CURRICULUM

OF

CHEMICAL ENGINEERING

BE, BSc

(Revised 2016)

HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

Prof. Dr. Mukhtar Ahmed	Chairman, HEC
Mr. Fida Hussain	Director General (Acad)
Ms. Ghayyur Fatima	Director (Curri)
Mr. Rizwan Shoukat	Deputy Director (Curri)
Mr. Abid Wahab	Assistant Director (Curri)
Mr. Riaz-ul-Haque	Assistant Director (Curri)

Composed by: Mr. Zulfiqar Ali, HEC, Islamabad

Table of Contents

1.	Minutes	6
2.	Rationale	9
3.	Mission Statement	10
4.	Objectives	10
5.	Framework for BE, BSc in Chemical Engineering	11
6.	Scheme of Studies for BE, BSc in Chemical Engineering	15
7.	Detail of Courses for BE, BSc in Chemical Engineering	17
8.	Social Sciences and Management Courses	67
9.	Recommendations	83

PREFACE

The curriculum, with varying definitions, is said to be a plan of the teaching-learning process that students of an academic programme are required to undergo. It includes objectives & learning outcomes, course contents, scheme of studies, teaching methodologies and methods of assessment of learning. Since knowledge in all disciplines and fields is expanding at a fast pace and new disciplines are also emerging; it is imperative that curricula be developed and revised accordingly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vide Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled "Supervision of Curricula and Textbooks and Maintenance of Standard of Education". With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

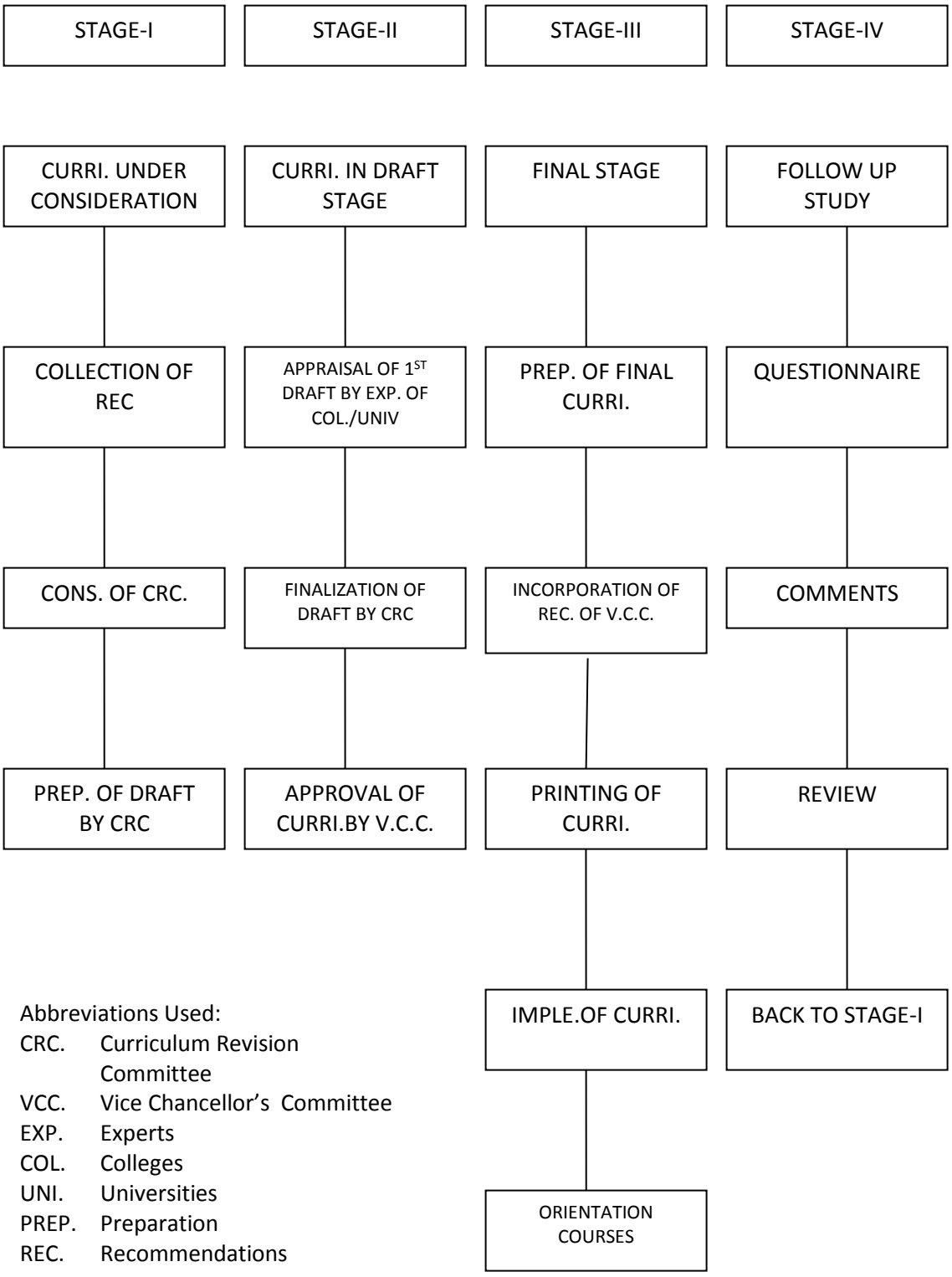
In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society by seeking nominations from their organizations.

In order to impart quality education which is at par with international standards, HEC NCRCs have developed unified templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering in 2007 and 2009.

It is hoped that this curriculum document, prepared by the respective NCRC's, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC http://hec.gov.pk/english/services/universities/RevisedCurricula/Pages/default.aspx

(Fida Hussain)
Director General (Academics)

CURRICULUM DEVELOPMENT PROCESS



Abbreviations Used:

CRC.	Curriculum Revision Committee
VCC.	Vice Chancellor's Committee
EXP.	Experts
COL.	Colleges
UNI.	Universities
PREP.	Preparation
REC.	Recommendations

MINUTES OF THE FINAL MEETING

The final meeting of National Curriculum Revision Committee (NCRC) in the discipline of Chemical Engineering was held from March 14-16, 2016 at HEC Regional Centre, Lahore to revise and prepare final draft curriculum for BE, BSc & ME, MSc levels of Chemical Engineering. The following members attended the meeting:-

