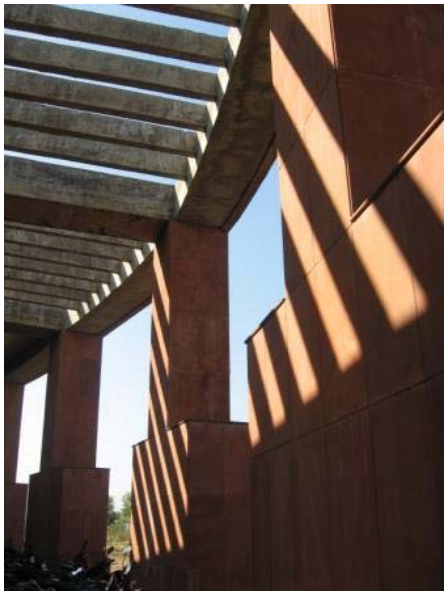
Course Structure and Syllabus
for
Second Year B. Tech. Programmes

(With effect from the Academic Year 2011-2012)



CHEMICAL ENGINEERING

Semester III				
Code	**Course of Study**	**L**	**P**	**C**
CHE 301	Fluid Flow Operations	4	-	8
CHE 302	Strength of Materials	4	-	8
CHE 303	Process Calculations	4	-	8
CHE 304	Solid-Fluid Operations	4	-	8
CHE 305	Engineering Mathematics – III	4	-	8
CHE 306	Numerical & Computational Techniques for Chemical Engineers	4	-	8
CHE 308	Seminar Report and Presentation [Self Study Report on any topic of choice based on the subjects studied so far]	-	-	4
Total		**24**	**-**	**52**
Semester IV				
Code	**Course of Study**	**L**	**P**	**C**
CHE 401	Chemical Engineering Thermodynamics - I	4	-	8
CHE 402	Heat Transfer Operations	4	-	8
CHE 403	Introduction to Bioprocess Engineering	3	-	8
CHE 404	Process Plant Utilities & Safety	4	-	8
CHE 405	*Elective – I	3	-	6
CHE 406	History of Science & Technology [Self Study course (objective: University level common exam]	-	-	4
CHE 407	Soft Skills Lab	-	2	2
CHE 408	Chemical Engineering Laboratory - I [Includes experiments in Chemistry, Fluid Flow Operations and Fluid & Solid-Fluid Operations]	-	6	6
CHE 409	Industrial Exposure (2 weeks after 4th semester. This course will be assessed in 5th semester)	-	-	-
Total		**18**	**08**	**50**

*Elective - I (courses): a) Nanotechnology Fundamentals,
b) Introduction to Polymer Science & Engineering,
c) Industrial Psychology and Human Resource management, and
d) Refinery Science & Engineering

THIRD SEMESTER

CHE 301 Fluid Flow Operations 8 credits

UNIT I
Continuity equation for compressible and incompressible fluids. Bernoulli equation, Euler equation. Equation of motion.

UNIT II
Types of flow, steady and unsteady, laminar and turbulent flows, relationship between shear stress and pressure gradient, Hagen Poiseuille equation. Prandtl mixing length theory and eddy diffusivity, losses in pipes and fittings.

UNIT III
Darcy-Weisbach equation for frictional head loss, friction factor, Moody diagram.
Velocity profile and boundary layer calculations for turbulent flow.
Flow through packed and fluidized beds.

UNIT IV
Pumps and compressors for handling different fluids, valves, pipe fittings and their standards, power requirement for flow. Piping layout and economical pipe diameter.

UNIT V
Flow measuring devices: orificemeter, venturimeter, rotameter, pitot tube, anemometer etc. Flow through constrictions such as notches, weirs, nozzles.

UNIT VI
Mixing and agitation, calculation of power numbers and mixing indices. Liquid-liquid and liquid solid mixing.
Vacuum producing devices. Introduction to non Newtonian flow and two phase flow.

Texts / References:
W. L. McCabe and J. C. Smith, P. Harriot, Unit Operations of Chemical Engineering 4th ed. McGraw Hill 1985.

