# M.E. (Chemical Engineering)

**Description of Courses**
**( For the details refer Bulletin 2020-21, Page VI-26-29)**

**L P U**

**CHE G511 Fluidisation Engineering 3 1 4**

Fundamentals, industrial applications; study, design and operation of fluidisation units.

**CHE G512 Petroleum Refining and Petro- Chemicals 3 1 4**

Origin, formation and composition of petroleum; history and development of refining; refinery products and test methods; classification and evaluation of oil stocks, fractionation of petroleum; thermal and catalytic processes; properties & production of petrochemicals.

**CHE G513 Environmental Management Systems 3 2 5**

Introduction to air & water pollutants & solid wastes; sampling & analysis techniques; impact of these on environment; national & international regulations; ISO series; conventional & non-conventional energy resources; life cycle analysis; environmental audit; sustainable developments; case studies.

**CHE G514 Evolutionary Computation 5**

Non-traditional optimization techniques; population based search algorithms; evolutionary strategies; evolutionary programming; simulated annealing; genetic algorithms; differential evolution; different strategies of differential evolution; Memetic algorithms; scatter search; ant colony optimization; self-organizing migrating algorithm; other emerging hybrid evolutionary computation techniques; engineering applications involving highly non-linear processes with many constraints and multi-objective optimization problems.

**CHE G521 Chemical Engineering Analysis 2 2 4**

Mathematical analysis of chemical engineering problems; introduction to modelling and simulation techniques in the analysis of systems; emphasis on applying mathematical techniques to real Chemical Engineering processes and on physical and mathematical interpretation of results; use of computer software for analysis and solution of mass and energy balances problems for complex processes.

**CHE G522 Polymer Technology 3 1 4**

Polymerisation techniques; classification of polymers; mechanism and kinetics of formation of polymers; different techniques for determination of different types of molecular weights; polymer structure; definition and measurement of glass transition and crystalline melting

temperatures; viscoelasticity and rubber elasticity behaviour; degradation and stability; polymer processing; rheology and applications. The course will terminate with several design projects on real life problems.

**CHE G523 Mathematical Methods in Chemical Engineering 3 2 5**

An introduction to mathematical modelling and simulation, Fundamentals of functional analysis, Linear algebraic equations and related numerical schemes, ODE's IVP and related numerical schemes, Partial differential equations and related numerical schemes, Optimization and related numerical schemes, Application of the above principles to solving problems in Chemical Engineering, Role of computer programming and packages in problem solving.

**CHE G524 Introduction to Multiphase Flow 3 1 4**

Introduction to multiphase flow, Single particle motion, Bubble and droplet transition, Marangoni effects, Bubble growth and collapse, Cavitation, Flow patterns, Internal flow energy conversions, Homogeneous flows, Flows with bubble and gas dynamics, Sprays, Granular flows, Drift flux models, System instabilities.

**CHE G525 Chemical Process and Equipment Design 3 1 4**

The nature and function of process design, Flow sheet preparation and drawing, Process Planning Scheduling and Flow Sheet Design, P and I diagrams, Piping Design, Pump size selection. Design information and data, Specification and design of process equipment, Rules of THUMB for design of equipment, Software use in process design, Process design of equipment in heat and mass transfer, reactors, pumps, etc., Mechanical design of selected equipment.

**CHE G526 Nuclear Engineering 3 1 4**

Review of Nuclear Physics, Mechanism of nuclear fission, Fission cross section, Fission products, Reactor Physics, Types of nuclear reactors, Construction and control of nuclear reactors, Heat transfer in nuclear reactors, Design and operation, Reactor shielding, Nuclear fuels, Moderators, Coolants, Reflectors and structural materials, Nuclear fuel cycle, Spent fuel characteristics, Reprocessing techniques role of solvent extraction in reprocessing, Reactor control and safety.

