Syllabus for the Position of Assistant Instructor

(*Chemical Engineering***)**

S.N.	Paper	Question Format	Full Marks	Number of Questions	Exam Time
1.	**Paper I**	Aptitude Test + Core Course (Objective)	20 +30	50	50 minutes
2.	**Paper II**	Core Course	100	10	3hrs
Total Written Exam Full Marks:			**150**		

(Detail Syllabus)

1 Process Calculations

1.1 Introductory Concepts: System of units, conversion of units, and dimensional consistency, Significant figures and validation of results, Mole and molecular weight, density, specific gravity, and concentration, temperature, pressure, hydrostatic head, and flow rate.

1.2 Ideal and 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

1.3 Material balances: material balances without chemical reaction, species mole balances, element material balances, material balances for combustion systems, Material balance involving recycles, bypass and purge systems.

1.4 Energy Balances: Types of energies, Energy balances without chemical reaction, Energy Balances with chemical reactions, Standard heat of formation, Heat of reaction, Heat of combustion, Humidity.

2 Fluid Mechanics:

2.1 Classification of Fluids and Fluid Properties: types of fluids- ideal and actual fluids, compressible and incompressible fluids, Newtonian and Non-Newtonian fluids, Newton's law of viscosity, surface tension and its effect.

2.2 Fluid flow: velocity gradient and rate of shear, viscosity, Reynold's number, boundary layer, basic equations of fluid flow, Bernoulli's equation and its correction factors.

2.3 Incompressible and compressible fluid: shear stress distribution, roughness and friction, effect of fittings and valves, mach number, equation for compressible fluids

2.4 Transport and metering of fluids: pipe and fittings, types of valves, centrifugal and reciprocating pumps, fans, blowers and compressors, venture meter, orifice meter and rotameter.

3 Mechanical operations:

3.1 Solid particles: characterization, particle shape and size, average particle size, type of standard screen series, sieve analysis, estimation of particle size, surface area and particle population based on screen analysis, ideal and actual screens, kneaders and and tumbling mixers.

3.2 Size reduction: crushing efficiency, crushing law and work index, crushers and grinders, wet and dry grinding, open-circuit and closed-circuit operation, mechanical and pneumatic conveying, elevators.

3.3 Separation methods: stationary screens and grizzlies, filtration, cake filters, filter press, rotary drum filter, filter media and filter aids, principle of cake filtration, clarifiers and thickeners, cyclones.

3.4 Fluidization: conditions and types of fluidization, minimum fluidization velocity, minimum porosity of bed and bed height, particulate and bubbling fluidization, application of fluidization, continuous fluidization.

4 Thermodynamics

4.1 First Law of Thermodynamics: internal energy, first law, energy balance for closed systems, thermodynamic state, state functions and processes, equilibrium and phase rule, enthalpy, heat capacity, mass and energy balances for open systems, isothermal, isobaric, isochoric, and adiabatic processes virial and cubic equations of state.

4.2 Second Law of Thermodynamics: statement of second law, reversible and irreversible processes, Carnot cycle, entropy, ideal work and lost work, Carnot Refrigerator, Choice of Refrigerant.

4.3 Thermodynamic Properties: property relations for homogeneous phases, Vapor/liquid equilibrium, VLE by Raoult's law, Dew point and bubble point calculations.

4.4 Solutions Thermodynamics and Chemical Reaction: Chemical potential, partial properties in binary solutions, fugacity and fugacity coefficients, activity coefficients, reaction coordinate.

5 Heat Transfer

5.1 Conduction: Fourier's law, thermal conductivity, heat conduction equations, composite wall structure, insulation and its optimum thickness, extended surfaces, steady and unsteady state heat conduction.

5.2 Convection: energy balance equations, heat transfer coefficients, logarithmic mean temperature difference, overall heat transfer coefficient, fouling factors. Newton's law of cooling, Heat transfer in laminar and turbulent flows inside tubes, Natural convection, dropwise and filwise condensation, boiling and condensation.

5.3 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.

