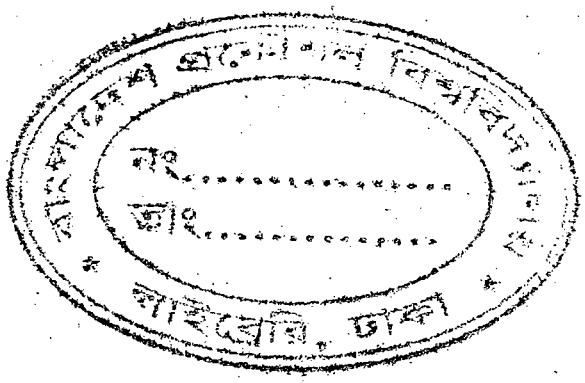
CHEMICAL ENGINEERING DEPARTMENT



Calendar
1993-94

Bangladesh University of Engineering & Technology
(BET), Dhaka-1000

GENERAL INFORMATION

HISTORICAL BACKGROUND

Bangladesh University of Engineering and Technology, abbreviated as BUET, is the oldest institution for the study of Engineering and Architecture in Bangladesh. The history of the institution dates back to the days of Dhaka Survey School which was established at Nalgola in 1876 to train surveyors for the then Government of Bengal of British India. As the years passed, the Survey School became the Ahsanullah School of Engineering offering three-year diploma courses in Civil, Electrical and Mechanical Engineering. In 1948, the School was upgraded to Ahsanullah Engineering College (on its present premises) as a Faculty of Engineering under the University of Dhaka, offering four-year bachelor's courses in Civil, Electrical, Mechanical and Chemical Engineering with a view to meet the increasing demand for engineers in the country and to expand the facilities for quicker advancement of engineering education. In order to create facilities for post graduate studies and research, Ahsanullah Engineering College was upgraded to the status of a University under the name of East Pakistan University of Engineering and Technology in the year 1962. After independence of Bangladesh in 1971, it was renamed as the Bangladesh University of Engineering and Technology. Starting with two faculties, the university has now enlarged into five faculties.

The BUET campus is in the heart of the city of Dhaka. It has a compact campus with halls of residence within walking distances of the academic buildings. The physical expansion of the University over the last ten years has been impressive with construction of new academic buildings, auditorium complex, students hall of residence etc.

Undergraduate courses in the faculties of Engineering, Civil Engineering, Electrical and Electronic Engineering and Mechanical Engineering extend over four years and lead to B.Sc. Engineering in Civil, Electrical & Electronic, Mechanical, Chemical, Metallurgical, Computer and Naval Architecture & Marine Engineering. In the faculty of Architecture and Planning the degree of bachelor of Architecture is obtained in five years.

Postgraduate studies and research are now among the primary functions of the University. Most of the departments under the different faculties offer M.Sc.Engg. and M.Engg. degrees and some departments have started Ph.D. courses. Postgraduate degrees in Architecture (M. Arch) and in Urban and Regional Planning (MURP) are offered by the faculty of Architecture and Planning. In addition to its own research programmes, the University undertakes research programmes sponsored by outside organizations, viz. UN Organizations, Commonwealth, University Grants Commission (UGC) etc. The expertise of the University teachers and the laboratory facilities of the University are also utilised to solve problems of and to provide up-to-date engineering and technological knowledge to the various organisations of the country. The University is persistent in its effort to improve its research facilities, staff position and courses and curricula to meet the growing technological challenges confronting the nation.

FACULTIES AND TEACHING DEPARTMENTS

The University has sixteen teaching departments under five faculties. Not all of them are degree offering. Faculty-wise list of the departments with the status of the degrees offered is given below:

Faculty of Civil Engineering

Department of Civil Engineering:	Both UG and PG
Department of Water Resources Engineering:	PG only

Faculty of Architecture and Planning

Department of Architecture:	Both UG and PG
Department of Urban & Regional Planning:	PG only
Department of Humanities:	Non degree offering

Faculty of Electrical and Electronic Engineering

Department of Electrical and Electronic Engineering:	Both UG and PG
Department of Computer Science and Engineering:	Both UG and PG

Faculty of Engineering

Department of Chemical Engineering:	Both UG and PG
Department of Metallurgical Engineering:	Both UG and PG
Department of Petroleum and Mineral Resources Engineering:	PG only
Department of Chemistry:	PG only
Department of Mathematics:	PG only
Department of Physics:	PG only

Faculty of Mechanical Engineering

Department of Industrial and Production Engineering	PG only
Department of Mechanical Engineering:	Both UG and PG
Department of Naval Architecture and Marine Engineering:	Both UG and PG

CHEMICAL ENGINEERING DEPARTMENT.

Professor and Head

M. Sabder Ali, B.Sc.Engg(Chem), MSc Engg, Ph.D.

Professor Emeritus

M.A. Naser, BSc (Hon), MSc, M.S.E, Ph.D.

Professors

Iqbal Mahmud, BSc Engg(Chem), MSc Tech, Ph.D.
Nooruddin Ahmed, BSc Engg(Chem), M.Sc Eng. Ph.D.
A.K.M. Abdul Quader, BSc Engg(Chem), Ph.D.

Associate Professors

Dil Afroza Begum, M.Sc, Ph.D.
Dr. Ijaz Hossain, BSc. Engg(Chem), M.Sc.Engg, Ph.D.

Assistant Professors

Sirajul Haque Khan, B.Sc.Engg(Chem), M.Sc.Engg.
M. Serajul Islam, B.Sc.Engg(Chem), Ph.D.
M. Hanif Siddiqui, B.Sc.Engg(Chem), M.Sc, Ph.D.

Lecturer

A.M. Mondal, B.Sc. Engg(Chem).
M.T. Islam, B.Sc. Engg(Chem).
S. Roy, B.Sc. Engg(Chem).

DEPARTMENT OF CHEMICAL ENGINEERING

Detailed Syllabus for B.Sc. Engineering

SUMMARY OF CREDIT HOURS

Term	Theory	Sessional
1	15	4.5
2	15	4.5
3	16	4.5
4	15	4.5
5	15	4.5
6	16	4.5
7	15	6.0
8	12	6.0
	119	39

TERM 1

Theory		Credits
1. Phy 101	Physical Optics, Heat, Waves and Oscillations	3
2. Chem 111	Inorganic Chemistry	3
3. Math 121	Differential Calculus and Co-ordinate Geometry	3
4. ME 141(N)	Engineering Mechanics	3
5. EEE 155(N)	Electrical Engineering Fundamentals	3

Sessional		Credits
1. Phy 102	Physics Sessional	1.5
2. Chem 112	Inorganic Analysis Sessional	1.5
3. EEE 156(N)	Electrical Engineering Fundamentals Sessional	1.5

TERM 2

Theory		Credits
1. ChE 111	Elements of Chemical Engineering	3
2. *Phy 105	Structure of Matters, Electricity and Magnetism and Modern Physics	3
3. Chem 131	Physical Chemistry I	3
4. Math 123	Integral Calculus and Differential Equations	3
5. Hum 101	English	3

Sessional		Credits
1. Chem 116	Inorganic Analysis II Sessional	1.5
2. Shop 120	Workshop	1.5
3. ME 160(N)	Mechanical Engineering Drawing	1.5

TERM 3

Theory			Credits
1.	ChE 201(N)	Material and Energy Balance	3
2.	ChE 203(N)	Chemical Engineering Thermodynamics I	3
3.	EEE 267(N)	Electrical and Electronics Technology	3
4.	Math 221(N)	Vector Analysis, Matrices, and Laplace Transforms	4
5.	Chem 235	Physical Chemistry II	3

Sessional			Credits
1.	ChE 208(N)	Computer Programming and Applications	1.5
2.	EEE 268(N)	Electrical and Electronics Technology Sessional	1.5
3.	Chem 236	Physical Chemistry Sessional	1.5

TERM 4

Theory			Credits
1.	ChE 205(N)	Fluid Mechanics	3
2.	ME 243(N)	Mechanics of Solids	3
3.	Math 223(N)	Numerical Analysis and Statistics	3
4.	Chem 221	Organic Chemistry	3
5.	Elective I		3

Sessional			Credits
1.	ChE 202(N)	Material and Energy Balance Sessional	1.5
2.	ChE 206(N)	Chemical Engineering Laboratory I	1.5
3.	Chem 222	Organic Chemistry Sessional	1.5

TERM 5

Theory			Credits
1.	ChE 301(N)	Heat Transfer	3
2.	ChE 303(N)	Mass Transfer I	3
3.	ChE 307(N)	Chemical Engineering Thermodynamics II	3
4.	Elective II		3
5.	Elective III		3

Sessional			Credits
1.	ChE 302(N)	Chemical Engineering Laboratory II	1.5
2.	ChE 308(N)	Chemical Process Analysis Sessional	1.5
3.	Chem 352	Instrumental Methods of Analysis Sessional	1.5

TERM 6

Theory			Credits
1.	ChE 305(N)	Mass Transfer II	3
2.	ChE 309(N)	Particle Technology	3
3.	ChE 311(N)	Special Topics in Unit Operations	4
4.	Elective IV		3
5.	Elective V		3

Sessional			Credits
1.	ChE 304(N)	Chemical Engineering Laboratory III	1.5
2.	ChE 306(N)	Chemical Engineering Laboratory IV	1.5
3.	ChE 310(N)	Computational Technique in Chemical Engineering	1.5

