Syllabus for Chemical Engineering(AChE)

1. **Introduction to Chemical Engineering (AChE01)**
   1.1 Overview of chemical engineering, Classification of reactions, Variables affecting rate, Definition of reaction rate, single and multiple reactions, Elementary and non-elementary reactions, Molecularity and order of reaction, Reaction pathways, Arrhenius law, Activation energy, Reversible and irreversible reactions, Reaction equilibrium. **(AChE101)**
   1.2 **Ideal and Real Gases:** ideal gases, real gases: equations of state and compressibility charts, real gas mixtures, Multiphase Equilibrium: phase diagrams and the phase rule, single-component two-phase systems, two-component gas/ single-component liquid systems, two-component gas/two-component liquid systems, multicomponent vapor-liquid equilibrium**(AChE0102)**
   1.3 Introduction to material balances, material balances without chemical reaction, stoichiometry and terminology for reaction systems, species mole balances, element material balances, material balances for combustion systems, Material balance involving recycles, bypass and purge systems; Combined material & energy balances for single stage processes, Material and Energy balance calculations for industrial processes. **(AChE0103)**
   1.4 Energy Balances, Terminology associated with energy balances, Types of energy to be included in energy balances, Energy balances without chemical reaction, Energy Balances with chemical reactions, Standard heat of formation, Heat of reaction, Integration of heat of formation and sensible heat, Heat of combustion**(AChE0104)**
   1.5 **Unit Processes:** Oxidation: Oxidizing agents, Liquid phase oxidation with oxidizing agents and oxygen; Nitration: nitration agents and nitration with reference to explosives; Halogenation: importance of halogenations; Hydrogenation: Industrial hydrogenation of fat and oil, Hydrolysis: Industrial Hydrolysis of fat, hydrolysis of carbohydrates, starch to dextrose; Polymerization: polymerization reactions, classifications of polymers, methods of polymerization**(AChE0105)**
   1.6 **Introduction to Modeling and Simulation:** Mathematical Techniques in Chemical Engineering , Chemical Processes, Simulation, Modeling, Process Modeling, An Overview of Modeling and Simulation: Strategy for Simulation, Approaches for Model Development, Types of Models, Types of Equations in a Model and Solution Strategy, **(AChE0106)**

2. **Chemical Engineering Thermodynamics(AChE02)**
   2.1 **Chemical reactions:** Gibbs energy, Entropy and Enthalpy changes of reactions; General Equations of Equilibrium, Phase and chemical-reaction equilibria; Homogeneous and heterogeneous reactions equilibria; Kinetics of chemical reactions, Reaction rate laws, Effect of Pressure, Effect of heat, Temperature and catalysts on chemical reactions**(AChE0201)**
   2.2 **Laws of Thermodynamics, its functions:** Introductory concepts and definitions, Energy and First law of Thermodynamics, Properties of a pure, simple compressible substances, Second law of thermodynamics Entropy, Analysis of thermal systems, Air-compressor**(AChE0202)**
   2.3 **Thermodynamics properties of fluids:** Volumetric properties of pure fluids; Pressure, Volume, Temperature Relations of Fluids; Thermodynamics of Solution; Thermodynamics of flow processes; Heat effects, Production of power from heat **(AChE0203)**

2.4 **Theories of reaction rates**: kinetics of homogenous reactions, single and multiple reaction in ideal reactors, non-ideal reactors; non-isothermal reactors, Batch and continuous flow reactors, kinetics of heterogenous catalytic reactions; diffusional effects in catalysis. **(AChE0204)**

2.5 **Heat of reaction:** Heat capacity calculations, Dissolution & laws of Thermochemistry, Effect of Pressure & Temperature on heat of reactions. **(AChE0205)**

2.6 **Refrigeration and Liquefaction:** Refrigeration cycle, Vapor compression cycle, Ecofriendly refrigerants, Absorption and adsorption refrigeration, Liquefaction processes. **(AChE0206)**

3 **Fluid Mechanics and Mechanical operations: (AChE03)**

3.1 **Classification of Fluids and Fluid Properties:** Types of Fluids- Ideal and Actual fluids, Compressible and Incompressible Fluids, Newtonian and Non-Newtonian fluids including time dependent and time independent fluids, Newton's law of viscosity, surface tension and its effect, Fluid pressure and its measurement**(AChE0301)**

3.2 **Fluid statics:** Kinematics of Fluid Flow, Viscous Flow, Introduction to Compressible flow, Basic Equations of Fluid Flow, Velocity field; Stream function; Irrotational flow; Integral and differential analysis for fluid motion: Reynolds' transport theorem; Euler & Bernoulli's equation; Dimensional analysis and similitude**(AChE0302)**