**CHE G527 Energy Conservation and Management 3 1 4**

Energy conservation, Growth and demand of energy, Energy availability, Comparison of specific energy use in select industry, Potential and status of energy in India, Energy saving potential in industries, Potential of energy efficiency in India, Energy available for industrial use and the role of conservation, Energy management and policy, Comprehensive energy conservation planning (CECP), Definition and principles of energy conservation, Energy conservation technologies, Cogeneration concept and scope, Energy audit and anagement. Energy conservation in utilities.

**CHE G528 Introduction to Nano Science and Technology 3 1 4**

Introduction to nano-science, Basic idea of solid state physics and quantum mechanics, Quantum wells, Wires and dots, Properties of nanomaterials, Carbon nanotubes, Nanosynthesis, Characterisation methods, Application of nano-materials to various fields like electronics, medical, MEMS, photonics, molecular switches and others, Special reference to Chemical Engineering as in catalysis, heat transfer and special additive and performance materials (nanofluids, nanocomposites), Future of nano science and technology, Large scale manufacture and technological issues.

**CHE G529 Pulp and Paper Technology 3 1 4**

Selection of pulp and paper making raw materials, Wood Anatomy- identification, Preparation of wood chips, Chip screening, Storage and chip conveying, Chemical composition of fibrous raw materials, Chemical Pulping, Mechanical Pulping, Chemical thermo-mechanical (CTP) processes, Waste Paper Pulping, Bleaching and washing, Chemical Recovery, Description of various grades of pulp & paper, Mechanical and chemical properties of pulp, Paper making, cellulose derivatives- preparation & end use, Environmental aspects in pulp and paper industry.

**CHE G531 Project Engineering 2 2 4**

Project feasibility studies and report; Project appraisal; Project solution and evaluation; Project planning; Economic decision making; Project preparation and management.

**CHE G532 Alternate Energy Resources 3 1 4**

The scope and present day technology in utilization of solar energy, wind power, tidal power, geothermal power, M.H.D. and fuel cells.

**CHE G533 Petroleum Product Characterization 3 2 5**

Methods of estimation of characterization parameters for pure hydrocarbons; methods of characterization of petroleum fractions and products; experimental methods on measurement of basic properties obtained from laboratory testing; methods of prediction of properties for defined mixtures from pure-component properties (normal boiling point, density, molecular weight, critical properties, etc.); methods of prediction of properties for undefined mixtures based on certain bulk properties; characterization methods for light and heavy as well as narrow and wide boiling range mixtures; predictive methods for some characteristics specifically applicable to petroleum fractions that affect the quality of a fuel; standard test methods recommended by ASTM for various properties; minimum laboratory data needed to characterize various fractions as well as analysis of laboratory data and criteria for development of a predictive method; introduction to characterization of crude oils and reservoir fluids; associated Petroleum Laboratory experiments.

**CHE G541 Process Plant Simulation** **2 2 4**

Computer aided analysis of chemical process systems; classification and development of mathematical models to various chemical engineering systems; decomposition of networks; tearing algorithms; numerical methods for convergence promotion and solving chemical engineering problems; traditional & non-traditional optimization techniques; specific purpose simulation; dynamic process plant simulation; case study problems using professional software packages.

**CHE G542 Computational Transport Phenomena** **3 2 5**

Concepts; partial differential equations: types, boundary conditions, finite difference scheme, error analysis, grid generation, stability criteria; conduction and convection : two-dimensional steady state problem, methods for solving coupled algebraic equations, finite element method; fluid flow : governing equations, various approach of simulation (stream-vorticity, primitive variable), staggered grid, similarity solution, Newton-Raphson method, explicit and implicit formulation; solution of Navier-Stokes equations : solution of full and parabolized equations, unsteady flow, MAC, SIMPLE algorithm, RNS method; Mass Transfer : dynamic model, mass transfer with simultaneous convection and diffusion, transient multicomponent diffusion; short projects on development of codes for various real life problems involving transport processes.