TERM 7

Theory			Credits
1.	ChE 401(N)	Reaction Engineering	3
2.	ChE 403(N)	Process Control	3
3.	ChE 405(N)	Process Design I	3
4.	Elective VI		3
5.	Elective VII		3

Sessional			Credits
1.	ChE 402(N)	Chemical Engineering Laboratory V	1.5
2.	ChE 400(N)	Project/Thesis I	3
3.	ChE 408(N)	Process Design Sessional I	1.5

TERM 8

Theory			Credits
1.	ChE 407(N)	Process Design II	2
2.	ChE 409(N)	Corrosion Engineering	3
3.	ChE 411(N)	Economics and Management of Chemical Process Industries	4
4.	Elective VIII		3

Sessional			Credits
1.	ChE 400(N)	Project/Thesis II	3
2.	ChE 408(N)	Process Design Sessional II	3

ELECTIVE COURSES

Elective I

Hum	103(N)	Economics (3 credits)
Hum	109(N)	Social Psychology (3 credits)

Elective II

Hum	203(N)	Government (3 credits)
Hum	201(N)	Sociology (3 credits)
Hum	303(N)	Principles of Accounting (3 credits)

Electives III - VIII

With the consent of adviser the student will choose any approved* 3rd level or above course, subject to fulfillment of the following requirements:

1. A maximum of 12 credits in Humanities will be counted for graduation.
2. A student will choose any one of the chemical engineering specialization groups. From this group the student must collect 6 credits (2 courses).
3. Students who choose Chemical Technology as their specialization group, must collect at least 3 credits (1 course) from the Chemical Engineering Science group.
4. A student must have at least 3 credits (1 course) from the Chemical Technology group.

*A list of approved courses of other departments will be made available to the students.

Elective Subjects Other Than Chemical Engineering

Chem 323	Organic Synthesis (3 credits)
Math 321	Complex Variables, Bessel's Function and Legendre Polynomials (3 credits)
Math 323	Fourier Integral, Harmonic Functions and Partial Differential Equations (3 credits)
Phy 303	Electrical and Magnetic Properties of Solids (3 credits)

ME 347	Mechanical Design of Process Equipment (3 credits)
Met 381	Fundamentals of Metallurgy (3 credits)

ELECTIVE COURSES IN CHEMICAL ENGINEERING

CHEMICAL TECHNOLOGY

ChE 431(N)	Food Preservation and Processing (3 credits)
ChE 433(N)	Polymers and Petrochemicals (3 credits)
ChE 435(N)	Glass, Ceramic and Cement Technology (3 credits)
ChE 437(N)	Refinery Engineering (3 credits)
ChE 439(N)	Polymer Processing (3 credits)
ChE 441(N)	Fertilizer, Pulp & Paper Technology (3 credits)
ChE 443(N)	Food and Sugar Technology (3 credits)

CHEMICAL ENGINEERING SCIENCE

ChE 451(N)	Fuels and Combustion Science (3 credits)
ChE 453(N)	Transport Phenomena (3 credits)
ChE 455(N)	Mathematical Models in Chemical Engineering (3 credits)
ChE 457(N)	Reactor Design (3 credits)
ChE 459(N)	Materials Science (3 credits)

BIOCHEMICAL ENGINEERING

ChE 471(N)	Biochemistry (3 credits)
ChE 473(N)	Biochemical Engineering I (3 credits)
ChE 475(N)	Biochemical Engineering II (3 credits)

ENVIRONMENTAL SCIENCE

ChE 481(N)	Environmental Science I (3 credits)
ChE 483(N)	Environmental Science II (3 credits)
ChE 485(N)	Industrial Pollution Control (3 credits)

PETROLEUM ENGINEERING

ChE 491(N)	Natural Gas Engineering (3 credits)
ChE 493(N)	Petroleum Reservoir Engineering (3 credits)

ChE 495(N) Gas & Oil Well Drilling & Logging (3 credits)
ChE 497(N) Transmission and Distribution of Natural Gas (3 credits)

DETAILED OUTLINE OF COURSES

ChE 111 Elements of Chemical Engineering
3.00 credits, 3 hours/week

Scope of chemical engineering. Principles of chemical engineering calculations: systems of units, basic concepts of dimensional analysis, process variables, basis of calculation, conservation of mass and energy. Material balance: overall component balance, recycle and bypass, simple reactive systems and combustion reactions. Energy balance; forms of energy and the First Law of Thermodynamics, thermodynamic data and tables., energy balance on closed and open systems. Application of mass and energy balance to real processes. Measurements of process variables: fluid statics and manometry, flow measurement, temperature measurement.

ChE 201(N) Material and Energy Balance
3.00 credits, 3 hours/week

Review of material balance involving recycle and purging operations. Operations involving vaporization, humidification, psychrometry and phase diagrams. Energy balance involving change of phases. Enthalpy-composition diagrams. Heats of formation and reaction: effects of temperature and pressure. Material balances with chemical reactions and multiple components including use of algebraic techniques. Energy balances on chemical processes. Stoichiometry and unit operations in industrial processes.

ChE 202(N) Material and Energy Balance Sessional
1.50 credits, 3 hours/week

Problem solving class based on Material an Energy Balance course.

ChE 203(N) Chemical Engineering Thermodynamics
3.00 credits, 3 hours/week

Introduction: the scope of thermodynamics; fundamental quantities; secondary quantities. The first law and other basic concepts: Joule's experiments; internal energy; the first law of thermodynamics; the thermodynamic state and state functions; extensive and intensive properties; enthalpy; steady state flow process; phase rule; reversible and irreversible processes; heat capacity. Volumetric properties of pure fluids: P-V-T behaviour of pure substances; ideal and non-ideal gas and equations of state; applications of equations of state. Heat effects: heat capacities of gases as a function of temperature; heat capacities of solids and liquids; heat effects accompanying phase changes of pure substances; standard heat of reaction; effect of temperature on the standard heat of reaction . The second law of thermodynamics : alternative statements of the second law; heat engine; thermodynamic temperature scales; concept of entropy; entropy changes and irreversibility. The third law of thermodynamics. Thermodynamic properties of fluids: relationships among thermodynamic properties; single phase and two phase system; types of thermodynamic diagrams. Conversion of heat into work by power cycles: vapour cycles; steam power plant; analysis of the steam power plant (boiler, economiser, superheater, steam turbine); internal combustion engines (Otto engine, diesel engine, gas turbine, jet engines).

ChE 205(N) Fluid Mechanics
3.00 credits, 3 hours/week

Review of fluid statics and manometry. Concept of shear stress and classification of fluids. Flow of fluids in closed conduits: laminar and turbulent flow; friction factor; frictional losses in pipes and fittings; expansion contraction losses; pipeline with pump or turbine; series and parallel pipeline. Fluid flow measurements. Dimensional analysis. Microscopic balances: conservation of mass and momentum; stresses in a fluid; symmetry of stresses; deformation; Newtonian fluid and constitutive equation; Navier-Stokes equations in different co-ordinate systems; solutions of Navier-Stokes equation. Macroscopic balance and its applications. Introduction to turbulence, compressible flow and multi-phase flow.

ChE 206(N) Chemical Engineering Laboratory I
1.50 credits, 3 hours/week

Laboratory work based on ChE 205(N)

ChE 208(N) Computer Programming and Applications
1.50 credits, 3 hours/week

An introductory course in FORTRAN programming and its applications to simple problems in Chemical Engineering.

ChE 301(N) Heat Transfer
3.00 credits, 3 hours/week

Modes of heat transfer. Conduction: mechanism of thermal conduction in solids, liquids and gases; other thermal properties; steady state heat conduction in one dimension; transient heat conduction. The basic equations of momentum and heat transport. Some approximate solutions of convection heat transfer. Dimensionless correlations for forced and free convection. Heat transfer with phase change: boiling and condensation. Thermal radiation: black body radiation; exchange between infinite and finite surfaces in different enclosures. Types of heat transfer equipment. Design of heat exchangers: mean temperature difference in different flow arrangements; thermal and mechanical design; materials of construction. Extended surfaces.

ChE 302(N) Chemical Engineering Laboratory II
1.50 credits, 3 hours/week

Laboratory work based on ChE 301(N) and ChE 303(N)

ChE 303(N) Mass Transfer I
3.00 credits, 3 hours/week

Introduction to mass transfer processes. Phase equilibria. Equilibrium stage concept. Solvent Extraction: liquid-liquid extraction in single and multiple contact extractor with completely immiscible and partially miscible solvent; use of triangular diagram for stage calculations; batch and continuous leaching and washing of solids. Binary distillation: equilibrium flash and differential distillation; batch and continuous distillation with reflux; use of enthalpy concentration diagram

and simplified methods for stage calculations. Gas-liquid absorption: analytical and graphical methods for stage calculations. Tray hydraulics and design considerations. Tray efficiency.

ChE 304(N) Chemical Engineering Laboratory III
1.50 credits, 3 hours/week

Laboratory work based on ChE 301(N), ChE 303(N) and ChE 305(N).