Sr. No.	Name & Address	Status
1.	Prof. Dr. Javaid Rabbani Khan, Professor, Department of Chemical Engineering, GIK University of Engineering Science & Technology, Topi, KP.	Convener
2.	Prof. Dr. Muhammad Tayyeb Javed, Head of Department, Department of Chemical Engineering, Pakistan Institute of Engineering and Applied Sciences, C-209, P.O. Nilore, Islamabad.	Member
3.	Dr. Arshad Chugtai, Visiting Faculty, School of Chemical & Materials Engineering (SCME), National University of Sciences & Technology, Sector H-12, Islamabad.	Member
4.	Dr. Muhammad Mazhar Iqbal, Director, Project Management Organization NESCOM, Opposite EME College, Peshawar Road, Golra More, Rawalpindi.	Member
5.	Prof. Dr. Amir Ijaz, Director. Institute of Chemical Engineering & Technology, New Campus, University of Punjab, Lahore.	Member
6.	Dr. Muhammad Jamil, HoD, Department of Chemical Engineering, University of Faisalabad, Amin Campus, West Canal Road, Faisalabad.	Member
7.	Dr. Ghulam Mustafa Mamoor, Professor, Department of Chemical Engineering, Wah Engineering College, University of Wah, Wah Cantt.	Member

8.	Dr. Fahad Rehman, Assistant Professor, Department of Chemical Engineering, COMSATS Institute of Information Technology, Defence Road, Off Raiwind Road, Lahore.	Member
9.	Prof. Dr. M. Suleman Tahir, Professor, Department of Chemical Engineering, University of Gujrat, Engineering Block, Hafiz Hayat Campus, Gujrat.	Member
10.	Dr. Inayatullah Memon, Professor & Chairman, Department of Chemical Engineering, NED University of Engineering &Technology, Main University Road, Karachi.	Member
11.	Mr. Abdul Waheed Bhutto Assistant Professor, Department of Chemical Engineering, Dawood University of Engineering & Technology, M.A Jinnah Road, Karachi.	Member
12.	Dr. Shaheen Aziz Shaikh, Professor, Department of Chemical Engineering, Mehran University of Engineering & Technology, Jamshoro.	Member
13.	Dr. Shagufta Ishtiaque, Assistant Professor/In-Charge, Department of Chemical Engineering, University of Karachi, Karachi.	Member
14.	Dr. Muhammad Najam Khan, Associate Professor / Chairperson, Department of Chemical Engineering, Balochistan University of Information Technology, Engineering & Management Science, Takatu Campus, Airport Road, Balili, Quetta.	Member
15.	Prof. Dr. Muhammad Zafar Noon, Campus Coordinator, Department of Chemical, Polymer Engineering, University of Engineering & Technology, KSK Campus, Lahore.	Member
16.	Prof. Dr. Shahid Raza Malik, Director / CEO, Department of Chemical Engineering, NFC Institute of Engineering & Fertilizer Research, Jaranwala Road, Faisalabad.	Member

17.	Dr. Muhammad Asim Ibrahim, Assistant Professor, Pakistan Institute of Engineering & Applied Sciences, C-209, P.O. Nilore, Islamabad.	Member
18.	Dr. Saeed Gul, (Secretary) Associate Professor, Department of Chemical Engineering, University of Engineering & Technology, University Campus, Peshawar.	Secretary

The meeting started with recitation of Verses from the Holy Quran by Mr. Rizwan Shoukat, Deputy Director HEC, and he welcomed the participants of the meeting on behalf of the Chairman HEC. He thanked the members of the committee and their institutions for their efforts and their quality contribution in the preparation of the curriculum. He also thanked the Convener, Prof. Dr. Javaid Rabbani Khan, for taking personal interest in the development of the curriculum and for excellent coordination of the efforts of the committee.

At the beginning of the regular agenda, the Convener and Secretary discussed the curriculum prepared by the members in the first meeting and thanked the members for providing additional information for the curriculum after the first meeting.

The committee also visited the Chemical Engineering Department of the University of the Punjab. All members of the committee appreciated the efforts and hospitality of Prof. Dr. Amir Ijaz Director Institute of Chemical Engineering & Technology (ICET) for arranging the visit of ICET postgraduate and undergraduate labs and interactive meeting with the faculty members.

The Convener, Prof. Dr. Javaid Rabbani Khan, closed the meeting with thanks on behalf of all committee members to HEC for its efforts on the advancement of higher education and for providing a platform at the national level to bring together the experts from various institutions to develop the electronic engineering curriculum. He thanked all members of the committee for their dedication, hard work, and excellent teamwork in the preparation of the revised curriculum. He requested the members of the committee to convey his thanks to their respective institutions for support of this task of national importance. Finally, he thanked Mr. Nazeer Hussain and the staff of the HEC Regional Centre, Lahore, for their dedicated support of the committee and generous hospitality.

RATIONALE:

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, pharmaceutical, metallurgical, plastics, pollution control etc.).

Chemical engineering is the application of mathematical and Natural Sciences by processing the raw material to finished product, economically without polluting environment for the benefit of mankind. Chemical engineering also applies the principles and application of other fields to improve and solve the problems of chemical engineering processes encountered in industries.

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, Islamiat 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 is incorporated as a part of all engineering course work.

MISSION STATEMENT:

Mission of chemical engineering undergraduate program is to provide qualified manpower with inter-disciplinary academic foundations needed to develop chemical products for the society. The program is aligned to integrate critical thinking, scholarly training, leadership qualities and sustainable vision in graduates to enable them to cope with the complex problems of the chemical and allied industries.

OBJECTIVES:

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

- Understanding of the needs of the society and demands of the 21st century and be able to improve quality of life
- Understanding of the principles of chemical engineering design and their application for sustainable development
- Ability to understand, analyze, interpret and solve problems of chemical and allied industries by using modern techniques, engineering tools, research and innovation
- Understanding of safety principles and practices in process industries
- Understanding of professional and ethical responsibilities

- Knowledge of contemporary issues and ability to work in multidisciplinary teams
- Leadership skills to serve on managerial positions within chemical and associated industries
- 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

ELIGIBILITY CRITERIA BE, BE in CHEMICAL ENGINEERING:

The eligibility criteria for admission to undergraduate degree in Chemical Engineering as prescribed by the Pakistan Engineering Council (PEC) is endorsed.

