 6.1 Refrigeration cycles (P–V, T–S, H–S, H–X diagrams) for vapour compression and Absortion refrigeration systems.
6.2 Evaluation of COP, duty and load of such cycles.

References :

1. Chemical Engineering Thermodynamics 2/e *(Sandler S.L.)* John Wiley, 1989.
2. Chemical Engineering Thermodynamics *(Daubert T.E.)* McGraw Hill, International edition, 1994.
3. Thermodynamics for Chemists *(Glasstone)* Van Nostrand East–West Press, 1964.
4. Phase Equilibria *(Walas J.W.)* Prentice Hall N.J.
5. Introduction to Chemical Engineering Thermodynamics 4/e, *(Smith J.M. and Van Ness H.C.)* McGraw Hill, 1994.
6. Chemical Engineering Thermodynamics *(Rao Y.V.C)* University Press, 1997

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Mass Transfer Operations –II

T.E. Sem.VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical with Oral Exam.	–	25
Term Work	–	25

SYLLABUS

1. **Review of Mass Transfer Operations-I : Mass Transfer coefficients, equilibrium stage operations etc.**
   Distillation:
   - Vapor–liquid equillibria, idea and non–idea solutions, effect of temperature / pressure on P–x, y plots, Azeotropes, immiscible liquids etc.
   - Flash distillation, binary and multi–component, Numerical examples.
   - Differential distillation, Rayleigh equation, Numerical examples.
   - Multistage distillation–Concept of stage by stage calculations for multicomponent systems. (Quantitative procedure only)
   - Multistage distillation–Binary distillation, Ponchon–Savarit methods, Numerical examples, McCabe–Thiele Method, Numerical Examples.
   - Packed bed distillation – Concepts of NTU, HTU, and HETP.
   - Distillation with immiscible liquids – Steam distillation, Numerical examples.
   - Concepts of Azeotropic, Extractive, Reactive distillation and Molecular distillation.

2. **Liquid–Liquid Extraction**
   - Definition and comparison with other separation operations
   - Mutual solubility's of liquids, liquid–liquid equilibria, Effect of temperature and pressure on equillibria. Other forms of representation of liquid–liquid equillibria (solvent free coordinates)
   - Choice of solvent
   - Similarities between extraction and distillation operations. Single stage operations. Numerical examples using various types of coordinates.

3. **Solid–liquid extraction (Leaching)**
   - Representation of equillibria. Construction of simple equilibrium curves. Numerical examples.
   - Similarities in calculations for liquid–liquid and solid–liquid extractions. Numerical examples for single stage, multistage–co–current, cross current and counter current operations. Equipments for leaching–description.

4. **Adsorption and ion exchange**
   - Types of adsorption, adsorption equillibria, Isotherms–Friendlich and Langmuir. Effect of temperature and pressure etc.
   - Stage wise (single / multi) cross current and counter current adsorption operations – graphical procedures. Application of Friendlich isotherm. Numerical examples.
   - Fixed bed adsorber design. Numerical examples using breakthrough curve data.
   - Pressure swing and Temperature swing adsorption operations.
   - Adsorption equipment – description and operation.
   - Ion–exchange– equillibria, equipments and calculations.
   - Application to chromatography, molecular sieves.

5. Crystallization

- Solubility curves, Theories of crystallization, Progress of crystallization
- Δ L Law of crystal growth.
- MSMPR model of crystallization, Population balance method.
- Material and energy balances for crystallizers, Numerical examples.
- Melt crystallizers
- Crystallization equipment–description.

6. Membrane Separation Operations

- Types of membranes–supported and unsupported. Modules for supported membranes. Transport through membranes–fluxes and polarization.
- Types of operations. Ultrafiltration, Reverse Osmosis, Electrodialysis, Pervaporation, Liquid membranes etc.
- Flux calculations and design operations for supported membranes, Numerical examples.
- Equipment and operations
  Introduction to combination separation processes.
- Comparison between all separation processes covered in MTO–I and MTO–II.
- Principles of selection of separation processes.

