MINISTRY OF HIGHER EDUCATION
AND SCIENTIFIC RESEARCH

UNIVERSITY OF
TECHNOLOGY

CHEMICAL ENGINEERING
DEPARTMENT

Ph.D, M.Sc.
PROGRAM IN
CHEMICAL ENGINEERING

OUTLINE OF SYLLABUSES
ALLOCATION OF SUBJECTS AND
WEEKLY LOAD

2021-2024

Preface

Postgraduate studies in the Department of Chemical Engineering were established in 1979 starting with a Master of Science degree (M.Sc.) in Industrial Unit Operation. The duration of the course was one year after which the student is granted a Higher Diploma Certificate which qualifies him for a second year during which the student is asked to prepare a dissertation in the field of industrial unit operation after which the student is granted M.Sc. degree.

The Doctor of Philosophy Degree in Chemical Engineering was established in 1987 which consists of a one year course after which the student has to sit a comprehensive examination and then prepare a thesis after a two year research project in any of the fine specializations of Chemical Engineering. Halted in 2006 and reopened in 2015-2016.

For the sake of catching up with the scientific development in the modern science frontiers, a Master of Science Course was established in 1987 in the field of Engineering Materials followed by Master of Science in Petroleum Refinery and Petrochemicals, and Master of Science in Corrosion Engineering both in 1988. The last two courses were halted for technical reasons and the first was re-established in 2004.

In 1998, M.Sc. degree in Biochemical Engineering was established. The course was halted for technical reasons in 2001. In 2001 a Higher Diploma Degree in Oil and Gas Refining Engineering was established followed by a Higher Diploma Degree in Industrial Pollution Engineering.

The duration of both higher diploma degrees was one year consisted of courses plus a research in the field concerned. These courses are both halted for technical academic reasons.

In the academic year 2004-2005, the post- graduate studies were concentrated only on the M.Sc. degree in Industrial Unit Operation and the M.Sc. course in Petroleum Refining and Petrochemical Industries was re-opened due to its importance in modern industries, Renamed in 2014-2015 to Oil and gas Refinery Engineering. In addition to the Ph.D. graduates the total number of post- graduate students graduated form the department is 428 Ph.D, M.Sc, HD up till 2015.

In 2010 a higher diploma degree in Petroleum Refining and Gas Technology was established. This course is specialized for the staff of the Ministry of Oil and it continues up to now.

The aims of the above degrees are to provide the graduates with advanced knowledge in the fundamental topics in Chemical Engineering and to prepare specialized personnel for scientific research and academic fields. Postgraduate studies involved a scientific collaboration strategy reflected by the joint supervision with pioneers in the field of Chemical Engineering from other universities and from industry to interchange knowledge and experience between university and industry.

Prof. Jamal M. Ali

Head of Chemical Engineering Department

M.Sc. Program in Chemical Engineering

CHEMICAL PROCESSING ENGINEERING

M.Sc. Program in Chemical Engineering
CHEMICAL PROCESSING ENGINEERING

First Term			
Code	**Subject**	**Hours / week**	**Units**
ChE-P-MS-0101	Fluid Flow	2	2
ChE-P-MS-0102	Mathematical Modeling and Numerical Analysis	3	3
ChE-P-MS-0011	Reactor Design	2	2
ChE-P-MS-0012	Separation Processes	2	2
ChE-P-MS-xxxx	Elective I	2	2
ChE-P-MS-1001	English Language (I)	1	1
Total		14	12

Second Term			
Code	**Subject**	**Hours / week**	**Units**
ChE-P-MS-0104	Heat Transfer	2	2
ChE-P-MS-0105	Thermodynamics	2	2
ChE-P-MS-0106	Mass Transfer	2	2
ChE-P-MS-0103	Process Control	2	2
ChE-P-MS-xxxx	Elective II	2	2
ChE-P-MS-1001	English Language (II)	1	1
ChE-P-MS-1002	Plagiarism	1	Pass
Total		12	11

Total Theoretical Units	**23**
Dissertation Units	**12**
Grand Total /Units	**35**

Electives			
Code	**Subject**	**Code**	**Subject**
ChE-P-MS-0109	Corrosion Engineering	ChE-P-MS-0016	Nanotechnology
ChE-P-MS-0108	Catalysts Engineering	ChE-P-MS-0015	Environmental Engineering
ChE-P-MS-0014	Polymer Technology		Instr. Tech. & Chem. Analysis Lab.

