CURRICULUM

Bachelor of Chemical Engineering

School of Chemical and Material Engineering (SCME)

National University of Sciences and Technology (NUST), Islamabad, Pakistan

2022

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BE Chemical

INTRODUCTION

BE. Chemical was launched in fall 2008 by School of Chemical & Material Engineering (SCME). The chemical engineering curriculum is designed so that its graduates are familiar with the techniques used in analyzing and solving engineering problems associated with the chemical and related industries (petroleum refining, pharmaceutical, metallurgical, polymer, bio-engineering, energy sector etc.).

The chemical engineering curriculum is so designed that it not only includes the core chemical engineering courses but also courses from basic sciences (mathematics, chemistry, physics), communication skills, Islamic and Pakistan studies, so that the graduate will not only have professional skills but also have a knowledge and understanding of basic principles, ethical considerations and leadership qualities.

Courses in chemical engineering fundamentals (material and energy balances) are introduced, followed by intensive work in engineering science and analysis (heat, mass, and momentum transfer; chemical thermodynamics; chemical reaction engineering; continuous and stage-wise separation processes; process dynamics and control). Computer solutions and simulation topics are stressed. An understanding of the ethical, and social issues, economic, and safety considerations in engineering practice is stressed throughout the curriculum. The appreciation of these professional concepts has been incorporated as a part of chemical engineering course work.

The curricula have been revised in 2018 to meet current requirement of industrial sector and society. According to current and forthcoming needs of industry & society new subjects have been included. Moreover contents of some subjects have been revised and there has been relocation of some subjects. All these changes will be helpful to produce required attributes in graduate engineers of current era and forthcoming needs.

MISSION

The goal of the Department of Chemical Engineering is to educate men and women who, as graduates of this program, are able to analyze industrial chemical engineering problems and synthesize solutions to those problems. The department provides the platform enabling graduates to routinely demonstrate appropriate and effective communication skill, design and conduct experiments, as well as analyze and interpret data, show initiative, curiosity and ability to work both independently and in teams, use computer tools necessary for engineering practice, accept responsibility for sustainable use of resources, and understand societal needs, and demonstrate professional attitudes and behaviors.

OBJECTIVES

This curriculum is designed to impart knowledge, skills and training in order to prepare graduates to have:

- Knowledge of fundamentals in chemistry, mathematics, and physics.
- Command of chemical engineering fundamentals including mass and energy balances, chemical thermodynamics, fluid flow, mass and energy transport, chemical kinetics and process dynamics.
- Understanding of the principles of chemical engineering design and their application for sustainable development.
- Ability to understand, analyzes, and solves problems of chemical and allied industries by modern techniques, engineering tools, research and innovation.
- Understanding of safety principles and practices in process industries.
- Knowledge of contemporary issues and ability to work in multi-disciplinary teams.
- Leadership skills to serve on managerial positions within chemical and associated industries with professional and ethical responsibilities.
- Understanding of life cycle environmental impacts of chemical and allied industries and their mitigation measures.
- Effective communication of technical knowledge, skills and training.
- Motivation to maintain and raise their level of engineering competence and achievement by engaging in lifelong learning.
- Understanding of professional and ethical responsibility of engineering practice.

ELIGIBILITY CRITERIA FOR CHEMICAL ENGINEERING

- F.Sc. (Pre-engineering) from any Board of Intermediate and Secondary Education or an equivalent qualification like Overseas High School Certificate / British General Certificate of Education (Advanced Level) / International Baccalaureate / Advanced Placement with Physics, Chemistry and Mathematics. All non-F.Sc. stream candidates are required to obtain equivalence certificates from IBCC in order to apply for the program.
- Candidates from F.Sc. stream can apply for NUST Entry Test on the basis of F.Sc Part-I but confirmation of their admission are subject to provision of HSSC certificate or Detailed Marks Certificate (with minimum 60% aggregate marks) before the commencement of relevant program of study.
- Candidates of O/A Level stream can apply on the basis of O level equivalence certificates duly obtained from Inter Board Committee of Chairmen (IBCC) office but confirmation of their admission is subject to provision of A Level equivalence certificate (Pre-engineering with minimum 60% Marks).

ASSESSMENT METHODOLOGY

Nature of Examination	Duration	Frequency	Weightage (%)
End semester examination	2- 3 hours	1	40-50
One Hour Test(s)*/ Mid Term	1-2 hour	• 1 CH Course – minimum 1 OHT • 2-4 CHs Courses – minimum 2 OHTs	30-40
Quizzes	-	• 1 CH Course – minimum 2 • 2 CHs and above Courses – minimum 3	10-15
Assignments	Own time	-	5-10
Project(s)	Own time	-	10-20
Lab Work /Projects	3 contact hours	1 per week for each lab CH	70-80

* Mid Semester Examination will be held in lieu of OHTs during Summer Semester.

GRADING SCHEME

Letter Grade	Grade Points
A	4.00
B+	3.5
B	3.00
C+	2.5
C	2.00
D+	1.50
D	1.00
F	0.00
I	Incomplete
W	Dropped

Faculty at Chemical Engineering Department, SCME, NUST

Name of faculty members	Designation	Qualification	Specialization
Dr Erum Pervaiz	Associate Professor/ HoD	PhD 2013, NUST	Reaction Engg /Catalysis/Thermodynamics
Dr. Asad Ullah Khan	Professor	PhD, Imperial College London	Rheology
Lt Col (R) Nadeem Ehsan	AP	M.Sc. Ordnance Engg. 1996.	Ballistics & Dynamics Systems
Dr. Muhammad Bilal Khan Niazi	Associate Professor	PhD Chemical Engg. 2013, University of Groningen, Netherlands	Product Technology
Dr Iftikhar Ahmad	Associate Professor	PhD 2014, Kyoto University	Process Systems Engineering
Dr Salman Raza Naqvi	Associate Professor	PhD 2015, UTP Malaysia	Gasification
Dr. Tayyaba Noor	Associate Professor	PhD 2013, NTNU Norway	Nanocatalysis
Dr. Sarah Farrukh	Associate Professor	PhD 2016, NUST	Membrane synthesis
Dr. Nouman Aslam Khan	AP	PhD 2018, Comsats Abbottabad	Numerical Maths
Dr. Zaib Jahan	AP	PhD 2018, NTNU, Norway	Membrane Technology
Dr. Taqi Mehran	AP	PhD 2017, UST, Korea	Advanced Energy Technology
Dr. Umair Sikandar	AP	PhD 2018, UTP.	Reaction Engg.

Dr. Syed Rafay Hussain Jafri	AP	PhD 2019, University of Technology, Malaysia.	Petroleum Engg.
Dr. Ayesha Raza	Lec.	MS 2016 NUST	Membrane Processes

Course framework

BE Chemical

Non Engineering Domain

Knowledge Area/Domain	Subject Area	Name of Course	Lec. CH	Lab CH	CHs
Humanities	English	English	2	0	2
		Communication Skills	2	0	2
		Technical & Business writing	2	0	2
	Culture	Pakistan Studies	2	0	2
		Islamic Studies	2	0	2
	Social Sciences	Elective III	3	0	3
Management Sciences		Engineering Economics	2	0	2
		Entrepreneurship	2	0	2
		Production & Operations Management	3	0	3
Natural Sciences	Physics	Applied Physics	2	1	3
	Mathematics	Calculus & Analytical Geometry	3	0	3
		Linear Algebra & ODEs	3	0	3
		Vector Calculus	3	0	3
		Numerical Methods	3	0	3
	Chemistry	Inorganic & Analytical Chemistry	3	1	4
		Organic & Biochemistry	3	1	4
			Total		**43**

Engineering Domain

Knowledge Area/Domain	Subject Area	Name of Course	Lec. CH	Lab CH	CHs
Computing	Fundamentals	Fundamentals of ICT	2	1	3
	Programming	Computer Programming	2	1	3
	Computer application in Chemical engineering Design	Chemical Process Design & Simulation	2	1	3
Engineering Foundation		Chemical Engineering Thermodynamics-I	3	0	3
		Chemical Process Technology	3	1	4
		Particulate Technology	3	1	4
		Mass Transfer	2	0	2
		Heat Transfer	3	1	4
		Chemical Process Principles	3	0	3
Major Based Core (Breadth)		Chemical Engineering Thermodynamics-II	3	1	4
		Fluid Mechanics	3	1	4
		Chemical Reaction Engineering	3	1	4
		Transport Phenomena	3	0	3
		Instrumentation & process control	3	1	4
		Simultaneous heat and mass transfer	6	2	8
		Fuel &Combustion	3	1	4
		Chemical Engineering Plant Design	3	0	3
		Advance Chemical Process Principles	3	0	3
		Chemical Process Safety	3	0	3
Major Based Core (Depth)		Elective-I	3	0	3
		Elective-II	3	0	3
Inter-Disciplinary Engineering Breadth		Workshop Practices	0	2	2
		Engineering Drawing & Graphics	1	1	2
		Fundamentals of engineering Materials	3	0	3
		Electrical Engineering	2	1	3
Industrial Training		4-6 weeks industrial training mandatory (non-Credit)			
Senior Design Project		Design Project- Part I (Final Year Project)	0	3	3
		Design Project- Part II (Final Year Project)	0	3	3
			Total		**91**

Scheme of Studies

Semester wise course distribution

No.	Course Title	Credit Hours	
Semester 1		**Theory**	**Labs**
HU-107	Pakistan Studies	2	0
PHY-102	Applied Physics	2	1
CHE-101	Chemical Process Principles-I	3	0
CS-100	Fundamentals of ICT	2	1
ME-105	Workshop Practice	0	1
MATH-101	Calculus and Analytical Geometry	3	0
HU-100	English	2	0
		Total:17	
Semester 2			
CS-114	Fundamentals of Programming	2	1
CH-102	Inorganic & Analytical Chemistry	3	1
HU-101	Islamic Studies	2	0
ME-109	Engineering Drawing	0	2
MATH-121	Linear Algebra and ODEs	3	0
HU-109	Communication Skills	2	0
		Total:16	
Semester 3			
CH-202	Organic & Biochemistry	3	1
CHE-221	Fluid Mechanics-I	3	0
CHE-231	Chemical Engineering Thermodynamics-I	3	0
CHE-202	Chemical Process Principles-II	3	0
MATH-243	Vector Calculus	3	0
MSE-101	Fundamentals of Engineering Materials	3	0
		Total:19	
Semester 4			
CHE-211	Chemical Process Technology	3	0
CHE-241	Mass Transfer	2	0
CHE-242	Heat Transfer	3	1
EE-103	Electrical Engineering	2	1
HU-212	Technical & Business writing	2	0
CHE-224	Fluid Mechanics –II	2	1
		Total:17	

Semester 5			
CHE-346	Particulate Technology	3	1
CHE-343	Simultaneous Heat & Mass Transfer-I	3	1
MATH-351	Numerical Methods	3	0
CHE-332	Chemical Engineering Thermodynamics-II	3	1
MGT-271	Entrepreneurship	2	0
		Total:17	
Semester 6			
CHE-348	Simultaneous Heat & Mass Transfer-II	3	1
CHE-323	Instrumentation & Process Control	3	1
CHE-347	Chemical Reaction Engineering	3	1
CHE-345	Transport Phenomena	3	0
ECO-130	Engineering Economics	2	0
		Total:17	
	Industrial Training (Non Credit)		
Semester 7			
CHE-422	Fuels & Combustion	3	1
CHE-451	Chemical Engineering Plant Design	3	0
CHE-499	Final Year Project	0	3
XXX-XXX	Elective – I	3	0
CHE-452	Chemical Process Design and Simulation	2	1
		Total:16	
Semester 8			
CHE-425	Maintenance & Process Safety	3	0
CHE-499	Final Year Project	0	3
OTM-456	Production & Operations Management	3	0
XXX-XXX	Elective-II	3	0
XX-XXX	Elective – III	3	0
		Total:15	
		Grand Total: 134	

Electives

No.	Course Title	Credit Hours	
CHE-340	Biochemistry	3	0
CHE-350	Petroleum Refinery Process	3	0
CHE-360	Fundamentals of Polymer Engineering	3	0
ENE-306	Fundamentals of Environmental Engineering	3	0
CHE-442	Membrane Technology	3	0
CHE-441	Fermentation Technology	3	0
OTM-454	Project Management	3	0
CHE-461	Polymer Reaction Engineering	3	0
CHE-491	Sustainability in Processes & Energy Systems	3	0
CHE-484	Natural Gas Engineering	3	0
MCG-126	Basic Concepts in Social Science	3	0
HU-115	Principles of Sociology	3	0
MCG-235	Logic and Critical Thinking	3	0

Semester-wise courses description

BE Chemical

Semester-1

HU-107: Pakistan Studies

Credit Hours: 2-0

Pre-requisite: None

Course Objectives: To emphasize on objective learning and analyze the contemporary problems faced by the nation

Course Contents:

Historical Perspective

- Ideological rationale with special reference to Sir Syed Ahmed Khan and Allama Iqbal
- Quaid-i-Azam: An Architect of Pakistan
- Factors leading to Muslims separatism

People and Land

- Location and geo-strategic importance
- Social Structure and cultural strengths & weaknesses
- Government and Politics in Pakistan
- From 1947 to date
- Foundation of foreign policy and foreign relations of Pakistan

Foreign policy statement

- Difference in foreign policy and foreign relations
- Relations of Pakistan with India, America & China
- Economic Development in Pakistan
- The structure & profile of Pakistani Economy & potential for its growth

Threats to National ProgressInternal Dynamics & Security

- The ethnic, linguistic and sectarian make up of Pakistan
- The potential for internal conflict and integration
- The relationship between internal conflict and external relations

Economy of Pakistan

- The key resources like water, energy, mineral resources
- The industrial and agricultural potential and their share in our economy

Social threats to Pakistan

- Moral & Ethical Crisis
- The magnitude and dimensions of corruption and its impact on security
- Religion an instrument of destabilization

Strength / Futuristic Outlook of Pakistan

Canal system and water reservoirs, Power potentials of Pakistan

- Canal system in 1947 and Indus Basin Treaty
- Need to develop water reservoirs and expand canal system
- Power generation potentials (Hydro Power)
- Glacier melting and floods

Human resource

- Demographic profile of Pakistan
- Skill development and directed educational effort

Course Outcomes: After successful completion of this course, a student should be able to understand the global politics and its influence on Pakistan and global economics and role of Pakistan

Recommended Books:

- Burki, Shahid Javed. State & Society in Pakistan, The Macmillan Press Ltd 1980.
- Akbar, S. Zaidi. Issue in Pakistan's Economy. Karachi: Oxford University Press, 2000.
- S.M. Burke and Lawrence Ziring. Pakistan's Foreign policy: A Historical analysis.
- Karachi: Oxford University Press, 1993.
- Mehmood, Safdar. Pakistan Political Roots & Development. Lahore, 1994.
- Amin, Tahir. Ethno - National Movement in Pakistan, Islamabad: Institute of Policy Studies, Islamabad.
- Afzal, M. Rafique. Political Parties in Pakistan, Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
- Sayeed, Khalid Bin. The Political System of Pakistan. Boston: Houghton
- 1967.
- Aziz, K. K. Party, Politics in Pakistan, Islamabad: National Commission on Historical and Cultural Research, 1976.

PHY-102: Applied Physics

Credit Hours: 2-1
Pre-requisites: None

Course Objectives

- To provide an understanding of the principles of physics.
- Core concepts in Newtonian Mechanics: space, time, mass, force, momentum, torque, and angular momentum
- The principles of mechanics

Course Contents

- Conservation Laws involving energy, momentum and angular momentum
- Heat transfer and thermometry
- Principles of Optics
- Linear propagation of light
- Magnification and optical lenses
- Electromagnetic effect
- Laws of electromagnetic induction
- Principal of transformer
- Galvanometer, ammeter, voltmeter, condensers and dielectric properties

Course Outcomes

- After taking this course, student should have knowledge regarding implementation of principles of physics in chemical engineering.

List of Practical

- Introduction to Lab
- Understanding Errors
- Mini-launcher (Exp. 1,2,3)
- Mini-launcher (Exp4,6)
- PA Scar with Mass (Exp. 1,2,3)
- PA Scar with Mass (Exp. 4,6)
- Gas Laws (Exp. 1,2,3)
- Faraday's Law
- Ripple Tank
- Fly Wheel
- DC Electronics

Suggested Books

- Young, Hugh D., and Roger A. Freedman. *University Physics*. *11th ed. with Mastering Physics. Reading, MA: Addison-Wesley, 2004.*

- J.L. Merriam, Santa B. and L.G. Krieg,), “Engineering Mechanics” Vol-1& 2, 5th Edition, Wiley &Sons(2003).
- B.M.Weedy, B. Cory, “Electric Power System”, 4th Edition, Wiley & Sons (1998).
- . Horowitz P, Winfield H, “The art of electronics sound” edition Cambridge University Press (2006).
- Safa O. Kasap, “Principles of electronic materials and devices”, 3rd Edition, McGraw-Hill, (2005).
- W.C. Bolton), “Mechanical Science”, 3rd Edition, Blackwell Publishing, (2005).
- Benson H. Horowitz, A.G. Phadke,), “Dynamics – Engineering Mechanics”, 2nd Edition, Wiley & Sons (2010).