Framework BE, BSc Chemical Engineering

Non-Engineering Domain									
Knowledge Area	**Subject Area**	**Name of Course**	**Th**	**Lab**	**C. Hrs**	**Total Courses**	**Total Credits**	**% Area**	**% overall**
Humanities	English	Functional English	3	0	3	3	6	15	5.2
		Communication Skills	0	1	1				
		Technical Report writing & Presentation skills	2	0	2				
	Culture	Pakistan Studies	1	0	1	2	3	7.5	2.2
		Islamic Studies/Ethics	2	0	2				
	*Social Sciences	Social Sciences-I	2	0	2	2	4	10	3.0
		Social Sciences-II (Chemical	2	0	2				
Management sciences	Management sciences	Industrial Management	2	0	2	2	4	10	3.0
		Entrepreneurship	2	0	2				
Natural Sciences	Physics	Applied Physics	3	1	4	1	4	10	3.0
	Mathematics	Maths-I (Calculus & Analytical Geometry)	3	0	3	4	11	27.5	7.5
		Maths-II (Applied Mathematics)	3	0	3				
		Maths-III (Chemical Engineering Mathematics)	3	0	3				
		Probability & Statistics	2	0	2				
	Chemistry	Inorganic & Organic Chemistry	3	1	4	2	8	20	6.0
		Physical & Analytical	3	1	4				
TOTAL						**16**	**40**	**100**	**30**

Engineering Domain									
Knowledge Area	**Subject Area**	**Name of Course**	**Th**	**Lab**	**C. Hrs**	**Total Courses**	**Total Credits**	**% Area**	**% Overall**
Computing	Fundamentals & Programming	Computer Programing	1	1	2	3	8	8.42	5.93
		Numerical Methods & Software Applications	2	1	3				
	Computer application in Chemical Engineering design	Process Design & Simulation	2	1	3				
Engineering Foundation	Engineering Foundation	Chemical Engineering Thermodynamics-I	3	1	4	8	28	29.47	20.74
		Particulate Technology	3	1	4				
		Mass Transfer	2	1	3				
		Chemical Process Technology	3	1	4				
		Fluid mechanics-I	3	1	4				
		Heat Transfer	3	1	4				
		Chemical Process Principles-I	3	0	3				
		Chemical Process Principles-II	2	0	2				
Major Based Core	Major Based Core (Breadth)	Instrumentation and Process Control	3	1	4	10	31	32.98	23.13
		Separation Processes-I	2	1	3				
		Separation Processes-II	2	1	3				
		Chemical Reaction Engineering	3	1	4				
		Fluid Mechanics-II	2	0	2				
		Transport Phenomena	3	0	3				
		Chemical Plant Design	3	0	3				
		Process Analysis & Optimization	3	0	3				
		Fuels & Energy	3	1	4				
		Chemical Engineering Thermodynamics- II	2	0	2				

Major	Major Based Core (Depth)	*Elective-I	3	0	3	3	9	9.57	7.15
		*Elective-II	3	0	3				
		*Elective-III	3	0	3				
Inter-disciplinary Engineering Breadth	Inter Disciplinary Engineering Breadth	Workshop practices	0	1	1	8	14	14.58	10.29
		Applied Electrical Engineering	2	1	3				
		Engineering Mechanics	2	0	2				
		Engineering Materials	2	0	2				
		Computer Aided Engineering Drawing	0	1	1				
		Engineering Drawing	0	1	1				
		Maintenance & Utility Engineering	2	0	2				
		Process Safety Management	2	0	2				
Design Project		Design project-Part I	0	3	3	2	6	6.25	4.41
		Design project-Part II	0	3	3				
TOTAL						**34**	**96**	**100**	**70**
Industrial Training	4-6 weeks industrial training mandatory (Non Credit)								
Grand Total						**50**	**136**		

*Elective subjects may be offered from the pool of subjects given below.

Electives		
Chemical Engineering	**Design Engineering**	**Oil & Gas**
Polymer Engineering	Computational Fluid Dynamics (CFD)	Petroleum Refinery Engineering
Novel Separation Processes	Statistical Experimental Design	Gas Processing
Operation Management	Process Design & Optimization	Petrochemicals
Molecular Modeling		

Mineral Processing		
Nanotechnology		
Biochemical Engineering	**Green Engineering**	**Nuclear**
Biochemical Engineering	Environmental Engineering	Introduction to Nuclear
Biochemical Separations	Green Technologies & sustainable Development	
	Industrial Ecology	
Biochemical Processes and Products	Waste Management	Nuclear Fuel Fabrication
	Sustainability in Processes & Energy System	
Process Engineering	**Energetic Materials**	**Energy & Power**
Process Analysis & Optimization	Science of Energetic Materials	Industrial Energy Systems
Chemical Wet Processing of Textiles	Rocket Propulsion	Sustainable Energy Resources
	Explosive Formulation, Manufacturing & Filling	

** New area/subjects can also be included according to the specialization/availability of the faculty and facilities and need of the province.

Scheme of Studies
BE, BSc Chemical Engineering

Semester 1 / Semester 2

Course Title	Th	Lab	C.Hrs	Course Title	Th	Lab	C.Hrs
Functional English	3	0	3	Physical & Analytical Chemistry	3	1	4
Islamic Studies/Ethics	2	0	2	Pakistan Studies	1	0	1
Chemical Process Principles-I	3	0	3	Applied Mathematics	3	0	3
Engineering Drawing	0	1	1	Applied Physics	3	1	4
Inorganic & Organic Chemistry	3	1	4	Communication Skills	0	1	1
Calculus & Analytical Geometry	3	0	3	Chemical Process Technology	3	1	4
Total	**14**	**2**	**16**	**Total**	**13**	**4**	**17**
First Year Credit Hours	**33**						

Semester 3 / Semester 4

Course Title	Th	Lab	C.Hrs	Course Title	Th	Lab	C.Hrs
Workshop Practices	0	1	1	Computer Aided Engineering Drawing	0	1	1
Computer Programming	1	1	2	Applied Electrical Engineering	2	1	3
Chemical Process Calculations-II	2	0	2	Chemical Engineering Thermodynamics-II	2	0	2
Chemical Engineering Thermodynamics-I	3	1	4	Chemical Engineering Mathematics	3	0	3
Social Sciences*	2	0	2	Particulate Technology	3	1	4
Fluid Mechanics-I	3	1	4	Fluid Mechanics II	2	0	2
Engineering Mechanics	2	0	2	Process Safety Management	2	0	2
Total	**13**	**4**	**17**	**Total**	**14**	**3**	**17**
Second Year Credit Hours	**34**						

Semester 5				Semester 6			
Course Title	**Th**	**Lab**	**C.Hrs**	**Course Title**	**Th**	**Lab**	**C.Hrs**
Mass Transfer	2	1	3	Instrumentation & Process Control	3	1	4
Chemical Reaction Engineering	3	1	4	Fuel & Energy	3	1	4
Engineering Materials	2	0	2	Chemical Engineering Economics	2	0	2
Heat Transfer	3	1	4	Separation Processes-I	2	1	3
Numerical Methods & Software Applications	2	1	3	Transport Phenomena	3	0	3
Probability and Statistics	2	0	2	Technical Report Writing & Presentation Skills	2	0	2
Total	**14**	**4**	**18**	**Total**	**15**	**3**	**18**
Third Year Credit Hours	**36**						