ChE 305(N) Mass Transfer II
3.00 credits, 3 hours/week

Basic mass transfer theories: diffusion of gases and liquids; diffusion through stagnant layer and equimolar counter diffusion; mass transfer between gas and liquid phases; two film and other theories; HTU and NTU concepts. Mass transfer coefficients. Continuous contact mass transfer: packed and spray column; gas absorption in packed column; continuous liquid-liquid extraction in columns. Multicomponent distillation: bubble and dewpoint calculations for multicomponent systems; simplified methods for calculation of stages. Principles of simultaneous heat and mass transfer in humidification-dehumidification, drying, evaporation and crystallisation operations. Adsorption: principles; industrial application with special emphasis on ion-exchange and pressure swing adsorption.

ChE 306(N) Chemical Engineering Laboratory IV
1.50 credits, 3 hours/week

Laboratory work based on ChE 309(N) and ChE 311(N)

ChE 307(N) Chemical Engineering Thermodynamics II
3.00 credits, 3 hours/week

Solution thermodynamics: relationships among the thermodynamic properties for systems of variable composition; partial molar properties; fugacity and fugacity coefficients; fugacities in ideal solutions; property changes of mixing; activity and activity coefficients; heat effects of mixing processes. Phase equilibria: nature and criteria of equilibrium; phase rule and Duhem's theorem; vapour-liquid equilibrium

calculations for miscible systems; Gibbs-Duhem equation. Chemical reaction equilibria: the reaction coordinate; criteria of equilibrium for chemical reactions; equilibrium constant; effect of temperature on equilibrium constant; evaluation of equilibrium constants; phase rule and Duhem's theorem for reacting systems. Thermodynamics of flow processes: conservation of mass and energy; mechanical energy balance; maximum velocity in pipe flow; metering and throttling processes; nozzles; compressors; ejectors. Refrigeration and liquefaction: Carnot refrigeration cycle; air-refrigeration cycle; vapour-compression cycles; comparison of refrigeration cycles; absorption refrigeration; heat pump; liquefaction processes. Thermodynamic analysis of processes: ideal work; lost work; thermodynamic analysis of steady flow processes.

ChE 308(N) Chemical Process Analysis Sessional
1.50 credits, 3 hours/week

Process descriptions and calculations of the following industries: Gaseous, liquid, solid & secondary fuels, sulfur compounds (sulfuric acid), nitrogen compounds (ammonia, urea), lime & cement, chloro-alkali industries, airconditioning & refrigeration (humidification-dehumidification), ceramic industry, phosphorus industry (phosphate fertilizer), soap & detergent, sugar industry, pulp & paper industry, fermentation industry, petroleum & petrochemicals.

ChE 309(N) Particle Technology
3.00 credits, 3 hours/week

Properties of particulate solids: particle size and shape; mean diameters; screen analysis; analytical size distribution functions; size distribution of feed and products of crystallizers and size reduction equipment. Bulk properties of particulates: Mohr stress diagram; storage of solids; bin design. Fluid-solid momentum transport: flow past a sphere; drag coefficient; terminal settling velocity; pressure drop in packed beds; fluidization and sedimentation; slurry transport and pneumatic conveying. Fluid-solid separation based on momentum transport: classification, pretreatment of solid-liquid mixture, theory of coagulation, flocculation and flotation; gravity thickening. Filtration: filtration operations and basic equations for incompressible and compressible cakes; deep bed,

pressure, vacuum and centrifugal filtration; filter media; filter aids; cake washing and dewatering; optimum design of semi-continuous filtration equipment.

ChE 310(N) Computational Technique in Chemical Engineering
1.50 credits, 3 hours/week

Computational techniques in numerical methods of solution of algebraic and transcendental equations, integration and differential equations. Application to chemical engineering design and optimization problems.

ChE 311(N) Special Topics in Unit Operations
4.00 credits, 4 hours/week

(The emphasis of the course is on equipment design and industrial practice) Mechanical separation: gravity settlers; impingement separators; centrifugal separators and scrubbers.

Crushing and grinding. Solid handling machinery. Fluid moving machinery. Ejectors and vacuum systems. Pressure relieving devices. Mixing and agitation. Crystallization, drying and evaporation.

ChE 400 Project/Thesis
6.00 credits, 6 hours/week for two terms

With the assistance of a teacher the student will select a problem in any field of chemical engineering. The problem must require experimental work and not be merely a paper thesis and must be sufficiently limited in scope so that the student can expect to attain a satisfactory solution in one year of work. The purpose of this course is to make the student responsible for planning and carrying out an engineering project and presenting his work as an acceptable engineering report.

(A student will work for 6 hours per week in term 7 and 6 hours per week in term 8 for this course. Credits will be given at the end of term 7 and term 8).

ChE 401(N) Reaction Engineering
3.00 credits, 3 hours/week

Kinetics of homogeneous reactions: variables affecting rate; elementary and non-elementary reactions. Thermodynamics of chemical reactions: temperature and pressure effects. Basic concepts in chemical kinetics : determination of the reaction rate expression; molecular interpretations of kinetic phenomena; multiple reactions; auto-catalytic reactions. Basic concepts in reactor design: types of reactors; ideal reactors; recycle reactor; auto-catalytic reactors; isothermal operation; treatment of multiple reactions; temperature and energy effects in chemical reactors; optimum temperature progression. Kinetics of heterogeneous reactions: mechanism of catalysis; types of catalysts; operation and properties of catalysts.

ChE 402(N) Chemical Engineering Laboratory V
1.50 credits, 3 hours/week

Laboratory work on fuel testing and based on ChE 401(N) and ChE 403(N).

ChE 403(N) Process Control
3.00 credits, 3 hours/week

Basic concepts of chemical process control: incentives for process control; design aspects; hardware elements. Modelling for control purposes: development of mathematical models; linearization of nonlinear systems; input-output model; transfer functions. Dynamic and static behavior of chemical processes: first, second and higher order processes; transportation lag; systems in series. Analysis and design of feedback control systems: concept of feedback control; feedback controllers and final control elements; block diagrams; closed loop responses; concept of stability; stability testing. Frequency response analysis: Bode diagrams; Nyquist plots; Bode and Nyquist stability criteria; control system design by frequency response analysis.

Analysis and design of advanced control systems: control of system with large dead time or inverse response; multiple-loop control systems; feedforward and ratio control; adaptive and inferential control. Design of control systems for multivariable

processes: synthesis of alternative control configurations for multiple-input and multiple-output processes; interaction and decoupling of control loops. Design of control systems for complete plants.

ChE 405(N) Process Design I
3.00 credits, 3 hours/week

Introduction, process design development and considerations. Cost estimation. Depreciation. Optimum design and economic design criteria. Design and costing of process equipment: pumps, compressors, turbines, heat exchanger, mass transfer columns, vessels, reactors etc. Selection of materials for equipment and services. Computer aided design.

ChE 407(N) Process Design II
2.00 credits, 2 hours/week

Project definition. Technical specification. Design basis. Process licensing. Basic and detailed engineering. Codes and standards, engineering specifications. Performance tests. Inspection. Procurement. Review and approval of engineering documents. Contract negotiation. Documentation.

ChE 408(N) Process Design Sessional
4.50 credits, 3 hours/week in First term and
6 hours/week in Second term

Integrated design of a chemical plant considering related design considerations and cost estimation.

(A student will work for 3 hours per week in term 7 and 6 hours per week in term 8 for this course. Credits will be given at the end of term 7 and Term 8).

ChE 409(N) Corrosion Engineering
3.00 credits, 3 hours/week

Different materials: Non-metals, metals and alloys. Corrosion and its mechanisms : different forms of corrosion ; their mechanisms and remedial measures. Methods of corrosion prevention. Steels, stainless steels and some of the common alloys used in process industries.

ChE 411(N) Economics and Management of Chemical Process Industries

4.00 credits, 4 hours/week

Economic environment. National economic policies. Five Year plans and sectoral plans. Concepts of value added and technology content added. Elements of input-output analysis. Alternatives in resource inputs. Investment costs. Interest calculations. Economic balance: Depreciation, Profitability and alternative investments. Project analysis: DCF, IRR, ERR etc.. Elements of risk analysis. Break even analysis and Minimum cost analysis. Capital budgeting. Functions of management in CPI: decision making; organizing, planning, directing, communicating, and controlling. Information management. Principles of production management. Marketing. Management of public sector. Quantitative techniques in decision making: Network analysis, Linear programming, Decision making under uncertainty.

ELECTIVES COURSES IN CHEMICAL ENGINEERING

CHEMICAL TECHNOLOGY

ChE 431(N) Food Preservation and Processing
3.00 credits, 3 hours/week

Food composition: carbohydrates, lipids, proteins, vitamins, minerals, pectic substances in food. Flavour, aroma and natural pigment of food. Enzymes: classification and function of enzymes. Food analysis: nutritive value of protein, carbohydrate, vitamins and minerals. Effect of cooking and processing on the nutritive value. Food additives. Fundamentals of microbiology: microbes in food and fermentation industries. Morphology, physiology and genetics of bacteria, moulds, yeasts, fungi, actinomycetes and algae. Principles of serology and immunology. Viruses. Growth and destruction of microorganisms; growth curve. Physical and chemical factors influencing the destruction of microorganisms. Energy metabolism of aerobic and anaerobic microbes. Nitrogen fixation. Microorganism in natural products and their control; source and prevention, general principles of food preservation. Microbiology of atmosphere, water, milk and milk products, fish, fruit, vegetables, meat, poultry products and canned foods. Basic principles of food plant sanitation. Food poisoning.