CHE-101: Chemical Process Principles-I

Credit Hours: 3-0
Pre-requisites: None

Course Objectives

- To teach the fundamental aspects of chemical engineering problem solving and provide the foundation for all subsequent engineering courses. It gives the opportunity to analyze and interpret data, to identify, formulate and solve engineering problems, and to use the techniques, skills and modern engineering tools necessary for engineering practice.
- It introduces the common engineering discipline of starting with multifaceted problem and systematically building the blend of information and techniques needed to solve it.
- Dimensions and conversions
- Mass and energy balance diagrams and tables

Course Contents

- Introduction to Chemical engineering: Basic concepts of chemical engineering; Units and dimensions, conversion of units.
- Process variables: Pressure, Temperature, Flow rate, Concentration and composition of mixtures.
- Use of literature to obtain physical, chemical, and thermodynamic properties of substances.
- Stoichiometry, Conversion, yield, and selectivity
- Material balances: Fundamentals of material balances, analysis of material balance problems.
- Material balances for single unit and multiple units, recycle, by-pass, and purge calculations.
- Material balance calculations involving gas laws
- Material balances for reactive systems

Course Outcomes

After completing this course, student will be able to

- Solve unknown variables using fundamental laws, empirical relationships and available data
- Formulate and solve material and energy balances on chemical process systems

- Extract data for pure compounds and mixtures from tables, charts, graphs, or phase diagrams and estimate via theoretical or empirical equations

Recommended Books

- Himmelblau David M. “Basic Principles and Calculations in Chemical Engineering”. 7th Ed. 2003. Prentice Hall PTR.
- Felder Richard M., Rousseau Ronald W. “Elementary Principles of Chemical Processes” 3nd Ed. 2001. John Willey & Sons.
- Reklaitis G.V., Schneider Daniel R. “Introduction to Material and Energy Balances” 1983. John Wiley & Sons.
- Hougen Olaf A., Watson Kenneth M. “Chemical Processes Principles”. 2004, John Wiley and Sons & CBS Publishers.
- Chopy& Hicks, “Handbook of Chemical Engineering Calculations”, 2nd Ed. 1994 McGraw-Hill Professional Publishing.
- Ghasem Nayef. HendaRedhouane, “Principles of Chemical Engineering Processes “, 2009, CRC Press.

CS-100: Fundamentals of ICT

Credit Hours: 2-1
Pre-requisites: None

Course Objectives

- To provide introduction about information and communication technologies for engineering discipline.
- Introduction of different concepts of ICT, computer hardware, software & computer networks

Course Contents

- Basic definitions and concepts of ICT; History, Basics
- Computer Hardware; Processors, Memory, Series Parallel and USB Ports
- Input and Output Devices; Peripheral Devices, Latest Gadgets (iPhone, iPod, PDAs)
- Storage and Data
- Number System; Binary, Octal, Hexadecimal
- Data Processing; How Computer Process Data, Machine Cycle, Factors Affecting Data Processing Speed
- Operating Systems; Types of operating, Managing Hardware, Windows, Linux etc.
- The Internet; world wide Web, Email, Social Networking, Web Blogging, E-commerce, Popular websites (Wikipedia, Skype)
- Computer networks; Common types of networks, Hybrid networks, Networks structure, Network Topologies and Protocols, Network Media, Network Hardware
- Database management; Types of Database, Database creation (Tables and Relations), Manipulation with data
- Software Programming and Development; Programming Languages, Compiler & Interpreter, Algorithm, Flow Chart
- Web Development (HTML)
- Security Issues in IT; Threats, Threats to users, Threats to hardware, Threats to Data, Countermeasures
- Project Presentations

Course Outcomes

After completing this course a student will be able to:

- Understand different terms associated with ICT
- Identify various hardware components of a computer system
- Identify various categories of software and their usage
- Define basic terms associated with computer networks and internet
- Define basic terms associated with communications and networking

- Understand different terms associated with the internet and World Wide Web
- Use various web tools including Web Browsers, Email clients and search utilities
- Use text processing, spreadsheets and presentation tools

Practicals

- Practical exercises relating to the topics covered in theory.

Recommended Books

Text Book

- Introduction to computers, Peter Norton, 6th International edition, McGraw Hill

Reference Books

- Using Information Technology : A practical introduction to computer & communication, 6th Edition, Williams Sawyer, McGraw Hill
- Computers communications & information : A user's introduction, Sarah E. Hutchinson and Stacey C. Sawyer 7th Edition
- Fundamentals of Information Technology, Alexis Leon and Mathews Leon, 2nd Edition

ME-105: Workshop Practice

Credit Hours: 0-1
Pre-requisites: None

Course Objectives

- To provide hands on training of workshop practices.
- Electrical / Mechanical Technology Introduction to electrical technology

Course Contents

- A.C/D.C. motors, their types and control
- Generators
- Transformers
- Single and three phase A.C. circuits
- Power factor
- Introduction to industrial electronics
- Introduction to machines and power transmission systems
- Prime movers; Pulley
- Gears and governors etc.

Course Outcomes

- Use of carpenter's tools
- Exercise in preparing simple joints, Bench fitting practice, exercise in marking and fittings
- Use of measuring instruments e.g. Smith's forge, exercise in bending, upsetting and swaging.
- Familiarizing the students with the following processes, e.g. Soldering and brazing, Welding, Heat treatment, Molding and casting.
- Simple machine shop processes, such as turning, shaping, milling and sheet metal work.

List of Practicals

- Common course offered by SMME and same practical's were performed in this course.

Suggested Books

- Chapman, W., "Workshop Technology: Part 1" 1972, Elsevier Science & Technology.
- Chapman, W., "Workshop Technology: Part 2" 1972, Elsevier Science & Technology.

MATH-101: Calculus and Analytical Geometry

Credit Hours: 3-0
Pre-requisites: None

Course objective

- The course reviews the concepts of basic Calculus; including Limits, continuity, differentiation and integration. A brief account of vectors, three dimensional geometry and complex numbers is also included as pre-calculus review.
- Stress is laid on applications of differentiation and integration to practical problems. Convergence/divergence of the Sequence and series are included towards the end of the syllabus.

Course Contents

- Introductory concepts in analytic geometry
- Limits, Continuity
- Trigonometric functions
- Techniques and applications of differentiation, Applications of the derivative
- The mean value theorem
- The definite and indefinite integral, and applications of integration
- Matrices, Addition and multiplication of matrices
- Rank of matrices
- Determinant of matrices, Hyperbolic and Inverse Hyperbolic functions
- Statistical treatment of data, Probability analysis and distribution including random variables, binomial distribution, passion approximation to binomial distribution, Probability density function, Sampling distribution, Regression analysis

Course Outcomes

- After studying this course, student should have understanding of the concepts of calculus, statistics and analytic geometry with emphasis on applications in Engineering

Recommended Books

- E. W. Swokovski, *Calculus, Brooks Cole Publishing*
- S. M. Yusuf*Calculus and Analytical Geometry*

HU-100: English

Credit Hours: 2-0
Pre-requisites: None

Course Objectives

- To enhance language skills and develop critical thinking.
- Basics of English Language
- Job Interviews and meetings

Course Contents

- The written word
- Telephone skills
- E-Communication
- Body Language
- Job Application & CVs
- Handling Conflict
- Public Speaking
- Audio-visual aids
- Working in global Teams
- Communicating Science & Technology
- Talking to the Media
- Online Communication & Management Skills

Course Outcomes

- After completion of this course, student communication skills should be better and personality should be groomed to represent him in any field

Suggested Books

- John Venables *Communication Skills for Engineers and Scientists.*

Semester 2

CS-114: Fundamentals of Programming

Credit Hours: 2-1
Pre-requisites: CS-100: Fundamentals of ICT

Course Objectives

- To provide knowledge about computer operations and fundamentals of programming.
- Arrays and other data structure concepts
- Data and dimension.
- Format, read, write and print
- Declarations, main program and termination

Course Contents

- Introduction, history and development of languages
- Elements of a language
- Instructions
- Data and addresses
- Syntax and instruction sets
- Mnemonics and arguments
- Variable types
- Names and character sets
- Constants and variables
- Real and integer data types
- Double precision
- Character
- Complex and logical variable Pointers
- Effective choice of variable types
- Declaration statements, e.g. common
- Arithmetic operations
- Operator symbols
- Arithmetic expressions
- Assignment statements
- Library functions
- Algorithms
- Program structure
- Input and output requirements
- Use of subroutines and functions
- Program flow: use of DO loops, IF statements, GOTO and labels
- Nesting of loops and IF blocks
- Structured programming
- Data Input/output using files
- File handling: Editing. Compiling, linking, loading and executing
- Opening and closing of files
- Program development
- Sequential modular layout
- Choice of step length and run time

- Initial and boundary conditions
- Flow diagrams
- Debugging
- Interpretation of error messages
- Functional testing and validation
- Good practice
- C++ and other advanced Computer Languages
- Introduction to AutoCAD
- User interface
- Entity selection
- Setting drawing limits
- Using the grid and snap
- Creating drawing geometry
- Modifying drawing geometry
- Typed input using Ortho
- Polar and object tracking
- Object snapping
- Screen manipulation
- Transformation commands
- Layers
- Hatching
- Properties
- Text creation and editing
- Dimension creation and editing
- Layouts/paper space
- Plotting

Course Outcomes

- Students should have knowledge regarding arithmetic operations, program structure, file handling and auto CAD.

List of Practicals

- Practical exercises relating to the topics covered in theory.

Suggested Books

- Sanford, Larry R. and Nyhoff, L., “Introduction to FORTRAN 90 for Engineers and Scientists”, Prentice Hall, 1996.
- Lafore “ Programming for PC using Turbo C++” SAMS
- Bob McFarlane, Robert McFarlane, “Beginning AutoCAD 2007”, Newnes, 20

CH-102: Inorganic & Analytical Chemistry

Credit Hours: 3-1
Pre-requisites: None

Course Objectives

- To apply knowledge of inorganic and analytical chemistry for understanding unit processes in chemical engineering.
- Physical transformation of pure substances and compounds
- Application of chemical kinetics in materials extraction and Processing

Course Contents

Inorganic section

- Overview of periodic table
- Atomic structure and electronic configuration (Molecular orbital theory)
- Dalton law, Hess law, Raoults law, Antoine equation
- Relative volatility, Enthalpy, Gibbs free energy, Helmholtz free energy reaction kinetics and Chemical equilibrium, Entropy
- Transition metals, Industrial Catalyst
- Coordination chemistry (Theory and nomenclature, structural isomerism, stereo isomerism, coordination number and structure), colloidal chemistry
- Chemistry of solutions (acid base theories, pH, buffer solutions)
- Industrial inorganic chemistry
- Electrochemistry (Oxidation reduction reactions, Introduction and theory, application, fuel cells)

Analytical section

- Introduction to analytical chemistry and instrumental techniques / qualitative and quantitative analysis
- Separation methods
- Chromatography-Introduction and theory
- Plane chromatography, Liquid-solid chromatography
- Paper chromatography
- Thin-layer and column chromatography
- Potentiometer, pH meter

- High performance liquid chromatography (Introduction, components, detectors, methodology and applications)
- Gas chromatography (Introduction, components, detectors, methodology and applications)
- Ion-exchange chromatography
- Electromagnetic radiations, Instruments for optical spectroscopy
- Spectroscopic methods (Introduction of IR, Mass and NMR)
- UV and visible spectroscopy (Introduction, theory and application)

Course Outcomes

After completing this course, student will be able to:

- Demonstrate chemistry proficiency in analytical and inorganic chemistry
- Have firm foundations in the fundamentals and application of current chemical and scientific theories
- Are able to design, carry out, record and analyze the results of chemical experiments
- Are able to use modern instrumentation and classical techniques, to design experiments, and to properly record the results of their experiment
- Are skilled in problems solving, critical thinking and analytical reasoning. Are able to identify and solve chemical problems and explore new areas of research
- Knows the proper procedures and regulations for safe handling and use of chemicals and can follow the proper procedures and regulations for safe handling when using chemicals

List of Practical's

Experiment No.	**Experiment Objective**
1	Estimation of the molarity and strength of a given sample of base by titrating it against a standard solution of acid. (Acid-Base titration)
2	Estimation of chloride ions in given sample of water by titrating it with $AgNO_3$ standard solution. Compare the results with the permissible limit of chloride ions in water (Argentometric titration)
3	Estimation and analysis of water hardness due to Ca^{+2} by titrating the complexed calcium ions with solution of EDTA (Complexometric Titration).
4	Calculation of number of molecules of water of crystallization in given sample of ferrous sulphate ($FeSO_4$) sample by permanganate titration (Redox Titration).
5	Use stalagmometer to find the surface tension of given liquid sample at room temperature. Compare the experimental results with literature.
6	Determine the melting point of the solid sample using Melting point apparatus. Compare the experimental value of melting point with the literature.

7	Estimation of metal ion concentration using Flame photometer. Identify the different colors of flame for samples.
8	UV-Visible Spectrophotometry of given liquid sample. Observe the readings of sample for various compositions.
9	Find the refractive index of a given sugar sample using Abbe's Refractometer apparatus. Compare the findings with the literature
10	FTIR-Spectroscopy of solid/liquid sample. Analyze the obtained results by comparing them with the literature.
11	Find the total dissolved salt (TDS) in tap water. Compare the values obtained with the permissible level of TDS in drinking water.
12	Determine the conductivity of electrolytic solutions of known concentration using the conductivity meter. Identify good conductors among the electrolytes
13	Demonstration and analysis of the given sample by High-performance liquid chromatography (HPLC) technique

Recommended Books:

- P. W. Atkins *Physical Chemistry, W H Freeman and Company, 5th Edition*
- P. J. Chenier, *Introduction to Industrial Chemistry* VCH
- D.A. Skoog and West, Analytical Chemistry, VCH

HU-101: Islamic Studies

Credit Hours: 2-0
Pre-requisites: None

Course Objectives

- To provide Basic information about Islamic Studies
- To enhance understanding of the students regarding Islamic Civilization
- To improve Students skill to perform prayers and other worships
- To enhance the skill of the students for understanding of issues related to faith and religious life
-

Course Contents

- **Study of the Quran - Guidance for Mankind**

Understanding of Quran

1.1. Introduction to the Quran

1.2. Main theme of the Quran

1.3. Significance of the Quran's preservation

1.4. Building a relationship with the Quran

1.1. Submission to Allah (SWT) Tawheed

1.2. Self-Purification

1.3. Tolerance

1.4. Wisdom

- **Sura Al-Hujrat (Adab-e-Nabvi and social evils)**

- **Verses of Surah Al-Mominoon (characteristics of faithful)**

- **Seerat of the Holy Prophet (PBUH) – Beacon of Enlightenment**

a) Life in Makkah – Prominent (features of Seerat like patience etc.)
b) Life in Madina (Social life, dealing with minorities, IR etc.)

- **Fundamental Human Rights**

a) Right to Life and Property
b) Right to protect one's Honor and Right to Justice
c) Last sermon of the Holy Prophet

- **Moral Values**

a) Truth and Honesty
b) Sincerity
c) Tolerance and forgiveness

d) Fulfillment of Promise
e) Etiquettes of Conversation

- **Islamic Civilization – Prominent Features**

a) Islamic Culture
b) Islam and Science & Education (Education & Science in Islam)
c) Islam and contemporary world

Text Books:

- Islamic Education by A.S Bukhari & MD Zafar
- Muslim characters by Muhammad Al-Ghazali

Reference Books:

- Mi'yaariIslamiat by Prof Dr. Hafiz M. Akhtar
- MadniMuaashra (Ahd-e-Risalatmei) by Akram Ziaul Umre
- The Sealed Nectar by Safi- ur- Rehman Al-Mubarakpuri.
- Way to Quran by Khurram Murad

ME-109: Engineering Drawing

Credit Hours: 0-2
Pre-requisites: None

Course objective

- To enable students to read, and produce 2D and 3D engineering drawings using CAD tools
- Modifying drawing geometry
- Transformation commands

Course Contents

- Introduction to CAD software, User interface, Entity selection
- Setting drawing limits, Using the grid and snap
- Creating drawing geometry, Typed input, Using Ortho
- Polar and object tracking
- Object snapping
- Screen 33 manipulation
- Layers
- Hatching properties
- Text creation and editing
- Dimension creation and editing
- Layouts/paper space
- Plotting

Course Outcomes

- After studying this course, student should be able to read and produce 2D and 3D engineering drawings using CAD tools.

List of Practical's

- Common course is offered by SMME.

Recommended Books

- Engineering Drawing and Graphic Technology 14thEdition by T.E. French, C.J. Vierk and R.J. Foster
- Elementary Engineering Drawing by N.D. Bhatt.
- AutoCAD 2002 User's Guide by Autodesk, Mastering AutoCAD 2002 by George Omura.

