

## DEPARTMENT OF CHEMICAL ENGINEERING

### **CHL603 Advanced Transport Phenomena**

*3 credits (3-0-0)*

Development of mass, momentum and energy balance equations. Equation of change for isothermal systems. Velocity distribution in flow systems. Interphase transport. Microscopic and macroscopic balances. Multicomponent systems and their transport characteristics. Energy transport in non-isothermal systems. Energy transport by radiation.

### **CHL604 Fluid Solid Reaction Engineering**

*4 credits (3-0-2)*

Elements of reaction kinetics. Kinetics of heterogeneous catalytic reactions. Transport process with fluid-solid heterogeneous reactions. Non-catalytic fluid, solid reactions. Catalyst deactivation. Gas-Liquid reactions. Regression and other statistical methods for Kinetic Parameter Estimation. Determination of transport and reaction parameters by experimental methods.

### **CHL626 Multi Phase Contactors**

*3 credits (3-0-0)*

Shell balance for momentum transfer. Velocity profiles. Residence time distribution Measurement techniques. RTD for single phase flow in tubes, coils, packed beds, stirred vessels. Multiphase flow. Stratified and dispersed flows. Interaction between phases Measurement techniques. Modelling and correlations of RTD in different contactors; Trickle beds, packed beds, bubble columns, spray columns, plate columns, fluidised beds etc. Prediction of Pressure drop; Friction factor, drag coefficient, single phase flow, multiphase flow. Lockhart Martinelli approach. Drift flow concept, Rheology.

### **CHL634 Management of R&D in Chemical Industries**

*3 credits (3-0-0)*

Introduction. Nature of planning. Choice and objectives of technological forecasting. Proposal preparation and motivative effort to initiate the research and developmental programme. Concept of creativity, group approach to idea generation. Conditions for successful growth of creative ideas to realisation. Quality of research personnel and staff selection. Organisation and special problems of research and development. Conducting a research and development project. Scheduling, monitoring, and decision-

making for cost effectiveness. Accountability and responsibility.

### **CHL653 Application of programming in Chemical Engineering**

*4 credits (3-0-2)*

Basic concept of OOP using C++, elements of C++ language, variables and constants, data types, operators, control statements, functions, reference variables and arguments, classes and objects, constructors and destructors, operator overloading, data and type conversions, derived classes and inheritance, pointers, virtual functions, streams, templates.

Elements of visual C++, dialogs and controls, Messages and commands, documents and views, reading and writing file, working with menus, bars and toolbars, common controls, multitasking with windows threads, building an ActiveX control, creating an ODBC Database access.

### **CHL701 Process Engineering**

*4 credits (3-0-2)*

Process Synthesis; Hierarchical conceptual design of process; Batch vs. continuous; input-output structure of flowsheet; choice of reactor; choice of separation system; Distillation column sequencing; Heat exchanger network design; Pinch technology; Utility selection; Steam and cooling water circuits.

Process economics: Cost estimation; annuities; perpetuities and present value; Tax and depreciation; Profitability measures; comparison of equipments and projects; NPV and DCFROR, Risk management.

Introductory Optimization: Linear programming and its use in process industry; transportation problems; integer programming (branch and bound method); use of commercial softwares LINDO, CPLEX.

Second Law Analysis: Estimate of inefficiency in equipment/process by finding lost work' modification of operating conditions/process to improve efficiency.

### **CHL702 Plant Design**

*4 credits (3-0-2)*

Plant layout, auxiliaries, materials handling, offsite facilities, selection and detailed design of equipments, e.g., mixers, conveyers, heat exchangers, separation equipments, pumps,

compressors, etc.

### **CHL705 Electrokinetic Transport in Chemical Engineering**

*4 credits (3-0-2)*

Definition of colloidal state and implications, intermolecular and surface forces, electrostatics, transport equations in electrolytic solution, electrokinetic phenomena, electrophoresis, sedimentation potential, coagulation of particles, Particle deposition and aggregation.

### **CHL707 Adsorption Separation Processes**

*3 credits (3-0-0)*

Microporous adsorbents, Physical adsorption and characterization of porous adsorbents, Adsorption equilibria, Diffusion in porous media, kinetics of adsorption in batch systems, Column processes, Chromatographic separation processes, Pressure swing adsorption, Structure and properties of ion exchange resins, Ion-exchange equilibrium, Ion-exchange kinetics, Ion-exchange columns, Behaviour of ion-exchanges in non-aqueous and mixed solvents.

### **CHL710 Process Dynamics and Control**

*5 credits (3-1-2)*

Lumped parameter systems—classical and multivariable control theory. Distributed parameter systems. Measurement of process variables such as temperature, pressure, composition, flow rate, level, density, etc. Dynamics of process instruments and loops. Analogue and digital signals, process actuators and control equipment.