**CHE G551 Advanced Separation Technology** **3 2 5**

A brief overview of the existing separation technologies such as adsorption-based separation, membrane separation, cryogenic separation, and biotechnology-based separation. Recent advancements on the above areas and the new concepts such as simulated moving bed adsorption, thermally coupled pressure swing adsorption, reactive distillation, bio-filtration, supercriticalfluid extraction etc. This course will terminate with several design projects on real life problems.

**CHE G552 Advanced Transport Phenomena** **5**

Viscosity, thermal conductivity and diffusivity, Shell momentum and energy balance, equations of change for isothermal and non-isothermal systems, Concentration distribution in solids and laminar flows, momentum, thermal and concentration boundary layers near walls, origin of turbulence, length scales in turbulent flows, Reynolds (RANS) equations, estimates of Reynolds stress (k-epsilon and k-omega type models), turbulent shear flow near a wall, turbulent flow in pipes and channels, turbulent heat transfer, Introduction to large eddy simulations models, rheology and material functions, non-Newtonian viscosity and generalized Newtonian models, Linear and non-linear visco-elasticity, radiation heat transfer, multi-component systems, Coupled heat and mass transfer, evaporation, boiling and condensation, chemical reactions, Special topics: Flow through porous media, compressible flows, multiphase flow, Transport phenomena in biochemical systems.

**CHE G553 Statistical Thermodynamics** **4**

Review: Classical thermodynamic and elementary Statistical Mechanics, Macroscopic and microscopic descriptions of the state of a system, Equilibrium ensembles, the partition function and thermodynamic properties; System of independent particles; Fluctuations and the compressibility equation; Chemical equilibrium in ideal gas mixtures; Molecular based equations of state, SAFT, Lattice statistics; Real gases, Virial equation; The liquid state: lattice models, distribution functions theories, perturbation theories; Liquid mixtures: solution theories and local composition models, Statistical thermodynamics of electrolytes.

**CHE G554 Computational Fluid Dynamics** **4**

Introduction to CFD, Equations of change for momentum, energy and mass transport, introduction to partial differential equations, Numerical analysis and discretization techniques, Managing uncertainties in CFD, grid generation, application of CFD to solve Chemical Engineering problems, Introduction to COMSOL, data analysis, validation and post processing.

**CHE G556 Electrochemical Engineering** **4**

Basic physics of galvanic cells, Electrochemical Energy conversion, Electrochemical Energy storage, Equivalent circuit dynamics, Impedance spectroscopy, Impedance of electrodes, Nernst equation, Fuel cells and batteries, Faradic equations in dilute solutions, Butler Volmer equation, Reactions in concentrated solutions, Ion absorption and intercalation, Concentration polarization, forced convection in fuel cells, Transient diffusion, Warburg impedance, Diffusion in concentrated solutions, Transport in bulk electrolytes, Ion concentration polarization, Double layer structure, Transport on porous media, Porous electrodes, Super capacitors, Electrostatic correlations.

**CHE G557 Energy Systems Engineering** **4**

Cradle to grave overview of major current and future energy conversion processes. Energy sources such as coal, natural gas, petroleum, biomass, uranium, wind, and solar. Fuel processing techniques such as Fischer-Tropsch synthesis, gasification, methane reforming, and CO2 reforming. Power generation technologies including steam turbines, gas turbines, wind turbines, fuel cells, and solar panels. Sustainability impact factors including water consumption, smog formation, and CO2 emissions. Advanced processing techniques such as combined cycles, turbine/fuel cell hybrids, and CO2 capture technologies. Real world use and application.

**CHE G558 Chemical Process Optimization** **4**

Introduction to Process Modelling and simulation, Fundamentals of analytical optimization. Survey of one dimensional line-search methods, and multi-dimensional unconstrained and constrained numerical optimization algorithms. Applications of linear programming, nonlinear

programming, mixed integer linear/ nonlinear programming, and parameter estimation in chemical engineering. Feasible-path and infeasible-path techniques for chemical process flowsheet optimization, Evolutionary computation in Chemical Engineering.