DESCRIPTION AND BREAKDOWN OF SUBJECTS
M.Sc. COURSE /CHEMICAL PROCESSING

ChE-P-MS-0101 - Fluid Flow

Newtonian law Viscosity and non- Newtonian models mechanisms of momentum transport; Shell momentum balances and viscosity distributions in laminar flow; The equation of change for isothermal systems; Viscosity distributions with more than one independent variable; Velocity in turbulent flow; Interphase transport in isothermal systems; Distribution of pipes.

ChE-P-MS-0102 - Mathematical Modeling and Numerical Analysis

Mathematical modeling

Mathematical models of mass transfer equipments, Batch and Continuous Distillation Columns, Reactive Distillation Column, Packed absorption Column with chemical reaction, Nano-membrane. Mathematical models of reactors, Batch, Continuous-Stirred Tank, Plug-flow, Biochemical, Photo and Membrane reactors, Heat exchangers. Simultaneous heat and mass transfer models. Desublimators.

Numerical Analysis

Solutions of nonlinear algebraic equations; Solution of simultaneous equations by matrix methods; Solution of ordinary differential equations; Solution of partial differential equations.

Numerical Analysis Laboratory

The laboratory work includes computer solutions of different chemical processes using numerical analysis techniques.

ChE-P-MS-0011 - Reactor Design

Non-isothermal Continuous-Flow Reactors (at Steady State): Continuous-Stirred Tank Reactor (CSTR): Adiabatic CSTR, CSTR with a cooling coil. Tubular Reactor: Adiabatic tubular reactor, tubular reactor with heat exchange, multi-stage adiabatic reactors. Multiple Steady States: removed heat, heat of generation, ignition-extinction curve, stable & unstable steady states. **Gas-Solid Non-catalytic Reactions**: Shrinking core model, conversion vs. time, rate controlling steps, conversion vs. length of a bed, mixture of particles of different sizes, moving-bed reactor. **Non-Ideal Flow Reactors** Macromixing and micromixing, Earliness of mixing, residence time distribution (RTD). Non-ideal flow reactors: Reactors with axial dispersion, Tanks-in-Series, Segregated flow, Performance of reactors with non-ideal flow. **Applied Computational Flow Dynamics (CFD)**: Introduction to CFD: What is CFD? advantages of CFD, applications of CFD, CFD-how it works.

ChE-P-MS-0012- Separation Processes

Design of freedom analysis. Ultrafiltration, Microfiltration, Nanofiltration. Pervaporation Membrane distillation hybrids. Gas separation. Pressure swing distillation. Extractive distillation. Reactive distillation. Homogeneous azeotropic distillation. Heterogeneous azeotropic distillation. Forward osmosis; Reverse osmosis; Adsorption and ion exchange.

ChE-P-MS-1001- English Language

English Language (I)

- Synonyms (Meanings)
- Confusion Words
- Parts of Speech
- Verb Tenses
- Passive Voice

English Language (II)

- Conditional sentences
- Relative Pronouns & Clauses
- Finite and Non-Finite Verbs
- Kinds of Subordinate Clauses
- Kinds of Sentences: the simple sentence, the Compound sentence, and the complex sentence.

ChE-P-MS-0104 - Heat Transfer

Hydrodynamic and thermal boundary layers. Analysis of heat transfer in laminar tube flow. Unsteady state heat transfer. Temperature profile in turbulent flow. Design of tubular furnace. Air cooler design.

ChE-P-MS-0105- Thermodynamics

Basic Concepts and Definitions: Basic thermodynamic terminology, Types of energy and thermodynamic properties, Fundamental equation of thermodynamics, Thermodynamics laws. Thermodynamics of Flow Process: Fundamental equations, Flow in pipes, Expansion processes (Nozzles and Turbines), Throttling processes (Joule-Thomson coefficient), Compression processes (Compressors and Pumps). Vapor-Liquid Equilibria – Ideal Behavior: Fundamentals of phase equilibrium (Duhem's theorem), Property change of mixing (Gibbs theorem), Vapor pressure (Antoine equation and Cox chart), Raults law (Dew and Bubble point calculation), Vapor-liquid diagrams of binary mixtures, Flash calculation. Vapor-Liquid Equilibria – Nonideal Behavior: Nomographs and charts of K-values, Polynomial equations of K-values, Tabulated K-values at different reduced conditions, Prediction of thermodynamic properties of fluids-nonideal behavior, Theorem of corresponding states and reduced conditions, Residual properties, Departure charts and tables of

thermodynamic properties, Computational path for property changes.Properties of Mixtures-Nonideal Behavior: Partial property and nonideal solution, Fugacity and fugacity coefficients of mixture components (Lewis-Randall rule), Activity and activity coefficient, Excess Gibbs free energy, Activity coefficients from VLE data.