. MATH-121: Linear Algebra and ODEs

Credit Hours: 3-0
Pre-requisites: MATH -101 Calculus and Analytical Geometry

Course Objectives

- Demonstrate properties of matrices used to solve systems of linear equation
- Solve first and higher order ODEs using conventional methods
- Apply the Laplace transform to solve initial value problems.

Course Contents

- Solution of linear systems, Gaussian elimination
- Gauss-Jordan method, Matrices, operation on matrices,
- Echelon and reduced echelon form. Inverse of a matrix (by elementary row operations)
- Determinants of a matrix, computing of determinants, definition of higher order determinants, expansion of determinants.
- Vector spaces, definition and examples, subspaces
- Linear combination and spanning set, linear dependency and independency
- Bases and dimension of a vector space, finite dimensional vector spaces
- Operations on subspaces, intersection of and sum of subspaces, eigenvalues and eigenvectors
- Introduction, classification of differential equations by type, Classification of differential equations, Interval of definition, solution curves, explicate and implicit solutions, Families of solutions, system of differential equations
- Differential equations as mathematical models, Solution Curves Without a Solution, direction Fields,
- Autonomous First-Order differential equations, critical points.
- Separable variables, solution by integration, solution curves, losing a solution, exact equations, differential of functions of two variables, exact differentials, solution procedure for
- exact differential equations, integrating factor
- Solution by substitution, homogenous equations, Bernoulli's equation, reduction to separation of variables, Higher order differential equations, homogenous equations, differential operators, superposition principal, general solutions, general solution of non-homogenous equations
- Reduction of order, homogeneous linear equations with constant coefficients
- Undetermined coefficients-superposition approach
- Introduction and properties of Laplace transform
- Solution of ODES by Laplace transforms

Course Outcomes

After completing this course, students should have developed a clear understanding of the fundamental concepts of linear algebra and ODEs and a range of skills allowing them to workeffectively with the concepts. After completing this course, students should demonstrate competency in the following skills:

- Introduction to matrices, Algebra of matrices, Special matrices
- Determinants and their properties
- Linear independence, bases, Vector space
- System of linear equation. Gauss elimination
- Eigenvalues, Eigenvectors
- Introduction to Differential Equations
    - ODE of First order and first degree
    - ODEs of second and higher orders
    - Non-homogeneous linear differential equations
    - System of linear differential equations
    - System of linear differential equations

Recommended Books

- G. Strang and S. Strang, Linear Algebra and Its Applications: Thomson, Brooks/Cole, 2006.
- Dennis G. Zill, Michael R. Cullen, Differential equations with boundary value problems, Brooks Cole, 2008
- John Polking, Al Boggess, Differential Equations with Boundary Value Problems, 2nd . Edition, Pearson,July 28, 2005
- Advanced Engineering Mathematics, Erwin Kreyszig, 10th edition, Wiley Publishers, 2011. (Reference)

HU-109: Communication Skills

Credit Hours: 2-0
Pre-requisites: None

Course objective

- To enable the students to meet their real life communication needs.
- Study skills, skimming and scanning intensive and extensive and speed reading summary precise writing and comprehension
- Presentation skills

Course Contents

- Communication skills-oral
- Communication skills-written
- Paragraph writing
- Practice in writing a good unified and coherent paragraph
- Essay writing
- CV and job application
- Translation skills
- Academic skills
- Letter/memo writing minutes of meetings
- Use of library and internet

Course Outcomes

- After taking this course student should have best communication and writing skills

Recommended Books

- Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. 3rd Edition. Oxford University Press 1986. ISBN 0 19 431350 6.
- Writing. Intermediate by Marie-ChristineBoutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
- Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).
- Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
- Reading and Study Skills by John Langan

Semester-3

CH-202: Organic & Biochemistry

Credit Hours: 3-1
Pre-requisites: None

Course Objectives

- To apply the knowledge of organic and bio chemistry in biochemical engineering to develop processes and products.
- Separation and purification techniques including recrystallization
- Introduction to Bio-Chemistry Fermentation Processes; Introduction to instrumental methods of analysis and their applications to organic compounds

Course Contents

Organic Chemistry

- structure and bonding,
- acids and bases,
- introduction to organic molecules and functional groups,
- alkanes,
- alkenes,
- alkynes,
- stereochemistry,
- understanding organic reactions,
- alkyl halides,
- alcohols, ethers and epoxides,
- oxidation reduction reactions,
- benzene and aromatic compounds,
- polymer chemistry

Biochemistry

- carbohydrates,
- amino acids,
- proteins,
- enzymes
- **l**ipids

Course Outcomes

Upon successful completion of this course students will be able to show a basic mastery of:

- Structure and properties of organic compounds
- Stereochemistry: stereoselective and stereospecific reactions

- Alkanes, Alkenes and Alkynes
- Free-radical addition and substitution reactions
- Nucleophilic addition and substitution reactions
- Alkyl halides
- Alcohols, Ethers
- Conjugation and resonance
- Cyclic Aliphatic compounds
- Aromatic compounds
- Demonstrate an understanding of organic molecules, their structures and effects on physical properties and chemical reactions.
- Carbohydrates
- Amino acids and proteins
- Enzymes
- Lipids
- Synthesize representative organic compounds in the laboratory
- Purify laboratory products by distillation and recrystallization.
- Determine theoretical and percent yields of laboratory products.

List of Practicals

Experiment No.	**Experiment Objective**
1	Synthesize Dibenzalacetone by aldol condensation reaction, analyze your product by its physical appearance and compute its actual and theoretical yield. Also compare your results with literature.
2	Synthesize the crystals of dibenzalacetone by recrystallization of crude product and estimate its melting point and purity by any suitable method of analysis. Also compare your findings with literature.
3	Compute the Rf value of unknown samples by Thin Layer Chromatography method and identify the samples by comparing your results with literature.
4	Synthesize Bio Diesel by transesterification reaction and separate the products by using separating funnel. Analyze your product by its physical appearance, also compute its actual and theoretical yield.
5	Perform the FTIR analysis of the products of transesterification reaction for the confirmation of biodiesel synthesis and prediction of its purity, also interpret the byproducts of the reaction by comparing the graphs with literature.
6	Synthesize soap by saponification reaction and separate the products by using vacuum filtration technique. Analyze your product by its physical appearance, also compute its actual and theoretical yield.
7	Perform the FTIR analysis of the products of saponification reaction for the confirmation of soap synthesis and prediction of its purity, also interpret the byproducts of the reaction by comparing the graphs with literature.

8	Synthesize Dibenzalacetone by aldol condensation reaction, analyze your product by its physical appearance and compute its actual and theoretical yield. Also compare your results with literature.
9	Synthesize 2,5-Dimethyl benzene by sulphonation reaction, analyze your product by its physical appearance and compute its actual and theoretical yield. Also estimate its melting point and purity by any suitable method of characterization.
10	Synthesize nitrobenzene by nitration of benzene, analyze your product by its physical appearance and compute its actual and theoretical yield. Also predict its purity by any suitable method of analysis.
11	Extract caffeine from coffee or tea and analyze your product by its physical appearance, also predict its melting point and purity by any suitable method of characterization.
12	Synthesize 2,4,6-Tribromoaniline by nucleophilic substitution reaction and analyze your product by its physical appearance. Also predict its purity by any suitable method of analysis.
13	Compute its actual and theoretical yield of 2,4,6-Tribromoaniline and estimate the melting point of sample by using melting point apparatus. Also compare your findings with literature.
14	Identify the unknown sugar samples by Osazone formation and compare your results with literature. Also compute the purity of samples by any suitable method of characterization.

Suggested Books

- Finar I. L., “Organic Chemistry- The Fundamental Principles” 1975, Vol.-I, The English Language Book Society and Longman Group Limited.
- Glasstone S. “Textbook of Physical Chemistry” 1951, 2nd Ed. Macmillan and Co. Limited.
- Paula Brown “Biochemistry”
- Volhardt K. Peter C. “Organic Chemistry” W.H.Freeman and Company.
- Maron Samuel H., Prutton Carl F. “Principles of Physical Chemistry” 4th Ed. Macmillan Publishing Co.
- Younis, M. “Organic Chemistry”
- Atkins P.W., “Physical Chemistry” 5th Ed. W.H.Freeman and Co. New York.
- IqbalZafar “Physical Chemistry”
- Vogal “ In-Organic Practical Chemistry” Addison Wesely

CHE-221: Fluid Mechanics-I

Credit Hours: 3-0
Pre-requisites. None

Course Objectives

- To introduce with the principles of force balances applied to fluid motion.
- It gives the introduction to the concepts and applications of fluid mechanics and dimensional analysis with an emphasis on fluid behavior, internal and external flows, analysis of engineering applications of incompressible pipe systems, Fluids have the ability to transport matter and its properties as well as transmit force, therefore fluid mechanics is a subject that is particularly open to cross fertilization with other sciences and disciplines of engineering.
- The subject of fluid mechanics will be highly relevant in such domains of chemical Engineering.

Course Contents

- Fluid Statics: pressure forces on surfaces, Pressure distribution, Head Calculations, pressure measuring devices, Buoyancy, Pressure in accelerated rigid body motions.
- Nature of Flow: Laminar & Turbulent Flow, Compressible & Non-Compressible
- Bernoulli's equation and its applications; Continuity Equation, Energy Relationships & the Bernoulli equation, pressure terminology, diffusers and sudden expansion
- Momentum of a Flowing Fluid; Newton's 2nd law of motion & Momentum Balance, Calculations for Laminar& Turbulent pipe flow, nozzle flow & other example
- Stress in Fluids; Viscosity, Newton's Law of Viscosity, Shear Stress Components, Newtonian and non-Newtonian flow
- Flow of Incompressible Newtonian Fluids in Pipes &Channels Shear stress in a pipe, Friction factor & pressure drop, Losses in fittings and bend pipes, enlargements and contractions, friction in non-circular channels, Velocity distribution for turbulent flow in a pipe.Piping network analysis
- Flow measurement; Orifice meter, Venturi meter, Rota meter, Nozzle. Notch and Wier, Electromagnetic flow meter,
- Flow of Compressible Newtonian Fluids
- Motion of particles in fluid; drag force on a spherical particles, motion of bubbles and drops, accelerated motion of particles in centrifugal field
- Sedimentation of fine particles and coarse particles

Course Outcomes

The student, upon completion of this course, will be able to:

- Formulate the principles of conservations of mass, momentum, and energy as applied to a variety of internal and external flows.

- Formulate solutions to flow problems, including those based on differential analysis, using appropriate fluid properties, flow conditions (i.e., laminar or turbulent)
- Solve conservation equations using a systematic approach based on different and/or integral analyses of conservation equations. The analyses will include concepts of fluid friction, momentum-force relationships, lift and drag, boundary layer theory, and pipe networks.
- Apply the principles of dimensional analysis and similitude to establish functional relations between important relevant parameters, and apply these to design.

Recommended Books:

- McCabe Warren L., Smith Julian C., Harriott peter “Unit Operations of chemical Engineering” 6th Ed. 2001. McGraw Hill Inc.
- Coulson J.M., Richardson J.F. “Chemical Engineering” Vol.-I, 1985. The English Book Society and Pergamon Press.
- Holland, F.A. & Bragg, R. “Fluid flow for Chemical Engineers”, 2nd Edition, Butterworth & Heinemann. 1995.
- White, F.M. “Fluid Mechanics”, 4th Edition, McGraw-Hill. 1999.
- Noel-de-Nevers “Fluid Mechanics for Chemical Engineers” McGraw Hill

CHE-231: Chemical Engineering Thermodynamics-I

Credit Hours: 3-0

Pre-requisites: None**(**Fundamental variables and its concept, Calculus & Differential Equations are necessary for deep understanding of thermodynamics. Chemical process calculation, material and energy balance).

Course Objectives

- To learn the scope and basic definitions of thermodynamics
- To learn the relationship between heat and work by understanding the significance of the first law of thermodynamics
- To learn the application of first and second law of thermodynamics.

Course Contents

- Chemical thermodynamics
- Scope and definitions
- Units and Dimensions
- Isolated systems
- Closed and open systems
- Intensive and extensive properties
- State and functions of state
- Thermodynamic Equilibrium
- Phase equilibrium
- Phase rule,Equation of states, Activity coefficient models
- First law of Thermodynamics
- Internal energy U
- Enthalpy H
- Reversibility
- Calorimetry
- Enthalpies of formation and reaction
- Dependence of U on temperature. Reversible processes
- Energy balance in closed system
- Mass and Energy Balances for Open Systems
- Bernoulli Equation, Steady Flow Processes
- First law as applied to ideal gases
- The Phase Rule
- P-V-T relationships for non-ideal gases
- Isothermal
- Isometric
- isobaric

- Polytrophic and adiabatic processes involving an ideal gas
- Application of virial equations
- Compressibility factors
- Cubic equation of state
- Acentric factor
- Generalized correlations for gases
- Generalized correlations for liquids
- Heat Effects; Sensible Heat Effects
- Latent Heats of Pure Substances
- Heat of Formation, Heat of Reaction & Combustion
- Dependence of H on temperature and industrial reaction
- Second Law of Thermodynamics
- Entropy; Equilibrium and observable change
- Changes in entropy with changes in P, V, and T, change in entropy in ideal gas
- Entropy balance in open system
- Measurement of entropy
- Third Law of Thermodynamics Kinetic Theory of Gases
- One component systems
- Clapeyron and Clausius-Clapeyron equations

Course Outcomes

- To apply the knowledge of law of thermodynamics in chemical engineering to develop processes and products.

Recommended Books

- Smith J.M., Van Ness H.C., Abbott M.M. “Chemical Engineering Thermodynamics” 6th Ed. 2001. McGraw Hill International Edition.
- Daubert Thomas E. “Chemical Engineering Thermodynamics”, 1st Ed. 1985, McGraw Hill Book Company.
- Sandler Stanley I. “Chemical and Engineering Thermodynamics” 3rd Ed. John Wiley and sons, Inc.
- Eastop, McConkey “Applied Thermodynamics” National Book Foundation.

CHE-202 : Chemical Process Principles-II

Credit Hours: 3-0
Pre-requisites: CHE-101. Chemical Process Principles-I

Course Objectives

- To develop learning to analyze and solve material balance problems in processing units.
- Balances for systems with recycle, purge and by-pass streams Mass balances for unit operations Tie components
- Case studies on balances for a selection of important industrial processes

Course Contents

- Concepts of Energy balance
- Energy balances, open system at steady state
- Energy balances on non-reactive systems
- Energy balances for phase change operations
- Temperature and pressure dependence for Energy balances
- Energy balances for reactive systems
- Energy balances for combustion processes
- Phase diagrams, multi-component gas-liquid systems, liquid-solid systems
- Balances for batch and continuous plant
- Simultaneous mass and energy balances
- Transient mass and energy balances
- Application of Computers in material and energy balances calculations

Course Outcomes

- After taking this course, student should know how to implement the stoichiometric calculations and equations to design a plant.

Recommended Books

- Himmelblau David M. “Basic Principles and Calculations in Chemical Engineering”. 7th Ed. 2003. Prentice Hall PTR
- Felder Richard M., Rousseau Ronald W. “Elementary Principles of Chemical Processes” 3rd Ed. 2001. John Willey & Sons.
- Reklaitis G.V., Schneider Daniel R. “Introduction to Material and Energy Balances” 1983. John Wiley & Sons.

- Hougen Olaf A., Watson Kenneth M. “Chemical Processes Principles”. 2004, John Wiley and Sons & CBS Publishers.
- Chopy& Hicks, “Handbook of Chemical Engineering Calculations” , 2nd Ed. 1994 McGraw-Hill Professional Publishing
- B.I. Bhatt, “ Stoichiometry” , 2004, McGraw Hill

MATH-243 : Vector Calculus

Credit Hours: 3-0
Pre-requisites: MATH-121 Linear Algebra and ODEs

Course Objectives

To develop understanding Vector Calculus and Partial Differential Equations.

Course Contents

- Analytical Geometry in 3-space
- Quadratic Surfaces
- Cylindrical and Spherical coordinates
- Parametric representation of curves, Arc length Curvature & Torsion
- Gradient of a Scalar Field and directional derivatives
- Divergence of a Vector Field.
- Curl of a Vector Field.
- Line integral, integration around closed curves.
- Application of double integrals, green's theorem.
- Surface Integrals.
- Triple integrals, Divergence theorem of Gauss.
- Stokes's theorem.
- Partial differential equations solvable as ODEs (separation of
- variables)
- Modeling a Vibrating String, Derivation of Wave Equation
- Solution by the Method of Separation of Variables using
- Fourier Series.
- Heat Equation; its Solution by Fourier Series.

Course Outcomes

- After this course, student should have understanding of analytical solution of first and second order differential equations.

Suggested Books

- E. Kreyszing, Advanced Engineering mathematics (9th edition).
- Swokowski, Onlinick & Pence: Calculus (6th Edition).
- Borisenko & Taranov, Vector and Tensor Analysis with Applications

MSE-101 : Fundamentals of Engineering Materials

Credit Hours: 3-0

Pre-requisites: None

Course Objectives

- To introduce the Materials Science and Engineering subject and classification of materials
- To teach the types of bonding in engineering materials/solids
- To introduce the Crystal structures and properties associated with them
- To introduce Strengthening mechanisms and imperfections in solids
- To introduce the Mechanical properties of materials and their measurements
- To study the processing of ceramics, composite, and polymeric materials.

