University Institute of Engineering & Technology
C.S.J.M.University Kanpur
Chemical Engineering

Semester-Wise Break up of courses

Semester-1

		L	T	P/D	Credits
HSS-101	Basic English	3	0	0	4
MTH-101	Mathematics-I	3	2	0	4
PHY-101	Physics-I	3	2	3	5
TCA-101	Engineering Drawing	2	1	3	5
TCA-102	Workshop Practice	1	1	6	5

Semester-II

CHM-101	Chemistry-I	3	2	3	5
ESC-101	Basic Electrical &Electronics Engg.	3	1	3	5
ISC-101	Programming &Computing	3	0	3	5
MTH-102	Mathematics-II	3	2	0	4
PHY-102	Physics-II	3	2	3	5

Semester-III

MTH-201	Mathematics-III	3	2	0	4
ESC-202	Thermodynamics	3	1	0	4
ESC-201	Engineering Mechanics	3	1	0	4
CHE-201	Process Calculations	3	1	0	4
CHE-202	Transport Processes & Unit Operations-I (Fluid Mechanics)	3	1	0	4

		L	T	P/D	Credits
Semester-IV					
CHE-203	Chemical Engg.Thermodynamics	3	1	0	4
CHE-204	Transport Processes & Unit Operation-II (Heat Transfer)	3	1	0	4
CHE-205	Chemical Process Industries-I	3	1	0	4
CHE-206	Transport Processes & Unit Operation-III (Mechanical Operations)	3	1	0	4
HSS-201	Industrial Management	3	0	0	4
Semester-V.					
CHE-301	Transport Processes & Unit Operation-IV (Mass Transfer-I)	3	1	0	4
CHE-302	Chemical Process Industries-II	3	1	0	4
CHE-303	Transport Process & Unit Operations Laboratory -I	0	0	4	4
CHE-304	Kinetics & Reactor Design-I	3	1	0	4
CHM-301	Chemistry-2	3	1	0	4
Semester-VI					
CHE-305	Transport Processes & Unit Operations-V (Mass Transfer-II)	3	1	0	4
CHE-306	Instrumentation & Process Control	3	1	0	4
CHE-307	Chemical Engg. Design-I	3	1	0	4
CHE-308	Transport Process & Unit Operations Laboratory-II	0	0	4	4
SST-301	Summer Training	0	0	2	2
CHE-50*	Departmental Elective	3	0	0	4

		L	T	P/D	Credits
Semester-VII					
CHE-401	Chemical Engg. Design-II	3	1	0	4
CHE-402	Kinetics & Reactor Design-II	3	1	0	4
CHE-403	Chemical Reaction Engg. Laboratory	0	0	4	4
PRT-401	Design Project-I	0	0	6	4
HSS-401	Industrial Economics	3	0	0	4
Semester-VIII					
CHE-404	Transport Phenomena	3	1	0	4
CHE-405	Instrumentation & Process Control Laboratory	0	0	4	4
CHE-50*	Departmental Elective	3	0	0	4
CHE-50*	Departmental Elective	3	0	0	4
PRT-402	Design Project-2	0	0	6	4

DETAILED COURSE CONTENT

CHE-201 Process Calculations 3-1-0-4

Introduction-Units, their dimensions and conversions, Dimensional consistency of equations, Dimensional and dimensionless constants, Mass and volume relations, Stoichiometric and composition relations, Excess reactants, Degree of completion, Conversion, Selectivity and Yield.

Gas laws-Ideal gas law, Dalton's Law, Amagat's Law, and Average molecular weight of gaseous mixtures.

Vapour pressure-Effect of temperature on vapour pressure, Vapour pressure plot (Cox chart), Vapour pressures of miscible and immiscible liquids and solutions, Raoult's Law and Henry's Law.

Relative Humidity and percent saturation; Dew point, Dry and Wet bulb temperatures; Use of humidity charts for engineering calculations.

Material balances for systems with and without chemical reactions, species and elemental balance. Analysis of systems with by-pass, recycle and purge.

Heat capacity of gases, liquids and solutions, Heat of fusion and vaporisation; Steady state energy balance for systems with and without chemical reactions; Calculations and application of heat of reaction, combustion, formation, neutralisation and solution; Enthalpy-concentration charts; Combustion of solids, liquids and gaseous fuels, Calculation of theoretical and actual flame temperatures. Degrees of freedom in steady state processes, solution of simultaneous material and energy balance problems using flow sheeting codes; Unsteady state material and energy balance

Text Books:

1. D.M.Himmelblau, Basic Principles and calculations in Chemical Engineering, Printice-Hall.
2. O.A. Hougen,K.M.Watson & R.A.Ragatz, Chemical process principles, John Willey & sons.