ChE-P-MS-0106 - Mass Transfer

Fundamentals of mass transport. Concentration distribution in solid and in laminar flow. The equation of change and their uses for multi-component systems. Mass transport with more than one independent variables. Interphase mass transport. Macroscopic balances for multicomponent system.

ChE-P-MS-0103 - Process Control

Analysis and design of feedback control system. Analysis and design of advanced control systems (feedforward control, adaptive control, cascade control, inferential control, Fuzzy-logic control, and neural control). Design of control system for multi control of complete variable process plant. Process control using digital computers. Interaction effect on the closed loop.

ChE-P-MS-1002 - Plagiarism

Essay writing process, Research paper abstract writing, Emphasizing Generalizing, Paraphrasing, Quoting, Text referencing, Unnecessary words, - Redundant words that can be omitted, Unnecessary Phrases.

ELECTIVES
CHEMICAL PROCESSING ENGINEERING

ChE-P-MS-0109 - Corrosion Engineering

Introduction to Corrosion. Basic Concepts in Corrosion: Anodic and cathodic reactions, Types of corrosion cells, Mechanism of corrosion of iron, Pourbaix diagrams, Corrosion Kinetic, Polarization, activation polarization, concentration polarization, combined polarization, Tafel equation, Evans diagrams, Mixed potential theory and its application, Determination of corrosion rate by electrochemical measurements. Kinetics of Passivity: Definition of important electrochemical parameters for active-passive metal, Measured vs. actual polarization, Behavior of active-passive metal control of passivity, Effects of environment. Corrosion Prevention: Cathodic protection, Anodic protection, Coating, Inhibitors, Corrosion prevention by design selection of materials for corrosion environment. Rotating Electrodes for Corrosion Study: Rotating cylinder electrode, Rotating disc electrode.

ChE-P-MS-0108- Catalysts Engineering

Catalyst functions. Organization of catalysis. Steps in catalytic reaction. Structures of catalysis. Catalyst component. Catalyst design. Catalytic material. Catalyst preparation. Physical adsorption of solid material. Chemisorptions. Catalyst characterization. Catalyst deactivation. Models for deactivation of catalyst. Case study for industrial and petroleum catalytic processes.

ChE-P-MS-0014- Polymer Technology

Introduction. Classification and types. Industrial application of polymers molecular weight determination. Kinetics of linear condensation

polymerization. Kinetics of addition polymerization; Thermodynamic of polymer

Copolymers types. Kinetics of copolymerization. Polymer systems, composite materials, thermal analysis (DSC), polymer blend.

ChE-P-MS-0016- Nanotechnology

Introduction; Simple kinetic theory; Schrodinger equation; Quantum wells; Rigid rotors; Electronic energy levels in crystals; Reciprocal lattice; Energy spectrum in Nanostructures; Specific heat of molecules; Effects of Nanostructures on energy storage; Electromagnetic waves; Acoustic waves; Laudauer formalism; Transport in carbon nanotubes.

ChE-P-MS-0015 - Environmental Engineering

Introduction, Terminology and (Laws and Regulations, Legalization), Water and wastewater Pollution and treatment methods, (Coagulation-flocculation). Advanced treatment methods for desalination by membrane separation (Reverse osmosis, electrodialysis metals and nanofiltration). Solid waste treatment methods. Removal of heavy metals from water.

Instrumental Techniques and Chemical Analysis for Environmental Pollution Monitoring

Measurement of: physical characteristics, solids (SS+TDS), turbidity, color, density inorganic nonmetallic constituents, pH, alkalinity, Phosphorus, sulfur, gases, metallic constituents, Fe, Cd, Cr, Cu, Pb, … organic constituents, BOD, COD and SCOD, TOC & DTOC, UV, interrelationships between BOD, COD and TOC, oil, grease, surfactants and VOC. Instrumental: FTIR, GS, HPLS, X-ray.

M.Sc. Program in Chemical Engineering

OIL AND GAS REFINARY ENGINEERING

M.Sc. Program in Chemical Engineering
OIL AND GAS REFINARY ENGINEERING

First Term			
Code	**Subject**	**Hours/week**	**Units**
ChE-R-MS-0101	Fluid Flow	2	2
ChE-R-MS-0102	Mathematical Modeling and Numerical Analysis	3	3
ChE-R-MS-0012	Heterogeneous Reactors	2	2
ChE-R-MS-0011	Petroleum Refining Engineering	2	2
ChE-R-MS-xxxx	Elective I	2	2
ChE-R-MS-1001	English Language (I)	1	1
Total		14	12