ChE 433(N) Polymers and Petrochemicals
3.00 credits, 3 hours/week

Introduction. Prospect of polymer and petrochemical industries in Bangladesh. Raw materials of polymers and petrochemicals. Petrochemicals: reaction mechanism, kinetics, manufacturing technologies and uses of ammonia, methanol, oxochemicals, acetylene, vinylchloride, synthetic detergents, olefins, dienes, waxes and aromatics. Polymers: classification of polymeric materials and their chemical structure; nomenclature for polymers; molecular weight and its measurement; polymerization mechanisms and methods; reactor types; manufacture and technological properties of PE, PP, PVC, PVA, PTFE, nylons, polyesters and rubbers (butadiene, isoprene, styrene).

ChE 435(N) Glass, Ceramics and Cement Technology
3.00 credits, 3 hours/week

Structural characteristics of ceramic materials. Kinetics of high temperature reaction including sintering and vitrification. Melting crystallization and glass formations. Ceramic phase equilibrium diagrams. Non-equilibrium phases. Raw materials, manufacturing processes and properties of glass, porcelain, refractories and whitewares. Glazing and decorating of porcelain and stonewares. Firing methods and kilns for ceramic and whitewares. Furnaces for glass manufacture. Raw materials, manufacturing processes and properties of cement. Heat and mass balance around kiln.

ChE 437(N) Refinery Engineering
3.00 credits, 3 hours/week

Introduction. Origin, formation and composition of petroleum. Evaluation of crude oils. Refinery products and their uses. Analysis of petroleum products. Fractionation of petroleum. Production of lubricating oils and greases. Bitumen production. Reaction mechanism, kinetics and technological aspects of some thermal and catalytical processes ; thermal cracking , coking, pyrolysis, catalytic cracking, hydrocracking, catalytic reforming, hydrogen treating, isomerization, alkylation. Refinery flow sheeting, equipment, design, layout, safety and environmental aspects. Discussion on ERL with emphasis on processing technology.

ChE 439(N) Polymer Processing
3.00 credits, 3 hours/week

Introduction to processing principles: mechanical, electrical, thermal and optical properties of polymeric materials with special reference to time-temperature and environmental effects and testing standards. Formulation and compounding: principles and practice, degradation and stabilization of polymers. Rheological properties of polymeric melt-solutions and suspension, and their measurements. Flow in channels of simple cross-section. Basic heat transfer. Analysis of the principles of extrusion, injection molding, film blowing, calendaring, mixing etc. for sizing equipment, power requirements and understanding of process performance. Processes and operations, planning of processing facilities, layout and maintenance. Health and safety measures.

ChE 441(N) Fertilizer, Pulp and Paper Technology
3.00 credits, 3 hours/week

The world fertilizer market. Fertilizer industries in Bangladesh Nitrogen fertilizers (ammonia, urea): raw materials, reaction kinetics, manufacturing processes, design considerations , status of production, comparative economics of different nitrogenous fertilizers. Phosphate fertilizers (SSP, TSP): raw materials, reaction kinetics, manufacturing processes, design considerations, comparative economics of different phosphate fertilizers. Manufacturing process of different potash fertilizers and their uses . Complex and compound fertilizers and their economics. Waste disposal methods. The world pulp and paper market. Pulp and paper industries in Bangladesh. Types of raw materials, composition and chemical properties of wood. Preparation of raw material for pulping. Comparative assessment of the different pulping processes. Kraft process: chemistry, digesters, black liquor recovery unit. Bleaching, beating and sizing. Paper making. Waste disposal methods.

ChE 443(N) Food and Sugar Technology
3.00 credits, 3 hours/week

Introduction to food technology. Principles of major preservation methods: drying, chemical, thermal, low temperature and freezing and irradiation. Unit operations in food processing and preservation: fluid flow, heat transfer, concentration by evaporation, drying, separation methods, mixing, size reduction and sterillization process. Calculations in food engineering. Packaging in food industry. Technology for processing and preservation of specific industries: cereals, fruits and vegetables, fish, milk and dairy products, oils and fats. Sugar technology: introduction, composition of cane and juice, manufacturing of raw cane sugar, extraction of juices, purification of juices, treatment of mud water and clarified juice, evaporation, heating, crystallization. Cane sugar refining: clarification, decolourization, crystallization and finishing. Microbiology in sugar manufacture and refining. Economics of sugar industry.

CHEMICAL ENGINEERING SCIENCE

ChE 451(N) Fuels and Combustion Science
3.00 credits, 3 hours/week

Energy situation and sources in Bangladesh. Classification and analysis of fuels. Essential properties of fuels. Purification and fuels processing. Storage and handling of fuels (designing of system and facilities). Energy saving devices. Design and sizing of burners. Combustion chambers, furnaces and stack for different fuels. Kinetics of combustion. Evaluation of burner and furnace operations. Sampling and analysis of flue gases. Design and operation of kilns and furnaces. Environmental consideration of energy use.

ChE 453(N) Transport Phenomena
3.00 credits, 3 hours/week

Application of shell balances and equations of change for momentum, energy and mass transfers. Laminar and turbulent flows, Multi-component systems. Analogy equations relating momentum, energy and mass transfer.

ChE 455(N) Mathematical models in Chemical Engineering
3.00 credits, 3 hours/week

Classification of mathematical models. Fundamental features of models. General methods of solution. Application to problems in staged operations, fluid mechanics, heat transfer and reactor design. Parameter estimation. Design of experiments. Optimization techniques.

Che 457(N) Reactor Design
3.00 credits, 3 hours/week

Review of homogeneous and heterogenous systems. Reactor design for adiabatic and nonadiabatic nonisothermal conditions. Reactor design for heterogeneous catalytic reactions. Heat and mass transport processes. Experimental reactors and treatment of data. Design of industrial reactors.

ChE 459(N) Materials Science
3.00 credits, 3 hours/week

Atomic bonding and crystal structure. Phase diagrams. Microstructures. Imperfection in crystals. Phases and interfaces in material systems. Transport in materials. Phase transformations. Annealing processes. Deformation of materials. Electrical, magnetic and optical behaviour of materials. Fracture. Deterioration of materials. Electronic structure and physical properties.

BIOCHEMICAL ENGINEERING

ChE 471(N) Biochemistry
3.00 credits, 3 hours/week

Introduction: molecular logic of living system. Biomolecules and cells. Sugars, polysaccharides, lipids-triglycerides, phospholipids, biological membranes. Proteins: aminoacid sequences, primary, secondary, tertiary and quaternary structure; classification of proteins. Enzymes mechanism: kinetics and inhibition. Nucleic acid: nucleotides, DNA, RNA composition and simple structure; replication, transcription and translation. Genetic code and genetic engineering. Vitamins and coenzymes. Digestion of polysaccharides, lipids and proteins. Metabolism and energy transfer; glycolysis and oxidative phosphorylation; biological high energy compounds. Oxidation of fatty acids and oxidative degradation of amino acids. Photosynthetic phosphorylation. Interrelationship and control metabolism. Some inborn errors of metabolism.

ChE 473(N) Biochemical Engineering I
3.00 credits, 3 hours/week

Introduction to biochemical engineering and concept of biological catalysts, nature of microorganisms, their requirements and classification, industrially important microorganisms. Kinetics of enzyme catalyzed reactions, Michaelis-Menten equation, immobilized-enzyme technology, immobilized enzyme kinetics. Metabolic stoichiometry and energetics. Molecular genetics and control systems. Batch fermentation: yield coefficients for biomass and product formation, rates of reaction, growth, limiting substrate concentrations, Monod's equation.

ChE 475(N) Biochemical Engineering II
3.00 credits, 3 hours/week

Design and analysis of biological reactors; ideal reactors, reactor dynamics, reactors with nonideal mixing, sterilization reactors, multiphase bio-reactors. Biological Industries and their engineering problem. Transport phenomena in bioprocess system: gas liquid mass transfer in cellular systems, determination of oxygen transfer rates, forced convection. Separation of cells and recovery of useful products. Bioprocess economics. Instrumentation and control. Analysis of multiple interacting microbial populations. Mixed microbial population in applications and natural systems: Biological wastewater treatment.

ENVIRONMENTAL SCIENCE

ChE 481(N) Environmental Science I
3.00 credits, 3 hours/week

Introduction to environmental engineering: environmental systems; environmental legislations and regulations; environmental ethics; material balance approach. Hydrology fundamentals: rainfall analysis; runoff analysis; groundwater and wells. Air pollution: origin and fate of air pollutants, atmospheric dispersion; stationary and mobile sources; source control. Noise pollution: noise effects; community noise sources and criteria; noise control.

ChE 483(N) Environmental Science II
3.00 credits, 3 hours/week

Water pollution: pollution source; source control. Municipal water treatment: primary, secondary and tertiary treatment; sludge treatment disposal. Wastewater treatment; disposal and reuse. Solid waste management: functional elements; treatment, disposal, conservation and recovery. Hazardous waste management.