### **CHL711 Numerical Methods in Chemical Engineering**

*4 credits (3-0-2)*

Efficient and recent numerical techniques applied to problems of chemical engineering interest. Basic methods and their applications. Solution of simultaneous linear and non-linear algebraic equations. Numerical differentiation and integration, ordinary and partial differential equations.

### **CHL712 Computer Aided Design in Chemical Engineering**

*3 credits (2-0-2)*

Software development for design of various chemical equipments. Design

of minimum energy heat exchanger network, sequencing and energy integration in distillation column simulation of process flow sheets using software package, Aspen Plus.

### **CHL714 Advanced Heat Transfer**

**3 credits (3-0-0)**

Formulation and solution of transient and steady-state conduction. Heat transfer analogies. Direct contact heat transfer. Radiative heat transfer from surfaces and flames. Combined convective and radiative heat transfer. Application to furnaces and kilns.

### **CHL717 Mechanical Design of Process Equipment**

**4 credits (3-0-2)**

Design of distillation columns operating under pressure or vacuum; design of tanks for storage of liquids and gases including the selection of accessories; design of tall absorption or stripping columns subjected to seismic and wind loading.

### **CHL723 Chemical Reaction and Reactor Engineering**

**3 credits (3-0-0)**

Theory of mass transfer with reaction. Enhancement factor for single irreversible and reversible reactions. Modelling of mass transfer accompanied by complex gas-liquid reactions.

Gas liquid reactor design.

Stability and control of chemical reactors. Runaway and parametric sensitivity of batch reactors; Modelling of solid catalyzed gas-liquid reactors; Design of trickle bed and slurry reactors.

### **CHL724 Environmental Engineering and Waste Management**

**4 credits (3-1-0)**

Ecology and Environment. Sources of air, water and solid Wastes. Air Pollution: Micrometeorology and dispersion of pollutants in environment. Fate of pollutants. Air pollution control technologies: centrifugal collectors, electrostatic precipitator, bag filter and wet scrubbers. Design and efficiencies. Combustion generated pollution, vehicles emission control. Case studies. Water Pollution: Water quality modelling for streams. Characterisation of effluents, effluent standards. Treatment methods. Primary methods: settling, pH control, chemical treatment. Secondary method: Biological treatment. Tertiary treatments like ozonisation, disinfection, etc. Solid waste

collection, treatment and disposal. Waste recovery system.

### **CHL727 Heterogeneous Catalysis and Catalytic Processes**

**4 credits (3-0-2)**

Basic concepts in heterogeneous catalysis, catalyst preparation and characterization, poisoning and regeneration. Industrially important catalysts and processes such as oxidation, processing of petroleum and hydrocarbons, synthesis gas and related processes, commercial reactors (adiabatic, fluidized bed, trickle-bed, slurry, etc.). Heat and mass transfer and its role in heterogeneous catalysis. Calculations of effective diffusivity and thermal conductivity of porous catalysts. Reactor modeling. Emphasizes the chemistry and engineering aspects of catalytic processes along with problems arising in industry. Catalyst deactivation kinetics and modeling.

### **CHL735 Design of Separation Processes**

**4 credits (3-0-2)**

Brief description of different processes (e.g., distillation, absorption, extraction, adsorption, drying, ion-exchange, membrane processes, chromatographic techniques, molecular sieves, foam fractionation, zone refining, multicomponent distillation, mass transfer with chemical reaction, etc.). Design principles.

Sizing of equipment and their design including fabrication details (plate tower, packed tower, bubble and sieve trays, evaporator).

### **CH740 Selected Topics in Chemical Engineering**

**3 credits (3-0-0)**

Various advanced topics in chemical engineering of interest to research and/or of industrial importance.

### **CH743 Petrochemical Technology**

**3 credits (3-0-0)**

Introduction composition of petroleum laboratory tests, refinery products, characterization of crude oil.

### **CHL751 Multi-component Mass Transfer**

**3 credits (3-0-0)**

Diffusion: Maxwell-Stefan's, Fick's and Irreversible Thermodynamics approaches to multicomponent diffusion. Estimation of multicomponent

Diffusion Coefficients. Effect of non-ideality of fluids, Linearized theory for multicomponent diffusion problems. Interphase mass transfer: mass transfer coefficients, bootstrap matrix, Film Theory, Surface renewal models, mass transfer in turbulent flows.

Laboratory/design activities could also be included.

### **CHD760 Minor Project**

**3 credits (0-0-6)**

### **M.S. (Research) in Chemical Engineering**

Minimum requirement of credits for this programme is 60. 20 credits of course work to be completed normally during first semester of admission and 40 credits of research work spread over two or more subsequent semesters.

### **CHL761 Chemical Engineering Mathematics**

**3 credits (3-0-0)**

Data Analysis: Classification, estimation and propagation of errors, Presentation of data, Statistical methods, sample and population distributions, testing of hypothesis, analysis of variance.