S. K. Gupta, Moment Transfer Operations, Tata McGraw Hill, 1979.

J. M. Coulson and J. F. Richardson, Chemical Engineering Vol. I Pergamon Press, 1970.

A. S. Foust, L. A. Wenzel, C. W. Clump, L. B. Andersen. Principles of Unit Operations, 2nd ed. John Wiley, New York, 1980.

CHE 302 Structural Mechanics 8 credits

Unit 1: Stress and Strain

Load and its effect, Types of stresses, Types of strain, Support and free body diagram, Types of structures, Equilibrium considerations, Thermal stresses and strains

Unit 2: Trusses

Stability of trusses on application of load, redundancy, Unstable trusses, Use of different methods for analysis of trusses, Condition for perfect trusses

Unit 3: Shear Force and Bending Moment

S. F. and B. M. diagram, Cantilever, Simply Supported Beams, Concentrated and Uniformly Distributed Loads

Unit 4: Torsion

Concept of torsion, Basic Torsion equation, Slope and Deflection of Beams, Cantilevers etc. Macaulay's Method.

Unit 5: Short and Long Columns, (Struts)

Basic Theory, Crippling loads and conditions thereof, Euler's and Rankine's Approach for the same.

Unit 6: Thick and Thin Cylinders

Radial and Longitudinal Stresses, Behavior of thin Cylinders, Problems on thin cylinders and Spherical shells, Behavior of thick cylinders

Texts and References:

1. Timoshenko & Young, "Strength of Materials."
2. V.N. Vazirani & Ratwani, "Analysis of Structures", Vol. I Khanna Publishers.
3. R.L. Bansal, "Strength of Materials", Luxmi Publishers.
4. Popov, "Strength of Materials", Prentice Hall of India.
5. Ramamrutham, Strength of materials.

CHE 303 Process Calculations 8 credits

UNIT I

Basic Concepts - Units and Dimensions, Steady state and dynamic processes, Lumped and distributed processes, Single and multiphase systems.
Types of Variables - Intensive and extensive variables, Specific properties, State variables.

UNIT II

Types of Equations - Mass and energy conservation, equilibrium relations, Rate laws, Constitutive equations for material behaviour, Correlations for physical and transport properties.

UNIT III

Material Balances for Steady State Processes - Properties of gases, liquids and solids equations of state, phase equilibria for ideal mixtures, Reactions and stoichiometry, Non-

UNIT IV

Reacting single phase systems - Single and multiple units without recycle, Systems with recycle, bypass and purge, Non-Reacting multi-phase sytems - Processes involving vaporization and condensation, Reacting systems.

UNIT V

Energy Balances for Steady State Processes - Specific heat capacity, Enthalpy, Heat of reaction, Thermo-chemistry, Isothermal systems, Adiabatic systems, Simultaneous material and energy balances.

UNIT VI

Unsteady State Material and Energy Balances - Reaction rate laws, Transport laws.
Introduction to Computer Aided Process Calculations - Degrees of Freedom and Specifications, Use of Spreadsheets, Tearing and Iterative techniques in Flowsheeting.

Texts / References:

D.M. Himmelblau, "Basic Principles and Calculations in Chemical Engineering", 6th Edition Prentice Hall of India, 1997.

B. I. Bhat and S. M. Vora, "Stoichiometry" Tata McGraw-Hill, New Delhi

CHE 304 Fluid & Solid-Fluid Operations 8 credits

UNIT I

Particulate Solids - Particle Characterization, Particulate Solids in Bulk, Blending of Solid Particle, Classification of Solid Particles
Size Reduction of Solids - Mechanism of Size Reduction. Energy for Size Reduction, Methods of Operating Crushers, Nature of Material to be Crushed, Types of Crushing Equipments

UNIT II

Sedimentation - Gravitational Sedimentation, Centrifugal Separation, Flocculation.

UNIT III

Flow through Packed Columns - Flow of a Single Fluid through a Granular Bed, Dispersion, Packed Columns
Fluidization - Characteristics of Fluidized Systems, Liquid-Solid and Gas-Solid Systems, Applications of the Fluidized Solids Technique.
Pneumatic and Hydraulic Conveying - Theory and Industrial Applications.