ChE 485(N) Industrial Pollution Control
3.00 credits, 3 hours/week

Scope and purpose. Source and nature of pollutants in air and water. Air pollution: measuring and estimating emission from

sources; meteorological factors; methods of reducing pollutants; physical combustion and catalytic combustion methods. Methods of gas cleaning: electrostatic precipitation, filtration, scrubbing, sonic and ultra-sonic agglomeration. Industrial effluent treatment. Disposal of hazardous and toxic wastes. Radiological protection principles. Pollution control of specific industries: tannery, pulp and paper, fertilizer, steel, refinery, metal finishing, food and pharmaceuticals.

PETROLEUM ENGINEERING

ChE 491(N) Natural Gas Engineering
3.00 credits, 3 hours/week

Introduction to the natural gas industry in Bangladesh. Phase behaviour of natural gas. Water-hydrocarbon systems. Gas well deliverability and tests of natural gas wells. Field processing of natural gas: dehydration and sweetening techniques; liquid hydrocarbon recovery; selection of processing plant and equipment.

ChE 493(N) Petroleum Reservoir Engineering
3.00 credits, 3 hours/week

Origin of petroleum. Petroleum traps. Rock properties: porosity and permeability; types and measurement techniques; Darcy's law and its applications. Review of reservoir fluid properties. Surface tension. Capillary phenomenon. Fluid saturations. Estimation of reserves and drive mechanisms in reservoirs.

ChE 495(N) Gas and Oil Well Drilling and Logging
3.00 credits, 3 hours/week

Gas and oil well drilling methods and equipment. Drilling fluids and their properties. Cementing and well completion. Well logging; types of logging techniques; interpretation of logging data.

ChE 497(N) Transmission and Distribution of Natural Gas

3.00 credits, 3 hours/week

Gas gathering systems. Flow calculations. Sizing of pipes for distribution systems. Network analysis. Construction, protection and maintenance of distribution systems. Economic factors.

SYLLABUS OF PHYSICS FOR THE DEPARTMENT OF CHEMICAL ENGINEERING

Phy 101 Physical Optics, Heat, Waves & Oscillation

3.00 credits, 3 hours/week

Physical Optics: Theories of light. Huygen's principle and construction. Interference of light. Young's double slit experiment. Fresnel bi-prism. Newton's rings. Interferometers. Diffraction of light. Fresnel and Fraunhoffer diffraction, Diffraction by single slit. Diffraction by double slit. Diffraction gratings. Polarization, production and analysis of polarized light. Optical activity. Optics of crystals.

Heat and Thermodynamics: Temperature, Zeroth law of thermodynamics, Thermometers-Constant volume. Platinum resistance, thermocouple. First law of thermodynamics and its application, Molar specific heats of gases. Isothermal and adiabatic relations, work done by a gas, kinetic theory of gases. Explanation of gas laws, Kinetic interpretation of temperature, Equipartition of energy and calculation of ratio of specific heats. Mean free path. Vander Waals equation of state. Second law of thermodynamics: reversible and irreversible processes, Carnot cycle, Efficiency, Carnot's theorem, Entropy.

Waves and Oscillations: Oscillations: S.H.M., Damped S.H. oscillations, Forced oscillations, Resonance, Vibrations of membranes and columns, Combination and composition of S.H. motions, Lissajous' figures. Transverse and longitudinal nature of waves. Travelling and standing waves. Intensity of a wave, Energy calculation of progressive and stationary waves, phase velocity, group velocity. Sound waves: Velocity of longitudinal wave in a gaseous medium. Doppler effect. Architectural acoustics: Sabine's formula, Requisites of a good auditorium.

Phy 105 Structure of matter, Electricity & magnetism and Modern Physics
3.00 credits, 3 hours/week

Structure of Matter: States of matter: solid, liquid and gas. Classification of solids: amorphous, crystalline, ceramics and polymers. Atomic arrangement in solids. Different types of bonds in solids: metallic, Vander Waals, covalent and ionic bond, packing in Solids, Interatomic distances and forces of equilibrium, X-ray diffraction. Bragg's law. Plasticity and elasticity. Distinction between metal, insulator and semi-conductor.

Electricity and magnetism: Electric charge, Coulomb's law. The electric field: calculation of the electric field strength, E. A dipole in an electric field. Electric flux and Gauss's law. Some application of Gauss's law. Electric potential V. Relation between E and V. Electric potential energy. Capacitors. Capacitance, Dielectrics: An atomic view, Dielectrics and Gauss's law; Current and resistance: Current and current density, Ohm's law. Resistivity: an atomic view, Ampere's law, Faraday's law, Lenz's law. Self Inductance and Mutual Inductance. Magnetic properties of matter: magnetomotive force, magnetic field intensity. Permeability, Susceptibility, Classifications of magnetic materials, Magnetisation curves.

Modern Physics: Michelson Morley's experiment. Galilean transformation. Special theory of relativity. Lorentz-transformation. Relative velocity. Length contraction. Time dilation. Mass-energy relation. Photo-electric effect. Compton effect, de-Broglie wave. Bohr's atom model; radioactive decay, half life, mean life, isotopes. Nuclear binding energy, alpha, beta, gamma decay.

Phy 303 Electrical and Magnetic Properties
3.00 credits, 3 hours/week

Free Electron Theory : Free electron theory of metals, density of states, Fermi-Energy, Explanation of electrical and thermal conductivity, specific heat, transport phenomena.

Band Theory of Solid: Crystal periodicity and Bloch function, Nearly free electron approximation. Tight binding approximation, Band gap E-K curve. Classification of metal, insulators and semi-conductors.

Semiconductors: Intrinsic and impurity semiconductors. Transport property of semiconductors. Frequency dependent conductivity. Contact phenomena, p-n junction. p-n-p and n-pn type semiconductor junctions and their characteristic properties.

Superconductivity: Meissner effect. London's theory. Type-I and Type-II superconductors. Thermodynamics of superconducting transitions. Coopers pair. BCS theory. High T_c superconductors.

Magnetism: Different types of magnetic materials. Para-, Ferro-, Ferri- and antiferro-magnetic materials. Weiss theory of ferro-magnetism. Exchange energy. Neel's theory of antiferromagnetism. Domains and Domain wall's. Magnetic anisotropy. Magnetostriction.

HUMANITIES COURSES FOR CHEMICAL ENGINEERING DEPARTMENT

Hum 101(N) English

3.00 credits, 3 hours/week

English phonetics: the places and manners of articulation of the English sounds. Vocabulary. English grammar: Construction of sentences; some grammatical problems. Comprehension. Paragraph writing. Precis writing. Amplification. Report writing. Commercial correspondence and tenders. Short stories written by some well known classic writers.

Hum 103(N) Economics

3.00 credits, 3 hours/week

Definition of Economics. Economics and Engineering.

Principles of Economics.

Micro-economics: The theory of demand and supply and their elasticities. Price determination. Nature of an economic theory, applicability of economic theories to the problems of developing countries. Indifference curve technique. Marginal analysis. Production, production function; types of productivity. Rational region of production of an engineering firm. Concepts of market and market structure. Cost analysis and cost function. Small scale production and large scale production. Optimization. Theory of distribution.

Macro-economics: Savings, investment, employment. National income analysis. Inflation. Monetary policy, Fiscal policy and trade policy with reference to Bangladesh.

Economics of development and planning.

Hum 109 Social Psychology

3.00 credits, 3 hours/week

Introduction to social psychology. The nature of social psychology. Social factors in perceptual-Cognitive Processes: Social perception; person perception; Social attitudes: the nature of attitude; the formation of attitude; the change of attitude.

Socialization: process of social learning; factors in conscience formation; socialization and family structure. Status and communication. Emerging norms and conformity. Leadership. Public opinion, propaganda and advertisement. Youths and Drugs: Youths in Bangladesh; sources of frustration among youths; drugs as a menace to society and to individuals.

Hum 201(N) Sociology

3/00 credits, 3 hours/week

Scope of Sociology: Micro and Macro Sociology. Some fundamental concepts.

Society: From savagery to civilization (Table).

Social evolution and Techniques of production: Social structure of Bangladesh. Oriental and Occidental Societies. Feudalism.

Industrial Revolution: the growth of capitalism, features, social consequences. Socialism. Fascism.

Social Control: Need, means, future of social control.

Leadership: Types, functions, techniques and social power.

Society and Population: Social determinants of fertility and mortality. Human migration. Demographic transition. Density, the standard of living. Population pyramid. Population and world resources, Malthusian, Optimum and socialistic population theory. Population Problem of Bangladesh.

Social Pathology: Crime, juvenile delinquency. Slum.

Nature of Social Change: Factors of Social Change: biological, physical, economic, cultural. Technological factor: Change in production technology, means of communication, transportation, Derivative social effects of converging material inventions. Effects of Technology on major social institutions. Social inventions: Urbanization and industrialization in Bangladesh.

Sociology of Development: Processes of development. Social Planning. Planning as a factor of Social change. Social Change in Bangladesh, Nature and trend.

Urban Ecology: City, pre-industrial and industrial; growth and nature of cities in Bangladesh.

Rural Sociology: Features of village community in Bangladesh, Social Mobility. Urban Rural contrast. Social structure of the tribal people of Bangladesh.

Hum 203(N) Government
3.00 credits, 3 hours per week

Scope: Some fundamental concepts of government and politics.

Origin of the State: Stages of development of modern state: nation, nationalism, internationalism, sovereignty: dejure and de-Facto sovereignty. Functions of State: individualism, socialism, welfare state, fascism.