Semester 7				Semester 8			
Course Title	**Lec**	**Lab**	**C.Hrs**	**Course Title**	**Lec**	**Lab**	**C.Hrs**
Separation Processes-II	2	1	3	Entrepreneurship	2	0	2
Industrial Management	2	0	2	Elective*-II	3	0	3
Chemical Plant Design	3	0	3	Elective*-III	3	0	3
Elective*-I	3	0	3	Process Design & Simulation	2	1	3
Design Project- I	0	3	3	Design Project-II	0	3	3
Process Analysis and optimization	3	0	3	Maintenance & Utility Engineering	2	0	2
Total	13	4	17	**Total**	12	4	16
Final Year Credit Hours	**33**						
Total Credit Hours	**136**						

DETAIL OF COURSES
FOR BE, BSc IN CHEMICAL ENGINEERING

SEMESTER 1

FUNCTIONAL ENGLISH

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the course:
To enhance language skills and develop critical thinking

Course Outline:
Basics of Grammar, parts of speech and use of articles, sentence structure, active and passive voice, practice in unified sentence, analysis of phrase, clause and sentence structure, transitive and intransitive verbs, punctuation and spelling.

Comprehension
Answers to questions on a given text

Discussion
General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

Listening
To be improved by showing documentaries/films carefully selected by subject teachers.

Translation skills
Urdu to English

Paragraph writing
Topics to be chosen at the discretion of the teacher

Presentation skills
Introduction

Recommended Books:

1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises
1. Third edition. Oxford University Press. 1997. ISBN 0194313492
2. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises Third edition. Oxford University Press. 1997. ISBN 0194313506
3. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.
4. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.

ISLAMIC STUDIES/ETHICS

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the course:

1 To provide Basic information about Islamic Studies
2 To enhance understanding of the students regarding Islamic Civilization
3 To improve Students skill to perform prayers and other worships
4 To enhance the skill of the students for understanding of issues related to faith and religious life**.**
5 Interrelationship of Islam and Science (Where we were and where we are?)

Course Outline:

INTRODUCTION TO QURANIC STUDIES

1) Basic Concepts of Quran
2) History of Quran
3) Uloom-ul -Quran

STUDY OF SELECTED TEXT OF HOLY QURAN

1) Verses of Surah Al-Baqra Related to Faith(Verse No-284-286)
2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
5) Verses of Surah Al-Inam Related to Ihkam(Verse No-152-154)

STUDY OF SELECTED TEXT OF HOLY QURAN

1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.)
2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
3) Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

SEERAT OF HOLY PROPHET (S.A.W) I

1) Life of Muhammad Bin Abdullah (Before Prophet Hood)
2) Life of Holy Prophet (S.A.W) in Makkah
3) Important Lessons Derived from the life of Holy Prophet in Makkah

SEERAT OF HOLY PROPHET (S.A.W) II

1) Life of Holy Prophet (S.A.W) in Madina
2) Important Events of Life of Holy Prophet in Madina
3) Important Lessons Derived from the life of Holy Prophet in Madina

INTRODUCTION TO SUNNAH

1) Basic Concepts of Hadith
2) History of Hadith
3) Kinds of Hadith

4) Uloom-ul-Hadith
5) Sunnah & Hadith
6) Legal Position of Sunnah

SELECTED STUDY FROM TEXT OF HADITH INTRODUCTION TO

ISLAMIC LAW & JURISPRUDENCE

1) Basic Concepts of Islamic Law & Jurisprudence
2) History & Importance of Islamic Law & Jurisprudence
3) Sources of Islamic Law & Jurisprudence
4) Nature of Differences in Islamic Law
5) Islam and Sectarianism

ISLAMIC CULTURE & CIVILIZATION

1) Basic Concepts of Islamic Culture & Civilization
2) Historical Development of Islamic Culture & Civilization
3) Characteristics of Islamic Culture & Civilization
4) Islamic Culture & Civilization and Contemporary Issues

ISLAM & SCIENCE

1) Basic Concepts of Islam & Science
2) Contributions of Muslims in the Development of Science
3) Quran & Science

ISLAMIC ECONOMIC SYSTEM

1) Basic Concepts of Islamic Economic System
2) Means of Distribution of wealth in Islamic Economics
3) Islamic Concept of Riba
4) Islamic Ways of Trade & Commerce

POLITICAL SYSTEM OF ISLAM

1) Basic Concepts of Islamic Political System
2) Islamic Concept of Sovereignty
3) Basic Institutions of Govt. in Islam

ISLAMIC HISTORY

1) Period of Khlaft-e-Rashida
2) Period of Ummayyads
3) Period of Abbasids

SOCIAL SYSTEM OF ISLAM

1) Basic Concepts of Social System Of Islam
2) Elements of Family
3) Ethical Values of Islam

Recommended Books:

1) Hameed ullah Muhammad, “Emergence of Islam” , IRI, Islamabad
2) Hameed ullah Muhammad, “Muslim Conduct of State”
3) Hameed ullah Muhammad, ‘Introduction to Islam
4) Mulana Muhammad Yousaf Islahi,”

5) Hussain Hamid Hassan, “An Introduction to the Study of Islamic Law” leaf Publication Islamabad, Pakistan.
6) Ahmad Hasan, “Principles of Islamic Jurisprudence” Islamic Research Institute, International Islamic University, Islamabad (1993)
7) Mir Waliullah, “Muslim Jurisprudence and the Quranic Law of Crimes” Islamic Book Service (1982)
8) H.S. Bhatia, “Studies in Islamic Law, Religion and Society” Deep & Deep Publications New Delhi (1989)
9) Dr. Muhammad Zia-ul-Haq, “Introduction to Al Sharia Al Islamia” Allama Iqbal Open University, Islamabad (2001)

CHEMICAL PROCESS PRINCIPLES – I

Credit hours: 3 (3-0) Prerequisites: N/A

Objectives of the Course:

To impart skills to understand the chemical process calculations and to find solution of material balance problems in processing units

Course Outline:

Units, dimensions and conversions, Temperature and Pressure scales, Composition of mixtures, Principles of stoichiometric combination.

Nature of balances: Concept of a balance. Input-output relationships. Steady-state considerations. Black box approach. Sub-systems and interconnections. Familiarization with flow sheets. Mass balance diagrams and tables.