Course Contents

- Introduction to materials science and engineering, Classifications of materials,
- Atomic Structure, Atomic bonding in solids,
- Crystal structures, Crystalline and non-crystalline materials,
- crystallographic points, directions and planes,
- Imperfections in crystalline solids,
- Microscopic examinations,
- Mechanical properties of solids, Elastic behavior of metals
- , Plastic behavior of metals, Compressive, shear and torsion, hardness,
- Property variability and design safety factor,
- Dislocations and plastic deformation,
- Strengthening Mechanism,
- Phase diagram, Binary Phase diagrams, Iron-Carbon system,
- Ceramic structures,
- Processing of ceramics,
- Polymeric materials and their processing,
- Composite materials and their processing.
- Real-world applications include engineered alloys, electronic and magnetic materials, ionic and network solids, polymers, and biomaterials

Course Outcomes

At the end of the course the students are expected to have learned the following:

- How to calculate the crystal structure density / Atomic packing factor
- To develop the understandings of crystallographic plans and directions
- To predict properties based on the microstructure present in the materials
- Find out mechanisms of strengthening in a material
- Understanding of materials processing and their structure-property relationship.

Recommended Books

- W. D. Callister Jr. , *Material Science and Engineering, An Introduction,7th Edition Wiley and Sons, 2007*
- Allen, S. M., and E. L. Thomas. *The Structure of Materials*. New York, NY: J. Wiley & Sons, 1999.

Semester 4

CHE-211: Chemical Process Technology

Credit Hours: 3-0
Pre-requisites: None

Course Objectives

- To familiarize students with conversion of raw materials into finished products on industrial scale using conventional and green technology.
- Development of Chemical Process Industry in Pakistan

Course Contents

- Basic Industries: Silicate and allied products, Glass
- Ceramics and Cement; Phosphorus
- Heavy Chemicals: Sulfuric Acid, Nitric Acid
- Sodium carbonate and sodium hydroxide
- Water conditioning
- Soap and Detergents; Leather processing and tanning
- Refractories; Types, properties, manufacture and major uses
- Gas and oil processing
- Synthesis Gas production from coal and biomass
- Reforming of natural gas for synthesis gas production
- Brief treatment of Oil refining
- Fertilizers; Urea, Potassium Nitrate, Super phosphate, Di-ammonium Phosphate
- Industrial gases; Carbon dioxide, Hydrogen, Nitrogen
- Chemical and fuels from Biomass
- Pulp and paper; Pulp manufacture, Comparison
- Description of different methods available; Paper making
- Sugar and Agro based industry. Biomass processing
- Fermentation Industries: Industrial alcohol and industrial solvents
- Food processing industry; food processing techniques, food by products.
- Plastic industry; Plastics, Types and their properties, Polymerization, Manufacture of plastics, Uses; synthetic fibers; Paints and Varnishes
- Synthetic fuels via Fischer-Tropsch reaction

Course Outcomes

- After taking this course, student should have knowledge how to produce finished products on industrial scale using conventional and green technology.

Recommended Books

- Austin George T. “Shreve’s Chemical Processes Industries” 6th Ed. 1997, McGraw Hill International Edition.
- Groggins P.H. “Unit Processes in Organic Synthesis” 4th Ed. 2005, Tata McGraw Hill Book Company, Inc.
- Pandey G.N. “A Textbook of Chemical Technology” 2nd Ed. Vol-I & II. 2000. Vikas Publishing House (Pvt) Limited
- Riegels Handbook of Industrial Chemistry, James A. Kent 2000, Springer/ Van Norstrand/ Rein Hold.

- Pandey G.N. “A Textbook of Chemical Technology” 2nd Ed. Vol-I & II. 2000. Vikas Publishing House (Pvt) Limited
- Riegels Handbook of Industrial Chemistry, James A. Kent 2000, Springer/ Van Norstrand/ Rein Hold.

- Kirk Othmer “Encyclopedia of Chemical Technology” 1999, Inter Science Publishers.
- Haidarilqbal “Chemical Industry in Pakistan” .1992. Industrial Research Service Karachi, Pakistan.

CHE-241: Mass Transfer

Credit Hours: 2-0
Pre-requisites: None

Course Objectives

- To study mass transfer for analysis of chemical engineering operations involving mass transfer, differential and stage wise separation processes, mass transfer accompanied by chemical reaction, general design and operation of mass-transfer equipment
- Film dominance and solubility. Schmidt, Sherwood, Stanton and Marshall numbers
- Find extensive application in chemical engineering problems

Course Contents

- Introduction to mass transfer; gradient driven transport
- Fundamentals:, Fick's law, diffusivity, diffusion through gases and liquids, equimolar counter diffusion, diffusion through a stagnant gas
- Mass transfer Theories The two-film theory, the penetration theory, surface renewable theory, concentration profiles,mass transfer at gas/liquid interfaces
- Concept of resistance to mass transfer,mass transfer coefficients(overall and film)
- Countercurrent mass transfer and concept of transfer units
- Modeling mass transport
- Transient and convective mass transfer
- Dimensionless and dimensional analysis in mass transfer
- Phase equilibrium and phase diagrams; single component systems, multi component systems, gas-liquid equilibrium, fluid solid equilibrium, Langmuir isotherm, liquid-liquid equilibrium and triangular phase diagrams
- Calculation of the number of theoretical stages for various cases of countercurrent and co current operations
- Case studies to solve mass transfer problems

Course Outcomes

After completing this course, student will be able to:

- Fundamental understanding of basics in mass transfer theories.
- Develop familiarity with major chemical process separations units.
- Apply appropriate criteria for selecting among alternative separation technologies.
- Apply mass transfer fundamentals to calculate rates of mass transfer for practical situations and to identify rate-limiting processes.

Recommended Books

- MeCabe Warren L., Smith Julian C., Harriott peter “Unit Operations of chemical Engineering” 7th Ed. 2005. McGraw Hill Inc.
- Coulson J.M., Richardson J.F. “Chemical Engineering” Vol-II, 5th Ed. 2002. The English Book Society and Pergamon Press.
- Incropera Frank P., De Witt David P. “Fundamentals of Heat and Mass Transfer” 3rd Ed. 1990. John Wiley and Sons.
- Treybal Robert E. “Mass Transfer Operations”, 1981, McGraw Hill Book Company.
- Schweitzer, “Handbook of Separation Techniques for Chemical Engineers”, 1979, McGraw Hill Book Co.
- Coulson J.M., Richardson J.F. “Chemical Engineering” Vol-I, 1999. The English Book Society and Pergamon Press
- Alan S.Foust, Leonard A.Wenzel “Principles of Unit Operations” 2nd Ed.1980. John Wiley & Sons
- DiranBasmadjian, “ Mass transfer ; principles and applications”,2004, CRC Press.

CHE-242: Heat Transfer

Credit Hours: 3-1
Pre-requisites: None

Course Objectives

- To study heat transfer for analysis of chemical engineering operations involving heat transfer
- Differential and stage wise separation processes
- Heat transfer accompanied by chemical reaction
- General design and operation of heat-transfer equipment.

Course Contents

- Conduction in Steady state and unsteady state cases for one dimension
- Heat transfer by convection (Natural & Forced Convection)
- Application of dimensional analysis to convection
- Heat transfer by Radiation
- Radiation from black and real surfaces, radiation between black surfaces, radiation between grey surfaces, radiation from gases
- Concept of film and overall heat transfer coefficients
- Unsteady state heat transfer
- Heat transfer equipment's, their types and selection criteria
- Heat Exchangers and their design
- Heat transfer with phase change; Condensation and boiling heat transfer and designing of single component condensers
- Evaporation: Heat transfer in evaporators, Single effect evaporators, Multiple-effect evaporators, the calculation of multiple-effect systems, comparison of forward and backward feeds, vapor compression evaporators, the heat pump cycle, Evaporator operation, Equipment for evaporation

Course Outcomes

- After taking this course, students should have understanding of the concepts and laws of heat transfer for design of heat transfer equipment.

List of Practicals

Sr No.	Name of Equipment	Name of related experiment
		1. To calculate the efficiency of a double pipe heat exchanger for parallel flow.

1	Concentric Double Pipe Heat Exchanger (DP)	2. To calculate the efficiency of a double pipe heat exchanger for counter flow. 3. To calculate heat flux and overall heat transfer Co-efficient in double pipe heat exchanger for parallel flow.
2	Shell & Tube Heat Exchanger (ST)	1. To calculate the efficiency of Shell & Tube heat exchanger for parallel flow. 2. To calculate the efficiency of Shell & Tube heat exchanger for counter flow. 3. Comparison of efficiency between parallel and counter flow in shell and tube heat exchanger.
3	Radiation Heat Transfer Unit (RHT)	1. To show that the intensity of radiation on surface is inversely proportional to the square of the distance of the surface from radiation source.. 2. To determine emissivity of radiation surface with different finishings namely polished, gray andblack metal 3. To show that intensity varies as fourth power of the source temperature.
4	Film & Drop wise Condensation Unit (FDC)	1. Film wise heat flux & surface heat transfer co efficient determination at constant pressure 2. Drop wise heat flux & surface heat transfer co efficient determination at constant pressure. 3. Effect of air inside the chamber of film and drop wise condensation unit.
5	Flow Boiling Demonstration Unit (FBD)	1. Demonstration of flow boiling within the tube of Flow Boiling Unit. 2. To demonstrate the circulation prompted by natural convection.

		3. To demonstrate the various stages in flow boiling including • Convective heat transfer to sub cooled liquid • Nucleation in sub cooled and saturated liquid • Slugging • Annular Flow • Droplet Entrainment Complete dry out to superheated vapour

Recommended Books

- Kern Donald Q. “Process Heat Transfer”, 1997, McGraw Hill Book Company.
- CengelYunus A. “Heat Transfer-A Practical approach”, 1988, McGraw Hill Book Company.
- Incropera Frank P., De Witt David P. “Fundamentals of Heat and Mass Transfer” 5rd Ed. 2002. John Wiley and Sons.
- Coulson J.M., Richardson J.F. “Chemical Engineering” Vol-I, 1999. The English Book Society and Pergamon Press
- Coulson J.M., Richardson J.F. “Chemical Engineering” Vol-II, 5th Ed. 2002. The English Book Society and Pergamon Press
- Hewitt &Bott. “Process Heat transfer”
- J.P. Holman, “Heat Transfer”, 2002, McGraw Hill Book Company.

EE-103: Electrical Engineering

Credit Hours: 2-1.
Pre-requisites: None

Course Objectives

- To impart the basic knowledge of electrical machines and electronics.

Course Contents

- Introduction to DC Circuits: Series and Parallel circuits, DC Circuit analysis
- Theory of Alternating Current
- Series and Parallel circuits
- Resistance, inductance and capacitance of AC circuits
- Power factor
- Resonance in RLC circuits
- Single and poly-phase circuits
- Power and power factor measurement
- Current and voltage relationship in phase and line circuits

Course Outcomes

- The students will get basic knowledge of electrical engineering to understand alternating current, direct current and associated circuits. They will also understand back ground information for electrical instruments and electrical machinery being used in chemical industry.

Recommended Books

- T.L. Floyd, D.M. Buchla, Electronic Fundamentals: Circuits, devices and applications, 8th Edition, Prentice Hall, (2009)
- J. Bird, Electrical circuit theory and technology, 2nd Edition, Newnes Publication, (2003)

HU-212 Technical &Business Writing

Credit Hours: **2-0**
Pre-requisites: None

Course Objectives

- To enhance technical and critical writing skills.
- Oral communication of scientific and technical information

Course Contents

- Develop skills that will enable you to produce clear and effective scientific and technical documents
- Basic principles of good writing-which scientific and technical writing shares with other forms of writing-and on types of documents common in scientific and technical fields and organizations

Course Outcomes

- After taking course, student should be able to produce clear and effective scientific and technical documents.

Suggested Books

- Markel, Mike. *Technical Communication*. 7th Ed. New York, NY: Bedford/St. Martin's, 2004.
- Lance A Parr *Report Writing Essentials, 2000 Edition*

CHE-224 : Fluid Mechanics-II

Credit hours:2-1

Prerequisites: CHE-221:Fluid Mechanics-I

Objectives of the Course:

- To impart in-depth knowledge about the selection and design of fluid flow systems in process industry

Course Contents:

- Flow through porous media,Carman-Kozney equation
- Flow through packed beds, types of packing, hydrodynamics of packed column
- Fluid Motion in the Presence of Solid Particles,Relative motion between a fluid and a single particle, Effect of presence of other particles and wall on the particle velocity
- Fluidization and types of fluidized beds and their use in chemical engineering
- Concept of hydrodynamic characteristics of fluidized beds
- Fluids mixing; types of mixing and mixing mechanism. Types of agitators and mixing equipment, power consumption in stirred vessels, static mixers
  Introduction to non-Newtonian fluids,Flow of Non-Newtonian Fluids
- Filtration; theory of filtration, filtration equipment, filtration practice, rate of filtration
- Gas cleaning, gas cleaning equipment, cyclone separators, electrostatic separators, liquid scrubbing.
- Centrifugal separation, separation of immiscible liquids of different densities
- Flow of multiphase mixtures, two-phase flow, flow regimes and flow pattern

List of Practicals

Experiment No.	Experiment Title
1	Calibrate the given Rotameter with respect to electromagnetic flow meter in flow meter trainer; also analyze the experimental results graphically.
2	Analyze different types of valves and flow through them, in pipe fittings apparatus, also compare the experimental findings with literature.
3	Compute the pressure drop across different flow meters i.e. orifice meter, venture meter and flow nozzle, in flow meter trainer, also analyze the experimental results graphically.
4	To find the pressure drop across different pipe fittings and bends in pipe fittings apparatus, also compare the experimental findings with literature.
5	Estimate the friction loss across pipe fittings; also compare the experimental findings with literature.

6	Compute the pressure drop on sudden contraction & expansion for different flow meters and find out the Reynolds's number for each flow, also analyze the experimental results graphically.
7	Demonstration of Bernoulli's theorem at convergent position in Bernoulli's Apparatus, also analyze the experimental results graphically.
8	Observation of difference between the convergent and divergent position, in Bernoulli's Apparatus, also compare the experimental findings with literature.
9	Demonstration of Bernoulli's theorem at divergent position, in Bernoulli's Apparatus, also analyzes the experimental results graphically.
10	Determination of Drag coefficient for smooth spheres, in drag coefficient apparatus, also compares the experimental findings with literature.
11	To observe and compare the difference of the movement of solids between the solid –liquid and solid –gas fluidization, also analyzes the experimental results graphically.
12	Determination of Drag coefficient for smooth spheres, in drag coefficient apparatus, also compares the experimental findings with literature.
13	Investigation of pumps in series and parallel configuration and determining the head, also analyzes the experimental results graphically.
14	Recording the pump characteristics curves for single, series and parallel configuration, also compares the experimental findings with literature.

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Recommended Books:

- Holland, F.A Bragg, R.: Fluid flow for chemical engineers", 2nd edition Butterwort and Heinemann,1995
- White,F.M " Fluid Mechanics|", 4th edition, McGraw-Hill, 1999.

Semester-5

CHE-346 : Particulate Technology

Credit Hours: 3-1
Pre-requisites: None

Course Objectives

- This course will enable students to understand the basic principles of handling solid particle and unit operations related with particles like crushing, screening, mixing etc.
- This course also deals with the basic principles of crystallization and some other separation techniques.

Course Contents

- Particle size distribution
- screening and sieving
- Mechanism of size reduction
- Machinery for crushing and grinding
- Pneumatic and hydraulic conveying Screw
- Vibrating Screens
- Solid-liquid and gas solid Separation, cyclone separators, electrostatic separators
- Belt conveyors and elevators
- Fluidization, characteristics of fluidized systems, applications of fluidization
- Flow pattern and baffles
- Agglomeration phenomena and its application e.g. granulation, pelletization, tabling and storage; dust explosion

Course Outcomes

- After completing this course, students must know the basic principles of handling solid particles and unit operations related to chemical engineering plant design.

List of Practical's

Experiment No.	Experiment Title
1	Compute the abrasion value of copper ore and brick sample by operating Jaw crusher. Analyze your experimental results graphically and compare your findings with literature.
2	Estimate the average diameters of crushed particles by operating jaw crusher and sieve shaker and plot the experimental results graphically.
3	Compute the individual and overall critical speed of ball mill using different sizes of grinding media and compare your results with literature.
4	Investigate the effect of RPM on particle size of the sample operating the ball mill at constant grinding media size. Analyze the findings graphically.