References :

1. Perry's Chemical Engineering Handbook, 6th Edition, *(Perry J.H and Chilton)* McGraw Hill, 1984 (or a later edition when available)
2. Mass Transfer *(Sherwood T.K., Pigford R.I. and Wilke C.R.)* McGraw Hill, 1975.
3. Phase Equillibria in Chemical Engineering, *(Walas S.M.)* Butterworth, Boston 1985
4. Azeotropic and Extractive distillation *(Hoffman E.J.)* Interscience Publishers Inc, New York, 1964.
5. Fundamentals of multicomponent distillation *(Holland C.D.)* McGraw Hill, New York, 1981.
6. Handbook of Seperation technique for Chemical Engineers, *(Schweitzer P.A.)* (Ed) McGraw Hill, New York , 1988
7. Chemical Process Equipment Selection and Design *(Walas S.M.)* Butterworth, London, 1989.
8. Mass Transfer Operations 3rd edition, *(Treybal R.E.)* McGraw Hill Newyork, 1980.
9. Unit Operations in Chemical Engineering 5th edition, *(McCabe, W.L. and Smith J.C.)* McGraw Hill, New York, 1993.
10. Transport Processes and Unit Operations *(Geankoplis C.J.)* Prentice Hall, New Delhi, 1997.
11. Coulson & Richardsons Chemical Engineering, vol–I *(Coulson J.M., Richardson, J.F.Backhurst, J.R and Harker, J.H.)* Butterworth Heinman, New Delhi, 2000.
12. Coulson & Richardsons Chemical Engineering, vol–II *(Coulson J.M., Richardson, J.F.Backhurst, J.R. and Harker, J.H.)* Asian Books Private Ltd. New Delhi – 1998.
13. Coulson & Richardsons Chemical Engineering *(R.K. Sinnot)* (Ed) Butterworth Heinman, New Delhi–2000

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Process Equipment Design & Drawing–II

T.E. Sem.VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical Exam.	–	–
Oral Exam.	–	25
Term Work	–	25

SYLLABUS

1. HEAT EXCHANGERS

Introduction :

Types of Heat Exchangers. Codes and Standards for Heat Exchangers Material of construction. Baffles and tie rods. Tube joining methods. Design of shell and tube heat exchanger (U–tube and fixed tube) as per IS: 4503 & TEMA standards i.e. shell, tube sheets, channel and channel cover, flanged joints Complete fabrication drawing for designed Heat Exchanger to a recommended scale.

2. EVAPORATORS AND CRYSTALLIZERS

Introduction :

Types of Evaporators. Material of construction. Entrainment separators and vapor release chambers. Complete design of Evaporators with design of calendria and tube, flange, evaporator drum & heads Types and design considerations for Crystallizers (No numerical problems on crystallizers).
Complete fabrication drawing for designed Evaporators to a recommended scale.

3. DISTILLATION AND ABSORPTION COLUMNS

Basic features of columns. Stresses in column shell. Shell thickness determination at various heights. Elastic stability under compression stresses. Allowable deflection. Column internals.
Design of supports for trays. Complete fabrication drawing for designed column to a recommended scale.

HIGH PRESSURE VESSELS.

Materials of construction. Review of design of thick cylinder. Prestressing. Design of high pressure vessels–Monoblock and Compound (Multi–layered) Design of shell and head along with stress distribution. Complete fabrication drawing for designed high–pressure vessels to a recommended scale.

4. HIGH PRESSURE VESSELS.

Materials of construction. Review of design of thick cylinder. Prestressing. Design of high pressure vessels–Monoblock and Compound (Multi–layered) Design of shell and head along with stress distribution. Complete fabrication drawing for designed high–pressure vessels to a recommended scale.

FILTERS

1. Study of various types of filters such as
   a. Vacuum filters.
   b. Pressure filters.
   c. Centrifuges.
   d. Rotary drum filters.