UNIT IV

Filtration - The Theory of Filtration. Filtration Practices, Filtration Equipments, Filtration in a Centrifuge and Filtration Calculations

UNIT V

Gas Cleaning - Gas Cleaning Equipments such as Gravity Separators, Centrifugal Separators, Electrostatic Precipitators etc.

UNIT VI

Flow of particulate matter - Flow of solids through silos and hoppers. Storage and transport of powders.

Size Enlargement - Principles of agglomeration palletizing (cone and disk), press and tabulating machines and extrusion and granulating machines.

Texts / References:

J. M. Coulson and J. F. Richardson, Chemical Engineering, Vol. 2, 4th ed. Pergamon Press

W. L. McCabe, J, C, Smith and P. Harriot, Unit Operations of Chemical Engineering, 4th ed. McGraw Hill, 1985

S. K. Gupta, Momentum Transfer Operations, Tata McGraw Hill, 1979.

A. S. Foust, L. A. Wenzel, C. W. Clump, L. B. Andersen, "Principles of Unit Operations", 2nd ed. Wiley, New York, 1980.

Text / Reference:

1. E. Kreyszig. Advanced Engineering Mathematics, Wiley eastern, 5th ed, 1985.
2. P. E. Danko, A. G. PoPov, T, Ya Koznevnikova, Higher Mathematics in problems and exercises part II. Mir publishers, Moscow, 1983.

CHE 305	Engineering Mathematics – III	8 credits

UNIT I

Power series methods for solution of ordinary differential equation legendre equations and legendre polynomials, Bessel equations Bessel functions of first and second kind; orthogonality, Strum Llouville problems.

UNIT II

Laplace transforms, Inverse transforms shifting on the S axis, Convolutions, Partial fractions.

UNIT III

Fourier series, half – range expansions, approximation by trigonometeric polynomials fourier integrals.

UNIT IV

Partial differential equations:

First and second order linear partial. differential. equations. with variable coefficients, wave equation and heat equation in one and two dimensions, Laplace equation in two and three dimensions (cartesian coordinates only) Transforms, techniques in o. d. e and p.d.e.

UNIT V

Infinite sequences and series of numbers, improper integrals

UNIT VI

Cauchy criterion, test of convergence, absolute and conditional convergence series of function, uniform convergence, power series, Badlus of convergence.

CHE 306 Numerical & Computational Techniques for Chemical Engineers 8 credits

UNIT I

Solutions of Linear Algebraic Equations - Gauss elimination and LU decomposition, Gauss-Jordan Elimination, Guass-Seidel and relaxation methods.

UNIT II

Eigen values and Eigen Vectors of Matrices - Faddeev-Leverrier method, Power method, Householder's and Given's method

UNIT III

Nonlinear Algebraic Equations - Fixed point method, Multivariable successive substitutions, Single variable Newton-Raphson Technique, Multivariable Newton-Raphson Technique

UNIT IV

Function Evaluation - Least-squares curve fit, Newton's Interpolation formulae, Newton's divided difference interpolation polynomial, Langrangian interpolation, Pade approximations, Cubic spline approximations

UNIT V

Ordinary Differential Equations (Initial value problems) - Runge Kutta Methods, Semi-implicit Runge Kutta Techniques, Step size control and estimates of error

UNIT VI

Ordinary Differential Equations (Boundary value problems) - Finite difference technique, Orthogonal collocation technique, Orthogonal collocation on finite elements
Partial Differential Equations – Introduction to finite difference technique

Texts / References:

S.K. Gupta, "Numerical Methods for Engineers", Wiley Eastern, 1995.

M.E. Davis, "Numerical Methods & Modeling for Chemical Engineers", Wiley, 1984.

CHE 307	Seminar Report and Presentation	4 credits

[Self Study Report on any topic of choice based on the subjects studied so far.]