5	Compute the percentage of magnetic particles for the unknown sample and predict the efficiency of magnetic separator. Compare the experimental results with literature.
6	Operate the magnetic separator at different RPM and interpret the experimental results graphically for different samples.
7	Synthesize the NaCl Crystals in Batch Crystallization and investigate the effect of cooling in Agitated Tank Crystallizer. Analyze the experimental results graphically.
8	Perform FTIR analysis of synthesized NaCl crystal to estimate the purity of sample. Compare the experimental results with literature.
9	Predict the particle size distribution of the product obtained from jaw crusher and analyze the effect of mesh number on particle size graphically.
10	Compute the particle size distribution of the product obtained from ball mill and interpret the effect of mesh number on particle size graphically.
11	Identify the unknown sample by computing its permeability by using distilled water as mother liquor. Analyze the findings graphically.
12	Predict the filtration rate of calcium carbonate solution by operating the plate and frame filter press assembly at constant feed rate. Analyze the findings graphically.
13	Compute the concentration of Titanium Oxide and Calcium carbonate solution by operating the centrifuge at constant RPM. Analyze the experimental results graphically.

Recommended Books

- McCabe Warren L, Smith Julian C, Harriott Peter., “Unit Operations, 6th edition, 2001, McGraw-Hill Inc.
- Coulson J.M, Richardson J.F., “Chemical Engineering”, 1999, Pergamon Press.
- Perry Robert H., Green Don W., “Perry’s Chemical Engineering Handbook, 7th Edition, 1997, McGraw-Hill Inc.
- Foz R. W and McDonald A.T., “Introduction to Fluid Mechanics, 1998, John Willey & Sons.
- Noel de Nevers, “Fluid Mechanics for Chemical Engineers”, 2005, McGrawHill Inc.
- Chopy and Hicks., Handbook of Chemical Engineering calculations,

CHE-343: Simultaneous Heat & Mass Transfer-I

Credit Hours: 3-1

Pre-requisites: CHE-242: Heat Transfer, CHE-241: Mass Transfer, MATH-243 Vector Calculus.

Course Objectives

- The objective of this course is to introduce the principles of simultaneous heat and mass transfer with emphasis on their applications to practical chemical engineering problems.
- The mathematical equations describing coupled heat and mass transfer processes are basics for designing the unit operations for thermal separation processes and humidification processes.
- Design of equipment based on worst case studies

Course Contents

- **Humidification and Cooling Towers**: Humidification terms
- Wet-bulb and adiabatic saturation temperature
- Humidity data for the air-water system
- Temperature-humidity chart
- Enthalpy-humidity chart
- Determination of humidity
- Humidification and dehumidification
- Cooling Towers Design: Basic principles, types, features and operation of various cooling towers
- Alternative sinks for waste heat
- Water and air based systems
- Environmental effects
- **Distillation**: Vapor-liquid equilibrium: Partial vaporization and condensation. T-X-Y and X-Y diagrams
- Composition calculations, Differential and flash distillation, rectification
- The fractionating column
- Concept of constant molal overflow
- Calculation of number of plates required for binary separations
- Lewis-Sorel, McCabe-Thiele Concept of operating lines. Intersection of operating lines and location of feed plate
- Importance of the reflux ratio
- Calculation of minimum reflux ratio
- Number of plates at total reflux
- Underwood and Fenske equations

- Selection of economic reflux ratio
- Effect of multiple feeds and side streams
- Plate efficiency and Murphree's formula
- Concept of a theoretical plate and HETP
- Method of transfer units and HTU
- Batch distillation: operation at constant product composition or constant reflux ratio
- Calculation of column, diameter and height
- **Absorption**: Extension of design techniques to absorption as appropriate, Absorption associated with chemical reaction
- Wetted wall columns and determination of transfer coefficient
- Equipment for gas adsorption: Packed and plate column, vessel with agitators, centrifugal absorber and spray tower
- **Crystallization** : growth and properties of crystals, effect of temperature on solubility, saturation, nucleation, effect of impurities on crystallization, equipment for crystallization, batch and continuous crystallizers

Course Outcomes

After completing this course, student will be able to:

- Fundamental understanding of basic equations describing coupled heat and mass transport in various unit operation with respect to chemical engineering.
- Understanding of pertinent processes in simultaneous heat and mass transfer.
- Understanding of humidification and dehumidification processes. Learning the design principles of cooling towers.
- Learning the fundamentals of crystallization process, selection and classification of crystallizers based on their respective applications.

List of Practicals

Experiment No.	**Experiment Objective**
1	Analyze the plot between time and Conductivity and determine the liquid diffusion coefficient of 1M NaCl solution on the Liquid Diffusion Coefficient Apparatus.
2	Interpret the results of the plot between time and Conductivity and compute the liquid diffusion coefficient of 2M NaCl solution on the Liquid Diffusion Coefficient Apparatus
3	By operating the Liquid Diffusion Coefficient Apparatus, analyze the plot between time and Conductivity and determine the liquid diffusion coefficient of 3M NaCl solution. Compare results with experiment 1 & 2.
4	To interpret the effect of air flow rate on range and approach of forced draft cooling tower andsummarize the relation between (a) % inlet air flow vs. range

	% inlet air flow vs. Approach
5	Determine the humidity of air at inlet and outlet conditions of forced draft cooling tower.
6	Analyze and compute the percentage effectiveness of forced draft cooling tower.
7	By operating forced draft cooling tower, analyze and evaluate the evaporative losses.
8	To interpret the effect of water flow rate on range and approach of forced draft cooling tower andsummarize the relation between (a) % inlet water flow vs. range (b) % inlet water flow vs. Approach
9	Demonstrate the distillation phenomenon by using 5% w/w solution of ethanol in water by operating batch distillation column.
10	Estimate the % purity of given sample and also determine the efficiency of batch distillation column.
11	Predict the effect of total reflux on % purity of product in batch distillation column.
12	Comparethe behavior of following variables at constant reflux and total reflux. (a) Heat power via distillate flow rate in batch distillation. (b) Composition change w.r.t temperature change in batch distillation column. Composition change w.r.t time change in batch distillation column.
13	Analyze and compute the gaseous diffusivity co-efficient.

Recommended Books

- McCabe Warren L., Smith Julian C., Harriott peter “Unit Operations of chemical Engineering” 7th Ed. 2005. McGraw Hill Inc.
- Coulson J.M., Richardson J.F. “Chemical Engineering” Vol.-II, 5th Ed. 2002. The English Book Society and Pergamon Press.
- Coulson J.M., Richardson J.F. “Chemical Engineering” Vol-I, 1999. The English Book Society and Pergamon Press
- Foust Alan S., Wenzel Leonard A., Clump Curtis W., Maus Louis and Anderen L. Bryce “Principles of Unit Operations” 2nd Ed. , 1963, John Wiley and sons.
- Incropera Frank P., De Witt David P. “Fundamentals of Heat and Mass Transfer” 3rd Ed. 1990. John Wiley and Sons.
- Treybal Robert E. “Mass Transfer Operations”, 1981, McGraw Hill Book Company.

MATH-351: Numerical Methods

Credit Hours: 3-0

Pre-requisites: MATH 1011 Calculus & Analytical Geometry,
MATH 121 Linear Algebra & ODEs

Course objective

- To introduce with numerical techniques to handle any mathematical problem having not an exact solution will handled with numerical techniques
- Simulation techniques will enable to solve the problems arising in advance courses
- To familiarize with the numerical methods programming in MATLAB

Course Contents

(Non) Linear Algebraic Equation(s):

- Bisection method, fixed point method, Newton's method, Newton Raphson method, Newton method for the system of nonlinear equations. Gauss Elimination, Gauss Jordan with pivoting strategies, LU-factorization, Jacobi & Gauss Seidel methods.

Interpolation:

- Lagrange, Divided difference, Cubic spline & Extrapolation.

Numerical differentiation:

- Forward/backward and three (five) points formulas.

Numerical integration:

- (Composite) Trapezoidal, Simpsons 1/3rd & Simpsons 3/8th rules, Gaussian Quadrature.

Differential equations (DE):

- Euler, Modified Euler, Taylor, Runge-Kutta, Multistep methods for one variable & system of ODEs.

Boundary Value Problems DE:

- Shooting method, Finite difference methods for ODE & PDE, Finite Element technique (Glerkin' Method).

Course Outcomes

- After taking this course, student should know the utilization of simulation techniques and MATLAB.

Suggested Books

- Alkis Constantinides & Navid Mostoufi, "Numerical Methods for Chemical Engineers with MATLAB Applications", Prentice Hall PTR, 1999.
- Norman W. Loney, "Applied Mathematical Methods for Chemical Engineers', CRC Press, 2006.

- Daniel Schiff, Ralph B. D'Agostino, "Practical Engineering Statistics", Wiley Interscience 1996.
- Douglas C.Montgomery, George C. Runger, Norma Faris Hubele, "Engineering Statistics", Johan Wiley & Sons 2007.

CHE-332: Chemical Engineering Thermodynamics -II

Credit Hours: 3-1
Pre-requisites: CHE-231: Chemical Engineering Thermodynamics 1

Course Objectives

- To develop an ability to apply chemical thermodynamics to systems to determine phase and chemical equilibrium
- Familiarity with terminology, theory, and common models used to describe solutions and mixtures
- Application of thermodynamics to flow processes

Course Contents

- Fundamental equations for closed systems
- Production of power from heat; Steam power plant, Heat engines, various cycles and turbine
- Liquefaction; Refrigeration and air conditioning in various cycles
- Two component systems. Liquid-vapor equilibrium with its models. Raoult's law, Henry's law
- Helmholtz function
- Gibbs function (free energy) G. Maxwell'' relationships
- Properties of mixtures of ideal gases. G for ideal and non-ideal gases
- Partial molar quantities
- Excess Thermodynamic Functions
- Chemical Equilibrium: equilibrium constants for gas phase reactions
- Factors affecting degree of conversion
- Equilibrium involving condensed phases. Equilibrium in solution mixing.
- Thermodynamics of cells
- Ideal and Non-ideal solutions
- Composition of vapor in equilibrium with liquid; Fractional distillation. Azeotropes. Liquid-solid equilibrium
- Compound formation. Solid solution

Course Outcomes

- Student should be able to understand and apply principles of thermodynamics on equilibrium calculations in multi-component and multiphase systems.

List of practicals

Sr No.	Name of Equipment	Name of related experiment
1	Mechanical Heat Pump (MHP)	1. To estimate & compute Power Input, heat Output of co-efficient of performance.
		2. To interpret heat pump performance curves over a range of source and delivery temperature.
		3. To interpret vapor compression cycle on P-h diagram and energy balance study & compare it with litrature.
		4. To estimate & compute heat pump performance curves over a range of evaporation and condensation temperatures.
		5. To predict & analyze cooling cycle by compression of vapor cycle of heat pump.
2	Single Cylinder Steam Engine (SE)	1. To estimate & compute the steam pressure curve for steam power plant.
		2. To estimate & compute the fuel consumption rate and power supplied by the fuel.
		3. To estimate & compute the amount of steam, steam power output and boiler efficiency.
3	Refrigeration Cycle Demonstration Unit (RC)	1. To estimate & compute the effect of compressor pressure ratio on volumetric efficiency.
		2. To interpret & analyze adiabatic compression and expansion by performing the experiment slowly, in incremental steps.
		3. To investigate, compute & analyze adiabatic compression and expansion by performing the experiment Fast, in incremental steps.
		4. To estimate & describe the relation between pressure and temperature for refrigeration cycle.
		5. To estimate & analyze the effect of evaporation and condensation temperatures in the cooling rate and in the heat transfer at the condenser.
4	Solar Energy Demonstration Unit	1. To estimate & compute the efficiency of

	(SEU)	solar energy demonstrator.
5	Thermal Expansion Unit (TE)	2. To investigate & describe the phenomena of thermal expansion & contraction of air.

Recommended Books

- Smith J.M., Van Ness H.C., Abbott M.M. “Chemical Engineering Thermodynamics” 6th Ed. 2001. McGraw Hill International Edition.
- Daubert Thomas E. “Chemical Engineering Thermodynamics”, 1st Ed. 1985, McGraw Hill Book Company.
- Sandler Stanley I. “Chemical and Engineering Thermodynamics” 3rd Ed. John Wiley and sons, Inc.

MGT-271: Entrepreneurship

Credit Hours: 2-0
Pre-requisites: None

Course Objectives

- To provide and understanding of basic principles and concepts to analyze the theories of entrepreneurship.
- Board of Directors and duties, management duties and takeover defenses.

Course Contents

- Theory of the Firm, theory of capital markets, legal characteristics of corporation, corporate charters, the structure of corporate law, financing of corporation, securities regulation. Milestones for successful venture planning, strategy Vs. Tactics from a venture planner, commercializing technology

Course Outcomes

- After completing this course, student should have the knowledge reading the principles and concepts to analyses the theories of entrepreneurship.

Recommended Books

- Neal R. Bevans, *Business Organizations and Corporate Law*
- Roberta Romano, *Foundations of Corporate Law, Foundation Press, 1993*

Robert D Hirsch, Michael P Peters, and Dean A. Shepherd, *Entrepreneurship, 2006*

Semester-6

CHE-348: Simultaneous Heat & Mass Transfer-II

Credit Hours: **3-1**
Pre-requisites: CHE-343: Simultaneous Heat & Mass Transfer-I

Course Objectives

- To introduce the principles of simultaneous heat and mass transfer with emphasis on their applications to practical chemical engineering problems.
- The mathematical equations describing coupled heat and mass transfer processes which provide basics for designing the unit operations for thermal separation processes.
- Design of equipment based on above mentioned knowledge

Course Contents

- Drying: General principles, Rate of drying, The mechanism of moisture movement during drying
- Diffusion and Capillary theory of drying
- Classification and selection of dryers(Tray, tunnel, rotary, drum, spray, pneumatic, fluidized beds, turbo-shelf, disc and centrifuge dryers)
- Solvent drying
- Superheated steam drying
- Freeze drying, flash drying, partial-recycle dryers
- The drying of gases
- Multi-component distillation: Degrees of freedom in separation specifications. Key components in multi-component mixtures and recovery fraction. Continuous flash distillation with heat balancing.
- Equilibrium and enthalpy expressions. Multi-stage distillation separations. Minimum stages in ideal systems (Fenske equation) and minimum reflux ratio calculations (Underwood equation)
- Approximate calculation of stages for partial reflux from the Gilliland and Erbar-Maddox correlations
- The column rating approach to rigorous distillation models
- The Wang-Henke model as applied to an ideal mixture for both simple and complex columns
- Numerical examples of multi-component separation problems. Side streams and partial condensers
- Column Design: Tray design; hydraulics and performance
- Azeotropic and Extractive distillation: Heterogeneous azeotropes. Illustrative examples of azeotropic distillations. Condensation of steam-hydrocarbon-inert gas mixtures with two liquid phases. Decanter design for separation of the phase, steam distillation.

- Liquid-Liquid extraction: Introduction, Extraction Processes, Equilibrium data
- Classification of extraction equipment
- Stage-wise equipment for extraction
- Differential contact equipment for extraction, Use of specialized fluids
- Leaching: General principles, Factors influencing the rate of extraction, Mass transfer in leaching operations, Equipments for leaching, Calculation of the number of stages by graphical methods
- Membrane separation: classification of membranes & processes, micro filtration, nano filtration, reverse osmosis, liquid separation gas separation
- Adsorption: Introduction, The nature of adsorbents, Adsorption equilibrium, Adsorption from liquids, structure of adsorbents, Adsorption equipment and regeneration of spent adsorbents

List of Practical

Sr No.	**Name of Equipment**	**Name of related experiment**
1	Gaseous Diffusion Coefficient Apparatus (GDC)	1. To find out Liquid Diffusion Coefficient of Acetone
		2. Determination of the mass transfer co efficient. 3. To calculate the amount of concentrated product & condensate.
2	Liquid Liquid Extraction Unit (LLE)	1. To study the liquid extraction of liquid mixtures by contact a solvent by using L.L.E
		2. To recover the solvent used in L .L.E experiment of liquid mixtures.
		3. To determine the distribution co-efficient for dichloromethane, water, Acetic acid to show its dependence on concentration.
3	Single Effect Falling Film	1. To find out evaporation losses by using Single Effect Falling Film Evaporator.
		2. To find out the efficiency of Single Effect Falling Film Evaporator by

	Evaporator (FFE)	using Single Effect Falling Film Evaporator.
		3. To find out product to condensate ratio.
4	Gas Purification Unit (GPU)	1. To calculate the amount of CO_2 absorbed in absorber by using DEA solution.
		2. To calculate the amount of CO2desorbed in stripper by using DEA solution.
		3. To calculate the overall efficiency of gas absorption column.
5	Tray Dryer (TD)	1. To find out moisture contents & drying rate of a wet solid being dried with fixed air temperature.
		2. To find out moisture contents & drying rate of a wet solid being dried with fixed air velocity.