2. Design of rotary drum filters which includes design of drum, shaft, bearing and drive system.

3. Complete fabrication drawing for designed rotary drum filter to a recommended scale.

4. AUXILLARY PROCESS VESSELS
   Study of various auxiliary process vessels such as
   a. Reflux drum.
   b. Compressor knock out drum.
   c. Liquid–liquid & gas–liquid separators.
   d. Entrainment separators.

5. PROCESS FLOW DIAGRAMS AND SYMBOLS
   1. Symbols of process equipments and their concept.
   2. Engineering line diagram (Flow diagram).
   3. Utility block diagram.
   4. Process flow diagram.
   5. P and ID preparations relevant to chemical engineering processes.

6. PIPING DESIGN AND LAYOUT
   1. Pipe sizing for gases and liquids.
   2. Piping for high temperature.
   3. Piping layout and its factors under consideration.
   4. Design of buried and overhead pipeline.

7. DESIGN OFFICE MANAGEMENT
   1. Generation of equipment data sheet/Specification sheet.
   2. Evolution of drawings.
   3. Importance of conclusion of projects. " As built drawings"

References :

1. Process Equipment Design – Vessel Design *(E. Brownell and Edwin, H. Young)* John Wiley, New York 1963.
2. Chemical Engineering Vol–6 Design *(J.M. Coulson, J.F. Richardson and P.K. Sinnot)* Pregamon press, International edition 1989.
3. Introduction to Chemical Equipment Design – Mechanical Aspects *(B.C. Bhattacharya)* CBS Publications.
4. Process Equipment Design *(M.V. Joshi)* Macmillan India.
5. Pressure Vessel Hand Book *(Eugene F.)* Megyesy Pressure Vessel Company USA.
6. Design of Machine Elements *(V.B. Bhandari)* McGraw Hill.
7. Appropriate ISI Specifications and codes for unfired pressure vessels, viz. IS:4503, IS:5403, IS:4049, IS:4864, IS:4870, IS:3138, IS:1239, IS:6392, IS:6418, IS:2062, IS:1730.
8. ASME Codes Division VIII, Section 1 & 2.
9. Equipment Design Handbook for refineries and chemical plant Vol 1 & 2 *(Evans F.L.)* Gulf Publishing 1980.
10. Structural Analysis and Design of Equipment *(Jawad M.H. Fav J.R.)* John Wiley 1984.

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Transport Phenomena

T.E. Sem.VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical Exam.	–	–
Oral Exam.	–	–
Term Work	–	25

SYLLABUS

1. Viscosity and mechanism of Momentum Transport, Thermal Conductivity and mechanism of energy transport, diffusivity and mechanism of mass transport.

2. Shell Balance: Velocity distribution in laminar flow, temperature distribution in solids and laminar flow, concentration distributions in solids and in laminar flow (restricted to rectangular and cylindrical coordinates only)

3. Equations of Change: Isothermal systems, non–isothermal system, multi–component systems (restricted to rectangular coordinate system).

4. More than one independent variable systems: velocity distribution, temperature distribution concentration distribution (restricted to rectangular and cylindrical coordinates only).

5. Turbulent Flow: Velocity distribution, temperature distribution, concentration distribution.

6. Interphase Transport: Isothermal systems, non–isothermal system, multi–component systems.

References :

1. Transport Phenomena *(G.D. Nageshwar)*
2. Transport Phenomenon, Edition–I, *(R.B. Bird, W.E. Stewart, E.N. Lightfoot)* John Wiley, 1960.
3. Momentum, Heat and Mass Transfer, 3rd Edition *(C.O.Bannet and J.E. Myers)* McGraw Hill, 1982.
4. Principles of Unit Operations, 2nd Edition *(S.Foust, L.A. Wenzel, C.W.Clums, L.Maus and L.A. Anderson)* Wiley, New York, 1980.