CHE-202 Transport Processes & Unit Operations-1 3-1-0-4
Fluid Mechanics

Properties of fluid - fluid and its properties, Newton's law of viscosity, Newtonian & non- Newtonian fluids, surface tension and its effect.
Fluid pressure and its measurement: mercury barometer, bourden pressure gauge, Piezo meter, differential & inclined manometer, micro manometer etc.
Kinematics of fluid flow- various types of flow, Reynold's experiment, Reynold's no., boundary layer theory and moody's chart.
Buoyancy & floatation- Archimedes principle, centre of buoyancy.
Dynamics of fluid motion- Continuity equation, Euler's equation, Bernoulli's equation, correction in Bernoulli's equation for effect of solid boundaries, pump work in Bernoulli's equation.

Flow measurement- venturi meter, orifice meter, pitot tube for velocity measurement, variable area meter(rotameter), flow nozzles.
Flow over notches & weirs; discharge over a triangular & rectangular notch.
Flow through pipe- pipes & tubes, energy losses in pipes, head loss due to sudden enlargement, contraction, vena contracta, entrance and exit losses
Dimentional analysis- Rayleigh's method and its draw back, Buckingham pi theorem.
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Text Books:

1. McCabe & Smith, Unit Operations in Chemical Engineering, Mc Graw Hill.
2. V. Gupta & S.K. Gupta, Fluid Mechanics & Application, New Age International Pvt. Ltd.

CHE-203 Chemical Engineering Thermodynamics 3-1-0-4

Introduction-Macroscopic and microscopic approaches; Units; Basic concepts of system, property, force, temperature, pressure, work, energy, heat and equilibrium

Review of First and Second law of thermodynamics for closed & open system,

P-v-T behaviour of pure substance- graphical, tabular and mathematical representation Ideal gas, Cubic equation of state; Virial equation of state, laws of corresponding states, compressibility factor, accentric factor, Generalized correlation for gases and liquids;

Thermodynamic Potentials and Thermodynamic Property relations-Postulates; Intensive properties; Criteria of equilibrium; Euler relation Gibbs Duhem relation; Potentials-A,G,H,U; Property relations for homogeneous phases; Maxwell's relation,

Thermodynamic Properties of Real Gases, Departure functions; Evaluation of departure functions; Partial Molar Property, fugacity and fugacity coefficient, estimation of fugacity coefficient, Thermodynamic Properties of Real Gas mixtures – mixing rules, prediction of P-v-T behaviour, departure functions, fugacity coefficients for real gases;

Fugacity of a component in a mixture, Fugacity of liquid and solid

Ideal solution; phase equilibrium problems; excess properties, excess Gibbs free energy models;Henry's law Basic equation for vapour liquid equilibrium; VLE at low to moderate pressures and high pressures-excess Gibbs free energy models, azeotropic data, bubble, dew point and flash calculations; Dilute Solution laws

Chemical Reaction Equilibrium- standard Gibbs free energy change and equilibrium constant, effect of temperature on equilibrium constant; homogeneous gas and liquid phase reactions;

Text Books:

1. Y.V.C. Rao, Chemical Engineering Thermodynamics, University Press.
2. Smith & van Ness, Introduction to Chemical Engineering Thermodynamics, McGraw Hill

CHE-204 Transport Processes & Unit Operations-II 3-1-0-4
Heat Transfer

General Principals of heat transfer by conduction, convection, radiation heat transfer.

Conduction- Fourier's law of heat conduction, steady state conduction in one dimension with out heat source e.g. Through plain wall ,cylindrical & spherical surfaces, thermal insulations, properties of insulating materials.
Convection- Natural & forced convection, concept of thermal boundary layer, laminar & turbulent flow heat transfer inside and out side tubes, dimensional analysis, determination of individual & overall heat transfer coefficients and their temperature dependency.
Heat exchangers- Types of heat exchangers like double pipe, shell & tube, plate type, extended surface, their construction and operation, basic calculations on heat exchangers.
Radiation- Basic laws of radiation heat transfer, black body & grey body concepts, view factor, combined heat transfer coefficients by convection and radiation.
Introduction to unsteady state heat transfer.
Heat transfer with phase change- condensation of pure and mixed vapours, film wise and drop wise condensation, calculations on condensers, heat transfer in boiling liquids, nucleate & film boiling.
Evaporation- elementary principals, types of evaporators, simple calculation on single and multiple effect evaporators, classification, principals, and design criteria.
Furnaces , their classification, applications and calculations on them.