Course Outcomes

- Learning the fundamentals of drying process, selection and classification of dryers based on their respective applications & design calculations for a dryer.
- Learning the fundamentals of multi-component, multi-stage distillation process, calculations for number of stages, reflux ratio & design principles of a distillation column.
- Understanding the principles of azeotropic and extractive distillation, decanter design for phase separations

Recommended Books

- McCabe Warren L., Smith Julian C., Harriott peter “Unit Operations of chemical Engineering” 7th Ed. 2005. McGraw Hill Inc.
- Coulson J.M., Richardson J.F. “Chemical Engineering” Vol.-II, 5th Ed. 2002. The English Book Society and Pergamon Press.
- Coulson J.M., Richardson J.F. “Chemical Engineering” Vol-I, 1999. The English Book Society and Pergamon Press
- Foust Alan S., Wenzel Leonard A., Clump Curtis W., Maus Louis and Anderen L. Bryce “Principles of Unit Operations” 2nd Ed. , 1963, John Wiley and sons.
- Incropera Frank P., De Witt David P. “Fundamentals of Heat and Mass Transfer” 3rd Ed. 1990. John Wiley and Sons.
- Treybal Robert E. “Mass Transfer Operations”, 1981, McGraw Hill Book Company.

CHE-323: Instrumentation and Process Control

Credit Hours: 3-1
Pre-requisites: None

Course Objectives

- The aim of studying Instrumentation and Process control is to familiarize with basic concepts process control and instrumentation required for controlling.
- Various control strategies, controlling equipment behaviors and their response analysis.

Course Contents

- Importance of process sensors and incentives for process control
- Instrumentation: Principles of measurement of temperature. Pressure level, flow, concentration. Description of sensors for process variables
- Characteristics and calibration of sensors
- Transmitters and transmission lines
- Instrumentation and Control systems documentation; Process Flow Diagram and P&ID Diagram
- Laplace transform of differential equations and characterization of systems
- Transfer functions and Block diagram
- Dynamic behavior of first and second order systems
- Feedback control; types of feed-back controllers
- Control valves; Fail safe mode, valve characteristics and valve sizing
- Dynamic behavior of feedback controlled processes; closed loop response, servo and regulator problems
- Frequency response analysis
- Stability analysis of feedback control system using Routh-hurwitz and Bode stability methods
- Multi-loop Control; cascade control, ratio control, split range control, feed-forward control
- Safety instrumented system; alarm, trip and interlock system

Course Outcomes

After completing this course, students must possess:

- Basic understanding of instrumentation, their principles of operation, advantages and disadvantages.
- Essential understanding of various instruments used and applied din process industry for process control.

- Complete knowledge of control system, its characteristics and components.
- Recognition and identification of various Process diagrams and symbols used in IPC.
- Different types of controllers, their application in industries, advantages and disadvantages.
- Basic design concepts of different controllers.
- Requirement for a successful installation, instrument checkout and controller tuning.

List of Practicals

Experiment No.	Experiment Title
1	Calibrate the automatic flow sensor with rotameter in the flow control unit and perform its line tracing
2	Calibrate the automatic temperature sensor with thermometer in the temperature control unit and perform its line tracing
3	Calibrate the automatic level sensor with manual scale reading in the level control unit and perform its line tracing
4	Calibrate the automatic pressure sensor with manometer in the pressure control unit and perform its line tracing
5	Implement the feedback control loop in ON/OFF mode in flow control unit to achieve required set point using different values of the tolerance band
6	Implement the feedback control loop in PID mode in flow control unit to achieve required set point using different values of the proportional band K_c
7	Implement the feedback control loop in ON/OFF mode in level control unit to achieve required set point using different values of the tolerance band and analyze the graphical variation of level with respect to time
8	Implement the feedback control loop in PID mode in level control unit to achieve required set point using different values of the proportional band K_c and analyze the graphical variation of level with respect to time
9	Implement the PID mode control loop in the pressure control unit for achieving different set points; also analyze the behavior of PID controller in case of an external disturbance
10	Implement the PID mode control loop in the pressure control unit for achieving required set point using different values of the proportional band K_c and conclude it graphically
11	Implement feedback control PI mode in the flow control unit for achieving required set point using Ziegler-Nichols control loop method
12	Implement feedback control PID mode in the flow control unit for achieving required set point using Ziegler-Nichols control loop method.

Recommended Books

- Smith, C. A, Corripio, A. B, Principles and Practice of Automatic Process Control, 3rd Edition, John Wiley, 2006.
- Marlin, T.E., Process Control, 2nd Ed., McGraw Hill Book Co., 2000.

- T.A.Hughes, Measurement and Control Basics, ISA Publication, 2002.
- Coughanown, D.R. and S.E.LeBlanc, Process system Analysis & Control, 3rd Edition McGraw Hill, 2009.
- Seborg, D.E, D.A. Mellichamp, T.F.Edgar, F.J.Doyle,Process Dynamics and Control, 3rd Edition, John Wiley, 2011.
- G. Stephanupolos,Chemical Process Control: An Introduction totheory and practice, Prentice Hall 2002.
- Anderson, N.A., Instrumentation for Process Measurement and Control, 3rd Edition, CRC Press, 1998.

CHE-347: Chemical Reaction Engineering

Credit Hours: 3-1
Pre-requisites: None

Course Objectives

- To provide in-depth knowledge of the application of laws of thermodynamics, reaction kinetics for the economical design of chemical reactors
- searching for a mechanism of reaction

Course Contents

- Kinetics of homogeneous reactions
- Rate of reaction
- Variables affecting the rate of reaction
- Order of reaction
- Rate constant
- Activation energy and temperature dependency
- Interpretation of batch reactor data for single and multiple reactions
- Integral method and differential method of analysis for constant volume and variable volume batch reactors
- Search for a rate equation
- Design of homogeneous reaction
- Batch, Mixed flow, Plug flow reactors
- Comparison of single reaction
- Multiple reaction systems in parallel/series
- Temperature and pressure effects
- Adiabatic and non-adiabatic operations
- Surface phenomenon and catalysis
- Heterogeneous reaction systems
- Rate equations for heterogeneous reactions
- Flow pattern, contacting and non- ideal flows
- Determination of rate controlling steps
- Kinetics of solid catalyzed reactions
- Design of fluid-solid catalytic reactors

Course Outcomes

- After taking this course, student should have knowledge how to implement reaction kinetics for the economical design of chemical reactors.

List of Practicals

Name of Equipment	Exp. No.	List of Experiments
	Lab-1	Line tracing, demonstration and understanding of software and calibration.
Batch Reactor	1	Determination of the ionic conductivities using conductivity cell and conductivity meter
	2	Obtaining the reaction order with respect to sodium hydroxide using initial rate method
	3	Perform integral method of analysis to estimate reaction equation
	4	Perform differential method of analysis to estimate reaction equation
	5	Perform the half-life method of analysis to estimate the reaction equation
CSTR	1	To calculate effect of temperature on conductivity using different solvents
	2	To estimate dependence of speed constant and conversion on temperature
	3	To determine the conversion regarding to residence time
PFR	1	To calculate the theoretical and practical conversion on PFR
	2	Variation of the kinetic constant with temperature. Arrhenius Equation
	3	To estimate dependence of residence time on conversion
Photo catalytic Reactor (PC)/ Electrochemical work station	1	U-V analysis to find out the reaction Kinetics
	2	To study photo degradation reaction for toxic dyes and study of reaction kinetics
	3	To study of oxygen reduction reaction using electrochemical workstation

Recommended Books

- Levenspiel Octave. “Chemical Reaction Engineering” 2nd Ed. 1999, John Willey & Sons Inc.
- Smith J.M. “Chemical Engineering Kinetic” 2001, McGraw Hill Book Co.
- Fogler H. Scott. “Elements of Chemical Reaction Engineering” 2nd Ed. 2001. Prentice Hall.
- E Bruce Naumen “Chemical Reactor Design, Optimization and Scale up” McGraw Hill 2000

CHE-345: Transport Phenomena

Credit Hours: 3-0

Pre-requisites: CHE-221: Fluid Mechanics-I,

CHE-343: Simultaneous Heat & Mass Transfer-I

Course Objectives

- To study transport phenomena to recognize the basic equations involving in momentum, energy and mass transfer.
- To introduce with the mathematical tools needed to develop and understand these basic equations are analogous, which gives a balanced overview in the field of transport phenomena.

Course Contents

- Transfer processes: A review of the mechanisms of momentum, energy and mass transport. Balance principles for momentum. Energy, and mass.
- Momentum transport: Diffusivity and mechanism of momentum transport. Derivation of equations of continuity and motion (Navier-Stokes). Application to laminar flow problems. Interphase transport in isothermal systems; friction factor. Macroscopic balances in isothermal systems.
- Energy transport: Thermal conductivity and mechanism of energy transport. Derivation of energy equation. Application to heat transfer problems involving conduction, free/forced convection and radiations. Interphase transport in non-isothermal systems, heat transfer coefficients. Macroscopic balances in non-isothermal systems.
- Mass transport: Diffusivity and mechanism of mass transport. Derivation of species conservation equations for binary and multi-component mixtures. Application to mass transfer problems with and without chemical reaction. Interphase transport in non-isothermal systems, mass transfer coefficients.
- Transport in turbulent flow: Fluctuations and time-averaged quantities. Time averaged form of the governing equations of momentum, energy and mass transport. Expressions for the Reynolds stresses, turbulent energy and mass flux. Temperature and concentration distribution in turbulent pipe flows

Course Outcomes

After completing this course, student will be able to:

- Fundamental understanding of basic equations that describes momentum, energy and mass transport
- Formulate macroscopic mass, momentum and energy balances and dimensional analysis to solve engineering problems related to fluid flow

- Solve equation of motion, equation of continuity and Navier-Stokes equations to analyze engineering problems related to Newtonian fluid flow in Laminar flow
- Develop and understand the equations of change which describe how the mass, energy, momentum and angular momentum change within the small region
- Determine the velocity, temperature and concentration profiles of different systems
- Numerical and analytical problems solving skills and techniques in the field of mass, energy, momentum and angular momentum
- Use these equations of change to solve the problems of transport phenomena
- Calculate heat transfer coefficients for different systems
- Determine the heat transfer rate for single and composite walls
- Estimate molar/mass flux and concentration profiles for steady-state and unsteady-state molecular diffusion

Recommended Books

- Bennett C.O., Myers J.E. “Momentum, Heat & Mass Transfer” 3rd Ed. 1983. McGraw Hill Book Company.
- Bird R. Byron, Stweart Warren E., Lightfoot Edwin N. “Transport Phenomena”, second edition,2002, John Wiley & Sons Inc.
- Brodkey Robert S., Hershey Harry C. “Transport Phenomena –A unified Approach”, 1988, McGraw Hill International Editions.
- J.R.Welty, C.E.Wicks, R.E.Wilson, and G.L.Rorer, “Fundamentals of Momentum, Heat, and Mass Transfer” 5 th Edition, 2008, John Wiley & Sons
- Tosun I. “ Modeling in Transport Phenomena: A Conceptual Approach”, 2nd Edition, 2007, Elsevier.

ECO-130: Engineering Economics

Credit Hours: 2-0
Pre-requisites: None

Course Objectives

- To familiarize students with the concepts of economics and their application in chemical engineering design for the purpose of cost estimation and profitability analysis.
- manufacturing economics modeling methods, and life-cycle environmental evaluation

Course Contents

- Material choice concepts
- fundamentals of engineering economics
- Engineering costs and costs estimation
- interest and equivalence
- arithmetic gradient
- geometric gradient
- economic criteria
- annual cash flow analysis
- rate of return analysis, incremental analysis
- uncertainty in future
- depreciation, income taxes
- inflation and price change
- selection of a minimum attractive rate of return
- economic analysis in the public sector

Course Outcomes

- Student should know how to implement the concepts of economics to design and estimate the cost of a chemical engineering design.

Recommended Books

- William G Sullivan, Elin M Wicks, and James Luxhoj, *Engineering Economy (13th Edition), 2005*
- GT.Thuesen and W.L.Fbrychy, Engineering Economy, 9th Edition Prentice Hall India, 2005
- Leland blank and Anthony, Tarquin, Engineering Economy, 9th edition, McGraw-Hill,2005
- Donald G. Newnan, Ted Eschenbach, and Jerome P. Lavelle, Engineering Economic Analysis, Oxford University Press 2006.

Semester-7

CHE-422: Fuels & Combustion

Credit Hours: 3-1
Pre-requisites: None

Course Objectives

- To provide in-depth knowledge of selection and efficient utilization of fossil fuels and alternate energy resources.
- Phase Interface Energy Balance

Course Contents

- Fuels Survey of available fuels; Industrial fuels
- Classification and storage of solid, liquids and gaseous fuels
- Criteria for the selection of fuels for industrial purposes; Coke and its industrial manufacture and uses
- Petroleum and its distillation products; Synthetic fuels Thermo-chemistry/Chemical Kinetics
- First law of Thermodynamics
- Enthalpy of Formation
- Enthalpy of Combustion and Heating Values
- Adiabatic Flame Temperature
- Chemical Equilibrium, Bimolecular Reactions & Collision Theory
- Rates of Reactions for multistep mechanisms
- Chemical Mechanisms of H_2-O_2 , CO oxidation
- Methane Combustion & others. Laminar Premixed & Diffusion Flames
- Mass and Energy conservation in premixed flames, structure of the ideal, adiabatic, one-dimensional, premixed flame, Properties of the premixed flame
- Properties of diffusion flames, Flame Diagnostics – Laser-induced fluorescence, Planar Imaging Techniques. Turbulent Flames
- Turbulent Premixed Flame Speed & Structure, Three Flame Regimes, Wrinkled Flame Regime, Flame lets in Eddies Regime & Flame Stabilization
- Jet Flames, Simplified Analysis and Flame liftoff and blowout. Some Applications; Industrial Gas Burners/Furnaces, Gas-Turbine Engines, Spark-Ignition Engines (2 Lectures)
- Droplet Evaporation and Burning
- Burning of a liquid droplet; Diffusion of oxygen outside the flame front, Droplet-Gas-, An expression for the Flame Temperature, Droplet Lifetimes
- Applications; Droplet combustion in heavy fuel oil burners, Diesel Engines, Liquid-Rocket Engines
- Burning of Solids

- Coal-fired Boilers, Burning of Coal – one-film model, two-film model, Coal combustion and particle burning times
- Detonations
- Shock Waves, Structure of detonation waves, Initiation of detonation and the deflagration to detonation transition, Detonation velocities

Course Outcomes

- After taking this course, student should have knowledge regarding selection of viable energy resources.

List of Practicals

Sr No.	Name of Equipment	Name of related experiment
1	Cloud and Pour Point Apparatus (CPP)	1. To predict & analyze the cloud and pour point of given sample of Kerosene oil.
		2. To predict & analyze the cloud and pour point of given sample of cooking oil.
		3. To predict & analyze the cloud and pour point of given sample of pyro diesel.
		4. To predict & analyze the cloud and pour point of given sample of high speed diesel.
		5. To predict & analyze the cloud and pour point of given sample of petrol.
2	Red Wood Viscometer (RWV)	1. To predict & compute kinematic viscosity of diesel oil by using Redwood viscometer.
		2. To predict & compute kinematic viscosity of petrol using Redwood viscometer.
3	Engler Viscometer (EV)	1. To predict & compute kinematic viscosity of cooking oil by using Engler viscometer.
		2. To predict & compute kinematic viscosity of lube oil by using Engler viscometer.
4	Flash & Fire Point Tester (FFP)	1. To predict & compute flash point & fire point of kerosene oil.
		2. To predict & compute flash point & fire point of diesel oil.
		3. To predict & describe flash point &

		fire point of blend of ethanol with water.
		4. To predict & describe flash point & fire point of blend of methanol with water.
		5. To predict & describe flash point & fire point of pyro diesel.
5	Junker Gas Calorimeter	1. To estimate, compute & analyze calorific value of gaseous fuel & flue gas.
		2. To estimate, compute & analyze the amount of process condensate during combustion of fuel.
6	Automatic Viscometer	1. To estimate, compute & analyze the viscosity of Brake Oil using Automatic Viscometer
	Open Ended Lab	To predict & compute Flash & Fire Point of different Diesel Blends

Recommended Books

- Turns, S R. “An Introduction to Combustion” 2nd Edition McGraw Hill. 2000.
- Griffiths, J.F. & Barnard, J.A. “Flame and Combustion”, 3rd Edition, Blackie Academic & Professional. 1995.
- Harked J.H., Backhurst J.R. “Fuel and Energy” , 1981, Academic Press”
- Probstein, “Synthetic Fuels”, McGraw Hill.
- Marion Smith, “Fuels and Combustion”, McGraw Hill.

CHE-451: Chemical Engineering Plant Design

Credit Hours: 3-0

Pre-requisites: CHE-343:Simultaneous Heat & Mass Transfer-I
CHE-345: Transport Phenomena
CHE-347:Chemical Reaction Engineering
CHE-348: Simultaneous Heat & Mass Transfer-II

Course Objectives

- This course is focused on the design and economic principles applied in chemical engineering processes and operations.
- This course fills the need for design, implementation and the control of existing chemical plant and new development. Knowledge of environment and safety issues regarding chemical plant with focus on minimization of pollution.
- Optimizing the energy needs, with focus on minimization of cost and maximization of profit. Different issues faced during the operation of plant. Different strategies for the design of chemical equipment including pumps, compressors, tanks, vessels, heat exchangers, towers and reactors.