Mass balances for items of plant, Choice of basis/datum for balances. Overall and component balances, Limiting and excess reactants. Balances for systems with recycle, purge and by-pass streams. Mass balances for reactive processes. Mass balances for unit operations, Tie components. Balances for batch and continuous plant.

Recommended Books:

1. Himmelblau David M. “Basic Principles and Calculations in Chemical Engineering”. 8th Ed. 2014. Prentice Hall PTR.
2. Felder Richard M., Rousseau Ronald W. “Elementary Principles of Chemical Processes” 4th Ed. 2015. John Willey & Sons.
3. Reklaitis G.V., Schneider Daniel R. “Introduction to Material and Energy Balances” 1983. John Wiley & Sons.
4. Hougen Olaf A., Watson Kenneth M. “Chemical Processes Principles”. 2004, John Wiley and Sons & CBS Publishers.
5. Chopy & Hicks, “Handbook of Chemical Engineering Calculations” , 2nd Ed. 1994 McGraw-Hill Professional Publishing.

ENGINEERING DRAWING

Credit hours: 1 (0,3,0) Prerequisites: N/A

Objectives of the Course:

To provide skills to understand, draw and interpret technical / engineering drawings

Course Outline:

Drawing equipment and the use of instruments; Basic drafting techniques and standards; Geometrical curves including plane curves; Cycloid; Hypocycloid and Involute. Intersections at various positions of geometrical bodies such as prisms, pyramids, cylinders and cones: Development of surfaces of prisms, pyramids, cylinders and cones. Freehand sketching of machine and engine components, Locking arrangements; Foundation bolts; Stuffing box; Shaft couplings; Foot step bearing; Pulleys; Engine connecting rod. Concept of working drawing of component parts of machines and engines. Size description, dimensions and specifications; Limit dimensioning and geometric tolerance; Limits; Fits and tolerances; Conventional symbols. Sectioning of machine and engine components; Orthographic projections and standard practices. Isometric views with particular reference to piping and ducting. Introduction to Computer aided drawing software.

Recommended Books:

1. Parkinson, A. C. "A First Year Engineering Drawing" 1958, Sir Isaac Pitman & Sons.
2. Engineering Drawing and Graphic Technology 14th Edition by T.E. French, C.J. Vierk and R.J. Foster
3. Engineering Drawing (53rd Edition, 2014) by N.D. Bhatt, Charotar Publishing House Pvt. Ltd.
4. Engineering Drawing and Graphic Technology (14th Edition,1993) by Thomas E. French, Charles Vierck & Robert Foster, McGraw-Hill Publishing Company

INORGANIC & ORGANIC CHEMISTRY

Credit hours: 4 (3,3,0) Prerequisites: N/A

Objectives of the Course:

To acquire knowledge of inorganic and organic chemistry for understanding unit processes in chemical engineering.

Course Outline:

Overview of periodic table: molecular orbital theory: Chemistry of solutions: Chemistry of transition metals, coordination compound and radioactive elements. Crystalline state of metals and lattice structure. Industrial inorganic Chemistry. Qualitative and group theory of inorganic Chemistry.

Molecular structure and bonding. Organic molecules and functional groups,

Inter conversion of functional groups, alkanes, alkenes, alkynes, stereochemistry. organic reactions, alkyl halides, alcohols, ethers and epoxides, oxidation reduction reactions, benzene and aromatic compounds, polymer chemistry.

Unit Processes; reaction mechanism of sulfonation; nitration; hydrogenation; amination; halogenation, oxidation, polymerization.

Lab Outline:

Practical exercises relating to the topics covered in theory.

Recommended Books:

1. Unit Process in Organic synthesis, P.H. Groggens, McGraw-Hill, 5th Ed. 1984.
2. Inorganic Chemistry, Gary L. Miessler, Donald A. Tarr, Prentice-Hall, 2003.

CALCULUS & ANALYTICAL GEOMETRY

Credit hours: 3 (3,0,0) Prerequisite: N/A

Objectives of the Course:

To develop understanding of the concepts of calculus and analytical geometry with emphasis on applications in Engineering

Course Outline:

Introduction to functions, introduction to limit, derivatives and their applications, partial derivatives, maxima and minima, integral calculus with applications including double and triple integrals, vector algebra, introduction to analytical geometry, straight line, surfaces, cylinders and cones in Cartesian, cylindrical and spherical coordinates. Complex numbers and complex variables.

Vector Calculus, Gradient, divergence, curl of the vector, Introduction to tensor calculus and their Engineering applications.

Recommended Books:

1. George B. Thomas and Ross L. Finney, “Calculus and Analytic Geometry, Addison-Wesley, ISBN: 0201531747.
2. George F. Simmons, “Calculus with Analytic Geometry”, McGraw-Hill, ISBN: 0070576424.
3. Gerald B. Folland, “Advanced Calculus”, Prentice Hall, ISBN: 0130652652.
4. Monty J. Strauss, Gerald L. Bradley and Karl J. Smith, “Calculus”, Prentice Hall, ISBN: 0130918717.

SEMESTER 2

PHYSICAL & ANALYTICAL CHEMISTRY

Credit hours: 4 (3,3,0) Prerequisites: N/A

Objectives of the Course:

To enhance the knowledge of Physical and Analytical chemistry and their relation with process industry.

Course Outline:

Kinetic theory of gases. Dalton's law, Henry's law and Raoult's law. Antoine equation. Relative volatility.

Surface Phenomena: Adsorption, catalysis, enzyme catalysis. Electrochemistry, including fuel cells. Colloidal chemistry, reaction kinetics and equilibrium.

Introduction to instrumental techniques involving potentiometery, pH-Metery: liquid solid chromatography: high performance liquid chromatography, ion exchange, gas chromatography, plane chromatography. Spectroscopy: Basics of spectroscopy; UV and visible spectroscopy.

Lab Outline:

Practical exercises relating to the topics covered in theory.

Recommended Books:

1. Kuhn, H., Forsterling, H. D., Waldeck, D. H., "Principles of Physical Chemistry" 2009, John Wiley & Sons.
2. Analytical Chemistry, G.L. Hargis, Prentice Hall Inc. 2000.
3. Analytical Chemistry, G.D. Christian, J. Wiley, 6th Ed. 2003
4. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West, FJ. Holler 7th Ed. Harcourt Asia, 2001.
5. Richard M. Pashley; Marilyn E. Karaman. "Applied Colloid and Surface Chemistry". John Wiley and Sons, Ltd. 2004.