Text Books:

1. D.Q. Kern, Process Heat Transfer, Mc Graw Hill.
2. Holman, Heat Transfer, Mc Graw Hill.

CHE-205 Chemical Process Industries-1 3-1-0-4

Overview-Typical chemical processes: unit operations and unit processes; classification of Indian chemical process industry;inorganic chemical industry; study aspects of a CPI-raw materials, process, chemical reactions, process and block flow diagram, major engineering issues and uses;
Water conditioning and treatment processes, softening and demineralization of water; air conditioning and treatment processes, air liquefaction: *Claude* and *Linde* processes.
Chemicals from sea, common salt (NaCl) manufacture: solar and vacuum evaporation methods.
Coal gasification technologies: *Lurgi, Winkler* & *Kopper Totzek* processes; various types of fuel gases: producer, water, coke oven, synthesis, LPG & natural gases, various industrial gases: carbon dioxide, hydrogen, oxygen, nitrogen, helium, acetylene, carbon monoxide, sulphur dioxide, their sources and applications.
Amorphous and crystalline forms of carbon, manufacture and applications of lamp black, carbon black and graphite; activated carbon and its manufacture by gaseous oxidation and chemical activation methods.
Various kinds of cements and their major constituents, cement manufacture by cement rock (limestone) beneficiation and *Portland* process.
Nature, types, composition and uses of glass, its manufacture: melting, shaping, annealing and finishing operations; *Fourcalt* and *float glass* processes.

Products and raw materials of chlor-alkali industry, *Trona* ore; Solvay process of manufacturing soda ash, caustic soda and chlorine manufacture by electrolytic process: mercury, diaphragm and membrane cells.
Major phosphorous products; *Fluorapatite* mineral; dry (electric furnace) method of recovering elemental phosphorus; phosphoric acid manufacture by dry and wet (sulphuric acid leaching and *IMI* or HCl digestion) methods; manufacture of phosphatic fertilizers: calcium phosphates, ammonium phosphate, nitro phosphate and sodium phosphate.
Manufacture of ammonia, urea, nitric acid and ammonium nitrate.
Sulphur-its forms, properties and sources, sulphur mining by *Frasch* process, sulphur recovery from pyrite ore by *Finnish* process, sulphur recovery from natural gas and petroleum refinery streams by *Claus* process; sulphuric acid manufacture by *Contact* process.

Text Books:
1. Dryden, Principles in Chemical Technology.
2. G.T. Austin, Shreve's Chemical Process Industries, Mc Graw Hill.

CHE-206 Transport Process & Unit Operation-3 3-1-0-4
Mechanical Operations

Solid handling- Introduction, particle shape, size, sphericity ; size reduction- Energy and power required in size reduction, Laws of crushing, Work index, Size reduction equipments- crusher, grinders, mills; Solid-solid separation- Screening, jigging, Tabling, Magnetic separation, Electrostatic separation, Flotation; Solid- liquid separation- Settling and sedimentation, Centrifugal separation, Filtration; Fluidization- Introduction, Flow through packed bed, Ergun equation, types of fluidization, Superficial velocity, Entrainment and Elutriation; Mixing and agitation- Introduction, Uses of mixing, Agitation equipment- Turbine, Impeller, Paddle, Flow pattern in agitated vessels, Prevention of swirling, Turbine design; Crystallization

Text Books:
1. Mc Cabe & Smith, Unit Operation in Chemical Engineering, Mc Graw Hill.
2. J.M.Coulson & J.F.Richardson, Chemical Engineering, Pergamon Press.

CHE-301 Transport Process & Unit Operation-4 3-1-0-4
Mass Transfer I

Vapour liquid equilibria; Raoult's law ; Relative volatility; minimum and maximum boiling mixtures; enthalpy concentration diagrams for binary systems;Flash, Differential and Steam Distillation; Azeotropic and Extractive Distillation;
Multistage tray towers; Graphical methods using Mc Cabe-Thiele and Ponchon – Savarit analysis; minimum reflux, total reflux and optimum reflux ratio, open steam, multiple feed and side stream
Multi component Calculations using Short-cut methods;
Absorption- Equilibrium, co-current operation, counter current multistage operation, dilute gas mixtures, Multicomponent absorption, tray efficiency;

Liquid-liquid Extraction-, choice of solvent, equilibria on triangular coordinates, single stage and multistage single cross current extraction, continuous counter current multistage extraction, insoluble liquids;
Solid-liquid Extraction- Method of operation, Shank's system and other systems, equilibrium curve, single stage and multistage single cross current leaching, multistage counter current leaching using rectangular and triangular method,
Adsorption- Adsorbents, adsorption equilibria, adsorption for dilute solutions, single stage and multistage single cross current operation, multistage counter current operation using Freundlich equation for equilibria,

Text Books:

1. R.E. Treybal, Mass Transfer Operations, Mc Graw Hill.

CHE-302 Chemical Process Industries-2 3-1-0-4
Prerequisites: CHE-201

Classification of organic and natural product industries, Basic sources of raw materials; Common pesticides, Manufacture of DDT, 2,4-D, BHC and parathion,
Important oil seeds, Extraction process, Physical and chemical refining of vegetable oil and by products, Hydrogenation of vegetable oils.
Difference between soaps and detergents, Classification of cleansing compounds, Kettle and Twithcell process of soap manufacture, Glycerol recovery, Manufacture of detergents: sulphated fatty alcohols and alkyl – aryl sulphonates.
Important features of Indian sugar industry, Major unit operation of sugar industry, Alcohol fermentation, Production of 95% alcohol and anhydrous or absolute alcohol from fermentation broth, Pollution problems.
Raw materials for pulp making, Kraft and Sulphite pulping methods, Semi-chemical pulping, Fourdrinier process of paper making, Pollution aspects.
Basic principles of polymerization reactions: stepwise and chain polymerization, general polymerization systems: bulk, solution, suspension and emulsion polymerisation, Synthesis of phenol formaldehyde, polyethylene, polystyrene and PVC, Various polymer processing techniques, Additives, Plastic recycling, Rubbers, their classification and processing, Specialty polymers.
Natural and synthetic fibres, Fibre properties important in textile production, Fibre spinning processes: melt, dry and wet spinning, Manufacture of nylon 6,6 and nylon 6 fibres, viscose rayon and polyester fibres.
Composition and characteristics, Formation theories, Petroleum exploration, enhanced oil recovery by water and steam injection technologies, Offshore drilling, Petroleum refining: Basic distillation, thermal cracking, alkylation and catalytic cracking, other refining unit processes: reforming, hydrodealkylation, isomerisation, hydrogenation, desulphurisation polymerisation etc. Important refinery products or fractions, Indian petroleum refineries.
Important petrochemicals, Feed stock, Common unit processes: cracking, alkylation-dealkylation and hydroalkylation, halogenation, oxidation, hydrogenation-

dehydrogenation; hydration-dehydration, nitration, amination, esterification, hydrolysis, hydroformylation or oxo process.

Text Books:

1. Dryden, Principle in Chemical Technology.
2. G.T. Austin; Chemical Process Industries.

CHE-303 Transport Process & Unit Operation Laboratory -1 0-0-4-4

Screen Analysis; Crushing efficiency for jaw crusher; Crusher rolls; Disintegrater; etc.; Sedimentation and Thickners; Viscosity measurement; Flow through pipes (Reynold'S experiment); Flow-Through Open Channels; Flow Through fitting and Joints; Orifice meter; Venturi meter; Rotameter; Verification of Bernoulli's Theorem; Characteristics of Centrifugal pumps; Fluidized bed; Spouted bed; Plate and Frame filter press; Rotary drum; Vacuum filter; Agitator and mixing.

CHE-304 Kinetics and Reactor Design-1 3-1-0-4

Introduction and overview of chemical reaction engineering
Rate equation of homogeneous reactions, concentration dependent term and temperature dependent term of the rate equation, rate expressions from mechanisms; non elementary homogeneous reactions;
Constant volume batch reactor; varying volume batch reactor; collection and analysis of batch data – integral and differential method; reversible reaction data, temperature and reaction rate;
Ideal batch reactor; steady state continuously stirred tank reactor; steady state plug flow reactor; size comparison of single reactions; multiple reactor systems; recycle reactor; autocatalytic reactions;
Design for parallel reactions- product distribution, fractional yield;
Design for series reactions; Series-Parallel reactions, Denbigh reactions
Non isothermal reactors, effects for single and multiple reactions, equilibrium conversions, adiabatic and non-adiabatic operations
Non ideal Reactors-Residence time distribution, E,C, F curves, segregation model, dispersion model, chemical reaction and dispersion, tank-in- series model;

Text Books:

1. O. Levenspiel, Chemical Reaction Engineering, John Willey & Sons.

CHE-305 Transport Process & Unit Operation-5 3-1-0-4
Mass Transfer II

Molecular diffusion: Diffusivity, flux J and N, steady state diffusion in fluid at rest and laminar flow, molecular diffusion in gases in non-diffusing and equimolal counter diffusion, Pseudo steady state diffusion through a stagnant gas film, steadystate diffusion