Citizenship: Rights, duties, hindrances to good citizenship.

Forms of Government: Aristotle's Classification. Modern Classification: democracy, dictatorship, cabinet, presidential, unitary and federal.

Organs of Government and Separation of Powers: Legislature, Executive, Judiciary. Bureaucracy.

The Electorate: Party system and Public Opinion.

Local Self Government.

Socio-political and economic background of the movement for Bangladesh.

Government and Politics in Bangladesh.

Some major administrative systems.

International Political Organisation: The U.N.O. and its Specialised agencies.

Hum 303 Principles of Accounting
3.00 credits, 3 hours/week

Accounting elements: the accounting equation, accounts, transactions, the double entry mechanism. Accounting procedure: the financial statements.

Cost in general: objectives and classifications. Overhead costs: allocation and apportionment. Product costing: cost sheet under job costing, operating costing and process costing. Costing of by-products and joint products.

Marginal costing: tools and techniques, cost-volume-profit analysis. Designing the optimal product-mix.

Relevant costing: analysing profitability within the firm. Guidelines for decision making: short-run decisions.

Long-run planning and control: capital budgeting. The master budget, flexible budget and standard cost. Variance analysis.

SYLLABUS OF MATHEMATICS FOR THE DEPARTMENT OF CHEMICAL ENGINEERING

Math 121 **Differential Calculus and Coordinate Geometry**
3.00 credits, 3 hours/week

Differential Calculus:

Continuity and differentiability of a function, Successive differentiation of various types of function. Leibnit'z theorem. Rolle's theorem, Mean value theorem and expansion of functions. Partial differentiation. Tangent and Normal in the cases of cartesian and polar co-ordinates. Maximum and minimum. Indeterminant forms.

Co-ordinate Geometry:

Changes of axes: Transformation of co-ordinates, simplification of equation of curves. Conic section (pair of straight line, system of circle, parabola, Ellipse, Hyperbola).

Math 123 **Integral Calculus and Differential Equation**
3.00 credits, 3 hours/week

Integral Calculus:
Integration by methods of substitution. Integration by the method of successive reduction. Definite integrals with properties. Improper integrals. Beta and Gamma function. Area

under a plane curve in cartesian and polar co-ordinates. Area of the region enclosed by the two curves in cartesian and polar co-ordinates. Arc lengths of curves in cartesian and polar co-ordinates. Area and volumes of surface of revolution.

Differential Equation: Solutions of first order differential equations by various method. Solutions of general linear equations of second and higher orders with constant co-efficients. Solution of homogeneous linear equations. Applications.

Solution of differential equations of the higher order when the dependent and independent variables are absent. Solution of differential equation by the method based on the factorization of the operators.

Math 221(N) Vector Analysis, Matrices, and Laplace Transform
4.00 credits, 4 hours/week

Vector Analysis: Scalars and vectors, equality of vectors. Addition and subtraction of vectors. Multiplication of vectors by scalars. Position vector of a point. Resolution of vectors. Scalar and vector product of two vectors and their geometrical interpretation. Triple products and multiple products. Application to geometry and mechanics. Linear dependence and independence of vectors. Differentiation and integration of vectors together with elementary applications. Definition of line, surface and volume integrals. Gradient, divergence and curl of point functions. Various formulae. Gauss's theorem, Stoke's theorem, Green's theorem and their applications.

Matrices: Definition of matrix. Different types of Matrices. Algebra of matrices. Adjoint and inverse of a matrix. Rank and elementary transformations of matrices. Normal and canonical forms. Solution of linear equations. Quadratic forms. Matrix polynomials. Caley-Hamilton theorem. Eigenvalues and eigenvectors.

Laplace Transform: Definition. Laplace transforms of some elementary functions. Sufficient conditions for existence of Laplace transforms. Inverse Laplace transforms. Laplace transforms of derivatives. The unit step function. Periodic function. Some special theorems on Laplace transforms. Partial fraction. Solutions of differential equations by Laplace transforms. Evaluation of improper integrals.

Math 223(N) Numerical Analysis and Statistics
3.00 credits, 3 hours/week

Numerical Analysis: Interpolation: Simple difference, Newton's formulae for forward and backward interpolation. Divided differences. Tables of divided differences. Relation between divided differences and simple differences. Newton's general interpolation formula. Lagrange's interpolation formula. Inverse interpolation by Lagrange's formula and by successive approximations. Numerical differentiation of Newton's forward and backward formulae. Numerical integration. General quadrature formula for equidistant ordinates. Trapezoidal rule. Simpson's rule. Weddle's rule. Calculation of errors. Relative study of three rules. Gauss's quadrature formula. Legendre polynomials. Newton's-Cotes formula. Principles of least squares. Curve fitting. Solution of algebraic and transcendental equations by graphical method. Regula-Falsi method. Newton-Raphson method, geometrical significance. Convergence of iteration and Newton-Raphson methods. Newton-Raphson method and iteration method for the solution of simultaneous equations. Solution of ordinary first order differential equations by Picard's and Euler's method. Runge-Kutta's methods for solving differential equations.

Statistics: Frequency distribution. Mean, median, mode and other measures of central tendency. Standard deviation and other measures of dispersion. Moments, skewness and kurtosis. Elementary probability theory and discontinuous probability distribution, e.g. binomial, Poison and negative binomial. Continuous probability distributions, e.g. normal and exponential. Characteristics of distributions. Hypothesis testing and regression analysis.

Math 321(N) Complex Variable, Bessel's Function and Legendre Polynomials
3.00 credits, 3 hours/week

Complex Variable: Complex number system. General functions of a complex variable. Limits and continuity of a function of complex variable and related theorems. Complex differentiation and the Cauchy-Riemann equations. Mapping by elementary functions. Line integral of a complex function. Cauchy's integral theorem. Cauchy's integral formula. Liouville's theorem.

Taylor's and Laurent's theorem. Singular points. Residue. Cauchy's residue theorem. Evaluation of residues. Contour integration. Conformal mapping.

Bessel Function and Legendre polynomials: Solution of differential equations in series by the method of Frobenius. Bessel's functions, Legendre's polynomials and their properties.

Math 323(N) **Fourier Analysis, Harmonic Functions and Partial Differential Equation**
3.00 credits, 3 hours/week

Fourier Analysis: Real and complex form. Finite transform. Fourier Integral. Fourier transforms and their uses in solving boundary value problems.

Harmonic functions: Definition of harmonics. Laplace equation in cartesian, polar cylindrical and spherical co-ordinates. Solutions of these equations together with applications. Gravitational potential due to a ring. Steady-state temperature. Potential inside or outside of a sphere. Properties of harmonic functions.

Partial Differential Equation: Introduction. Equations of the linear and non-linear first order. Standard forms. Linear equations of higher order. Equations of the second order with variable co-efficients.

SYLLABUS OF ELECTRICAL ENGINEERING FOR THE DEPARTMENT OF CHEMICAL ENGINEERING

EEE 155(N) **Electrical Engineering Fundamentals**
3.00 credits, 3 hours/week

Electrical units and standards. Electrical networks and circuits theorems, introduction to measuring instruments.

Alternating current, RLC series, parallel circuits, magnetic concepts and magnetic circuits.

EEE 156(N) **Electrical Engineering Fundamentals Sessional**
1.50 credits, 3 hours/week

Laboratory experiments based on EEE 155(N).

EEE 267 **Electrical and Electronic Technology**
3.00 credits, 3 hours/week

Balanced three-phase circuits. Introduction to single-phase and three-phase transformers. Principles of construction, operation and applications of DC generator, DC motor, synchronous generator, synchronous motor and induction motors.

Semiconductor diode, transistors, operational amplifiers (OPAMs), silicon controlled rectifiers (SCR's): principles of operation and applications. Oscilloscope, Transducers: temperature, pressure, flow-rate, speed and torque measurements.

EEE 268(N) **Electrical and Electronic Technology Sessional**
3.00 credits, 3 hours/week

Laboratory experiments based on EEE 267(N).

SYLLABUS OF MECHANICAL ENGINEERING FOR THE DEPARTMENT OF CHEMICAL ENGINEERING

ME 141(N) **Engineering Mechanics**
3.00 credits, 3 hours/week

Basic concepts of mechanics: Statics of particles and rigid bodies:-Centroids of lines: areas and volumes: Forces in trusses and frames. Friction: Moments of inertia of areas and masses. Relative motion Kinematics of particles. Newton's Second Law of motion. Principles of work and energy. System of particles. Kinematics of rigid bodies. Kinematics of plane motion of rigid bodies forces and acceleration.

ME 160(N) **Mechanical Engineering Drawing-I**
1.50 credits, 3 hours/week

Introduction; Instruments and their uses: First and Third Angle Projections: Orthographic Drawings: Isometric Views: Missing lines and views: Sectional views and conventional practices: Auxiliary views.

ME 243(N) Mechanics of Solids
3.00 credits, 3 hours/week

Stress analysis: statically indeterminate axially loaded member, axially loaded member, thermal and centrifugal stresses. Stresses in thin and thick walled cylinders and spheres.

Beams: shear force and bending moment diagrams: Various types of stresses in beams. Flexure formula: Deflection of beams, integration and area moment methods. Introduction to reinforced concrete beams and slabs.