**CHE G559 Reactor Physics and Engineering 5**

Nuclear Reactions, Binding Energy, Fission Reactions, Fissile and Fertile Materials, Radioactive Decay; Neutron Cross Sections, Nuclear Fuel Properties, Moderators, Energy Spectra, Infinite Medium Multiplication, Power Reactor Core & Kinetics, Neutron Balance & Diffusion Equation, Four-factor formula, Two-group analysis, criticality equation, Electrical power generation from nuclear fission, fundamental aspects of fission chain reaction, and reactor design. Reactor concepts & types, their static and dynamic characteristics Reactor operation and control, Startup and shut down of systems.

**CHE G560 Nuclear Fuel Cycle and Waste Management 5**

Processing of nuclear fuel with descriptions of mining, milling, conversion, enrichment, fabrication, irradiation & properties of irradiated fuel, reprocessing, and waste disposal. In-core and out-of-core nuclear fuel management design, Nuclear power plant and fuel cycle economics, Management of spent fuel, high-level waste, uranium mill tailings, low-level waste and decommissioning wastes. Fundamental processes and governing equations for waste management systems, safety assessment of waste disposal facilities, Chemical Engineering operations in Nuclear fuel manufacture, waste reprocessing operations and waste management, Process Engineering for Nuclear Industry.

**CHE G561 Nuclear Reactor Control and Instrumentation 4**

Fundamentals of process instrumentation and control, Open and closed loops, SCADA and DDC, PLC, Alarms and Safety interlocks for shutdown and emergency shutdown, special sensors and sensor specifications for Nuclear Industry, Nuclear reactor safety, Special control logic for Nuclear safety, reliability and redundancy, Nucleonics: application of Nuclear materials and radiation in measurement techniques, Nucleonics based instruments for analysis, Design, maintenance and operation of such instruments. Calorimetry, detection of alpha, beta and gamma rays including spectrometry, liquid scintillation counting.

**CHE G562 Thermal Hydraulics and Heat Transfer 4**

Thermal-hydraulic core design and analysis of nuclear systems, Single and two-phase flow, Flow regimes, pressure drops, frictional losses, pumping power modeling of fluid systems. Design constraints imposed by thermal-hydraulics heat generation, temperature distribution, heat removal, reactor heat sources & coolants, departure from nucleate boiling, boiling heat transfer, critical heat flux conduction in reactor components and fuel elements, heat transfer in reactor fuel bundles and heat exchangers, application of CFD in thermo-hydraulics of core.

**CHE G563 Nuclear Chemical Engineering 4**

Solvent Extraction, Ion Exchange, Decontamination, Isotope Separation, Unit operations and processes used in the Production of Heavy Water, Desalination, Thermo-chemical Cycle for Hydrogen Production, district heating, nuclear propulsion, waste processing including vitrification.

**CHE G564 Nuclear Materials and Radiation Damage** **4**

Nuclear Materials; fabrication and quality control, non – destructive evaluation and irradiation behavior of uranium, plutonium and thorium based ceramic, metallic and composite fuels; fuel failure, post irradiation examination and mitigation of fuel failure; fabrication, heat treatment, property evaluation and irradiation behavior of fuel cladding and core structural materials e.g. aluminum & alloys for research reactors, zirconium alloys for water cooled nuclear power reactors and stainless steels and oxide dispersion strengthened (ODS) steel for fast reactors; physical, chemical and instrumental methods of analysis of nuclear materials and real time accounting of nuclear materials, radiation damage of nuclear fuels, pressure vessel, pressure tubes and other structural materials including radiation-embrittlement, void swelling, irradiation growth and creep, fracture toughness etc.

**CHE G565 Radiation and Radio Isotopes Applications** **4**

Nuclear non-power research reactors, measurement of radiation and use of neutron radiography, neutron diffraction and activation analysis for materials characterization; Production of Radioisotopes and their applications in medicine and healthcare, food and agriculture including food irradiation & preservation, radiation induced mutation for seed and crop, sterilization and application of radioactive tracers in basic and applied research.