3.3 **Internal and external fluid flow:** friction factor; Energy losses in fittings, valves etc.; Friction in pipes & Channels, Flow measuring devices; Pumping of fluids; Agitation and mixing of liquids: equipment, agitation of liquids, types of impellers, power consumption in agitated vessels etc. **(AChE0303)**

3.4 Solids, characteristics of solid particles, type of standard screen series, sieve analysis, Size reduction and enlargement, crushers, grinders, disintegrates for coarse & intermediate, wet and dry grinding, energy and power requirements, law of crushers, work index, etc., Conveyers: mechanical and pneumatic conveying, elevators etc. **(AChE0304)**

3.5 **Screening and other separation methods:** screen analysis, estimation of particle size, surface area and particle population based on screen analysis, ideal and actual screens, principles of elutriation, flotation, jigging, electrostatics, and magnetic separation processes **(AChE0305)**

3.6 Sedimentation, settling velocity, flocculation, Fluidizations, dense phase fluidization and boiling beds, Minimum fluidization velocity, minimum porosity of bed and bed height, batch &continuous fluidization, Filtration, filter media, filter aids, batch and continuous filtration, filtration equipment, vacuum filter, rotary drum filters. **(AChE0306)**

4. Chemical Reaction Engineering (AChE04)

4.1. **Mole Balances:** mole balance equations for batch and continuous reactors, introduction of industrial reactors, mole balance equations in terms of conversion, applications of the conversion equation for reactors, calculation of reactors in series, space time and space velocity. **(AChE0401)**

4.2.**Rate Laws and Stoichiometry:** expression and interpretation of rate laws, reaction rate constants, expression and interpretation of rate laws, design structure for isothermal reactors, design of batch reactors, design of single CSTR and CSTRs in series, design of tubular reactors, pressure drops in reactors, application of software to reactor designs. **(AChE0402)**

4.3.**Collection and Analysis of Rate Data:** the algorithm for data analysis, determination of rate law parameters by differential and integral methods, determination of rate law parameters by method of initial rates and differential reactors, evaluation of laboratory reactors, yield and selectivity in multiple reactions, maximizing desired product in series reactions, algorithm for solution of complex reactions. **(AChE0403)**

4.4. **Reaction Mechanisms:** pseudo-steady-state hypothesis, searching for a mechanism, chain reactions and reaction pathways, Enzymatic reactions and Bioreactors: -enzymatic reaction fundamentals, inhibition of enzyme reactions, bioreactors, Energy Balances for Non-isothermal Reactors: - derivation of the energy balance equations, application to adiabatic reactors, application to non-adiabatic tubular reactors, application to equilibrium reactors, application to non-adiabatic CSTR reactors, Analysis of two-dimensional non-isothermal reactors**(AChE0404)**

4.5.**Catalysis and Catalytic Reactors:** catalysts and steps in a catalytic reaction, reaction mechanism and synthesizing a rate law, heterogeneous data analysis, chemical vapor deposition, catalyst deactivation, Diffusion Effects on Heterogeneous Reactions: - effects of external diffusion, effects of internal diffusion, Residence Time Distributions in Chemical Reactors: - characterization and measurement of RTD, analysis of RTD in different reactors, reactor modeling with RTD **(AChE0405)**

4.6. **Biochemical Engineering:** Basic of microbiology, Chemicals for Life- Lipids, Sugar and Polysaccharides, From Nucleotides to RNA and DNA, Amino, Peptides and Protein, Hybrid Biochemicals, The Kinetics of Enzyme-Catalyzed Reactions, Metabolic Stoichiometry and Energetic, Molecular Genetics and Control System: **(AChE0406)**

5. **Energy and Heat Transfer(AChE05)**
5.1. **Fossil fuels, Combustion and Chemical processes, Fuel calculations:** Different forms of energy: renewable vs non-renewable, conventional vs non-conventional, Electrochemical cell , Water splitting, small hydro power plants, Hydrogen energy and Fuels cells, Solar energy (thermal and photovoltaic (PV) applications, Wind energy, Geothermal, Biofuels (solid, liquid and gaseous biofuels), Nuclear energy, Waste to energy, sanitary land fill, gasification, etc. **(AChE0501)**

5.2. **Conduction:** Fourier conduction equation, Thermal conductivity, Heat conduction equations: Composite wall structure, Insulation and its optimum thickness, Extended surfaces, Steady state heat conduction, Unsteady state conduction. **(AChE0502)**

5.3. Convection: Newton's law of cooling, Heat transfer in laminar and turbulent flows inside tubes, Heat transfer by external flows across: Cylinders, tube bank and spheres, Natural convection, Convection with phase change: Boiling and condensation. **(AChE0503)**