Second Term			
Code	**Subject**	**Hours/week**	**Units**
ChE-R-MS-0104	Heat Transfer	2	2
ChE-R-MS-0105	Thermodynamics	2	2
ChE-R-MS-0106	Mass Transfer	2	2
ChE-R-MS-0012	Gas Technology	2	2
ChE-R-MS-xxxx	Elective II	2	2
ChE-R-MS-1001	English Language (II)	1	1
ChE-R-MS-1002	Plagiarism	1	Pass
Total		12	11

Total Theoretical Units	**23**
Dissertation Units	**12**
Grand Total /Units	**35**

Electives			
Code	**Subject**	**Code**	**Subject**
ChE-R-MS-0103	Process Control	ChE-R-MS-0109	Corrosion Engineering in Oil Equipment
ChE-R-MS-0013	Petrochemical Complexes	ChE-R-MS-0015	Pollution from Petroleum Industries
ChE-R-MS-0014	Energy Conservation		Instr. Tech. & Chem. Analysis Lab.

DESCRIPTION AND BREAKDOWN OF SUBJECTS
M.Sc. COURSE/ OIL AND GAS REFINARY ENGINEEERING

ChE-R-MS-0101 - Fluid Flow

Newtonian law Viscosity and non- Newtonian models viscosity and mechanisms of momentum transport; Shell momentum balances and viscosity distributions in laminar flow: The equation of change for isothermal systems; Viscosity distributions with more than one independent variable: Velocity in turbulent flow: Interphase transport in isothermal systems; Two-Phase Flow.

ChE-R-MS-0102 - Mathematical Modeling and Numerical Analysis

Mathematical modeling

Mathematical models of mass transfer equipments, Batch and Continuous Distillation Columns, Reactive Distillation Column, Packed absorption Column with chemical reaction, Nano-membrane. Mathematical models of reactors, Batch, Continuous-Stirred Tank, Plug-flow, Fluid catalytic cracking unit (FCC) , Heat exchangers. Simultaneous heat and mass transfer models.

Numerical Analysis

Solutions of nonlinear algebraic equations; Solution of simultaneous equations by matrix methods; Curve fitting, Interpolating and extrapolating

technique; Solution of ordinary differential equations; Solution of partial differential equations.

Numerical Analysis Laboratory

The laboratory work includes computer solutions of different chemical processes using numerical analysis techniques.

ChE-R-MS-0012- Heterogeneous Reactors

Fluid-phase reactions catalyzed by solids: Physical properties of porous solids: Specific surface area, density, porosity, micro- and macro-pores, average pore radius, tortuosity, diffusion (Bulk, Kundson, and effective). External transport processes in heterogeneous reactions (mass and heat-transfer coefficients (fluid-particle) in packed bed), quantitative treatment of external transport effects, Internal transport process (reaction and diffusion in porous catalyst, intrapellet mass and heat transfer, mass and heat transfer with reaction). **Fluidized-bed reactor**: Fluidization regimes, minimum fluidization velocity, terminal velocity, one-phase and two-phase models. **Non-Ideal Flow Reactors**: Characteristics of nonideal flow: Macromixing and micromixing, Earliness of mixing, residence time distribution (RTD). Non-ideal flow reactors: Reactors with axial dispersion, Tanks-in-Series, segregated flow reactor, Performance of reactors with non-ideal flow.

ChE-R-MS-0011- Petroleum Refinery Engineering

An introduction to crude oil and its processing. Products and a refinery configuration. The atmospheric and vacuum crude distillation units. The distillation of the ‘Light Ends’ from crude oil. Catalytic reforming. Fluid catalytic cracking. Distillate hydrocracking. Hydrotreating. Gasoline components: Motor fuel alkylation, Isomerization technologies.

ChE-R-MS-0104 - Heat Transfer

Hydrodynamic and thermal boundary layers. Analysis of heat transfer in laminar tube flow. Unsteady state heat transfer. Temperature profile in turbulent flow. Design of tubular furnace. Air cooler design.

ChE-R-MS-1001- English Language

English Language (I)

- Synonyms (Meanings)
- Confusion Words
- Parts of Speech
- Verb Tenses
- Passive Voice

English Language (II)

- Conditional sentences
- Relative Pronouns & Clauses
- Finite and Non-Finite Verbs
- Kinds of Subordinate Clauses
- Kinds of Sentences: the simple sentence, the Compound sentence, and the complex sentence.

ChE-R-MS-0106 - Mass Transfer

Fundamentals of mass transport. Concentration distribution in solid and in laminar flow. The equation of change and their uses for multi-component systems. Mass transport with more than one independent variables. Interphase mass transport. Macroscopic balances for multicomponent system.