Every student is required to prepare a seminar report on latest developments that have taken place in any one the courses he has studied so far. The students can avail the guidance from the faculty members while undergoing this course. Every student is required to give power point presentation of his seminar topic before the panel of examiners.

FOURTH SEMESTER

CHE 401	Chemical Engineering Thermodynamics – I	8 credits

Unit 1

1. **INTRODUCTION :** The Scope of thermodynamics; Dimensions and units; Measures of Amount or size; Force; Temperature; Pressure; Work; Energy; Heat.

2. **THE FIRST LAW OF THERMODYNAMICS:** Joule's Experiments; Internal Energy; The First Law of Thermodynamics; Energy balance for closed systems; Thermodynamic state and state functions; Equilibrium; The phase rule; The reversible process; Constant V and constant P processes; Enthalpy; Heat capacity; Mass and energy balances for open systems.

UNIT 2

3. **VOLUMETRIC PROPERTIES OF PURE FLUIDS :** PVT Behaviour of pure substances; the Virial Equation; The Ideal Gas; Application of the Virial Equation; Cubic Equations of State; Generalised Correlation's for gases; Generalised correlation's for Liquids

Unit 3

4. **HEAT EFFECTS:** Sensible Heat Effects, Heat Effects Accompanying Phase Changes of Pure Substances,The Standard Heat of Reaction, The Standard Heat of Formation, The Standard Heat of Combustion, Effect of Temperature on the standard Heat of Reaction.

UNIT 4

5. **THE SECOND LAW OF THERMODYNAMICS :** Statement of the Second law : The Heat Engine; Thermodynamic Temperature Scales; Entropy; Entropy changes of an ideal gas; Mathematical statement of the Second Law; Entropy balance for open systems; Calculation of ideal work; Lost work; The Third Law of Thermodynamics; Entropy from the Microscopic view point.

UNIT 5

6. **THERMODYNAMIC PROPERTIES OF FLUIDS:** Property Relations for Homogeneous phase; Residual Properties; Residual properties by equations of state; Two phase systems, Thermodynamic diagrams; Tables of Thermodynamic properties; Generalised property correlations for gases.

7. **APPLICATIONS OF THERMODYNAMICS TO FLOW PROCESSES:** Duct flow of compressible fluids; Turbines (expanders); Compression processes.

UNIT 6

8. **REFRIGERATION AND LIQUEFACTION :** The Carnot Refrigerator; the vapour-compression cycle; The Choice of refrigerant; Absorption Refrigeration; The heat pump; Liquefaction Processes.

TEXT BOOK :

1. Smith J.M, Van Ness H.C and Abbott M.M. - Introduction to Chemical Engineering Thermodynamics - 6th Edition, Mc Graw Hill International (2001).

REFERENCE BOOK :

1. Rao, Y.V.C. - Chemical Engineering Thermodynamics - Universities Press (India) Ltd., 1997.
2. Narayanan, K.V. - Chemical Engineering Thermodynamics - Prentice Hall of India Pvt. Ltd. – 2001
3. Hougen O.A, Watson. K.M and Ragatz R.A - Chemical Process Principles (Part - II) - 2nd edn., Asia Publishing House.

CHE 402 Heat Transfer Operations 8 credits

UNIT I

Conduction through a single homogeneous solid, thermal conductivity of solids, liquids and gases. Conduction through several bodies in series. Contact resistances. Unsteady state heat conduction, lumped heat capacity system, transient heat flow in a semi-infinite solid.

UNIT II

Heat transfer by Convection: Forced convection, Laminar heat transfer on a flat plate Laminar and turbulent flow heat transfer inside and outside tubes. Film and overall heat transfer coefficients. Resistance concept, Coefficients for scale deposits, L.M.T.D. in heat exchangers with co and counter current flow. Heat exchanger design, Effectiveness – N T U method in finned tube heat exchangers.

UNIT III

Natural convection: Heat transfer from plates and cylinders in verticals and horizontal configuration, natural convection to spheres.
Heat transfer with phase change, i. e. heat transfer in Boiling and condensation, Single and multiple effect evaporators.