5.4. **Radiation:** Theories of radiation, electromagnetic spectrum, thermal radiation, spectral emissive power, surface emission, Basic equations, Emissivity, Absorption, Black and gray body, Thermal radiation between two surfaces, radiation shields**(AChE0504)**

5.5. **Heat Exchangers:** Types, constructional details and internal components and their functions, condensers, Heat exchangers: Double pipe, shell and tube, air-cooled, plate type, compact heat exchangers, Fouling of heat exchangers. **(AChE0505)**

5.6. **Evaporators:** Classification, Single and multiple effect evaporators, Performance of evaporators: Capacity and economy, Methods of feeding; Reactor Heating and Cooling Systems: Time required for heating and cooling of agitated batch reactors, Helical cooling coils, Jacketed vessels**(AChE0506)**

6. **Mass Transfer :(AChE06)**
    6.1 **Diffusion:** Steady state molecular diffusion in gases and liquids, Fick's Laws of diffusion, Correlation for diffusivity in gases and liquids for binary and multi-component systems, Diffusivity measurement and prediction, Diffusion in solids, Types of solid diffusion**(AChE0601)**
    6.2 **Mass Transfer by Convection:** Concepts of molecular diffusion and mass transfer coefficient, Mass transfer coefficients in laminar flow and turbulent flow, Mass, heat and momentum transfer analogy, Chilton-Colburn analogy, Reynolds analogy, dimensionless number, Simultaneous heat and mass transfer. Equilibrium curve, Diffusion between phases, Overall mass transfer coefficient, Two film theory in mass transfer, Steady state concurrent and counter current Process, Stages and Multistage cascade. **(AChE0602)**
    6.3 **Distillation and Extraction:** Distillation – types of distillation, Flash distillation, Batch distillation; Binary distillation; introduction to multi-component distillation. Liquid liquid extraction Principles, phase equilibrium diagrams, leaching principles. **(AChE0603)**
    6.4 **Absorption and Adsorption:** Introduction and principles of absorption and desorption, Equilibrium solubility of gases in liquids, isothermal and adiabatic gas liquid contact, Packings and solvent selection, Material balance in absorber, Counter-current multistage operations, Adsorption and principles of adsorption, selection criteria for adsorbent. **(AChE0604)**
    6.5 **Crystallization and Drying:** Nucleation and crystal growth, Batch crystallization, crystallization equipment; Drying Equilibria, drying rate curve and drying time. **(AChE0605)**
    6.6 **Mass transfer equipment:** Gas dispersed: bubble column, Spray tower, Tray tower, Packed tower, Continuous contact equipment, Design of absorption towers-Packed and trayed tower design. Drying equipment and selection, Cooling tower. **(AChE0606)**

7. **Chemical Industrial Technology: (AChE07)**
    7.1 **Manufacturing of alkalies and acids- Alkalies:** Chlor-Alkali industries: soda ash, chlorine and caustic soda: Acid industries: sulfur, sulfuric acid, hydrochloric acid, nitric acid phosphoric acid; Industrial gases: CO_2, dry ice, H_2, N_2, O_2, acetylene, etc. Production of Synthesis Gas, Gasification of coal and chemicals from coal; Ammonia, Manufacture of Industrial solvents: Methanol, Diethyl ether, Acetone, etc. **(AChE0701)**
    7.2 **Manufacturing of Cement industries:** Portland cements, Types, compounds in cements, setting and hardening of cements, other cements, refractories and its classifications; Glass industries, Manufacturing procedure of glass and special glasses; Surface coating industries: Manufacture of paints, pigments, varnishes, enamel, lacquers: Types of paints and its raw materials; Paints manufacture; Varnishes and its characteristics; different types of enamel, Lacquers and its composition; Lacquer oils**(AChE0702)**
    7.3 **Phosphate industries:** phosphoric acid (wet process), normal superphosphate and triple superphosphate, monoammonium phosphate (MAP), diammonium phosphate

(DAP); Nitrogen industries: synthetic ammonia, nitric acid, urea, ammonium nitrate and sulfate; Potassium industries: potassium chloride, potassium sulfate **(AChE0703)**

7.4 **Natural product processing:** pulp, pulping processes, recovery of the black liquor, paper; sugar from cane, cane sugar refining, starch; Industrial microbial processes and edible oils: ethyl alcohol, citric acid, vegetable oils and animal fats; Soaps and detergents: soap and toilet bar soap, glycerin removal, detergents; Fiber and rubber industries: Production of fibers, polyamides, polyesters, rayon, styrene butadiene rubber (SBR): Dyes and Pesticides: Classification and Manufacture of dyes, pesticides**(AChE0704)**