in multicomponent mixtures, molecular diffusion in liquid, diffusivity of gases and liquids, diffusion through varying cross- sectional area
Diffusion in solids-through polymers, porous solids, unsteady state diffusion in slabs, cylinders and spheres, transient mass transfer in semi infinite medium
Mass transfer coefficient in different units, mass transfer from a gas into a falling liquid film, eddy diffusion, Prandtl mixing length;
Film theory: Lewis, Penetration and Surface Renewal theory; dimensionless numbers
Flow past solids, Interphase mass transfer
Combination of resistances, overall coefficient, correction applied to individual coefficient, heat, mass and momenteum transfer analogies, j_H and j_D factor
Gas Absorption: Packed towers, pressure drop and flooding in opacked towers, Design of packed towers, Height of Transfer Unit, concept of H_{tG}, H_{tL} , H_{tOG} and H_{tOL}, desorption, Mass transfer coefficient in packed beds
Drying: Definition, drying operation, recycle of air, rate of batch drying, constant and falling rate, mechanism of batch drying, tray drying with varying air conditions continuous dryers, Introduction to rotary dryers, rotary drum dryers and spray dryers
Humidification and Dehumidification: Psychrometric chart, wet bulb and adiabatic saturation temperation, design of cooling towers and dehumidifiers
Adsorption: Adsorption in continuous column, breakthrough curve

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Text Books:

1. R.E. Treybal, Mass Transfer Operations, Mc Graw Hill.

CHE 306 Instrumentation & Process Control 3-1-0-4

Introduction to control aspects their needs & application in industries ,Classification of variables, control aspects of a chemical plant, stirred tank heater, flow in tank & their control aspects
Introduction to mathematical modeling, state variables and state equations, dead time, modeling with dead time, degree of freedom, linearization of nonlinear system, deviation variables, multivariable system linearization.
Laplace transform of step, impulse , pulse ,ramp, trigonometric functions, Laplcae transform of derivative and integral functions, initial value theorem , Final value theorem,Dirac delta functions, Inverse Laplace transform, solution of linear differential equation using Laplace transform, transfer function and input –output model.
Poles & zeros of system, dynamic behavior of first order system, Time constant , steady state gain,
Dynamic behaviors of second order system , overdamped , critically damped , underdamped response their characteristics, overshoot ,decay ratio, period of oscillation ,rise time , ultimate period , delay time, study of interacting & noninteracting response, Inverse response, multicapacity process,
Concept of Feedback system , types of controller , on-off, P,PI,PID controller, introduction to measuring sensors, transmission lines, final control elements, signal flow graph theory to solve feedback loop,

Criteria for stability, characteristic equation, Routh –Hurwitz criteria of stability,Root-Locous analysis,
Design of controllers, Simple performance criteria, Time Integral performance criteria, Frequency response analysis of linear processes, Bode stability criteria, Nyquist stability criteria , gain margin, phase margin, Ziegler Nichols tuning technique , Cohen –coon tuning technique

Text Books:

1. D.R. Coughnour, Process system Analysis & Control, Mc Graw Hill.
2. George Stenphanopolous, An Introduction of Process Dynamics & Control.

CHE-307 Chemical Engineering Design-1 3-1-0-4

Stages involved in design, Chemical Engg. Plant design,Process design, Development General overall design consideration,
Cost estimation, Factors affecting Profitability of Investments, Optimum design, Optimum economic design, Optimum Operation design, Practical considerations in design, Design approach.
Flow- sheeting presentation, manual Flow- sheet calculation, Computer –aided Flow-sheeting-simple material balance program.
P and I diagram, Valve selection, pumps, control and instrumentation, typical control systems, data acquisition
Types of design, Feasibility survey, Process development, Design construction & operations, Safety analysis, Selection of size, Plant layout, Cost & asset accounting, Cost estimation, Interest & investments costs, Taxes, Depreciation & Depletion, Profitability, Alternative investments & replacements, Optimum design & Design strategy.

Text Books:

1. M.S.Peters and K.D.Timmerhaus, Plant Design and economics for chemical Engineering, Mc Graw Hill.

CHE-308 Transport Process & Unit Operations-2 (Laboratory) 0-0-4-4

Heat conduction through rods of different materials; Thermal conductivity of insulating materials; Boiling and Condensation; Double pipe Heat Exchanger; Shell & Tube Heat Exchanger; Long tube evaporator; Distillation; Batch & Continous column; Absorption with and without chemical reaction; Liquid-liquid extraction/leaching; Adiabatic humidifier, Water cooler; Driers; Tray, Rotary, Spray; Ion exchange, Reverse osmosis.

SST-301 Summer In Plant Training 0-0-0-2

A written report and an oral presentation/ interview during the (following) semester after successful completion of an 8-week industrial in-plant training with a chemical industry taken during the summer break.

CHE-401 Chemical Engineering Design-2 3-1-0-4

Introduction, nature of design, anatomy of a chemical manufacturing process,

organisation of a chemical engineering project, project documentation, codes and standard, factor of safety, degree of freedom and design variables, optimisation.