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ELECTIVE (i) Piping Engineering

T.E. Sem.VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical Exam.	–	–
Oral Exam.	–	–
Term Work	–	25

SYLLABUS

1. 1. INTRODUCTION

Role of piping, Scope of piping engineering, Responsibilities of piping engineer, Inputs received by piping engineers and output given by them, Interactions of piping engineers with other disciplines such as process engineering, instrumentation engineering etc., Introduction to engineering line diagram, Process flow diagram and piping and instrumentation diagram for process plant utilities including various symbols.

2. MATERIAL OF CONSTRUCTION AND FABRICATION

Selection of various piping materials such as Ferrous, non–ferrous and non–metallic, Piping fabrication, Precautions, Preparations of pipe edges.

Designation of coated electrodes, Requirements of weld tests, Hot bending and cold bending operations, Fabrication specifications.

2. CODES/STANDARDS/STATUTARY REGULATIONS

Statuary rules and regulations such as C.O.E, S.M.P.V. rules, Petroleum rules, Gas cylinder rules, Factories act, I.B.R. and N.F.P.A. rules, Codes and standards such as A.N.S.I. codes for pressure piping 31.1 and 31.3 standards, D.I.N. and A.P.I .

3. PIPE AND PIPE FITTINGS

Introduction to various standard pipe fittings, pipe flanges and gaskets and their selection and specification, Design calculations for

1. Schedule number and pipe thickness.
2. I.D. sizing for liquids and gases

PAGE MISSING

References :

1. Piping Design Handbook *(Mcketta J.J.)* Gulf Publications, 1992
2. Pipeline Rules of Thumb Handbook *(McAllister E.W.)* Gulf Publication, 1979.
3. Analysis and Control of Unsteady Flow in Pipelines, 2/e *(Watters G.Z.)* Butterworth, 1986.
4. Solid liquid flow slurry pipe line transportation *(Wasp E.J.)* Gulf publication, Houston, 1979.
5. Design of Piping System, 2/e *(Kellogg)* M.W. Kellogg Co. 1976.
6. Process Piping Design Vol .1 and 2 *(Weaver R.)* Gulf Publication, 1981.
7. Valve Selection Handbook *(Zappe R.W.)* Gulf Publication, 1981
8. Pipe Stress Analysis *(Sam Kannapan, P.E.)* Willey – Interscience Publications.
9. Handbook of Piping Design, *(G.K.Shau)* New Age International Publisher.
10. Equipment Design Handbook of Refineries and Chemical Plants Vol.1 and 2 *(Evans F.L.)* Gulf Publications.

Numerical Methods in Chemical Engineering

T.E. Sem.VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical Exam.	–	–
Oral Exam.	–	–
Term Work	–	25

SYLLABUS

1. Solutions of Linear Algebraic Equations: Gauss elimination and LU decomposition, Gauss Jordan elimination, Gauss Seidel and relaxation methods.

2. Eigen Values and Eigen Vectors of Matrices, Faddeev–Leverrier method, Power method, Householder's and Given Method

3. Nonlinear Algebric Equations: Fixed Point method, Multivariable successive substitutions, Single variable Newton –Raphson Technique, Multivariable Newton –Raphson Technique

4. Function Evaluation: Least–square curve fit, Newton's Interpolation formulae, Newton's Divided difference Interpolation polynomial, Lagrangian Interpolation, Pade approximations, Cubic spline approximations.

5. Ordinary Differential Equations (Initial value problem): Runge Kutta Methids, Semi–implicit Runga Kutta Techniques, Step size Control and estimates of erro

6. Ordinary Differential Equation (Boundary value problems) Finite difference technique, orthogonal collocation technique, orthogonal collocation on finite elements.
   Partial differential Equations: Introduction to Finite Difference Techniques

References :

1. Numerical Methods & Modelling for Engineers *(M.E. Davis)* Wiley, 1984.
2. Numerical Methods for Engineers *(S.K. Gupta)* Wiley Eastern, 1995.
3. MATLAB Programming for Engineers *(Stephen J. Chapman)* Cengage Learning, 3rd Edition, 2008.