Course Contents

- Introduction to design, and general design considerations
- Design information and data; sources of physical properties, design codes and standards
- Material and energy balances for plant design
- Development of process flow diagrams
- Design of heat and mass transfer equipment
- Selection of materials for process equipment
- Selection pumps and compressors
- Vessel design: Low, medium and high pressure storage and transportation vessels. Cryogenic vessels
- Cost estimation and feasibility analysis
- Health and safety; Fire and explosion hazards; HAZOP; Optimum design; Design codes & standards

Course Outcomes

The student, upon completion of this course, will be able to:

- Analyze the aspects of chemical process design, equipment and materials of construction
- Conduct energy and mass balances for a chemical process
- Draw, read and calculate the process flow sheets and P&I diagrams

- Evaluate capital, purchased equipment and operating cost for chemical engineering plant
- Apply the engineering concepts to design heat and mass transfer process and equipment
- Conduct safety and loss prevention analysis, Hazard analysis
- Select site layout, plant location and assess/prevent the environmental impact of the chemical plant

Recommended Books

- Peters Max S., Timmerhaus Klaus D. “Plant Design and Economics for chemical Engineers” 4th Ed. 1991. McGraw Hill Inc.
- Ludwig Ernest E. “Applied Process Design for Chemical and Petrochemical Plants” Vol. 1, 2& 3, 3rd Ed.2002, Gulf Publishing Company.
- Walas Stanley M. “Chemical Process Equipment – Selection and Design “Butterworth Heinemann” 1999.
- Coulson J.M, andRichardson, “Chemical Engineering”,Vol.VI, “Butterworth Heinemann” 1999.
- Wells G. L. Rose L.M. “The art of Chemical Process Design” 1986. Elsevier.
- Smith Robin “Chemical Process Design” 1995. McGraw Hill Inc.
- Backhurst&Harker, “Chemical Process Design, John Willey
- Evans, “Handbook of Chemical Equipment Design”
- E.L. Cussler and G.D. Moggridge, “Chemical Product Design”, 2001, Cambridge University Press.
- Special Issue of Chemical Engineering Research and Design, Part A 80 (A1), 2002 on “Process and Product Development”
- James Wel, Molecular Structure and Property: Product Engineering, Ind. Engg. Chem. Res. 41(8) 1917-1919 (200

CHE-499 Final Year Project

Elective-I (Technical)

CHE-452: Chemical Process Design and Simulation

Credit Hours: 2-1
Pre-requisites: CHE-316:Simultaneous Heat & Mass Transfer
CHE-323:Transport Phenomena

Course Objectives

- To learn fundamentals of Chemical Process Design and Simulation, and get skills of using Aspen HYSYS software for designing Process Flow Diagram (PFD) of any assigned chemical engineering process.
- Additionally, basics of Matlab will be taught to have an alternative or supporting system to Aspen HYSYS for dealing with more challenging design problems.

Course Contents

- Design & Simulation Software: Introduction to various design and simulation software e.g., HYSYS, ChemCAD etc. (A particular software may be selected to cover the rest of the course contents)
- A review of capabilities and limitations of the design / simulation software. Flowsheets and sub-flowsheets.
- Defining process streams and use of Fluid Packages
- Adding common unit operations in the flow sheet. Drawing simple Process Flow Diagrams (PFD) in HYSYS, steady state material and energy balances using graphical user interface and worksheet. Adding instrumentation and control components. Simple transient calculations.
- MATLAB Primer: Introduction to MATLAB, Linear algebra applications: matrix calculations, solution of linear equations, Eigen value calculation
- Plotting of various types of graphs using ezplot and plot functions. Symbolic mathematics: symbolic differentiation and solution of differential equations. Numerical solution / calculation of integrals, derivatives, and differential equations.
- Introduction to Simulink, simulation of a typical feedback control loop in Simulink

Course Outcomes

After completing this course, student will have the fundamental understanding of Aspen HYSYS and MATLAB. He/she will be able to use the skills of Aspen HYSYS to design a process pertaining to chemical engineering.

List of Practical

Practical exercises relating to the topics covered in theory.

Recommended Books

- Systematic Methods of Chemical Process Design, Lorenz T. Biegler/Ignacio E. Grossmann/Arthur W. Westerberg, Prentice Hall PTR, New Jersey 07458
- Chemical Process Design and Integration, Robin Smith. (E-Book)
- Integrated design and simulation of Chemical processes, Mexandre C. Dimian. (E-Book)
- Aspen HYSYS and MATLAB User Guides.

Semester-8

CHE-425: Maintenance and Process Safety

Credit Hours:3-0

Pre-requisites: None

Course Objectives:
To familiarize the students with the Importance of process safety with increased productivity and overall safety of plant and personnel

Course Contents

- Types of maintenance; preventive, predictive, and total productive maintenance
- Maintenance of rotary and stationery equipment
- Inspection techniques, non-destructive testing techniques
- Lubrication and lubricants
- Basic concepts: hazard, risk, hazard rules, types of accidents their causes & effects
- Risk analysis methodologies, Evaluation of risk and quantification
- Hazard Identifications: HAZOP, HAZAN, safety review and safety audit
- Gas, vapor and dust explosion
- Fire and Explosion**:**:The fire triangle and the factor contributing to fire and explosion
- Concept of Ignition, ignition energy. source of ignition, auto ignition, auto oxidation, adiabatic compression, role of fuel spray, purging of equipment, ventilation of space, control of static electricity
- Safety equipment: firefighting and sprinkle system
- Runaway reactions: causes, characterization, prevention, vent sizing
- Atmospheric dispersion: factors affecting dispersion and their modeling
- Safety management: process safety management, disaster control organization, OSHA guidelines
- Toxicology and industrial hygiene: Typical toxins and their biological effects, toxicological parameters, release and flow of toxic gases
- Environment impact assessment: cost and benefits of EIA, EIA process, public consultation and participation in EIA process, EIA method & its techniques for impact prediction and evaluation

Recommended Books

- Crowl D. Y, Louvar J.F.Chemical Process Safety Fundamentals with Applications. Prentice Hall, Englewood, 1990.
- Pandya C.L, Hazards in Chemical Units, Oxford ISH 1991.
- Grimaldi J. H, Simonds, R.H, .Safety Management. 5/e AITBS, Delhi,1990
- Roy E. Sandlers, .Chemical Process Safety., Learning from Case Histories,Butterworth. 1999.

- Marc J.Assael and Konstantinos E. Kakosimos, Fires, Explosion and Toxic Gas Dispersion, CRC Press, 2010
- Thomas A. Wester-Kamp, “ Maintenance Manager’s Standard Manual, Prentice-Hall.

OMT-456: Production & Operations Management

Credit Hours: 3-0
Pre-requisites: None

Course Objectives

- The objective of course is to give students an introduction to the functional area of production and operations management as practiced in manufacturing industries and the services sector.
- It includes, waiting lines, quality control, just-in-time systems, forecasting, aggregate planning, inventory management, materials requirements planning (MRP), and operations scheduling.
- Decision-making, project management, facility layout in both manufacturing and services industries
- Types of production
- Capital investment for manufacturing

Course Contents

- Manufacturing systems
- Production principle
- Transformation of input into output
- Definition of systems
- Structural aspects of manufacturing systems
- Mass production
- Integrated manufacturing and management
- Material and technological information flow
- Product/process planning and design
- Layout planning and design, aggregate production planning
- Production scheduling
- Production control and quality
- Value and cost
- Manufacturing cost
- Product cost
- Profit planning and breakeven analysis

Course Outcomes

- After taking this course, student should have knowledge regarding principles and techniques used in different chemical plants.

Recommended Books

- KatsundoHitomi, *Manufacturing Systems Engineering: A Unified Approach to Manufacturing Technology, Production Management and Industrial Economics, 2nd Edition, 1996, Taylor and Francis, London.*
- Walter Rautenstrauch, *The Economics Of Industrial Management.*

CHE-499: Final Year Project

Elective-II

Elective-III (Social)

ELECTIVE SUBJECTS

CHE-340: Biochemistry

Credit Hours: 3-0
Pre-requisites: CH-202: Organic & Biochemistry

Course Objectives

- To familiarize students with basic concepts of biological science and its applications in chemical engineering.
- Introduction to biochemistry

Course Contents

- Carbohydrates: Introduction, classification, structural chemistry, chemical properties with detailed studies of glucose, fructose, sucrose and cellulose
- Proteins: Introduction, classification, amino acids chemistry, synthesis and reactions of amino acids. Primary and secondary structures of proteins. Chemistry of polypeptides
- Lipids: Introduction, classification, structure and reaction chemistry with emphasis on fatty acids. soaps and detergents
- Enzymes: Introduction, nomenclature, classification, enzyme inhibitors, co-factors, kinetics and mechanism of enzyme action
- Metabolism of carbohydrates, proteins and lipids

Course Outcomes:

- After taking this course, student should be familiar with the concepts of biological science and its application to be used in chemical engineering.

Recommended Books

- Biochemistry, Christopher K. Mathews, 3rd edition, 2004, John Wiley & Sons.
- Principles of biochemistry, Horton H. R. et al., 4th edition, (Pearson)
- An Introduction to biochemistry, Trudy McKee, James R. McKee, 1999.
- Biochemistry, R. H. Garrett, C. M. Grisham, 1998, Harcourt College Pub.
- Concise Encyclopedia of Biochemistry, Thomas A. Scott, 3rd ed., 1981.

CHE-350: Petroleum Refinery Processes

Credit Hours: 3-0
Pre-requisites: None

Course objective

- The proposed specialization stream would provide an opportunity for the chemical engineering students to be trained as professionals equipped with academic background and skills to tackle the technical challenges related to Oil & Gas Industry.
- The graduating students would have a diverse range of venues to work in different areas like, oil wells, offshore drilling, oil/gas exploration, Oil refining and gas processing facilities.

Course Contents

- Introduction; origin; formation and composition of petroleum
- Indigenous and world resources
- Refinery products; properties; significant tests and standard test methods; characterization and evaluation of crude oil stocks
- generation of crude processing data; Crude pre-heating and preliminary treatment; pipestill heaters
- Desalting; atmospheric and vacuum distillation; steam stripping; arrangement of towers
- Calculation of number of trays, types of reflux employed; Packie's approach; processing plans, schemes and product patterns of refineries.
- Modern separation, conversion and treatment processes;Thermal and catalytic cracking and reforming isomerization. Merox treatment. Naptha and Diesel hydrodesulfurization. hydro-cracking, residue up-gradation, lube oil production.
- Auxiliary processes and operations; Sour water strippers, amine treatment, sulfur recovery units, hydrogen production, refinery corrosion and metals; blending plants, product design and marketing
- Use of linear programming techniques to solve refinery blending and production problems; Overview of petroleum act.

Course Outcomes

- After taking this course, student should have knowledge regarding all the important processes and operations going on in petroleum industry.

Recommended Books

- W. L. Nelson, Petroleum Refinery Engineering, 1991, McGraw-Hill.
- G. D. Hobson, Modern Petroleum technology, 1991, Applied Sc. Publisher.

- J. H. Gary and G.E Handwerk, Petroleum Refinery Technology & Economics, 2001, Dekker.
- S. Parkash, Refining Processes Handbook, 2003, Elsevier/GPP.
- R.A.Meyers, Handbook of Petroleum Refining Processes, 1996, McGraw-Hill.

CHE-360: Fundamentals of Polymer Engineering

Credit Hours: 3-0
Pre-requisites: None

Course objective

- To enhance the knowledge of polymers, their raw materials, processing techniques, and uses

Course Contents

- Structure and properties of polymers
- Analysis and testing of polymers
- Methods of polymerization and co-polymerization
- Preparation and properties of commercially important polymers
- Polymers processing, equipment and machinery
- Polymer blends, formulation and performances
- Synthesis of high polymers, properties, thermodynamics and molecular weight
- Polymer additives, blends and composites
- Commodity thermoplastics and specializing polymers
- Polymer processing and theology
- Application of polymers

Course Outcomes

- After taking this course, student should have knowledge the importance and utilization of polymers in chemical industry.

Recommended Books

- Fried Joel R. “Polymer Science and Technology”, 2000, Prentice Hall.
- Stanley Middlean, Fundamentals of Polymer Engineering, 3rd Edition,1996
- Tim A. Ossworld, Georg Menges, Hanser Material Science of Polymer for Engineering 2003.
- I. M. Ward & D. W. Hadley, Wiley, An Introduction to the Mechanical Properties of Solid Polymer, 3rd Edition, 1998.

ENE-306: Fundamentals of Environmental Engineering

Credit Hours: 3-0
Pre-requisites: None

Course objective

- To impart knowledge of environmental pollution, its control considering the national and international standards, and its impact on environment and ecology.
- pollution concept, types of pollution
- water pollution control technologies
- water treatment technologies, soil pollution control technologies

Course Contents

- Introduction to environment and ecology
- Environmental policy and standards
- Environmental Monitoring (Air, Water & Soil)
- Objectives of sampling and monitoring programme
- Design and types of samples
- Pre-sampling requirements/information
- sampling and design purposes
- Air pollution control technologies
- noise pollution control technologies
- Biotechnology for environment
- industrial pollution control; Occupational safety devices
- Principles and purposes of IEE and EIA and its significance for the society
- Cost and benefits of EIA
- Main stages in EIA process
- Public consultation and participation in EIA process. EIA methods and techniques for impact prediction and evaluation

Course Outcomes

- After taking this course, student vision regarding impact of chemical processes on the environment should be improved.

Recommended Books

- Cheremisinoff, “Handbook of air pollution prevention and control”, 2002.
- P.Venugopala,”Textbook of Environmental Engineering” PHI Learning Pvt. Ltd, 2002
- Gilbert M. Master and Wendell P, Ela, “Introduction to Environmental Engineering and Science” 3rd Edition, 2007.

CHE-442: Membrane Technology

Credit Hours: 3-0
Pre-requisites: None

Course Objectives

- This course basically focused on liquid and gas separation technologies applied in Chemical and Bio-chemical engineering processes and operations. This course deals with procedures, designs and implementations of different separation technologies.
- Knowledge of purification of water and separation of different gases for further utilization. Advantages from medical point of view include drug delivery and artificial kidneys. Purification of Natural and Flue gases to avoid global warming and increasing the efficiency of fuel. Different modules and chemicals used in these separation techniques.
- This course gives an overall analysis and comparison of different separation techniques from the point of view of efficiency and economics.

Course Contents

- Membranes for separation processes
- Membrane materials, membrane preparation
- Characterization of membranes
- Membrane transport/solution-diffusion model
- Membrane transport/pore model
- Membrane modules
- Concentration profiles in laminar flow channels
- Membrane reactors, membrane processes

Course Outcomes

The student, upon completion of this course, will be able to:

- Analyze the aspects of liquid and gas separation techniques, design, equipment and materials of construction
- Synthesize different membranes using different procedures.
- Learn reverse osmosis and gas separation mathematical models
- Learn various separation mechanisms involve in these techniques.
- Analyze the effect of different membrane modules in each separation technique
- Conduct safety and loss prevention analysis, Hazard analysis
- Analyze these techniques economically, using data of different papers published recently

Recommended Books

Marcel Mulder,Basic Principles of Membrane Technology.

R.W.Baker," Membrane Technology and Applications", 2006, Wiley.

CHE-441 Fermentation Technologies

Credit Hours: 3-0
Pre-requisites: CHE-340 Biochemistry

Course Objectives

- To teach the fundamental aspects of Fermentation Technology
- Fermenter: Design, operation and applications

Course Contents

- Fermentation biotechnology: Introduction and historical perspective
- Microbiology of industrial fermentations
- Fermentation kinetics
- Microbial synthesis of commercial products
- Biomass fermentation for bio-fuels, Optimization of fermentation processes by quantitative analysis
- Biosensors and Bio-processing monitoring and control
- Control of Fermentation processes
- Kinetics, modeling, optimization and control of fermentation process
- Separations and purifications techniques in fermentation
- Enzymology, safety aspects in working with enzymes
- Industrial fermentation, production processes of various industrial products. The fermentation industries such as glutamic acid, citric acid baker yeast, enzymatic conversion of starch to glucose/fructose syrup
- Hydrodynamics of aerated systems: Flow regime (laminar/turbulence) & bubble size effects on oxygen transfer
- Fermenter Mathematic modeling: Batch fermenter, Chemostat fermenter

Learning Objectives

- Examine the application of biological and engineering principles to problems involving biological/biochemical systems
- Recognize the fundamentals of fermentation technology
- Assess power requirements in bioreactors, modeling of bioprocesses, traditional and new concepts in bioprocess monitoring, and the biological basis for industrial fermentations and cell cultures
- Distinguish bioreactor operations, oxygen transfer and shear in bioreactors, process improvement through metabolic manipulations, and scale-up of bioreactors
- Analyze the bioprocess paradigm: scale-down, bioprocess economics, sterilization
- Examine considerations in bioprocess sterilization in biological manufacturing

Course Outcomes

- After taking this course, student should have knowledge regarding the fundamental aspects of fermentation technology and their utilization in chemical engineering industry.