Fundamentals of material balances, Fundamentals of Energy balances
Equipment selection, specification and design: Separation processes, solid- solid separations, screening, liquid-solid cyclones, hydro separators and seizers, hydraulic jig , tables, classifying centrifuges, flotation separators, Electrostatic separators, liquid solid separators- thickeners and classifiers, filtration, centrifuges, hydro-cyclones, separation of dissolve solids- Evaporation and crystallisation, liquid- liquid separation- Decanters, centrifugal separators, gas – solid separation, gas –liquid separation.
Separation columns: Continuous distillation : process description , reflux considerations , feed-point location, selection of column pressure, stage equations, dew point – bubble points, Equilibrium flash calculations, design variable in distillation,
design method for binary system: basic equations, McCabe –Thiele method, low product concentration s, Smoker equations
Multicomponent distillation ; Key component , number of column s, short –cut method for stage and reflux requirement s, pseudo- bninary systems, Smith –Brinkley method, Empirical correlations, rigorous solution procedures, batch distillation , Plate efficiency, Column sizing, Plate hydraulic design, Packed columns
Heat transfer Equipment : Overall heat transfer coefficient , fouling factors , shell and tube heat exchangers, tube count, shell type; Baffles support plate and tie rods tube sheet shell and headers nozzles, mean temperature difference
General design consideration ; Fluid allocation shell and tube fluid velocity stream temperature pressure drop, Shell side heat transfer and pressure drop : flow pattern , design methods, Kern's Method, Bell's method, shell and bundle geometry, Effect of fouling on pressure drop, Condensers , Reboilers and Vaporisers
Pressure vessels

Text Books:

1. J.M. Coulson & J.F. Richardson, Chemical Engineering, Pergammon Press.
2. M. V. Joshi & V. V. Mahajan , Process Equipment Design, Macmillan

CHE-402 Kinetics and Reactor Design-II 3-1-0-4

Introduction to heterogeneous reaction , solid catalyzed reaction , rate equation for surface kinetics , preparation & characterization of catalyst , performance equation for reactors containing porous catalyst particle, Experimental methods for finding rates, product distribution in multiple reaction,
Fluid particle reaction kinetics -selection of a model , shrinking core model for spherical particle of changing & unchanging size, comparison of various model selected, determining controlling resistances and rate equation, fluied particle reactor design , instantaneous reaction ,
Adsorption -Physical & chemical Adsorption, Langmuir & freundlich isotherms, rate equation for physical , surface reaction & desorption mechanism

Gas liquid reactions - Gas –liquid reactor, Thiele modulus, effectiveness factor

Deactivation of catalyst-Mechanism of deactivation of catalyst, rate & performance study of deactivation, Rate equation in fluid –fluid reaction , fluid particle reaction kinetics ,

Text Books:

1. J.M.Smith, Chemical Engineering Kinetics, Mc Graw Hill.
2. O. Levenspiel, Chemical Reaction Engineering, John Willey & Sons.
3. H. Scott. Fogler; Elements of Chemical Reaction Engineering

CHE-403 Chemical Reaction Engineering (Laboratory) 0-0-4-4

Batch reactor- Reaction Rate Constant; Semi Batch Reactor- Reaction Rate Constant; Continuous Stirred Tank Reactor; Plug Flow reactor; Differential, Integral; Residence Time Distributions in non- ideal Reactors; Fluid Particle Reaction for Shrinking Spherical Particle; Recycle reactor; Characteristics of heterogeneous catalysts (BET method, HE-Hg method); Basket type mixed reactor solid catalytic reactions; Catalytic gas-phase reactions in constant volume bomb; Catalytic liquid phase reaction; Fluidized bed reactor.

CHE-404 Transport Phenomena 3-1-0-4

Introduction, Analogies between momentum, heat and mass transfer and defining of dimensionless number, Reynolds transport theorem, Eulerian and Lagrangian approach, Navier stokes equation; Introduction of Fluids kinematics vorticity; Introduction of molecular and convective flux.

Momentum Transport Phenomena-Newton's law of Viscosity, , Prediction of viscosity and its dependence on temperature, pressure, Non– Newtonian models at steady state for Newton's law of Viscosity, Momentum transport in laminar flow, Boundary conditions and shell balance approach for stress distribution; profiles for flow of a falling film, flow through circular tube, flow through an Annulus, Adjacent flow of two Immiscible fluids.

Equation of continuity, motion and mechanical energy their applications in fluid flow problems for isothermal system

Energy Transport Phenomena-Energy transport in laminar flow: Fourier's law of heat conduction,thermal conductivities and its dependence on temperature, pressure, Boundary conditions, Shell balance approach for different types of heat sources, Heat conduction through composite walls, Principle of extended surfaces, free and forced convection.