5.4 Heat Exchangers: parallel flow, counter flow and cross flow heat exchangers, shell and tube heat exchangers, log mean temperature difference for parallel and counter flow heat exchangers, shell and tube condensers, extended surface equipment, air-cooled condensers, fouling of heat exchangers.

6 Mass Transfer:

6.1 Diffusion and convection theory: Steady state molecular diffusion in gases and liquids, Fick's Laws of diffusion, diffusion in solids, concepts of molecular diffusion and mass transfer coefficient, Chilton-Colburn analogy, Reynolds analogy, Equilibrium curve, Diffusion between phases, mass transfer coefficient, boundary layer theory, penetration and two film theory.

6.2 Distillation and Extraction: flash distillation, rectification, material balance and enthalpy balance, operating line, reflux ratio, feed plate location, minimum number of plates, optimum reflux ratio, sieve-plate column, batch distillation, binary distillation, multi-component phase equilibria and flash distillation, Liquid extraction principles, and extraction equipment.

6.3 Absorption and Adsorption: principles of absorption and desorption, material balance in absorber, limiting gas-liquid ratio, rate of absorption, tower height, Packings and solvent selection, equilibrium solubility of gases in liquids, isothermal and adiabatic gas liquid contact, Counter-current multistage operations, design of packed towers, Adsorption equipment, adsorption isotherms, principles of adsorption, selection criteria for adsorbent. adsorber design,

6.4 Leaching and Drying: leaching principle's and equipment, principles of continuous countercurrent leaching, classification of dryers, principles of drying, moisture, drying Equilibria, drying rate curve and drying time, tray dryer, screen-conveyor dryer, rotary dryer, fluid-bed dryer, cooling tower

7 Chemical Reaction Engineering

7.1 Mole Balances, Rate Laws and Stoichiometry: mole balance equations for batch and continuous reactors, mole balance equations in terms of conversion for batch and flow systems, applications of the conversion equation for reactors, reactors in series, space time and space velocity, reaction order and rate laws of elementary and non elementary reactions, stoichiometric table for batch and flow systems,

7.2 Isothermal reactor design and Rate Data: algorithm for isothermal reactors, design of batch reactors, design of single CSTR and CSTRs in series and parallel, design of tubular reactors, determination of rate law parameters by differential and integral methods, differential reactors, yield and selectivity in multiple reactions, maximizing desired product in series reactions.

7.3 Reaction Mechanisms: pseudo-steady-state hypothesis, searching for a mechanism, chain reactions and reaction pathways, enzymatic reaction fundamentals, inhibition of enzyme reactions, bioreactors, energy balances for non-isothermal reactors, nonisothermal continuous flow reactors, equilibrium conversion.

7.4 Catalysis and Catalytic Reactors: catalyst and it's properties, steps in a catalytic reaction, reaction mechanism and synthesizing a rate law, rate limiting step, chemical vapor deposition, catalyst deactivation, effects of external diffusion, effects of internal diffusion, characterization and measurement of residence time distributions, analysis of RTD in different reactors.

8 Process Control:

8.1 Linear Open-loop Systems: Dynamic behavior of chemical processes, Controller modes (P, PI and PID), 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.

8.2 Linear Closed-loop systems: Controllers and final control elements, control valves, block diagram, Transient response of simple control system.

8.3 Frequency response: Frequency domain analysis, control system designed by frequency response, bode stability criteria, different methods of tuning of controllers.

8.4 Advanced control schemes: Feed forward, Feedback, cascade, and ratio.

9 Chemical Industrial Technology:

9.1 Production of soda ash and caustic soda, production of gases CO_2, H_2, N_2, and O_2, production of sulfuric acid.

9.2 Types and compounds of cements, setting and hardening of cements, manufacturing process of cement, types of glass, manufacturing procedure of glass.
9.3 Manufacture of synthetic ammonia and urea, production of polyesters, manufacture of ethylene and propylene.
9.4 Manufacturing procedure of pulp and paper, sugar from cane, ethyl alcohol, vegetable oils and animal fats, soaps and detergents.