UNIT IV

Heat Transfer by Radiation: Black and gray body radiations, view factor, luminous and non-luminous gases. Combined heat transfer, i.e. conduction, convection and radiation together.

Concept of critical insulation thickness.

UNIT V

Combined natural and forced convection: Fluid flow and heat transfer across cylinders and spheres. Combined natural and forced convection heat transfer in horizontal circular conduits. Heat transfer in extended surfaces such as fins, conduction convection heat transfer, forced convection heat transfer in circular conduits with longitudinal fins.
Heat transfer in non Newtonian fluids.

UNIT VI

Heat exchanger design: Design of single and multi pass shell and tube type exchangers using LMTD and effectiveness – NTU methods.
Spiral coil and plate type heat exchangers.
Single and multi phase condenser. Design of Reboilers vapourisers.
Kettle type and Thermosiphon reboilers, forced circulation vaporizers.
Heat transfer in agitated vessels both, jacketed and with coil, Determination of overall heat transfer coefficient, transient heating or cooling,
Heat transfer in packed and fluidized beds.

Texts / References:

J. M. Coulson and J. F. Richardson, “Chemical Engineering”, Vol. 1 ELBS, Pergamon press, 1970

J. M. Coulson and J. F. Richardson, “Chemical Engineering” Vol. 2 ELBS, Pergamon press, 1970

W. L. McCabe J. C. Smith and P. Harriot, “Unit Operations of Chemical Engineering”, 4th ed. McGraw Hill 1985.

D. Q. Kern, “Process Heat Transfer”, McGraw Hill, 1950.

CHE 403 Introduction to Bio-process Engineering 8 credits

Unit 1

Introduction to biological science, biological system as a complex chemical factory, role of chemical engineers in biotechnology, structure and function microbial , plant and animal cells and cellular organelles, structure and function of chemicals of life like lipids, carbohydrates, DNA, RNA and proteins.

Unit 2

Metabolism, central metabolic pathways, regulation of metabolic pathways, nucleic acid metabolism and protein synthesis, principles of bioenergetics, stoichiometry of biochemical reactions.

Unit 3

Microbial growth kinetics, introduction to unstructured and structured models, models of mixed cultures

Unit 4

Structure and function of enzymes, enzyme kinetics, immobilized enzymes, manufacture of enzymes

Unit 5

Biochemical process development and bioreactors using biocatalysts, bioreactor design, fermentation technology and downstream processing

Unit 6

Introduction of genetic engineering, recombinant DNA technology, application of biotechnology such as bioremediation, biosensors, enzyme therapy, artificial organs, biofuels, biofertilizers.

Books:

1)Bailey and Ollis, “Biochemical Engineering fundamentals”, McGraw Hill publications

2) Shuler and Kargi, “Bioprocess engineering: Basic concepts”.

CHE 404 Process Plant Utilities and Safety 8 credits

Utilities

UNIT I

Identification of common plant utilities: water, compressed air, steam, vacuum, refrigeration, venting, flaring and pollution abating. Water and its quality, storage and distribution for cooling and fire fighting.

UNIT II

Steam generation by boilers: Types of boilers and their operation, Steam generation by utilizing process waste heat using thermic fluids, Distribution of steam in a plant.

UNIT III

Principles of refrigeration: Creation of low temperature using various refrigerants. Creation of low pressure/vacuum by pumps and ejectors.

Safety

Unit IV

Safety in Chemical Processes: Introduction, Chemical Process classification, Process design and safety parameters. Safety parameters in the process design of phenol from cumene, safety in polyvinyl chloride plant.

Chemicals and their Hazards: Introduction, Acetonitrile, acetyl chloride, butyl amine, acrylamide, acrylonitrile, allyl alcohol, benzene, bromine, isopropyl alcohol,

acetaldehyde, ethylene oxide, butane, n-hexane, anhydrous ammonia, acetone, toluene, p-xylene, acetic acid, monochloro benzene, oleum, carbon monoxide.