ChE-R-MS-0012- Gas Technology

Overview of natural gas industry. Natural gas liquid separation. Condensate stabilization. Natural gas sweetening. Acid gases removal. Natural gas dehydration. Water removal. Natural gas liquids recovery. Gas to liquids technology.

ChE-R-MS-0105 - Thermodynamics

Basic Concepts and Definitions: Basic thermodynamic terminology, Types of energy and thermodynamic properties, Fundamental equation of thermodynamics, Thermodynamics laws. Thermodynamics of Flow Process: Fundamental equations, Flow in pipes, Expansion processes (Nozzles and Turbines), Throttling processes (Joule-Thomson coefficient), Compression processes (Compressors and Pumps). Vapor-Liquid Equilibria – Ideal Behavior: Fundamentals of phase equilibrium (Duhem's theorem), Property change of mixing (Gibbs theorem), Vapor pressure (Antoine equation and Cox chart), Raults law (Dew and Bubble point calculation), Vapor-liquid diagrams of binary mixtures, Flash calculation. Vapor-Liquid Equilibria – Nonideal Behavior: Nomographs and charts of K-values, Polynomial equations of K-values, Tabulated K-values at different reduced conditions, Prediction of thermodynamic properties of fluids-nonideal behavior, Theorem of corresponding states and reduced conditions, Residual properties, Departure charts and tables of thermodynamic properties, Computational path for property changes.Properties of Mixtures-Nonideal Behavior: Partial property and nonideal solution, Fugacity and fugacity coefficients of mixture components (Lewis-Randall rule), Activity and activity coefficient, Excess Gibbs free energy, Activity coefficients from VLE data.

ChE-R-MS-1002 - Plagiarism

Essay writing process, Research paper abstract writing, Emphasizing Generalizing, Paraphrasing, Quoting, Text referencing, Unnecessary words, - Redundant words that can be omitted, Unnecessary Phrases.

ELECTIVES
OIL AND GAS REFINARY ENGINEERING

ChE-R-MS-0103 - Process Control

Analysis and design of feedback control system. Analysis and design of advanced control systems (feedforward control, adaptive control, cascade control, inferential control, Fuzzy-logic control, and neural control). Design of control system for multi control of complete variable process plant. Process control using digital computers. Interaction effect on the closed loop.

ChE-R-MS-0013- Petrochemical Complexes

Introduction. Production of low olefins ethylene. Type of crackers, quenchers, scrubbers. Production of ethylene from liquid feed stocks. Comparison of equipment used in case of naphtha feed stock or gasoil or crude oil. Hydropyrolysis, mill second furnace, cracking by steam and molten salt. Production of diolefins. BD production by dehydrogenation process and others. Isoprene. Synthesis Gas: Comparison between steam reforming and partial oxidation of production of H2. Chemical derived from Synthesis Gas. Chemical derived from ethylene. Ethanol chemical derived from propylene acrylonitrile. BTX: production of Benzene, Benzoic acid, LBA. Polymers: introduction, classification molecular weight determination. Polymerization systems. Thermoplastic: LDPE, HDPE, PP, PVC, PS.

ChE-R-MS-0014 - Energy Conservation

Different energy sources. Present and future shares of the various energy kinds. Technical ways of converting available energy into work. Various field of energy saving in insulating buildings, pipes, tanks, and equipment. Increasing efficiency of the different heat units especially furnaces, air coolers, and shell and tubes heat exchangers. The various techniques of enhancing heat transfer coefficients. Drag reduction and optimum velocity in pumping of fluids. Energy conservation in various unit operations. Energy conservation in power generation plants. Direct and indirect conservation of heat into work. Cogeneration of power. Higher efficiency for power cycles.

ChE-R-MS-0109 - Corrosion Engineering in Oil Equipment

Introduction to Corrosion: Definitions, why metal corrode?, corrosive environment, consequences of corrosion. Basic Concepts in Corrosion: Definition of anode and cathode, anodic reactions characteristics, cathodic reactions characteristics. Types of corrosion cells. Classification of corrosion. Forms of corrosion. Thermodynamics: Concept of free energy. Reversible electrode potential, Nernest equation. Application of free energy of corrosion cell. Kinetics of aqueous corrosion: Faraday's law. Polarization, activation polarization, concentration polarization, combined polarization. Measurement of corrosion: Immersion test. Electrochemical technique. Tafel extrapolation, linear polarization. Passivity, definition of important electrochemical parameters for active-passive metals. References electrodes. Pourbaix diagrams. Corrosion prevention, cathodic protection.