10 Transport Phenomena

10.1 Introduction: Basic principles and equations of change in transport of momentum, heat and mass; Viscosity, thermal conductivity and diffusivity; Shell balance for simple situations to obtain shear stress, velocity, heat flux, temperature, mass flux and concentration distributions.
10.2 Equations of Change for isothermal and non-isothermal systems: Equations of continuity, motion, mechanical energy, angular momentum, energy, and equation of continuity for multicomponent mixture, dimensional analysis of the equation of change.
10.3 Distributions with More than One Independent Variable: Unsteady state flow, creeping flow around a sphere, flow through a rectangular channel, unsteady heat conduction in slabs with and without changing heat flux, heat conduction in laminar in compressible flow
10.4 Interphase Transport in Isothermal and Non-Isothermal Mixtures: Friction factor and heat and mass transfer coefficients, Heat and mass transfer in fluids flowing through closed conduits and packed beds

Paper I: Objective (Core Course + Aptitude Test) Marks: 1 × 50 = 50

S.N.	Area of Questions	Number Questions
1	Process Calculations	3
2	Fluid Mechanics, Mechanical operations	6
3	Thermodynamics	4
4	Heat Transfer	4
5	Mass Transfer	4
6	Chemical Reaction Engineering, Process control	6
7	Chemical Industrial Technology, Transport Phenomena	7
8.	TU Laws 2049, TU Teacher and Officers Service laws (2050) (Section 5, 6,9, and 10), TU Economic Management and Procurement laws (2050) (Section 12, 13 and 14)	10
9.	General ICT Knowledge and Recent Trends, Nepal Constitution (Section 2, 3,7,8,9,11,13,14,17,18 and 20)	6

Paper II: **Core Course** **Marks: 10 × 10 = 100**

Subjective Knowledge

S.N.	**Area of Questions**	**No of Questions**
1.	Process Calculations Fluid Mechanics and Mechanical operations Thermodynamics Heat Transfer	**4 × 10 = 40 Marks**
2.	Mass Transfer Chemical Reaction Engineering Process control Chemical Industrial Technology Transport Phenomena	**5 × 10 = 50 Marks**
3.	TU Laws 2049, TU Teacher and Officers Service laws (2050) (Section 5,6,9, and 10), TU Economic Management and Procurement laws (2050) (Section 12, 13 and 14)	**1 × 10 = 10 Marks**

In subjective Knowledge questions, each 10 marks question may be subdivided into two subdivision a and b.

द्रष्टव्य :

1. लिखित परीक्षाको लागि १०० पूर्णाङ्कको एक पत्र हुनेछ ।

2. वस्तुगत बहुवैकल्पिक (Multiple Choice) प्रश्नको विकल्प छनौट गर्दा गलत विकल्प छानेमा ऋणात्मक मूल्याङ्कन (Negative Marking) गरिने छ । अर्थात् यसरी मूल्याङ्कन गर्दा प्रत्येक गलत उत्तरको लागि २० प्रतिशत अङ्ककट्टा गरिनेछ । बहुवैकल्पिक प्रश्नको २० प्रतिशत अङ्क प्राप्ताङ्कबाट घटाइने छ । (उदाहरणका लागि परीक्षार्थीले २० अङ्कको बहुवैकल्पिक प्रश्नमा १५

प्रश्नको सही उत्तर र ५ प्रश्नको गलत उत्तर दिएमा निजको प्राप्ताङ्क (०.२० × ५=१.००) अर्थात् १५–१= १४ अङ्क हुनेछ। तर उत्तर नदिएमा त्यस बापत अङ्क दिइने छैन र अङ्क कट्टा पनि गरिने छैन।

3. विषयगत प्रश्नको हकमा एउटै प्रश्नका दुई वा दुई भन्दा बढी भाग (Two or more parts of a single question) वा एउटा प्रश्न अन्तर्गत दुई वा बढी टिप्पणीहरू (Short notes) सोध्न सकिने छ।

4. प्रत्येक पत्रको उत्तीर्णाङ्क पूर्णाङ्कको ४० प्रतिशत हुनेछ।

5. भाषा विषयबाहेक अन्य विषयका लागि उत्तरको माध्यम अंग्रेजी वा नेपाली हुनेछ।