Pakistan Studies (Compulsory)

Introduction/Objectives:

- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

Course Outline:

1. **Historical Perspective**
   a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.
   b. Factors leading to Muslim separatism

c. People and Land
    i. Indus Civilization
    ii. Muslim advent
    iii. Location and geo-physical features.

2. **Government and Politics in Pakistan**
   Political and constitutional phases:
   a. 1947-58
   b. 1958-71
   c. 1971-77
   d. 1977-88
   e. 1988-99
   f. 1999 onward
3. **Contemporary Pakistan**
   a. Economic institutions and issues
   b. Society and social structure
   c. Ethnicity
   d. Foreign policy of Pakistan and challenges
   e. Futuristic outlook of Pakistan

Recommended Books:

1. Burki, Shahid Javed. *State & Society in Pakistan,* The MacMillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
3. S. M. Burke and Lawrence Ziring. Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots & Development.* Lahore, 1994.
5. Wilcox, Wayne. *The Emergence of Bangladesh,* Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota,* Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
7. Amin, Tahir. *Ethno - National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: Wm Dawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh.* Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan,* Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan.* Boston: Houghton Mifflin, 1967.
12. Aziz, K. K. *Party, Politics in Pakistan,* Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.

APPLIED MATHEMATICS

Credit hours: 3 (3,0,0) Prerequisite: N/A

Objectives of the Course:

To provide an understanding of analytical solution of higher order and partial differential equations concerning to transport processes.

Course Outline:

Differential equations and their classification, formation of differential equations. Differential equations of first order. Methods of solution of differential equations of first order and first-degree: Separable equations, homogenous equations, equations reducible to homogenous, exact differential equations, integrating factor, linear equations, Bernoulli equations, orthogonal trajectories in Cartesian and polar coordinates, application of first order differential equations. Non-linear first order differential equations.

Higher order linear differential equations: Homogeneous linear equations of order n with constant coefficients, auxiliary/characteristics equations. Solution of higher order differential equation according to the roots of auxiliary equation. Non- homogenous linear equations. Working rules for finding particular integral. Cauchy Euler Equation. Application of partial differential equations for various transport processes in chemical engineering.

Recommended Books:

1. Erwin Kreyszig, “Advanced Engineering Mathematics”, John Wiley & Sons, ISBN: 0471728977.
2. John Polking, Al Boggess, David Arnold “Differential Equations”, Prentice Hall, ISBN: 0131437380
3. Stephen Goode, “Differential Equations and Linear Algebra”, Prentice Hall, ISBN: 013263757X.
4. Larry A. Glasgow, “Applied Mathematics for Science and Engineering” 2014, Wiley.

APPLIED PHYSICS

Credit hours: 4 (3,3,0) Prerequisites: N/A

Objectives of the course:

To learn the fundamental principles of physics and their applications

Course Outline:

Electrostatics and Magnetism: Coulombs Law. Electrostatic potential energy of discrete charges, Continuous charge distribution, Gauss’s Law, Electric field around conductors. Dielectrics. Dual trace oscilloscope with demonstration. Magnetic fields. Magnetic force on current. Hall effect. Biot-Savart Law. Ampere’s Law, Fields of rings and coils. Magnetic dipole. Diamagnetism, Paramagnetism and Ferromagnetism.

Waves and Oscillations: Free oscillation of systems with one and more degrees of freedom. Solution for Modes. Classical wave equation. Transverse modes for continuous string. Standing waves. Dispersion relation for waves. LC network and coupled pendulums. Plasma oscillations.

Semi-Conductors: Energy levels in a semiconductor, Hole concept, Intrinsic and Extrinsic regions, PNP, NPN junction. Transistor, LEDs, Amplifiers Optics and Lasers: Harmonic traveling waves in one dimension. Near and far fields. Two-slit interference. Huygens Principle. Single-slit diffraction. Resolving power of optical instruments. Diffraction Grating. Lasers, Population inversion. Resonant cavities. Quantum efficiency. He-Ne, Ruby and CO_2 lasers. Doppler effect and sonic boom.

Modern Physics: Inadequacy of classical physics, Plank's explanations of black body radiation. Photoelectric effect, Compton effect. Bohr's theory of Hydrogen atom, Atomic spectra, De-Broglie hypothesis, Braggs Law, Atomic nucleus, Mass energy relation, Exponential decay and half-life. Nuclear stability and radioactivity, Alpha decay, Beta decay, Gamma decay attenuation, Fission, Energy release, Nuclear Fusion.

Lab Outline:
Practical exercises relating to the topics covered in theory.

Recommended Book:
1. Dale Ewen "Applied Physics" 2009, Prentice Hall, Inc.

English II (Communication Skills)
Credit hours: 1 (0,3,0) Prerequisites: N/A

Objectives: Enable the students to meet their real life communication needs.

Course Contents:

Paragraph writing
Practice in writing a good, unified and coherent paragraph

Essay writing
Introduction

CV and job application

Translation skills
Urdu to English

Study skills
Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension

Academic skills
Letter/memo writing, minutes of meetings, use of library and internet

Presentation skills
Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

Recommended Books:

Communication Skills

a) Grammar
   1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.

b) Writing
   1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
   2. 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).

c) Reading
   1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
   2. Reading and Study Skills by John Langan
   3. Study Skills by Richard York.

CHEMICAL PROCESS TECHNOLOGY

Credit hours: 4 (3,3,0) Prerequisites: N/A

Objectives of the Course:

To familiarize students with conversion of raw materials into finished products on industrial scale using conventional and green technology.

Course Outline:

History and Development of Chemical Process Industry in Pakistan. Drawing Symbols of equipment used in a process industry. Drawing of process flow diagram using computer softwares like MS Visio. Inorganic chemicals manufacturing (acids, alkali and salts), Soaps and Detergents, Cement and Ceramics, Glass, Water treatment and Purification, Fertilizers manufacture, (Urea, Ammonium Nitrate, Super Phosphate, Di-ammonium Phosphate) and introduction to pesticides, Pulp and Paper manufacture. Sugar Manufacture, Polymers manufacture (PVC, Phenol and Urea Formaldehyde), Plastics Additives & Molding Machines and introduction to Rubber, Synthetic fiber

(Manufacture of PET). Leather industry. Food and Beverages, Paints &, coating Industries, Applications of Sustainable and Green technology.

Lab outline:

Practical exercises relating to the topics covered in theory.