ChE-R-MS-0015- Pollution from Petroleum Industries

Introduction, Terminology and (Laws and Regulations, Legalization) Water pollution in oil industry and oily waste-water treatment methods (Floatation process and other treatment methods); Air pollution in refineries; Ventilation equipment design in refineries, Oil wastes and methods of treatment, Oil disasters. Treatment by adsorption processes.

Instrumental Techniques and Chemical Analysis for Environmental Pollution Monitoring

Measurement of: physical characteristics, solids (SS+TDS), turbidity, color, density inorganic nonmetallic constituents, pH, alkalinity, Phosphorus, sulfur, gases, metallic constituents, Fe, Cd, Cr, Cu, Pb, … organic constituents, BOD, COD and SCOD, TOC & DTOC, UV, interrelationships between BOD, COD and TOC, oil, grease, surfactants and VOC. Instrumental: FTIR, GS, HPLS, X-ray.

PhD Program in Chemical Engineering

PhD Program in Chemical Engineering

First Term			
Code	**Subject**	**Hours/week**	**Units**
ChE-PhD-0101	Advanced Fluid Flow	3	3
ChE-PhD-0102	Non-linear Mathematics	2	2
ChE-PhD-0105	Advanced Chemical Engineering Thermodynamics	2	2
ChE-PhD-xxxx	Elective I	2	2
ChE-PhD-1001	Technical English I	1	1
Total		10	10

Second Term			
Code	**Subject**	**Hours/week**	**Units**
ChE-PhD-0103	Advanced Reactor Engineering	3	3
ChE-PhD-0104	Advanced Heat Transfer	2	2
ChE-PhD-0106	Advanced Mass Transfer	2	2
ChE-PhD-xxxx	Elective II	2	2
ChE-PhD-1001	Technical English II	1	1
ChE-PhD-1002	Plagiarism	1	Pass
Total		10	10

Total Theoretical Units	**20**
Thesis Units	**40**
Grand Total /Units	**60**

Electives			
Code	**Subject**	**Code**	**Subject**
ChE-PhD-0115	**Advanced Environmental Engineering**	ChE-PhD-0114	**Energy Conservation**
ChE-PhD-0111	**Advanced Petroleum Refining Engineering**	ChE-PhD-0107	**Interfacial Phenomena**
ChE-PhD-0110	**Advanced Biochemical Engineering**	ChE-PhD-0108	**Advanced Composite Materials Engineering**
ChE-PhD-0112	**Particles Technology**	ChE-PhD-0116	**Advanced Optimization**

DESCRIPTION AND BREAKDOWN OF SUBJECTS
Ph.D. COURSE CHEMICAL PROCESS

ChE-PhD-0101 – Advanced Fluid Flow

Fundamental of Momentum Eqn. for Newtonian and non-Newtonian flow. The Stream function, Potential and Irrotational, Rotational flow, and Computational fluid dynamics. Dimensional analysis and Similarity. The Boundary layer Equations. Velocity distribution in Turbulent flow. Non-Newtonian fluids. Two-Phase flow and Modeling.

ChE-PhD-0102 – Non-linear Mathematics

Types of non-linear Differential Equations, solution of N.L.DE direct methods, linearization technique, graphical methods (Phase plane, Isocline, Lineard and Delta), asymptotic methods (Poincare, Lindstedt, Krylov and Bogoliubov). Stability Analysis of N.L system (Liapunovs' method) . Large non-linearities, periodic processing.

ChE-PhD-0105 – Advanced Chemical Engineering Thermodynamics

Introduction to Thermodynamics and statistical mechanics, Internal energy, First law of thermodynamics. Concept of entropy, Second law of

thermodynamics : Extremum principles of Energy and Entropy. Legendre transforms of energy and reformulation of second law in terms of the Legendre transforms, Maxwell relations, Maximum work theorem.

Conditions of phase equilibrium and Its applications, Gibbs Duhem relations, Gibbs phase rule, Cojugate variables, Criteria for stability and its implications.

Chemical reactions: condition of equilibrium for a reaction mixture, Equilibrium constants, Heat of reaction. Thermodynamics of fluid-fluid interfaces: Dividing surface, surface excess quantities, condition of equilibrium at interfaces, Kelvin equation, Gibbs adsorption isotherm,Thermodynamics of fluid-solid interfaces : condition of equilibrium with respect to dissolution and growth of solids. Classical mechanics: Lagrangian formulation, Constants of motion, Hamilton's principle, phase space, concept of statistical ensemble, Statistical independence of macroscopic bodies, Liouville equation, Measurements and ensemble averages. Microcanonical, canonical and Grand-canonical ensembles. Gibbs entropy formula and Boltzmann entropy formula, Partition functions, Fluctuations and stability. Ideal gas : Analytical derivations of the partition functions of ideal gas in various ensembles and thermodynamic properties, Ideal solid : Analytical derivation of partition function, heat capacity, Non-ideal gases, Virial equation of state, Second virial coefficient. Liquids : Distribution functions, pair correlation function g(r) and experimental measurement of g(r) by diffraction, Meanfield theory and perturbation theory. Dilute solutions and colligative properties: Derivation of Raoults law, Henry's law, Van't Hoff 's formula for osmotic pressure. Boiling point elevation, freezing point depression. Introductory Quantum Statistical mechanics : Schrödinger Wave equation, Degeneracy, Partition functions. Ideal gas of polyatomic particles, Molecular partition functions, Einstein and Debye theory of perfect crystals.