7.5 **Petroleum refining:** Exploration, constituents of petroleum, Refinery processes, crude distillation, Conversion processes, catalytic cracking, Reforming, catalytic reforming; Petrochemical industries: Precursors of petrochemicals, Manufacture of ethylene and propylene; Polymer based Industries: Engineering plastics, polymers and commercial resins, thermoplastic plastic, PE, PP, and PVC ; resins: phenol formaldehyde, urea formaldehyde, melamine formaldehyde, and epoxy resin **(AChE0705)**

7.6 **Nano Technology:** Introduction of nanoparticles/ nanostructured materials, Classification of Nano materials, Application of Nanomaterials/Nanotechnology Devices in daily life, Application in medicine, Application in agriculture and food industry. **(AChE0706)**

8 Instrumentation and Process control :(AChE08)

8.1 Introduction to process control, Mathematical modeling, Dynamic behavior of chemical processes, Controller modes (P, PI and PID), control valves. **(AChE0801)**

8.2 **Advanced control schemes:** Feed forward, Feedback, cascade, ratio, application to equipment such as distillation-columns, reactors. **(AChE0802)**

8.3 **Linear Open-loop Systems:** First, second and higher order systems, Linearization, Response to step, pulse, impulse and ramp inputs, Level tank U-tube manometer, Interacting and noninteracting systems, Dead time. **(AChE0803)**

8.4 **Linear Closed-loop systems:** Controllers and final control elements, control valves, block diagram, Transient response of simple control system**(AChE0804)**

8.5 **Frequency response:** Frequency domain analysis, control system designed by frequency response, bode stability criteria, different methods of tuning of controllers. **(AChE0805)**

8.6 **Instrumentations:** Classification and Elements of measuring instruments, working principles of transducers/instruments employed for the measurement of temperature, pressure, flow, liquid level, Moisture and humidity analysis, pH measurements, High performance liquid chromatography (HPLC) **(AChE0806)**

9 Safety, waste management and quality control:(AChE09)

9.1 Types of hazards in chemical industries, Hazards due to high pressure & explosions, dust & vapor cloud explosions, vacuum temperature, inflammable materials, toxic materials, chemicals, chemical reactions and operations, electrostatics, ionizing radiation etc.; Noise hazards effects of noise hazards on personnel and plant operation; Fire & Explosion indices and hazard analysis **(AChE0901)**

9.2 Occupational health and safety management, safety culture; storage of dangerous materials; Safety protection, equipment for personal & plant for various hazards, Safety procedures; Disaster management, insurance, worker's safety Act **(AChE0902)**

9.3 Concepts and definition of pollution, Sources and effects of environmental pollution, air pollution, water pollution, land pollution, environmental laws & standards; design of pollution Abatement systems for particulate matter and gaseous constituents; **(AChE0903)**

9.4 Management of industrial waste reuse, recycling, impact of pollution on environment and it's assessment; Magnitude of industrial waste problem, hazardous waste disposal and effluents, effluent standards and stream standard. **(AChE0904)**

9.5 **Solid-waste disposal and recovery of useful products:** Modification; recovery of by-products; energy recovery; waste utilization and recycle and reuse; Waste Minimization; Environmental Policy, Act and Regulations, ISO 14001; Concept of Cleaner Production **(AChE0905)**

9.6 Quality and quality control, Quality Circle, Total Quality Management, Quality Management System, Standardization and Certification, Nepal Standard (Certification Mark) Act 2037, Regulation 2040, Consumer Protection Act **(AChE0906)**

10. Project Planning, Design and Implementation: (AALL10)

10.1. **Engineering drawings and its concepts:** Fundamentals of standard drawing sheets, dimensions, scale, line diagram, orthographic projection, isometric projection/view, pictorial views, and sectional drawing. **(AALL1001)**

10.2. **Engineering Economics:** understanding of project cash flow; discount rate, interest and time value of money; basic methodologies for engineering economics analysis (Discounted Payback Period, NPV, IRR & MARR); comparison of alternatives, depreciation system and taxation system in Nepal**(AALL1002)**

10.3. **Project planning and scheduling:** project classifications; project life cycle phases; project planning process; project scheduling (bar chart, CPM, PERT); resources levelling and smoothing; monitoring/evaluation/controlling. **(AALL1003)**

10.4. **Project management:** Information system; project risk analysis and management; project financing, tender and its process, and contract management. **(AALL1004)**

10.5. **Engineering professional practice:** Environment and society; professional ethics; regulatory environment; contemporary issues/problems in engineering; occupational health and safety; roles/responsibilities of Nepal Engineers Association (NEA).   **(AALL1005)**

10.6. **Engineering Regulatory Body:** Nepal Engineering Council (Acts & Regulations). **(AALL1006)**