Recommended Books:

1. Austin George T. "Shreve's Chemical Processes Industries" 6th Ed. 1997, McGraw-Hill International Edition.
2. Haidari Iqbal "Chemical Industry in Pakistan",1992. Industrial Research Service Karachi, Pakistan.
3. Pandey G. N. "A Textbook of Chemical Technology" 2nd Ed. Vol-I & II. 2000. Vikas Publishing House (Pvt) Limited
4. Riegels Handbook of Industrial Chemistry, James A. Kent 2000, Springer/Van Norstrand/Rein Hold.
5. Kirk Othmer "Encyclopedia of Chemical Technology" 1999, Inter Science Publishers.
6. Jacob A. Moulin, Michiel Makkee, Annelies E. van Diepen, " Chemical Process Technology, 2nd Edition, 2013, Wiley.
7. Anne E. Marteel-Parrish and Martin A. Abraham, "Green Chemistry and Engineering: A pathway to Sustainability", 2014, Wiley.
8. Bailey's Industrial Oil and Fat Products, 6 Volume Set, 6th Edition, Fereidoon Shahidi (Editor), 2005, John Wiley & Sons, Inc.

SEMESTER 3

WORKSHOP PRACTICES

Credit hours: 1 (0,3,0) Prerequisites: N/A

Objectives of the Course:

To provide hands on training skills of workshop machines and tools.

Course Outline:

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

Recommended Books:

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

COMPUTER PROGRAMMING

Credit hours: 3 (2,3,0) Prerequisites: N/A

Objectives of the Course:

To develop programming skills to solve problems of Chemical Engineering

Course Outline

Introduction to development of programming 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 variables. Pointers, arrays and other data structure concepts. Effective choice of variable types. Declaration statements, e.g. common, data and dimension. Format: read, write and print.

Arithmetic operations: Operator symbols. Arithmetic expressions; Assignment statements. Library functions. Algorithms.

Program structure: Declarations, main program and termination. 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. Importance of comments. Debugging. Interpretation of error messages. Functional testing and validation. Good practice.

Lab Outline:

Practical exercises relating to the topics covered in theory.

Recommended Books:

1. Sanford, Larry R. and Nyhoff, L., “Introduction to FORTRAN 90 for Engineers and Scientists”, Prentice Hall, 1996.
2. Lafore “ Programming for PC using Turbo C++” SAMS
3. Bob McFarlane, Robert McFarlane, “Beginning AutoCAD 2007”, Newnes, 2007
4. Wilson, John E., “3D Modeling in AutoCAD”, CMP Books, 2001.
5. Bruce A. Finlayson. “Introduction to Chemical Engineering Computing”. John Wiley and Sons, Ltd. 2006.

CHEMICAL PROCESS PRINCIPLES– II

Credit hours: 2 (2,0,0)

Prerequisites: Chemical Process Calculations-I

Objectives of the course:

To study complex problems of simultaneous material and energy balances in Chemical Engineering Calculations.

Course Outline:

Components of Energy balance. Balances with reaction: Mass and energy balances for reacting systems. Balances for combustion processes. Environmental balances. Sub-systems and interconnections. Concept of integrated pollution control. Case studies on balances for a selection of important industrial processes. Efficiency and conversion. Standard states. Temperature dependence. Heat Effects. Application of Computers in stoichiometric calculations.

Simultaneous mass and energy balances. Temperature and pressure dependence. Balances for condensing systems. Dynamic balances.

Recommended Books:

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

CHEMICAL ENGINEERING THERMODYNAMICS- I

Credit hours 4 (3, 3, 0) Prerequisites: N/A

Objectives of the Course:

To familiarize students with the definitions, concepts, and laws of thermodynamics and their engineering applications

Course Outline:

Introduction, thermodynamic systems and processes, equilibrium, thermodynamic variables, intensive and extensive variables, thermodynamic properties, state functions, derived intensive variables. Types of work, kinetic and potential energy, the first law of thermodynamics, internal energy, energy transfer by heat, energy balance, energy analysis of cycles. Quasi-static processes, reversibility, heat capacities.

Property relations relevant to engineering thermodynamics, P-V-T relation, evaluating thermodynamic properties, generalized compressibility chart Ideal gas model, internal energy, enthalpy and specific heat of ideal gases, evaluating changes in specific enthalpy and internal energy for ideal gases, polytropic process of an ideal gas. Introducing the control volume, conservation of mass and energy in a control volume, Steady-state and transient forms of mass and energy rate balances. Second law of thermodynamics, irreversible processes, entropy, the Carnot cycle.

Applying the second law to thermodynamic cycles, the Carnot cycle. The Clausius inequality, entropy changes, evaluating entropy data. Entropy balance for closed systems, entropy rate balance for control volumes, isentropic processes, isentropic efficiencies of turbines, nozzles, etc.

Equations of state, property relations from exact differentials, fundamental thermodynamic functions, relations for gas mixtures and multi-component systems, the Gibbs-Duhem relation.

Applications to flow processes, nozzles, turbines, compressors, Heat Engines, Refrigeration & Air Conditioning, and Liquefaction of gases.

Lab Outline:

Practical exercises relating to the topics covered in theory.

Recommended Books:

1. Smith J.M., Van Ness H.C., Abbott M.M. "Chemical Engineering Thermodynamics" 8th Ed. 2005. McGraw-Hill International Edition.
2. Daubert Thomas E. "Chemical Engineering Thermodynamics", 1st Ed. 1985, McGraw-Hill Book Company.
3. Sandler Stanley I. "Chemical and Engineering Thermodynamics" 3rd Ed. John Wiley and Aons, Inc.
4. Eastop, Mc Conkey "Applied Thermodynamics" National Book Foundation
5. Moran M. J., Shapiro H. N., "Fundamentals of Engineering Thermodynamics" 6th Ed. John Wiley and Sons, Inc.
6. Cengel, Y. A., Boles, M. A., "Thermodynamics: An Engineering Approach", 2008, McGraw-Hill.

FLUID MECHANICS-I

Credit hours: 4 (3,3,0) Prerequisites: N/A

Objectives of the Course:

To impart knowledge of the concepts and laws of fluid mechanics, and their applications in pipe sizing and flow metering.

Course Outline:

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, Concept of centrifugal pumps; Centrifugal pump characteristics; NPSH and its application in chemical engineering; concept of specific speed; similarity laws in centrifugal pumps; pumps in series and parallel; Positive displacement pumps, their classification, characteristics and selection; matching system characteristics with pump characteristics.