Torsion formula: Angle of twist: Modulus of rupture. Helical springs. Combined stresses. Principal stress. Mohr's Circle: Columns: Fuler's formula, intermediate column formulas, the secant formula. Flexure formula of curved beams.

Introduction to experimental stress analysis techniques. Strain energy. Failure theories.

ME 347 Mechanical Design of Process Equipment
3.00 credits, 3 hours/week

Vessels: classification, fundamental principles and design equations, codes and standards: Design of thin-walled cylinders and spherical shells under internal pressure: Design of thin-walled cylindrical vessels under external pressures:

Design of vessels subject to combined loading: Vessel heads and supports: Bolted flanged joints: High pressure vessels: Performance tests.

Shell and tube heat exchangers: general considerations and thickness of various components. Pipeline: wall thickness and schedule number.

SYLLABUS OF CHEMISTRY FOR THE DEPARTMENT OF CHEMICAL ENGINEERING

Chem 111 Inorganic Chemistry
3.00 credits, 3 hours/week

Modern concept of atomic structure; periodic table and its application; isotopes and application of radioactive isotopes;

brief discussion on noble gas; different types of chemical bonds, wave nature of electron, advanced concept of chemical bonds, hybridization, molecular structure; theories of coordination compounds, application of stability of complex compounds. General treatment of the elements of different groups. Modern theories of acids and bases.

Chem 112 **Inorganic Analysis I Sessional**
1.50 credits, 3 hours/week

Volumetric analysis: acid-base titration, oxidation-reduction titration and iodometric titration, precipitation titration. Gravimetric analysis: estimation of sulfate and zinc. Separation and estimation of iron and calcium, copper and zinc from their mixtures.

Chem 131 **Physical Chemistry I**
3.00 credits, 3 hours/week

Types of solutions, measures of composition. Solubility. Dilute solutions and colligative properties. Colloidal solution. Thermo-chemistry. Second law of thermodynamics and its applications. Chemical equilibrium of homogeneous and heterogeneous reactions. Thermodynamic treatment of equilibrium constant. Ionization of water and pH scale.

Chem 116 **Inorganic Analysis Sessional**
1.50 credits, 3 hours/week

Complexometric titration. Analysis of water and some industrial products.

Chem 235 **Physical Chemistry II**
3.00 credits, 3 hours/week

Chemical kinetics. Adsorption and adsorption isotherm. Catalysis. Molecular spectroscopy. Rotational, vibrational and electronic spectra of molecules.

Phase equilibria: phase rule and its application. Electrolytic conduction. Electrical properties of solution. Interionic attraction theory. Electrochemical cells. Thermodynamics of electrochemical cells. Application of emf measurements. Ionic equilibria. Buffer solution. Henderson equation and its application.

Chem 236 Physical Chemistry Sessional
1.50 credits, 3 hours/week

Partition co-efficient. Equilibrium constant by distribution method; heat of reaction by calorimetry; Heat of solution by solubility measurement. Viscosity measurement. Determination of specific rate constant. Measurement of equivalent conductance and solubility of sparingly soluble salt.

Chem 221 Organic Chemistry
3.00 credits, 3 hours/week

The hybridization of carbon atom and covalent bonding. A comprehensive study of aliphatic hydrocarbons with special reference to nomenclatures, method of preparation, properties and important uses. Types of reactions of aliphatic hydrocarbons and their industrial applications. Structure, nomenclature, preparation, properties, reactions and industrial applications of aliphatic hydrocarbon homologues. Aromatic compounds and aromaticity; preparation, properties, reactions and industrial applications of benzene and its derivatives. Heterocyclic compounds and their applications.

Chem 222 Organic Chemistry Sessional
1.50 credits, 3 hours/week

Detection of elements in organic compounds. Identification of functional groups. Preparation of different organic compounds. Separation, purification and characterization of organic compounds.

Chem 323 Organic Synthesis
3.00 credits, 3 hours/week

Formation of carbon-carbon single bond and carbon-carbon multiple bonds using different synthetic methods such as alkylation, cyclization and polymerization. Selective introduction and manipulation of functional groups. Selectivity in functional group reactions. Activating, protecting and blocking of groups. Synthesis and chemistry of industrially important organic compounds. Characterization of organic compounds by spectroscopy methods of analysis.

Chem 352 **Instrumental Methods of Analysis**
1.50 credits, 3 hours/week

Spectrophotometry. Potentiometric titration; pH-titration. Conductometric titration. Thin layer chromatography.

POSTGRADUATE COURSES

TRANSPORT PROCESS AND REACTION ENGINEERING

ChE 6101 Transport Phenomena

Concepts of unified treatment of transport process. Theories of viscosity, thermal conductivity and diffussivity. Generalized expressions for transport fluxes. Multicomponent equations of change. Analytical and approximate solutions of equations of change in momentum, heat and mass transfer processes.

ChE 6102 Advanced Thermodynamics

Review of thermodynamic principles. Estimation of thermodynamic properties, ideal and non-ideal solution, phase equilibria, reacting mixtures.

ChE 6103 Fluid Mechanics

Viscosity and the mechanism of momentum transport. Kinematics of fluid in motion. Stress in a fluid and the equations of motion of a fluid. Analytical solutions of Newtonian and non-Newtonian fluids in simple geometries. Ordering and approximations in fluid flow, creeping flow, boundary layer flow. Introduction to perturbation and numerical solutions of fluid mechanical problems.

ChE 6104 Heat Transfer

Thermal conductivity and the mechanism of energy transport. The basic equations of momentum and energy transport. Analytical and numerical solutions of unsteady state and steady state heat conduction problems. Analytical solution of Laminar forced convection heat transfer problems for Newtonian and non-Newtonian fluids. Thermal boundary layer. Turbulent heat transport. Heat transfer with boiling and condensation. Design of heat exchangers.

ChE 6105 Mass Transfer

Diffusivity and mechanisms of mass transport. The equations of change for multicomponent system. Steady and unsteady state

diffusion in stagnant medium. Convective mass transfer in laminar and turbulent flows. Interphase transport and mass transfer at higher mass flux.

ChE 6106 Kinetics and Catalysis

Definitions and concepts: The chemical basis of catalysis, classification of catalysts, adsorption and adsorption isotherms, multilayer adsorption theory and the BET equation, kinetics of heterogeneous reactions, model discrimination and parameter estimation, structure of heterogeneous catalysts, Catalyst design, preparation and characterization. Role of transport processes in heterogeneous catalysis, catalyst deactivation, gas-liquid reactions, non-catalytic gas-solid reaction, homogeneous catalysis. Examples of industrial heterogeneous catalytic reactions.

ChE 6107 Advanced Chemical Reactor Design

Study of the factors involved in the design and operation of Chemical reactors for both homogeneous and heterogeneous systems, batch reactors, continuous flow stirred tank reactors, tubular reactors, multibed adiabatic reactors and cold shot converters. Determination of optimal temperature gradients and yields, catalysts effectiveness factors, optimal control with decaying catalysts, reactor optimization problems in local industries.

ChE 6108 Equilibrium Stage Processes

Review of underlying principles of equilibrium stage processes, multicomponent distillation, Calculation of stages by short cut methods using Fenske, Underwood and Gilliand correlation, graphical methods, computer aided methods. Azeotropic and extractive distillation. Multicomponent absorption for dilute and concentrated solutions, nonisothermal absorption. Mass transfer accompanied by irreversible and reversible reactions.

ChE 6109 Non-Newtonian Fluid Flow and Heat Transfer

Classification of non-Newtonian fluids. Experimental characterization principles and methods. Flow in simple geometry in laminar, transition and turbulent regimes. Drag reduction. Mixing. Heat transfer. Flow in packed/porous media.

PROCESS ENGINEERING AND TECHNOLOGY

ChE 6201 Advanced Plant Design

Review of process plant design. Technical specification, Design basis, process licensing, engineering studies, Codes and standards, review and approval of engineering documents. Engineering procurement, cost estimation, Plant start-up and commissioning, performance guarantee. Optimization techniques. Principles of computer aided design.

ChE 6202 Polymer Science for Chemical Engineers

Characterization, rheology and other properties of polymers. Polymerization principles and kinetics. Commercial polymers and their applications. Polymer degradation and stabilization. Technology of polymer processing, design of polymer processing plants.

ChE 6203 Nuclear Chemical Engineering

Nuclear reactors and nuclear fuel cycles. Nuclear radiation and interaction with matter, elements of reactor physics. Separation processes in the nuclear industry. Reprocessing and waste management. Reactor safety and assessment of accident, risk.

ChE 6204 Electrochemical Engineering

Introduction to the electrochemical systems. Equilibrium potential, theory of overvoltages, irreversible electrode kinetics, ionic transfer, mass transfer at electrode surfaces. Application in the areas of corrosion, batteries, fuel cells, chemical synthesis, molten electrolyte, electrowinning, and electro refining processes. Electrochemical reactor design.

ChE 6205 Corrosion Science and Engineering

Electrochemical thermodynamics and kinetics. Theory of overvoltage, kinetics of dissolution processes. Mixed potentials and exchange current, depolarizers and theories of passivation. Pourbaix's diagrams, principles and applications. Oxidation and high temperature metal-gas reactions. Defect structures. Mechanical influences, stress corrosion and fatigue. Velocity effects. Corrosion rate measurements. Tafel extrapolation and linear polarization. Statistical considerations.