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Optimization & Operation Research

T.E. Sem.VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical Exam.	–	–
Oral Exam.	–	–
Term Work	–	25

SYLLABUS

1. Introduction and concept of optimization, Optimization problems in chemical engineering: Heat exchanger, reactor, fluid flow, separation chain, inventory control, Analytical methods for unconstrained single variable optimization.
2. Numerical Method
   a. Newton
   b. Quasi–Newton
   c. Secant
   d. Region elimination method
      i. Golden section
      ii. Fibonnaci
      iii. Dichotomous.

   Numerical method for unconstrained multivariable optimizations

   A. Direct Method
      i. Univariate Search.
      ii. Conjugate directions search
   B. Indirect Method
      i. Gradient
      ii. Conjugate gradient.
      iii. Newton
3. Linear Programming
   A. Graphical Solution.
   B. Simplex Method
   C. Duality and duel simplex.
   D. Integer programming. (Branch and Bound only)
   E. Transportation Problem.
   F. Assignment Problem
4. Dynamic programming.
   A. Calculus method of solution.
   B. Tabulation Method of Solution.
5. Inventory Control
   A. EQQ single item static model.
   B. Static Model with price breaks.
   C. Static Model with shortage permitted.

   Quenching Theory
   A. Cost Model
   B. Aspiration Level Model

   Game Theory.

6. Introduction to CPM– PERT.
   A. Network representation.
   B. Critical path calculation
   C. Resource Planning.

References :

1. Problems in Operation Research *(P.K.Gupta and Manmohan)*
2. Problems and solutions is operation Research *(V.K.Kapoor)*
3. Operation Research–Theory and Application *(J.K.Sharma)*
4. Principles of Operation Research *(Narvey M. Wanger)*
5. Dynamic Programming *(Roberts)*
6. Optimization of chemical process *(T. Edger, M. Himmelblau)*
7. Engineering Optimization *(S.S.Rao)*
8. Operation Research *(Hanndy A. Tabba)*
9. Theory and problems of operation research *(Richard Bronsan)* Schaums Outline series
10. Problems in Optimization Research *(P.K.Gupta and D.S.Hira)*

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Computer Aided Design

T.E. Sem.VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical Exam.	–	–
Oral Exam.	–	–
Term Work	–	25

SYLLABUS

1. Structure and Scope of Computer Aided Design System, Introduction to properties databases and their application for Thermo–Physical, Thermodynamic and Transport Properties Computation.

2. Calculation of pressure drop in a pipe including pipe fittings such as valves and elbows, using Chen's method to determine friction factor.

3. Calculation of the dew point and bubble point of gas mixture. Tower sizing of valve trays, Nutter method for calculating tower diameter where valve trays are used. Design of packed tower using pressure drop correlation by Sherood, Shipley and Holloway.

4. LMTD calculation in shell and tube heat exchanger. Rating of shell and tube heat exchanger with no phase change, using friction factor given by Hedric correlation. Estimation of heat transfer coefficients for tubes in transition region. Design of double pipe heat exchanger using bare or longitudinal; finned tubes calculation of heat load, LMTD for counter current flow, correlated heat transfer coefficient, the heat transfer surface and pressure drop on tube and shell sides.

5. Process Design of Horizontal and Vertical Storage Vessel

6. Computer Flow Sheeting.

References :

1. Mastering Autocad *(Rice and Baker)* BPB Publication, 1991.
2. Fundamentals and Modelling of Separation Processes *(Holland C.D.)* Prentice Hall, New Jersy, 1975.
3. Fortran Programs for Chemical Process Design, Analysis and Simulation *(A Kayode Coker)* Gulf Publishing Co. 1995.
4. Product & Process Design Principles *(Warren D. Seider, J.D.Seader and Daniel R. Lewin)* Wiley Student Edition, 2004.

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