Unit V

Hazards in Chemical Process plants: Introduction, Hazards, Hazard code and explosive limit, electrical safety in chemical process plants, static electricity hazards, pressure vessel hazards, LEL and UEL of various compounds, explosive hazard, flammable liquid hazards, protection to storage tanks, fire zone location, fireball, fireball hazard.

Safety in handling gases, liquids and solids: Introduction, safety in handling of gases, chlorine hazards, chlorine leakage management, safety in handling of fluorine, important safety considerations in ammonia storage, flammable solids storage, flammable liquid storage, handling of LNG, requirements to be fulfilled for storing hydrocarbons or chemicals, fail safe concept, transportation of hazardous chemicals, Hazardous in plastics processing.

Unit VI

Combating Chemical Fires: Classification of fires, control of high vaour pressure fire, fire fighting foams, foam for fire protection, Foam characteristics, gaseous agent extinguishing system, automatic sprinkler system, chemical extinguishing powders, natural gas fire control.

Portable fire extinguishers: Soda-acid extinguishers, carbon dioxide extinguisher, dry chemical fire extinguisher, general safety precautions for maintenance of fire extinguishers.

Safety Checklist: safety studies for chemical plants, safety checklist during startup, safety checklist during shutdown mode, safety checklist for installation, safety needs during construction. Protective devices.

Text / Reference:

1. D. A. Wangham, Theory and practice of Heat engines, ELBS cambridge University press, 1970.
2. J. L. Threlkeld, Thermal Environmental Engineering, Prentic Hall 1970.
3. S.D.Dawande, Chemical Hazards and safety, Dennet & Co publishers, 2007

CHE 405 Elective – I 6 credits

a) Nanotechnology Fundamentals

Unit 1

Basic Concepts; Molecular Structures;

Unit 2
MacroMolecular Structures;

Unit 3
Surfaces and Interfaces; Thin Films;

Unit 4
NanoParticles; NanoPorous Structures;

Unit 5
NanoTubes and Fibers;

Unit 6
Nanocomposites; Nanosystems

b) Introduction to Polymer Science & Engineering

Unit 1
Introductory concepts and fundamentals: Definitions and concepts of plastics and polymers, comer, co-monomer, mesomer, co-polymer, functionality, visco-elasticity, Classification of polymers, methods of determining molecular weights of polymers-

(i) Methods based on colligative properties
(ii) Sedimentation velocity method
(iii) Sedimentation equilibrium method
(iv) Gel-chromatography method
(v) Light scattering analysis method
(vi) End-group analysis method

Natural polymers- brief study of rubber, shellac, rosin, cellulose, proteins, Lignin's,

Unit 2
Chemistry of polymerization: Elementary concepts of addition polymerization, condensation polymerization and co-polymerization, glass transition temperature of polymers, methods of determining Tg, degradation of polymers due to mechanical, hydrolytic, thermal and backbone effects,
Relation of the mechanical, thermal, electrical, physical and chemical properties with the structure of the polymer,

Unit 3
Methods of polymerization: Mass, solution, emulsion and suspension, role of the initiators, catalysts, inhibitors, solvents, fillers, reinforcing agents, stabilizers, plasticizers, lubricants, blowing agents, coupling agents, flame retardants, photo-degradants and bio-degradable on polymerization,

Unit 4
Methods of manufacture, properties and uses of the following addition products;
Polyethylene (LDPE and HDPE) , polypropylene, PVC and its copolymers, Polystyrene and its copolymers, acetals and PTFE (polytetraflouroethylene),

Unit 5

Methods of manufacture, properties and uses of the following condensation products: (i) Polyesters-PMMA, PET and ALKYO, (ii) PF-, UF- and MF-resins (iii) epoxy resins, polyurethanes and silicones,

Unit 6

Description of the following processing methods: (with the principles involved and equipments used) Mixing and compounding, extrusion, calendaring, laminating, moulding-compression, transfer, injection and blow moulding.