Recommended Books

- Fermentation and biochemical engineering handbook, Henry C. Vogel, 2nd edition, 1996.
- Principles of fermentation technology, by P. F. Stan bury, 2nd edition, 1999.
- Fermentation Microbiology and Biotechnology, E. M. El-Manse and C. Bryce, 2nd edition, 2006.
- Microbial Biotechnology: Principles and Applications, Lee Yuan Kun, 2nd edition,
- Fermentation Microbiology and Biotechnology, Mans El-Mans, Charles F. A. Bryce
- Modeling and Control of Fermentation Processes, James R. Leigh
- Biofuels for Fuel Cells: Renewable Energy from Biomass Fermentation, P N L Lens, P. Wassermann.

OTM-454: Project Management

Credit Hours: 3-0
Pre-requisites: None

Course Objectives

- To provide understanding of the principles and techniques of project management.

Course Contents

- Concepts of project management, project initiation, methodologies, project proposal process, project proposal document, milestones and deliverables, different kinds of projects and stakeholders, objectives, project plan and project approach, staffing plan, quality plan, deployment plan, organizational plan, monitoring and reporting processes.
- Decision Support System (DSS), Project schedule, project development, managing obstacles and risks, managing communication, integration and testing, project closure, case studies.

Course Outcomes

- After completing this course, student should know how to manage a project in industry.

Recommended Books

- Colleen Gorton and Erika McCulloch, Fundamentals of Technology Project Management, 2004, MC Press.
- Harold, Cerner, Project Management: A systematic approach to Planning, Scheduling and Controlling, 9th Edition, 2006 John Wiley and Sons.

CHE-461 Polymer Reaction Engineering

Credit Hours: 3-0
Pre-requisites: None

Course objective

- The proposed specialization stream would provide an opportunity for the chemical engineering students to be trained as professionals equipped with academic background and skills to tackle the technical challenges related to Polymer processing/manufacturing Industry.
- The graduating students would have a diverse range of avenues to work in technical areas related to polymer/plastics and rubber manufacturing, processing and applications which also include various sectors of our strategic organization. Polymers provide materials for light weight composite structures.

Course Contents

- Introduction to polymerization processes
- Polymerization reactions
- Polymerization techniques
- Step-Growth Polymerization
- Equal reactivity Hypothesis
- Equilibrium step-growth polymerization
- Reaction engineering of MWD of ARB polymerization
- Chain-Growth of polymerization
- Radical polymerization, kinetic modeling of radical polymerization, Ionic/anionic polymerization
- Reaction engineering of chain-growth polymerization
- Polymer reaction engineering aspects
- Design of reactors
- Co-polymerization, recycling and degradation of polymers
- Suspension polymerization
- Emulsion polymerization

- Emulsion polymerization CSTR
- Time dependent emulsion polymerization

Course Outcomes

- After taking this course, student should have knowledge the importance and utilization of polymers in chemical industry.

Recommended Books

- Fried Joel R. “Polymer Science and Technology”, 2000, Prentice Hall.
- Stanley Middlean, Fundamentals of Polymer Engineering, 3rd Edition,1996
- Tim A. Ossworld, Georg Menges, Hanser Material Science of Polymer for Engineering 2003.
- I. M. Ward & D. W. Hadley, Wiley, An Introduction to the Mechanical Properties of Solid Polymer, 3rd Edition, 1998

CHE-491: Sustainability in Process & Energy Systems

Credit Hours: 3-0
Pre-requisites: None

Course objective

- To provide an understanding of sustainability in process industry & energy systems

Course Contents

- Fundamentals of sustainability
- Process Intensification; Using Methods & Using equipment
- Process integration & Process optimization
- Concepts and possibility of bio-based platform; starches, sugars, vegetable oil, algae
- Renewable energy sources: Solar, wind, biomass and hydrogen/fuel cell
- Energy efficiency and low carbon intensity
- Life cycle analysis; four phases of LCA, Goals and scope, Inventory analysis, Impact assessment. Interpretation
- Industrial ecology; material flow analysis, energy and green-house gas accounting

Recommended Books

- Krisnan Sankaranarayanan, Jakobe Swaan Arnos, Hedzer J.rander Kool, Efficiency and sustainability in Energy and Chemical industry, , CRC Press,2004
- Jiri Klems, Sustainability in process industry: Integration and Optimization, , McGraw Hill,2011.
- Sanjay Kumar Sharma and Ackmez Mudhoo, Green Chemistry for Environmental Sustainability, CRC Press, 2011

Course Outcomes

- The student will the importance of sustainability, and will learn methodology to implement this knowledge to design processes for sustainability

CHE-482: Natural Gas Engineering

Credit Hours: 3-0
Pre-requisites: None

Course objective

- To provide an understanding of natural gas, its purification, transmission and distribution

Course Contents

- Introduction: Occurrence of natural gas. Indigenous & world N.G. reserves & production.
- Introduction to natural gas industry, N.G. as domestic, commercial & industrial fuel and as raw material for downstream petrochemical industry
- Constituents of natural gas & compositions of gases from various fields of the country
- Physical, chemical, thermal, thermodynamic and transport properties of natural gas. Gas laws & equations of state. PVT relations. Use of compressibility factor charts. Prediction of properties of gaseous mixtures
- Gas Conditioning &Processing **:**Gas cleaning : principles, methods & equipment. Introduction to various absorption, adsorption and chemical conversion gas purification processes.
- Sulphur recovery from sour natural gas recovery of LPG from N.G. recovery of helium from N.G., new trends in gas purification.
- Gas Transmission: Outline of major steps in a transmission pipeline project. Pipeline flow formulae/equations: Transmission factor. Pipeline capacity/deliverability & efficiency. Gas compressor stations.
- Piping codes and standards. Classification of steel pipe construction, Pipeline routing using topographical maps. Right of way. Looping & branching. Series & parallel pipe circuits. Steps of pipeline construction. Pipeline coating & laying. Pipeline protection, monitoring and maintenance. Operational problems of high-pressure pipelines.
- Gas Distribution: City-gate stations. Gas odourization Character of distribution system loads : Estimation of design loads, sizing of services & stub mains, modification of existing systems, design of a new distribution system. Types of distribution system.
- Flow calculations & sizing of mains using practical flow equations. Distribution pressures. Types of distribution network. Network diagram and its related concepts & principles.
- Gas metering. Pressure regulators : domestic, commercial & industrial.

Course Outcome

- The students will get adequate information regarding natural gas its processing, transmission and distribution.

Recommended Books

- Ej Hoffman, Membrane, “Separation Technology and Processing”, Gulf Publishing Company,2003
- . Khol, A and Nielsen, R, , “Gas Purification” 5th Edition, gulf Publishing, Houston,1997
- Kidnay A.J and W.R. Parrish, , Fundamentals of Natural Gas Processing CRC Press; New York,2006
- Katz, D.L., Cornell, D., Kobayashi, R., Poettmann, F.H., Vary, J.A., Elenbass J.R., and Weinaug, C.F., , Handbook of Natural Gas Engineering”, McGRaw-Hill, New York,1959
- Katz, D.L. and Lee, R.L, , “Natural Gas Engineering”, McGraw-Hill, New York,1990

MCG-126: Basic Concepts in Social Science

Credit Hours: 3-0

Pre-requisites: None

Course Objectives

- This course aims at equipping the students with the basics of economics, sociology and political science. Primarily, it is a course of general nature to expand the knowledge base of students on socio-political issues and their impact on Chemical industry.

Course Contents

Economics

- Nature, Scope, & Importance of Economics
- Economic Systems
- Monetary, fiscal and Taxation policies
- Trade and Market
- International Economic Forums

Sociology

- Nature, Scope, & Importance of Sociology
- Socialization: from infancy to old age
- Social Interaction in Everyday life
- Groups and Organizations
- Social, Global and Gender stratification

Political Science

- Nature, Scope and importance of Political Science.
- State: its origin and evolution; Western and Islamic concepts of State.
- Organs of Government: Legislature, Executive, Judiciary.
- Forms of Government: Unitary, Federal, Parliamentary and Presidential.
- Political Parties, Interest Groups, Public Opinion, Electoral process.

Course Outcomes

After completion of course, students shall be able to:

- Understand the basic of the most important economic systems in the world.
- Understand major sociological concepts of human society.
- Understand the major processes prevailing in political science.

Recommended Books

- Choudhry, Ahmad Shafi*Usul-e-Siyasiat,* Lahore: Standard Book Depot,(1996).

- Haq, Mazherul*Theory and Practice in Political Science.* Lahore: Bookland, (1996).
- M. Haralambes and Holborn *Sociology themes and Perspectives***.** London: Collin Educational, an Imprint of Harper Collins Publishers(1991).
- Rodee, Anderson *Introduction to Political Science.*, National Book Foundation Islamabad, (2002).
- Sarwar, Mohammad *Introduction to Political Science,* Lahore: IlmiKutubKhana, (1996).
- Giddens, Anthony, Sociology 4th Edition, Cambridge Polity Press, 2004.

HU-115: PRINCIPLES OF SOCIOLOGY

Credit Hours: 3-0
Pre-requisites: None

Course Contents

- An overview of sociology as a social science.
  a. Genesis, definition and characteristic of sociology.
  b. Different fields of sociology.
  c. Theoretical principles & their comparison

- **Culture & society**
  a. Culture-definition, significance & cultural base.
  b. Exponential principles – values, norms, folkways, mores, values.
  c. Group & social structure-primary, secondary, small groups, status, role & institutions

- **Social Institutions**
  a. Family-definition, concept, characteristics.
  b. Biological basis & functions of family.
  c. Education-functional, cultural & social integration and development

- **Societal Order & State Institutions**
  a. Religion-definition, role & conflict analysis.
  b. Economic order-theories, industrialization and modernization
  c. Political order-authority, functional and conflict approaches

- **Socialization**
  a. Foundations for socialization
  b. The self and socialization
  c. Socialization across the life

- **Social Stratification**
  a. Patterns of social stratification
  b. The class system
  c. Social mobility

- **Deviance and crime**
  a. The nature of deviance
  b. Sociological perspective on deviance
  c. Crime and social justice system

- **Social change**
  a. A world of change
  b. Collector behavior
  c. Social movements

- **The Human Environment**
  a. Population and elements of change
  b. The urban environment
  c. The ecological environment

- **Gender Perspective**
  a. Equalities and differences
  b. Sex and gender
  c. Families at work

- **Race and ethnicity**
  a. Thinking about race and ethnicity
  b. Theoretical approaches to race and ethnicity
  c. Old and contemporary ethnicity

- **Social justice and Inequalities**
  a. Changing perspective on inequalities
  b. Global perspective and analysis
  c. Cultural dimensions and human rights

- **Power in Society**
  a. Power modernity and sociology
  b. Power of elites
  c. Plural model of power

- **Cultural globalization**
  a. Globalization leads to cultural homogenization
  b. Globalization for cultural integration
  c. Globalization and cultural conflict resolution

Recommended Books

- Michael Hughes, Sociology-The Core the McGraw-Hill 1999
- Bernad,A, and T. Burgess, Sociology, Cambridge University Press, (2004).
- DuBrin, A.J., Human Relations: Interpersonal Job Oriented Skills, Prentice-Hall, (2007).

MCG-235:Logic and Critical Thinking

Credit Hours: 3-0
Pre-requisites: None

Course Objective

- This course explores the relationship of communications and critical thinking with a focus on good reasoning and the impediments to its mastery.
- This course emphasizes the development of skills in logical processes including familiarity with the more common fallacies.
- This course is designed for students learning to apply principles of critical thinking to the practical problems of everyday life.

Course Contents

- **Basic Concepts**
  - Arguments, Premises, and Conclusions
  - Recognizing Arguments
  - Deduction and Induction
  - Validity, Truth, Soundness, Strength, Cogency
  - Arguments Forms: Proving Invalidity
- **Language: Meaning and Definition**
  - Varieties of Meaning
  - The Intension and Extension of Terms
  - Definitions and Their Purposes
- **Propositional Logic**
  - Symbols and Translation
  - Truth: Functions
  - Truth Tables for Propositions
  - Truth Tables for Arguments
- **Natural Deduction in Propositional Logic**
  - Rules of Implication
  - Rules of Replacement
- **Conditional Proof**
- **Induction**
  - Causality and Mill's Methods
- **Probability**
  - Statistical Reasoning
  - Hypothetical / Scientific Reasoning

Course Outcomes

After completion of course, students shall be able to:

- Understand the basics of logical thinking

- Understand the role of language and thinking processes in one's life.
- Analyze ones thinking processes logically and learn to think logically

Recommended Books

- Hodges, Wilfrid. . *Logic: An Introduction to Elementary Logic*. 2nd ed. (2002)
- Hurley, Patrick J.*Concise Introduction to Logic* W/CD, 9 ed. Wadsworth Publishing Co., Belmont, CA., (2005).
- Jason, Gary. *Critical Thinking: Developing an Effective World View.* 1 ed. Wadsworth Publishing Co., Belmont, CA. . (2001)
- Moore, Brooke N. & Parker, Richard..*Critical Thinking*, 8 ed. McGraw-Hill. (2005)
- Vaughn Lewis, The power of critical thinking, Oxford University Press, (2005)

Scheme of Studies

No.	Course Title	Credit Hours		Pre-Requisite
Semester 1		**Theory**	**Labs**	
HU-107	Pakistan Studies	2	0	Nil
PHY-102	Applied Physics	2	1	
CHE-101	Chemical Process Principles-I (Programme Specific)	3	0	
CS-100	Fundamentals of ICT (Programme Specific)	2	1	
ME-105	Workshop Practice	0	1	
MATH-101	Calculus and Analytical Geometry	3	0	
HU-100	English	2	0	
		Total:17		
Semester 2				**Pre-Requisite**
CS-114	Fundamentals of Programming	2	1	(CS-100) Fundamentals of ICT
CH-102	Inorganic & Analytical Chemistry (Programme Specific)	3	1	Nil
HU-101	Islamic Studies	2	0	Nil
ME-109	Engineering Drawing	0	2	Nil
MATH-121	Linear Algebra and ODEs	3	0	(MATH-101) Calculus and Analytical Geometry
HU-109	Communication Skills	2	0	Nil
		Total:16		
Semester 3				**Pre-Requisite**
CH-202	Organic & Biochemistry	3	1	Nil
CHE-221	Fluid Mechanics-I	3	0	Nil
CHE-231	Chemical Engineering Thermodynamics-I	3	0	Nil
CHE-202	Advanced Chemical Process Principles	3	0	(CHE-101) CPP-I
MATH-112	Calculus-II	3	0	(MATH-101) Calculus & Analytical Geometry
MSE-101	Fundamentals of Engineering Materials	3	0	Nil
		Total:19		
Semester 4				**Pre-Requisite**
CHE-211	Chemical Process Technology	3	0	Nil
CHE-241	Mass Transfer	2	0	
CHE-242	Heat Transfer	3	1	
EE-103	Electrical Engineering	2	1	

HU-212	Technical & Business writing	2	0	
CHE-224	Fluid Mechanics –II	2	1	(CHE-221) Fluid Mechanics-I
		Total:17		
Semester 5				**Pre-Requisite**
CHE-346	Particulate Technology	3	1	
CHE-343	Simultaneous Heat & Mass Transfer-I	3	1	(CHE-242) Heat Transfer, (CHE-241) Mass Transfer, (MATH-121) Linear Algebra & ODES
MATH-351	Numerical Methods	3	0	(MATH-101) Calculus & Analytical Geometry(MATH-121) Linear Algebra & ODES
CHE-332	Chemical Engineering Thermodynamics-II	3	1	(CHE-231) Chemical Engg Thermodynamics-1
MGT-271	Entrepreneurship	2	0	Nil
		Total:17		
Semester 6				**Pre-Requisite**
CHE-348	Simultaneous Heat & Mass Transfer-II	3	1	(CHE-343) Simultaneous Heat & Mass Transfer-I
CHE-323	Instrumentation & Process Control	3	1	Nil
CHE-347	Chemical Reaction Engineering	3	1	Nil
CHE-345	Transport Phenomena	3	0	(CHE-221) Fluid Mechanics-I (CHE-343) Simultaneous Heat & Mass Transfer-I
ECO-130	Engineering Economics	2	0	Nil
		Total:17		
	Industrial Training (Non Credit)			
Semester 7				**Pre-Requisite**
CHE-422	Fuels & Combustion	3	1	Nil
CHE-451	Chemical Engineering Plant Design	3	0	(CHE-343) Simultaneous Heat & Mass Transfer-I (CHE-345) Transport

				Phenomena (CHE-347) Chemical Reaction Engineering (CHE-348) Simultaneous Heat & Mass Transfer-II
CHE-499	Final Year Project	0	3	Nil
XXX-XXX	Elective-I (Technical)	3	0	
CHE-452	Chemical Process Design and Simulation	2	1	(CHE-348) Simultaneous Heat & Mass Transfer-II **(**CHE-345) Transport Phenomena
		Total:16		
Semester 8				**Pre-Requisite**
CHE-425	Maintenance & Process Safety	3	0	Nil
CHE-499	Final Year Project	0	3	Nil
OTM-456	Production &Operational Management	3	0	Nil
XXX-XXX	Elective – II (Technical)	3	0	Nil
XX-XXX	Elective – III (social)	3	0	Nil
		Total:15		
		Grand Total: 134		