Solution of equations: Vector spaces, basis, matrices and differential operators. Eigen values, vectors and functions. Solvability conditions for linear equations, Sturm-Liouville Theory, Separation of variables and Fourier transform, Frobenius method for ordinary differential equations, Greens Function and its application.

### **CHL762 Modeling, Simulation and Control**

**4 credits (3-0-2)**

Development of conservation and constitutive equations for a variety of chemical engineering unit operations and processes under steady state and unsteady state conditions, their analysis and solution. Concept of lumped and distributed parameter models. Introduction to steady state and dynamic simulation software. Study of plant wide control schemes.

### **CHL763 Computer Process Control**

**3 credits (3-0-0)**

16 bit microprocessor architecture, overview of IBM PC to Pentium Computer, Computer- Process Interface equipment, DDC, Distributed Process Control, Supervisory Control, PLC, Fuzzy Logic and Neural Networks, Applications in Control of Chemical Processes.

**CHL766 Interfacial Engineering**  
3 credits (3-0-0)

Concept and definition of interface. Physical surfaces. Surface chemistry and physics of colloids, thin films, dispersions, emulsions, foams, polyaphrons. Interfacial processes such as crystallization, epitaxy, froth flotation, adsorption, adsorptive bubble separation, catalysis, reaction-injection moulding, microencapsulation. Industrial aspects of interfacial engineering.

**CHL768 Fundamentals of Computational Fluid Dynamics**

3 credits (2-0-2)

*Overlaps with: AML811*

Review of basic fluid mechanics and the governing (Navier-Stokes) equations; Techniques for solution of PDEs – finite difference method, finite element method and finite volume method; Finite volume (FV) method in one-dimension; Differencing schemes; Steady and unsteady calculations; Boundary conditions; FV discretization in two and three dimensions; SIMPLE algorithm and flow field calculations; variants of SIMPLE. Turbulence and turbulence modeling; illustrative flow computations; Commercial softwares FLUENT and CFX – grid generation, flow prediction and post-processing.

**CHD770 Major Project Part-I**  
(0-0-12)**CHD780 Major Project Part-II**  
(0-0-24)**CHL773 Planning of Experiments and Analysis of Engineering Data**

4 credits (3-0-2)

Graphical method of model selection from experimental data. Two variable equations. Linear and logarithmic plots, modified Logarithmic and semi-logarithmic plots. Reciprocal plots. Equations for bunched data. Elongated "S" curve. Sigmoid curves..... Three variable empirical equations. Multivariable empirical equation.... Dimensionless numbers. Nomography; Introduction, modulus and scale and principle of construction. Application of logarithmic charts. Equations of the form  $F_1(x) + F_2(X) = F_3(X)$ . Selection of empirical equation for fitting experimental data Testing of hyposthesis, Testing of means and

variances. Planning of experiments as per factorial design to estimated significant variables which affect the process. Fractional factorial design to use significant variables to estimates the relationship between the significant variables and independent variable Response surface analysis by reducing the equations developed to canonic equations... Estimations of parameters in equations of second order with interaction factor. Case studies on application to research and industrial data analysis.

**CHL774 Process Optimization**  
4 credits (3-0-2)

Formulation of an optimization problem, Convexity Analysis, Linear Programming, Nonlinear Programming, Optimality Conditions, Dynamic Optimization, Dynamic Programming, Introduction to Mixed Integer Programming. Laboratory/design activities could also be included.

**CHL793 Membrane Science and Engineering (3-1-0)**  
3 credits (3-0-0)

Introduction to membrane separation processes, their classification, and applications. General transport theories including theory of irreversible thermodynamics for multicomponent systems.

Membrane preparation techniques. Design and analysis and industrial application of various membrane processes such as reverse osmosis, ultrafiltration electro dialysis, dialysis, liquid membrane separation, gas permeation and pervaporation.

**CHL794 Petroleum Refinery Engineering (3-0-2)**  
4 credits (3-0-2)

Introduction : Composition of petroleum, laboratory tests, refinery products, characterization of crude oil. Design of crude oil distillation column. Catalytic cracking. Catalytic reforming. Delayed coking. Furnace design. Hydrogenation and Hydrocracking. Isomerization, Alkylation and Polymerization. Lube oil manufacturing. Energy conservation in petroleum refineries. New Trends in petroleum refinery operations. Pyrolysis of Naphtha and light hydrocarbons: modeling (time permitting).

**CHL795 Agro Process Technology**  
3 credits (3-0-0)

Post Harvest Technology of Cereals, Pulses and Oilseeds. Processing of oil seeds, solvent extraction, utilization of

rice bran .Storage of food grains. Food chemistry.