Text books:

1. `Plastic Materials' by J.A.Brydson, Newnes-Butterworths (London) 1989
2. `Textbook of Polymer Science', Billymeyer, F.W.Jr., 3rd edition, John Wiley & Sons,

Reference books:

1. 'Introduction to Plastics' by J.H.Briston and C.C. Gosselin, Newnes, London
2. 'Polymeric Materials' by C.C.Winding and G.D.Hiatt, McGraw-Hill Publishers

c) Industrial Psychology and Human Resource Management

Unit 1

Understanding human experience and behaviour: Definition, schools, methods, branches and application of psychology for engineers;

Unit 2

Measuring human abilities; Intelligence, Personnel testing.

Unit 3

The individual working life : personality - definition, approaches and theories; Psychological problems of everyday life: Stress and coping;

Unit 4

Psychological disorders, work and mental health; Human learning; Motivation : the concept and theoretical framework, motivating people at work;

Unit 5

Attitude and work behaviour, Group dynamics.

Unit 6

Intergroup relations, conflict resolutions; Leadership and management.

Texts/References

1. J.V. McConnel, Psychology, New York, Holt, Rinehart & Winston, 1986.
2. C. T. Morgan, R. A. King, J. R. Weiss and J. Schopler, Introduction to Psychology, 7th ed., McGraw Hill, 1986.
3. D. G. Myers, Psychology, 4th ed., Worth, New York, 1995.
4. S. E. Asch, Social Psychology, OUP Oxford, 1987. HS

d) Refinery Science & Engineering

Unit 1
Fundamental Concepts of Reservoir Engineering: Porosity, fluid saturation, permeability, flow through layered beds, flow through series beds, Klinkenberg effect. Effective permeability, Relative permeability calculating relative permeability data, phase behavior.

Unit 2
Oil Reservoirs: Reservoir driving mechanisms, basic equation and tools. Volatile oil reservoirs. Identification of volatile oil reservoirs. Ultimate recovery. Predicting reservoir behavior.

Depletion drive reservoirs: Predicting reservoir performance. Mechanics of reservoir performance, prediction procedure. Procedure for reservoir performance prediction. Limitation of predictions. Relating reservoir performance to time. Factors affecting ultimate recovery. Analyzing gas oil ratio history.

Unit 3
Water drive reservoirs: Effect of free gas saturation on recovery. Predicting reservoir performance, calculating water influx. Use of the unsteady state equation in predicting reservoir performance, validity of performance prediction. Limitations in predicting reservoir performance. The material balance equation as a straight line.

Unit 4
Gravity drainage reservoirs: Permeability in the direction of dip. Dip of the reservoir. Reservoir producing rates. Oil viscosity. Relative permeability characteristics. Fundamental recovery process. Predicting reservoir performance. Apparent relative permeability. Oil saturation method.

Combination drive reservoirs: Index of drives. Equations used. Material balance equations. Instantaneous gas oil ratio equation.

Unit 5
Pressure maintenance: Pressure maintenance by gas injection. Condensing gas drive. Predicting performance by gas injection. Injected gas drive index. Pressure maintenance by water injection. Predicting performance by water injection. Index of injected water drive. Control of the gas cap. Typical water injection pressure maintenance operations.

Unit 6
Improving oil recovery: Improving oil recovery by fluid injection immiscible gas-water. Miscible fluid injection thermal oil recovery. Predicting recovery form fluid injection products. Stiles's method of water flood prediction. Derivation of water out and recovery equations. Frontal advance technique for predicting results of either water or gas injection. Well arrangements, peripheral water flooding. Predicting behavior of peripheral water floods. Special consideration involved in water flooding. Water flood case history. Predicting the results of water flooding.

Text Book:

Reservoir Engineering Manual, 2nd Edition, Frank W. Cole, Gulf Publishing Company, Houston, Texas 1989.

CHE 406 History of Science & Technology 4 credits

[Self Study course (objective: University level common exam]

Unit 1

1. Historical Perspective :

The Nature of Science and Technology , Roots of Science and Technology in India , Science and Society , Scientists and Society , Science and Faith and The Rise of Applied Sciences.

Unit 2

2. Polices and Plans After Independence :

Nehru's vision of Science for Independent India, Science and Technology Developments in the New Era Science and Technology Developments during the Five Year Plan Periods and Science and Technology Policy Resolutions.