ChE 6206 Corrosion Protection systems

Principles of protection, passivation and inhibition. Various protection systems, material selection, alteration of environment, design, coating inhibitors and passivators. Electrochemical systems, cathodic and anodic protection, design and applications. Economics of protection, multiple systems. Corrosion testing and practical applications.

ChE 6207 Ion Exchange

Structure and properties of ion exchangers. Preparation of ion exchangers, ion exchange capacity, equilibria of ion exchange and thermodynamic models of equilibria. Ion exchange in concentrated solutions. Ion exchange column calculation. Water treatment by ion exchange. Ion exchange membranes.

ChE 6208 Adsorption and Diffusion in Porous Media

Fundamentals of adsorption, pore structure, surface area measurement, diffusion in porous media. Adsorption processes and chromatography. Chemical aspects of heterogeneous catalysis. Simultaneous diffusion and reaction in a porous catalyst. Heat transfer effects in adsorption.

ChE 6209 Fluidization and its Applications

Fluid-particle interaction; hydrodynamics of fluidization. Typical gas and liquid fluidized beds. Stability of fluidized beds. Bubble dynamics. Fluidized bed reactor design. Industrial Applications of fluidized beds.

ChE 6210 Industrial Safety

Introduction to occupational health and hygiene. Industrial safety legislation. Toxicity and TLV, explosion and flammability. Hazard identification and precautions. Dow F and E index, Mond-Dow index, hazard operability studies. Hazard analysis, safety check lists. Working environment requirements. Safety problems to specific processing plants including nuclear installation.

COMPUTER APPLICATION AND PROCESS CONTROL

ChE 6301 Advanced Numerical Methods in Chemical Engineering

Review of numerical techniques, Application of the methods of weighted residuals, orthogonal collocation and finite element methods to solution of problems in transport process and reaction engineering.

ChE 6302 Process Dynamics

A study of the dynamic behaviour of lumped and distributed system, dynamic model building and analysis. Interpretation of frequency and time response of linear systems. State-space methods, approximations to models and responses, stability analysis, sand the behaviour of nonlinear systems. Applications to heat exchangers, tubular reactors and fixed bed sorption processes.

ChE 6303 Process Control

A survey of selected advanced topics of control as applied to chemical processes, mathematical modeling, parameter estimation and process identification, multivariable control, optimal and adaptive control, Real time, digital control.

ChE 6304 Computer Aided Process Design

Use of computer to solve large scale problems in chemical process plant design and simulation, Review of existing computer aided process design packages (CAD). Comparative advantages and disadvantages of sequential and equation based flowsheet simulation. Introduction to process structure and

organization. Selected topics in recycle convergence acceleration, ordering of computations, tearing techniques and optimization as applied to process design. Simulation and optimization of some realistic chemical engineering systems using a CAD package.

ChE 6305 Optimization Techniques in Chemical Engineering

Study of optimization algorithms and their application to chemical engineering problems. Linear and nonlinear programming. Optimum search methods. geometric programming.

ENERGY AND ENVIRONMENTAL ENGINEERING

ChE 6401 Fuels and Combustion Science

Review of the basic concepts of flame propagation and stabilization in premixed laminar and turbulent flames. Theory of laminar and turbulent diffusion flames. Burning velocity. Flame structure, quenching and flame stabilization. Flame propagation, explosion and detonation. Dynamics of the thermal requirements of ignition, extinction, combustion, Combustion aerodynamics. Burning gaseous and liquid fuel. Single droplet burning, burning of sprays. Solid fuel combustion, kinetics of microheterogeneous processes. Combustion in fluidized beds. Principles of burner and combustion chamber design.

ChE 6402 Combustion Engineering and Technology

The role of combustion in process engineering, power generation and manufacturing. Energy audit. Available heat in relation to batch and continuous processes. Waste heat recovery. Principles of operation, performance and mechanical design of the main types of burners and furnaces. Reduction of pollutant emission by combustion modifications. Measurement and control in flames. Combustion noise and oscillation. Combustion of physical and mathematical modeling for predicting furnace performance. Economy in the use of energy.

ChE 6403 Energy Management and Modeling

Energy auditing, energy conservation schemes, energy conversion, representation of energy consumption in the industry. Costing techniques, financial appraisal and profitability, investment decisions. Energy utilization and conversion systems. Thermal energy and electrical energy systems. Waste heat recovery. Energy modeling.

ChE 6404 Industrial Furnaces

Physical, chemical and thermal properties of refractories and other high temperature insulating materials. Design principles of industrial furnaces, petroleum heaters, different types of reformers, converters and regenerators. Analysis of industrial furnaces and fired heaters used in chemical process plants. Specification of fuels for furnaces. Instrumentation and control of furnaces.

ChE 6405 Water Pollution and Control

Water quality standards and wastewater characterizations. Sources and nature of waterpollution. Physical, chemical and biological methods of waste treatment. Disposal of highly toxic wastes. Oil spills and clean-up methods. Soil reclamation. Process control and monitoring standards. Cost analysis. Legislation. Pollution control of pulp and paper, fertilizer, refinery, steel and metal finishing, food and pharmaceutical industries.

ChE 6406 Air Pollution and Control

Nature and properties of the atmosphere. Pollutants, sources, methods of control, Stack gas clean-up from industrial plants, stack design, automobile exhausts, monitoring. Air quality standards. Legislation.

FOOD AND BIOCHEMICAL ENGINEERING

ChE 6501 Chemistry and Microbiology of Food

Chemistry and biochemistry of food products. Compositions and nutritive values of foods. Microbiology of food. Physiology and genetics of bacteria, moulds, yeasts, fungi, versus and algae. Growth and destruction of microorganisms. Microbial spoilage of food. Food poisoning.

ChE 6502 Food Processing and Preservation

Food preservation principles. Unit operations and unit processes in food processing. Effects of processing on food products. Evaluation of different processing techniques. Design of food processing equipment and plants. Plant effluent treatment and waste management.

ChE 6503 Food Technology

An in depth study of different food processing industries with special reference to processing of cereal, vegetable, fruit, milk, fish, edible oils and production of fermented food products and sugar technology.

ChE 6504 Fermentation Technology

Morphology and physiology of industrial microorganisms. Separation, identification and quantitative estimation of microorganisms. Fermentation process kinetics. Rheological properties of biological fluids. Design, operation and control of industrial fermentors. Application of fermentation technology in industries.

ChE 6505 Biochemical Engineering

The application of chemical engineering principles of mass, momentum and energy transport as well as reaction kinetics to biochemical reaction systems. Design of biochemical systems based on transport process and chemical reaction principles. Study of different phases of some common biochemical systems.

ChE 6506 Quality Control in Food and Biochemical Industries

Food legislation. Principles of quality control. Chemical, physical and organoleptic methods for examination of foods and biochemical products. Laboratory control methods for processing plants. Detection of pathogens in food. Plant sanitation and quality assurance program in food and biochemical manufacture.

PETROLEUM AND NATURAL GAS ENGINEERING

ChE 6601 Introduction to Petroleum Engineering

An overview of hydrocarbon energy resources of Bangladesh. Origin and chemistry of petroleum. Classification of hydrocarbon deposits and their genesis. The nature of hydrocarbons. Physical properties of source rocks and their characterization. Geophysical exploration of hydrocarbons.

ChE 6602 Petroleum Reservoir Fluids

Composition and nature of petroleum reservoir fluids. Phase reservoir behavior of multicomponent hydrocarbons and hydrocarbon-nonhydrocarbon systems. Production of equilibrium ratios. Rock and fluid property correlations.

ChE 6603 Oil Well Drilling and Completion

Elements of rock mechanics. Drilling fluids and their properties. Flow of drilling fluids. Drilling methods and equipment. Well test methods and evaluation of wells. Cementing and well completion. Safety requirements for petroleum exploration and development.

ChE 6604 Petroleum Production Technology

An overview of well completion. Theory of reservoir fluid flow, flow measurement and control. Primary and secondary recovery, Fluid separation and treatment. Design and operation of gathering lines and production facilities. Well testing and recompletion. Oil and gas regulations.

ChE 6605 Well Logging and Formation Evaluation

Background of well logging and its purposes, Different types of well logging, their principles and applications. Physical properties of the porous media, fluid saturations and chemical composition of the saturating fluids. Interpretation and use of the information of logging in reservoir engineering.

ChE 6606 Reservoir Engineering

Characteristics of reservoir materials. Fluid flow through porous media. Methods of analysis and estimation of reservoir. Reservoir simulation. Practical aspects related to the development and use of reservoir models.

ChE 6607 Natural Gas Engineering

A review of the physical and chemical properties of natural gas, phase behavior, vapor-liquid equilibrium data and computation, water-hydrocarbon systems, flow of gas-liquid mixtures, engineering principles used in the production of natural gas and its associated liquids. A detailed review of design and operations criteria encountered in the production, well head treatment of natural gas, producing and testing of gas wells, dew point control, LPG recovery, sulfur recovery, environmental control problems in natural gas processing, gas sweetening.

ChE 6608 Transmission and Distribution of Natural Gas

Review of theories of fluid flow. Load gathering for distribution system planning. Flow calculations, layout and sizing of distribution piping systems. Network analysis. Construction and maintenance of distribution systems, economics of distribution. Design problems on distribution systems.