**CHE G566 Nuclear Safety, Security and Safeguards** **4**

Radiation interaction & safety, environmental aspects, internal and external dose evaluation, reactor effluents and release of radioactivity, Operational and maintenance safety, Hazop and Hazan analysis, HSE issues and systems management in Nuclear installations and Nuclear industry and Nuclear Laboratories, Design basis threat (DBT) and threat analysis and evaluation, Detection, delay and response technologies and evaluation, Incorporating insider threat/wrong operation in DBT, Security and safety in Nuclear Materials Transportation, Nuclear forensics and consequence management, Nuclear systems safety and security analysis, Technologies and techniques for securing nuclear materials, Nuclear materials safeguard systems from theft, spillage and other unforeseen incidents, Fuel facility safe-guard systems, Design of safeguard systems, Intrinsic and Extrinsic safeguard and proliferation resistance of fissile and fertile materials, Technical issues associated with Nuclear Non Proliferation, Facility inspection, safety, security and safeguard audit, Elements of non-proliferation policies, treaties and enforcement technologies.

**CHE G567 Natural Gas Processing** **4**

Overview of Natural Gas industry; Overview of Gas Plant processing; Field operation and inlet receiving; Compression; Gas treating; Gas dehydration; Hydrocarbon recovery; Nitrogen rejec-tion; Trace component recovery or removal; Liquids processing; Sulfur

recovery; Transportation and storage; Liquefied Natural Gas; Capital cost of Gas processing facilities; Natural gas processing plants.

**CHE G568 Modeling and Simulation in Petroleum Refining 4**

Introduction to modeling and simulation; Numerical methods and software; Modeling and simulation of multi-component distillation columns; Reactor modeling in the petroleum refining industry; Modeling of catalytic hydro-treating; Modeling of catalytic reforming; Modeling and simulation of fluidized-bed catalytic cracking converters.

**CHE G569 Petroleum Production Economics 4**

Cash flow analysis in the petroleum industry (definition of cash flow, deriving net cash flow under tax/royalty systems and production sharing contracts, depreciation methods, inflation, sunk costs). Economic indicators (net present value, rate of return and other indicators). Fiscal analysis (the nature of petroleum fiscal regimes, the effects of fiscal regimes on exploration and field development decision making, economic analysis of fiscal regimes in India & abroad).

**CHE G611 Computer Aided Analysis and Design 2 3 5**

The course aims at developing complete self reliance in solving analysis & design problems of engineering with the aid of computers. It stresses upon the use of more powerful tools including system planning, simulation and modelling. The student will take up a design project and will work independently on the project guided by the instructor or resource person as and when required. The effort must culminate with a CAD program and a project report.

**CHE G613 Advanced Mass Transfer 3 2 5**

Use of stage and differential contact concepts in design of mass transfer equipment; methods of determining and interpretation of rate data; multicomponent distillation, absorption and extraction.

**CHE G614 Advanced Heat Transfer 3 2 5**

Heat conduction with unsteady boundary conditions; recent advances in natural and forced convection; condensation and boiling phenomena; heat transfer in high speed flows; liquid metal heat transfer, radioactive metal heat-transfer between surfaces in absorbing media; complex problems involving simultaneous conduction, convection and radiation.

**CHE G615 Advanced Separation Processes 3 2 5**

Shortcut and rigorous methods of conventional separation processes such as multicomponent distillation, absorption, stripping and extraction; Azeotropic and Extractive distillation; adsorption based separation, simulated moving bed adsorption, thermally coupled pressure swing adsorption; cryogenic separation, gas liquefaction; membrane based separation, pervaporation, liquid membrane; biotechnology based separation, modeling approach, design considerations, biofiltration; reactive distillation; super critical fluid extraction.