Development of food chemistry. Edible oils and fats: physical and chemical properties, Carbohydrates, Proteins, Flavours and aroma of food. Food preservation and processing: Nutritive aspects of food, food additives, Food adulteration and simple detection techniques, Soilage of food, food poisoning, micro-organisms in foods, Sanitation and cleaning requirements for food processing plants Quality control and quality assurance.

Food preservation : principles and methods, Fruits and fruit products, Vegetables and vegetable products.

By-product utilization, Waste utilization. Packaging and packaging materials.

Case studies: Biomass utilization, solvent extraction of neem oil and by products from neem seeds, solvent extraction of jojoba oil, Solvent extraction of hops.

**CHD801 Major Project (Part-I)**  
6 credits**CHD802 Major Project (Part-II)**  
12 credits**CHL807 Population Balance Modelling**  
3 credits (3-0-0)*Pre-requisites : CHL361*

Particle size distribution, Crystal size distribution, Communiton processes and other particulate processes, Representation of distribution, Properties of distributions, Particle phase space, population fluxes distributions, particle phase space, population fluxes-convections, Birth and death, particle number continuity equation, Population balance over a macroscopic external coordinate region, Moment transformation of population balance over a macroscopic external coordinate region, Macro-moment equations..., Recovery of particle size distribution function..., Steady state MSMPR crystalliser, Significance of distribution representation, Exponential distribution, Mass balance, Dynamic population balance, CSD transients, Transient moment equations, Transient size distribution by method of characteristics, Stability of CSD, Crystallisation kinetics, Nucleation, Crystal growth, Communiton

Processes, Microbial population, Residence-time distribution, Dispersed-phase mixing.

### **CHL813 Thermodynamics and Process Design**

*3 credits (2-0-2)*

*Pre-requisites: CHL711*

Thermophysical properties of pure fluids : Equilibrium properties such as vapour pressure, latent heats, critical constant and PVT behaviour. Transport properties such as viscosity, thermal conductivity and diffusivity, estimation and correlation methods. Properties of multicomponent systems : V-L-E using equations and state and group contribution methods. L-L-E correlation and prediction.

Homogeneous and heterogeneous chemical equilibria with competing chemical reactions.

### **CHL830 Advanced Computational Techniques in Chemical Engineering**

*3 credits (2-0-2)*

*Pre-requisites: CHL711*

Introduction, Review of fundamental conservation equations for momentum, heat and mass transport. Formulation of problems in steady state. Weighted residual methods: orthogonal collocation, Galerkin finite element, Fourier collocation. Application to reaction-diffusion in porous catalysts pellets. The non-isothermal situation. Calculation of effectiveness factor. Application in micro-fluid mechanics-particle capture efficiency in

suspension flows. Moving boundary problems. Transient problems leading to PDEs. Examples in heat and mass transfer and their numerical solution. The MonteCarlo method and its diverse applications. Computational laboratory exercises.

### **CHL864 Applications of AI and ANN in Chemical Engineering**

*4 credits (3-0-2)*

*Pre-requisites: EEL758*

AI and Chemical Engineering, Expert System and Chemical Engineering-CONPHYDE and OPS5, KBS for Process Synthesis and Design, Design problem solving, Product design methodologies – polymeric composites, molecules, developing design support environment, Process plant diagnosis and safety analysis (Falcon), Expert system tools and shells for Chemical Engineering – critical evaluation of KBES tools such as KEE, ART, INSIGHT2 +, NEXPERT, etc. from the perspective of Chemical Engineers.

### **CHL869 Applications of Computational Fluid Dynamics**

*3 credits (2-0-2)*

*Pre-requisites: CHL768*

Brief review of CFD for single phase flows; Solution of scalar equations – heat and mass transfer; Application to heat exchanger and stirred tank flows; CFD for multiphase systems – Lagrange-Euler and Euler – Euler approaches; Multiphase models – granular kinetic theory; Reaction modeling; Volume of Fluid (VOF)

method for two-phase flow with interfaces; Current status of multiphase flow simulation in various chemical process equipment—bubble column, phase separator, packed bed, fluidized bed, polymerization reactor, cyclones etc.

### **CHD895 Major Project (M.S. Research)**

*40 credits (0-0-80)*

### **CHP711 Process Development Laboratory**

*3 credits (0-0-6)*

Selection of a problem. Definition of the problem. Literature Search. Design of an experimental program. Fabrication of necessary equipment. Operation of the equipment. Interpretation of data, report writing and oral defence. Measurements, and interpretation of data.

### **CHP754 Applications of Simulation Software**

*2 credits (1-0-2)*

Introduction to simulation software packages - PROII, Aspen Plus, HEXTRAN, Data reconciliation. Techniques of solving recycle flow problems. Techniques Dynamic simulation. Practice sessions with 'Simsci' and Aspen Plus software for steady state simulation of chemical plants.

### **CHS 780 Independent Study**

*3 credits (0-3-0)*