Equation of change for Non-isothermal systems, The Equations of energy, Equation of motion for free and forced convection in Non-isothermal flow, steady flow of a non-isothermal film, Transpiration cooling , free convection from a vertical plate.

Mass Transport Phenomena-Fick's law of diffusion, Prediction of diffusivity and its dependence on temperature and pressure for gas ,liquids and solids, Boundary conditions, Shell balance approach for mass transfer problems, Diffusion through Stagnant gas film, Diffusion with homogeneous and heterogeneous chemical reaction, Diffusion in to a falling liquid film, Diffusion and chemical reaction in porous catalyst and the effectiveness factor, equation of continuity for binary mixtures. equation of change to set up diffusion problems for simultaneous heat and mass transfer, thermal diffusion, pressure diffusion, forced diffusion.

Text Books:

1. Bird Stewart & Lightfoot, Transport Phenomena.

CHE-405 Instrumentation & Process Control (Laboratory)0-0-4-4

Calibration and response of a thermocouple; Calibration of pressure gauge by dead weight loster; Calibration of flow measuring devices; Viz. Orifice meter, venturimeter Etc. Calibration of diaphragm control valve; Calibration of levelling measuring device, pressure type; Calibration of moisture meter, Viz; IR moisture meter, Rapid moisture meter, Innersal moisture meter, etc.; Measurement of humidity by hair-hygrometer, Wet & Dry Bulb thermometer; Study of On-Off Controller; Study of PID controller; Dynamic response of liquid heating system; Dynamic response of interacting non interacting first ordsr system; Dynamic response of heat exchanger/Distillation column.

PRT-401 Design Project-I 0-0-6-4

Prerequisites: CHE-202,204,206,301,305

Equipment design to be done by groups of students.

PRT-402 Design Project-2

Prerequisites: CHE-307

Detailed plant design project to be done by groups of students.

List of possible departmental electives:

(1) Polymer Engineering (CHE-501)
(2) Safety in Chemical process Industries. (CHE-502)
(3) Petroleum Engineering. (CHE-503)
(4) Environmental Pollution & Control (CHE-504)
(5) Non conventional energy sources (CHE-505)
(6) Numerical methods for Chemical Engineers(CHE 506)
(7) Advanced Separation Processes (CHE 507)
(8) Optimization Techniques (CHE 508)
(9) Biochemical Engineering (CHE 509)
(10) Process Modelling and Simulation (CHE 510)

CHE 501 Polymer Engineering 3-0-0-4

Introduction – defining polymers, classification, molecular weight distributions, conformations

Addition polymerization or chain growth polymerization, radical, ionic and Ziegler-Natta polymer, kinetics

Step growth polymerization, kinetics

Techniques of polymerizations; Characterisation- measurement of molecular weight, thermal behaviour, morphology, viscoelastic behaviour, mechanical properties

Polymer processing; rubbers, plastics and fibres

Text Books:

1. George Odian, Principles of Polymerization, John Wiley
2. Billmeyer, Polymer Science and Engineering, John Wiley

CHE 502 Safety in Chemical Process Industries 3-0-0-4

Concept and definitions, safety culture, storage of dangerous materials, plant and plant layout, safety system, technology and process selection, scale of disaster.

Vapour cloud, explosion, control of toxic chemicals, run away reactions, fire and explosion, high pressure relief system, hazardous properties of chemicals.

Risk and hazard management, safety Vs production, risk assessment and analysis, hazard models and risk data, identification, minimization and analysis of hazard.

Tackling disaster, plant of emergency, risk management routines, emergency shutdown systems, Role of computer in safety, prevention of hazard, human element, technology and process selection, design of safety audit system and disaster management.

Text Books:

1. G. L. Wells, Safety in Chemical Process Industries, McGraw Hill

CHE 503 Petroleum Engineering 3-0-0-4

Introduction to mineral oils, their origin and mode of occurrence; Oil resources and refineries in India Composition of petroleum, refinery products and their test methods Evaluation of oil stacks introduction to processing of petroleum; general processing & crude distillation, refinery products and their application, natural gas, gasoline, naphtha kerosene, fuel oil and gas oil, petroleum waxes, lubricating oils, tar and asphalts.

Petroleum refining processes and operation: thermal cracking, catalytic cracking, hydro-forming, catalytic reforming, alkylation, polymerization, isomerization and other auxiliary process e.g vis-breaking, de-waxing and de-asphalting operations.

Manufacture of paraffins wax and microcrystalline waxes.

Introduction to lubricants: liquid, solid and gas lubricants and their application.

Lubricating oils: liquids mineral lubricants, synthetic liquids lubricants; Physical properties, additives, manufacture of lubrication oils; Analysis of lubricating oils;

Lubricating Greases: properties, types, ingredients, additives, analysis of lubricating greaser as per BIS test methods; Manufacture of lubricating greases-processes and equipments.