**CHE G616 Petroleum Reservoir Engineering 3 2 5**

Origin and composition of petroleum; Geographic distribution of oil; Petroleum geology; Exploration, drilling and recovery; Drilling methods and drilling fluids; Lubricants and spotting fluids; Corrosion control; Analytical and test methods; Enhanced oil recovery; Injection fluids; Polymer and caustic flooding; Use of surfactants; Improvement of oil displacement efficiency; Environmental and economic aspects.

**CHE G617 Petroleum Refinery Engineering 3 2 5**

History and development of refining; Indian petroleum industry; Composition of petroleum, laboratory tests, refinery products; Classification, characterization and evaluation of crude oil; Trends of petroleum products; Atmospheric and vacuum distillation; Design of crude distillation column; Catalytic cracking; Hydrotreating and Hydrocracking; Catalytic reforming; Delayed coking and visbreaking; Furnace design; Isomerization, alkylation and polymerization; Lube oil manufacturing; Energy conservation in petroleum refineries; Environmental aspects of refining.

**CHE G618 Petroleum Downstream Processing 3 2 5**

Petrochemical feedstock; Pyrolysis of Naptha and light hydro-carbons; First generation petrochemicals: Ethylene, Propylene, Butylenes, Acetylene, Butadienes, Chloroprene, cyclohexane, BTX, Polymethyl Benzenes; Second generation petrochemicals: synthesis gas, methanol, ethanol, ethylene oxide, propylene oxide, acetone, allyl alcohol, glycerol, acrylonitrile, Acrylic acid and derivatives, phenol, aniline, nylon monomers, polyester monomers, styrene and other monomers; Third generation petrochemicals: plastics, rubbers, fibres, resins, detergents, pesticides, dyes, protein, explosives, petroleum coke and carbon black; Catalysts in petroleum refining and petrochemicals processes; Transportation of dangerous goods; Health and safety in petrochemical industries; Pollution and toxicity; Future of petrochemicals.

**CHE G619 Process Intensification 3 2 5**

A brief review of the process intensification (PI), includes philosophy and principles of PI; equipments and methods for PI; few examples of their application on the commercial scale, such as multifunctional reactors, hybrid processes, monolithic reactors, high gravity reactors etc., industrial practice of PI- methodology and applications; PI by process synthesis; PI by plant safety. This course will terminate with several design projects on real life problems.

**CHE G620 Energy Integration Analysis** **3 2 5**

Importance and scope of application of Energy Integration; Pinch technology tools, targeting, design, synthesis and optimization of heat exchanger networks (HEN); Interfacing HEN synthesis with heat exchanger design, Retrofitting, energy integration of distillation and evaporation processes, mathematical programming approach, Artificial intelligence based approaches.

**CHE G621 Fluid Dynamics** **2 3 5**

Mechanics of turbulent flow; semi-empirical expressions; statistical concepts; stability theory;flow of non-Newtonian fluids; stationary and moving shock waves; Prandtl-Mayer expressions; two and three dimensional subsonic and supersonic flow; methods of characteristics; small perturbation theory and similarity rules.

**CHE G622 Advanced Chemical Engineering Thermodynamics** **3 2 5**

Review of fundamental principles; statistical foundations; thermodynamic properties of pure substances and mixtures, their estimation and correlation; stability and equilibrium criteria for homogeneous and heterogeneous systems; thermodynamics of irreversible processes.

**CHE G641 Reaction Engineering** **3 2 5**

Design of multi-phase reactors; analyses of gas-liquid and gas-liquid-solid reactions; intrinsic kinetics of catalytic reactions; residence time distribution models for micro-and macro-mixing; mathematical models for gas-liquid-solid reactors; laboratory reactors; dynamics and design of various multi-phase reactors such as trickle bed reactors, bubble column reactors, segmented-bed reactors, slurry reactors, spouted bed reactors, pulsating reactors, fluidized bed reactors, etc.; optimization of chemical reactors.