ChE-PhD-1001 – Technical English

Technical English (I)

- Introduction about Sentence Structure
- Parts of speech
- Precise words and simple words
- Sentences and Fragments
- Mid Term Exam
- Misused words and Redundant Words
- Types of sentences
- Tenses
- Unnecessary words and Phrases

Technical English (II)

- Ed and - ing Adjectives
- Writing a Research Paper Abstract
- The English We Speak
- Language Functions
- Grammar Points
- Mid Term Exam
- Essay Writing
- Scientific Communication
- Writing a Proposal Abstract
- Words in the News

ChE-PhD-0103 – Advanced Reactor Engineering

Mixing effects (segregation and micromixing) on reactor performance, analysis of reactor stability, 1- and 2- D models for packed bed reactors, heterogeneous non-catalytic reactions, heat and mass transfer effects in porous catalyst particles, reduction of data for catalytic reactions and scale-up concepts. Examples from packed, fluidized bed and transport reactors, polymer reactors and 3-phase reactors, will used.

ChE-PhD-0104 – Advanced Heat Transfer

- **Heat transfer in gas -liquid phase:**

Heat transfer in pool boiling, Heat transfer in flow boiling, Boiling correlations,

Condensation heat transfer, Laminar flow condensation, Turbulent film condensation, Drop wise condensation

- **Heat transfer to non-Newtonian fluids:**

Review of non-Newtonian fluid flow, Heat transfer to power-low fluids in laminar flow, Isothermal tube wall, Constant heat flux at tube wall, Heat transfer in transitional and turbulent flow

- **Heat transfer in fluidized beds:**

Heat transfer in gas-solid fluidized bed, -Heat transfer in liquid-solid fluidized bed

- **Unsteady state heat transfer in three dimensions:**

Transient heat conduction in solids with finite conduction and convective resistance, Transient heat conduction in semi-infinite, Multi dimensional unsteady state system.

ChE-PhD-0106 –Advanced Mass Transfer

Mass transfer across selectively permeable membranes. Mass transfer in turbulent region. Diffusion in a plan sheet, cylinder and sphere. Diffusion in heterogeneous media. Moving boundaries. Diffusion and chemical reaction.

ChE-PhD-0106 –Advanced Environmental Engineering

Gas Cleaning: Basic data requirements, Classification of sampling, Collection and analysis of a major, minor gases constituents. Isokinetic sampling and probes for solid and liquid particles. Classification of size analysis methods. Monitoring atmosphere pollution. Settling Chambers. Inertial Devices. Centrifugal Collectors. Particulate Scrubbers.

ChE-PhD-0112 – Particles Technology

Particle Characterizations. Particulate solids in bulk. Blending of solid particles. Classification theory, and Classifier Performance. Motion

of particles in a Fluid. Flow of Fluids through granular beds and Packed columns. Fluidization and analysis of different phases: Gross behavior of fluidized beds. Bubble in dense beds. The emulsion phase in dense bubbling beds. Flow Pattern of gases through fluidized beds.

ChE-PhD-0107 – Interfacial Phenomena

Introduction. Surface tension and kinetics of surface molecules. Effect of curvature on physical properties, General Kelvin equation. Surface energy and entropy, and molecular theories. Interfacial tension and entropy. Cohesion and adhesion, Spreading of one liquid on another. Spreading from solids. Relations between surface and interfacial tensions, Gibbs' treatment, Antonoff 's relationship. Oil drops on water, Theory of contact angles, Magnitudes of contact angles of liquids on solids. Spreading coefficients, Adhesion of liquids to solids, De-wetting by surface active agents, Contact between two liquids and a solid. Measurements of surface and interfacial tensions. Measurements of contact angles and spreading coefficients. Distribution potentials, Diffusion potentials, Interfacial and surface potentials, Components of surface potential due to an electrically neutral monolayer, Gouy theory. Disperse phase systems: Colloids, Emulsions, Foams, Surface and Interfacial Processes: Crystallization, Froth flotation, Detergency.