Introduction to petrochemicals; manufacture of alkyl aryl compounds, ethylene oxide; condensation products benzene, toluene, xylene, buta-di-enes, vinyl chloride and styrene etc

Textbooks:

1. Petroleum Refinery Engineering, Nelson, McGraw Hill
2. Petroleum Refining Technology, Dr. Ram Prasad, Khanna Publishers

CHE 504 Environmental Pollution and Control 3-0-0-4

Introduction and importance of Environmental Pollution, case studies;
Air Pollution – sources, causes, effects; meteorological and natural purification processes; control of air pollutants – particulates and gases –design aspects ; automobile pollution;
Water Pollution – classification and characterization of water pollutants, sources, causes, effects of water pollution; control processes : physical- design of equalization tanks, sedimentation tanks clarifiers etc., chemical- coagulation, disinfection, adsorption etc., biological – introduction to bacterial growth and kinetics, BOD estimation, aerobic and anaerobic treatment methods, activated sludge process, trickling filters- design aspects, sludge disposal, clarified water disposal,
Solid-waste management, Noise Pollution, Radioactive Pollution

Text Books:

1. Metcalf & Eddy, Waste Water Engineering- Treatment Disposal and Reuse, Tata McGraw Hill
2. De Nevers, Air Pollution Control Engineering, McGraw Hill
3. Wark & Werner, Air Pollution
4. C. S. Rao, Environmental Pollution Control, CBS Publishers
5. Peavy & Rowe, Environmental Engineering, McGraw Hill

CHE 505 Non conventional energy sources 3-0-0-4

Introduction to energy sources- energy consumption as a measure of prosperity, Indian energy future, renewable energy sources, prospects of renewable energy sources;
Solar Radiation and its measurement, solar energy collectors-flat plate, concentrating collectors, solar pond etc.;
Wind energy- principle of wind energy conversion, site selection considerations, WECS, types of wind machines;
Biomass-conversion technologies, biogas generation, biogas plants, pyrolysis
Geothermal energy- sources, vapour dominated, liquid dominated systems, applications and advantages
Energy from the oceans- OTEC, tidal energy, closed cycle and open cycle OTEC, Magneto Hydro Dynamic power generation, principle and systems
Chemical energy sources- fuel cells (H_2, O_2 cell), advantages, disadvantages, batteries

Hydrogen energy-methods of production, use as fuel
Solid waste as energy sourse

Text Books:

1. G. D. Rai, Non Conventional Energy Sources, Khanna Publishers

CHE 506 Numerical Methods for Chemical Engineers 3-0-0-4

Least Square method and curve fitting of data, cubic spline problems, approximation of functions interpolation and extrapolation of techniques; forward, backward and central difference, error approximation; derivatives from difference tables;
Numerical integration – Newton Cotes Integration technique, Simpson's 1/3 rd and 3/8th rule, trapezoidal rule, Gaussian quadrature;
Multiple Integral solution of Non-linear equation, bisection methods, regular-falsi method, Newton-Raphson methods, Euler's method, Euler's modified iteration technique, Picaed method, Runge-Kutta 4^{th} order technique, Taylor series method;
Solutions of ordinary differential equation (initial and boundary value problem)
Linear programming, simplex method, dual simplex, charne penalty method

Text Books:

1. S. K. Gupta, Numerical Methods for Chemical Engineers, New Age International

CHE 507 Advanced Separation Processes 3-0-0-4

CHE 508 Optimization Techniques 3-0-0-4

Analytical method necessary and sufficient conditions for optimum in single and multi-variable unconstrained and constrained problems
Unconstrained one dimensional search, Newton, Quasi-Newton and Secant method for uni-dimensional search, region elimination methods (Golden Section, Fibonacci, Dichotomus etc)
Linear Programming, Graphical simplex method, revised simplex method, duality and transportation problems
Unconstrained multi-variable search, direct methods, Indirect method, Finite difference approximation
Dynamic Programming, Principle of optimality, Discrete and continuous dynamic programming

Text Books:

1. T.E. Edger, D.M. Himmelblau, Optimization of Chemical Processes, McGraw Hill
2. Hameed S. Taha, Operational Research
3. G. C. Onwubolu, B.V. Babu, New Optimization Techniques in Engineering
4. S.S. Rao, Engineering Optimization

CHE 509 Biochemical Engineering 3-0-0-4

Text Books:

1. S. K. Gupta, Numerical Methods for Chemical Engineers, New Age International

CHE 510 Process Modelling and Simulation 3-0-0-4

Text Books:

1. S. K. Gupta, Numerical Methods for Chemical Engineers, New Age International