Unit 3

3. Research and Development (R&D) in India :

Expenditure in R&D, Science and Technology Education, Research Activities and Promotion of Technology Development, Technology Mission, Programms Aimed at Technological self Reliance, Activities of Council of Scientific and Industrial Research (CSIR).

Unit 4 & 5

4. Science and Technological Developments in Major Areas :

Space – Objectives of Space Programms, Geostationary Satellite Services – INSAT System and INSAT Services Remote Sensing Applications, Launch Vehicle Technology

Ocean Development – Objectives of Ocean Development, Biological and Mineral Resources, Marine Research and Capacity Building;

Defense Research --- Spin –off Technologies for Civilian Use;

Biotechnology--Applications of Biotechnology in – Medicine, Biocatalysts, Agriculture, Food, Fuel and Fodder, Development of Biosensors and Animal Husbandry;

Energy – Research and Development in Conservation of Energy , India's Nuclear Energy Programme –Technology Spin –offs.

Unit 6

5. Nexus Between Technology Transfer and Development :

Transfer of Technology—Types, Methods, Mechanisms, Process, Channels and Techniques: Appropriate Technology, Technology Assessment, Technological Forecasting, Technological Innovations and Barriers of Technological Change.

Test Books :

1. Kalpana Rajaram , **Science and Technology in India,** Published and Distributed by Spectrum Books (P) Ltd., New Delhi-58.

2. Srinivasan, M., Management of Science and Technology (Problems & Prospects), East – West Press (P) Ltd., New Delhi.

Reference Books :

1. Ramasamy , K. A. and Seshagiri Rao, K.,(Eds**.) Science, Technology and Education for Development,** K., Nayudamma Memorial Science Foundation, Channai-8.
2. Kohili, G. R., **The Role and impact of Science and Technology in The development of India,** Surjeet Publications.
3. Government of India, **Five Year Plans**, Planning Commission, New Delhi. Sharma, K. D. and Quresh M. A., **Science, Technology and Development**, Sterling Publications (p) Ltd. New Delhi.

CHE 407 Soft Skills Lab 2 credits

Reading: Reading Comprehension**,** Note Making**,** Reading Journal Articles**,** Reading and
Interpreting Graphic communication.
Writing: Paragraphs, Letters**,** Writing Research Articles**,** Report Writing**,** Process Writing.
Speaking: Classroom Talk, Social Conversation**,** Group Discussions**,** Facing Interviews,
Making seminar Presentations, Speaking on Telephone.
Listening: Listening Comprehension**,** Note Taking **,** Listening for academic and career needs.
Soft Skills: Etiquettes, Grooming**,** Professional code of conduct.

CHE 408 Chemical Engineering Laboratory – I 2 credits

LIST OF PRACTICALS:

A. Fluid Flow Operations

1. Determination of flow regimes -Reynolds' apparatus
2. Verification of Bernoulli's equation
3. Determination of Fanning friction factor for smooth and rough pipes
4. Determination of equivalent length of pipe fittings
5. Determination of viscosity with capillary tube viscometer.
6. Determination of friction factor for flow through packed bed.
7. Study of venture meter
8. Study of orifice meter
9. Study of characteristics of centrifugal pump
10. Study of Rota meter

B. Solid-Fluid Operations

1. Determination of screen effectiveness

2. Dry screen analysis
3. Wet screen analysis
4. Study of sedimentation
5. Study of air elutriation
6. Study of cyclone separator
7. Study of froth flotation

CHE 409 Industrial Exposure

Industrial Exposure

This is an Audit course. Students who would like to spend their part of the vacation in industry will have to request the Training Co-ordinator of the Department for providing request letters to the industries. With the request letters, the students will approach the industry of their interest for getting necessary permission to have Industrial Exposure for a period of four weeks. On completion of exposure the concerned student will prepare a report and submit the same to the Training Co-ordinator of the department. The student earns Audit for this Exposure course and the same will be indicated in his/her 5^{th} semester grade report.