ChE-PhD-0108 – Advanced Composite Materials Engineering

Introduction: Types and constituents, reinforcement and matrices, interface and mechanism of strengthening. Metal Matrix Composites: Processing: Liquid state processes, solid state processes and in situ processes. Interface: Role, reactions, bonding mechanisms and bond strength. Properties and applications: Strength, stiffness, creep, fatigue and

fracture; thermal, damping and tribological properties. Polymer Matrix Composites Processing: Hand lay up and spray technique, filament winding pultrusion, resin transfer moulding, bag and injection moulding, sheet moulding compound . Properties: Mechanical, damping, environmental effect and fracture. Ceramic Matrix Composites Processing: Cold pressing & sintering, hot pressing reaction bonding processes, infiltration, in-situ chemical reaction, Sol-Gel and polymer pyrolysis, self-propagating high temperature synthesis. Carbon- carbon composites, Interfaces Properties and applications: Strength, toughness and thermal shock resistance. Nanocomposite materials. Application of advanced composite materials in Biomedical and/ Aerospace applications.

ChE-PhD-0116 –Advanced Optimization

An introduction to modern optimization having application in engineering economics, data analysis process design and dynamics, methods such as Fibonacci, PSO, Harmonic, and mathematical and dynamical programming.

ChE-PhD-0114 – Energy Conservation

- **Introduction to Energy Technology:**

Terms and definitions; Review of energy reserve, production and consumption trends in Iraq and the world. Use of energy and its impact on the environment; A survey of energy sources and technologies such as solar, wind, fossil fuels, and nuclear energy; Other energy source technologies as appropriate (such as wave, tidal, geothermal, biomass, hydro, and ocean thermal energy, etc.).

- **Energy and Environment:**

This section provides students with exposure to a wide range of current energy and energy-related environmental policies that foster the

development and mass deployment of sustainable energy technologies (e.g. energy efficiency, renewable energy, and other lower-carbon technologies), fuels, and practices. The primary focus will be on environmental disasters due energy consumption, and the conventions and protocols related to energy and environment.

- **Energy Conservation and Management:**

Energy management; energy audit; material and energy balance; Energy Monitoring and Targeting; Global Environmental Concerns; thermal energy management; Energy Efficiency on Boilers; Energy Efficiency on Steam System; Energy Efficiency on Insulation and Refractory; FBC Boilers; Waste Heat Recovery; Electric Motors; Compressed Air System; HVAC and Refrigeration System; Fans and Blowers; Pumps and Pumping System; Energy carriers including hydrogen and bio-fuels as appropriate; Energy storage technologies as appropriate.

- **Modeling and Simulation in Energy Technology:**

This section focused on the basics of modeling with emphasis of process and process modeling; Simulation and Optimization of Thermal Systems; Energy as a measure of the quality of energy, and exergy destruction as an indicator for environmental impact; energy analysis; role of modeling in energy transfer; statistical models

- **Energy Economics and Policies:**

Energy policy considerations and design of future sustainable energy systems; Strategic Energy Planning; Financing of Renewable Energy Systems; Demand Side Management of Energy

ChE-PhD-0111 –Advanced Petroleum Refining Engineering

Petroleum refining overview; Crude oil pretreatment: Desalting, heating, crude distillation (atmospheric and vacuum distillation) ; Recent

developments in Conversion Processes: Hydrocracking , Fluid catalytic cracking, Delayed coking , Fluid coking, Visbreaking, Solvent deasphalting, Resid hydrocracking; Recent advances in Upgrading Processes: Hydrotreating, Catalytic reforming, Isomerization , Alkylation; Supporting Processes: Acid gas removal, Sulfur recovery, Hydrogen production, Product blending; Recent developments in heavy oil processing.

ChE-PhD-0106 –Advanced Biochemical Engineering

Basics of Biology, overview of Biotechnology, Diversity in Microbial cells, Chemicals for Life; Kinetic of Enzyme Catalysis; Immobilized Enzymes: effects of intra and inter- phase mass transfer on enzyme kinetics; Major metabolic pathways : Bioenergetics, Glucose metabolism, Biosynthesis; Microbial Growth: Continuum and Stochastic Models; Design, Analysis and Stability of Bioreactors; Kinetic of Receptor- Ligand Binding; Bio- Product Recovery & Bio – separation, Manufacture of Biochemical Products.

ChE-PhD-1002 – Plagiarism

Essay writing process, Research paper abstract writing, Emphasizing Generalizing, Paraphrasing, Quoting, Text referencing, Unnecessary words, - Redundant words that can be omitted, Unnecessary Phrases.