Recommended Books:

1. Holland, F.A. Bragg, R. "Fluid flow for Chemical Engineers", 2nd Edition, Butterworth & Heinemann. 1995.
2. White, F.M. "Fluid Mechanics", 7th Edition, McGraw-Hill. 2011.
3. Noel-de-Nevers "Fluid Mechanics for Chemical Engineers" McGraw-Hill, 2004
4. McCabe Warren L., Smith Julian C., Harriott peter "Unit Operations of Chemical Engineering" 7th Edition, 2010. McGraw-Hill Inc.
5. Coulson J.M., Richardson J.F. "Chemical Engineering" Vol-I, 6th 1999. Butterworth, Elsevier.
6. Munson B.R., Huebsch W.W., Rothmayer A.P. "Fundamental of Fluid Mechanics" Wiley; 7th edition, 2012
7. Fundamental of Fluid Mechanics, 6th Edition.

ENGINEERING MECHANICS

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the Course:

To impart knowledge of mechanics of engineering materials that is generally part of the process industry.

Course Outline:

General principles of statics; Review of vector addition and subtraction;

Cartesian vectors

Position vectors; Force vector directed along a line. Dot product and cross products. Laws of triangle and parallelogram law of forces. Momentum; Conditions of equilibrium of particles; Free-body diagrams; Co-planar force systems. Moment of force; Scalar and vector formulation, Moment of a couple. Conditions of equilibrium of a rigid body in two dimensions. Free body diagrams and equations. Structural Analysis; Methods of joints and sections, Rules for Zero Force members.

Kinematics of particles; Rectilinear and curvilinear motion of particles; Components of velocity and acceleration kinetics of particles. Newton's second law of motion; Dynamic Equilibrium. Work; Energy; Power; Impulse and momentum.

Recommended Books:

1. Bedford, A., Fowler, W. L., "Engineering Mechanics: Statics & Dynamics Principles" 2003, Prentice Hall.
2. Hibbeler, R. C., "Engineering Mechanics: Statics" 2009, Prentice Hall.

SEMESTER 4

COMPUTER AIDED ENGINEERING DRAWING

Credit hours: 1 (0,3,0) Prerequisites: N/A

Objectives of the Course:

To enable students to understand and produce 2D and 3D engineering drawings using CAD tools.

Course Outline:

Introduction to CAD software: 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.

Recommended Books:

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

APPLIED ELECTRICAL ENGINEERING

Credit hours: 3 (2,3,0) Prerequisites: N/A

Objectives of the Course:

To impart the basic knowledge of electrical machines and electronic devices

Course Outline:

Introduction to electrical engineering; A.C/D.C Motors, their types and control; Generators; Transformers; Single and multi-phase. A.C circuits; Power factor; Introduction to electronics and circuit analysis. Integrated circuits, resisters, micro- processors. Controller and their types

Recommended Books:

1. Thomas L. Floyd, David M. Buchla, "Electronics Fundamentals: Circuits, Devices, and Applications",8th Ed. 2009, Prentice Hall
2. John Bird, "Electrical Circuit Theory and Technology", 2nd Ed., 2003, Newnes Publication.
3. C.L. Wahdwa, "Basic Electrical Engineering", 2nd Ed., 2006, New Age International Publishers
4. Heinz Schmidt-Walter, Ralf Kories, "Electrical Engineering: a pocket reference", 2007, Artech House
5. Allan R. Hambley, "Electrical Engineering: Principles and Applications", 5th Ed., 2010, Prentice Hall

CHEMICAL ENGINEERING THERMODYNAMICS- II

Credit hours: 2 (2,0,0)

Prerequisites: Chemical Engineering Thermodynamics- I.

Objectives of the Course:

To enable students to understand and apply principles of thermodynamics on equilibrium calculations in multi-component and multiphase systems.

Course Outline:

General Vapour Liquid Equilibrium (VLE) behaviour: Equilibrium criterion and Raoults's law.

VLE calculations – Bubble point, Dew point and Flash calculations.

Partial molar quantities; Excess properties; Chemical potential, fugacity and activity coefficients; Theory and applications.

Chemical reaction equilibrium and equilibrium constants; single and multi-reaction equilibria, Dependence of equilibrium constant on T, P, and composition.

Chemical and phase equilibrium, phase transitions, Gibbs free energy and phase diagrams, chemical potential, chemical potential in solutions, ideal reacting gas mixture.

Calculations in Phase Equilibria: Liquid-Liquid; Liquid-Solid. Thermodynamic Analysis of Chemical Processes.

Introduction to Statistical Thermodynamics.

Recommended Books:

1. Smith J. M., Van Ness H. C., Abbott M. M. "Chemical Engineering Thermodynamics" 6th Ed. 2001. McGraw-Hill International Edition.
2. Daubert Thomas E. "Chemical Engineering Thermodynamics", 1st Ed. 1985, McGraw-Hill Book Company.
3. Sandler Stanley I. "Chemical and Engineering Thermodynamics" 3rd Ed. John Wiley and Sons, Inc.
4. Eastop, Mc Conkey "Applied Thermodynamics" National Book Foundation
5. Moran M. J., Shapiro H. N., "Fundamentals of Engineering Thermodynamics" 6th Ed, John Wiley & Sons
6. Cengel, Y. A., Boles, M. A., "Thermodynamics: An Engineering Approach", 2008, McGraw-Hill.

CHEMICAL ENGINEERING MATHEMATICS

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To focus on use and application of mathematical methods in the areas relevant to chemical engineering.

Course Outline:

Application of following mathematical techniques to the chemical engineering problems, Laplace transform, solution of differential equations using laplace transforms, fourier transform and its applications. Special functions e.g. gamma function, error function, bessel function.

Vector calculus, gradient, divergence, and curl of a vector and their applications. Introduction to tensor calculus.

Matrices: Addition & multiplication of matrices, determinant of matrices.

Recommended Books:

1. Edwards, C., and D. Penney. *Elementary Differential Equations with Boundary Value Problems*. 6th Ed. Upper Saddle River, NJ: Prentice Hall, 2003.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley, 2006.

PARTICULATE TECHNOLOGY

Credit hours: 4 (3,3,0) Prerequisites: N/A

Objectives of the Course:

To provide understanding of the fundamentals of particle technology with the emphasis on applications in chemical and process industries

Course Outline:

Characterization of particle and particulate systems (Sieve analysis, Particle size analysis); Processing (Granulation, Sedimentation); Particle Formation

(Granulation, Size Reduction); Description & Energy calculations for coarse to ultrafine size reducing equipment, Agglomeration.

Storage and Transport (Hopper Design, Conveyers and its types Pneumatic Conveying, Standpipes, Slurry Flow); Mechanical Separation (Filtration and its types, Settling, Cyclones); Properties of Particulate Systems (Colloids, Respirable Drugs, Coal-Water Slurries, Slurry Rheology). Hazards identification of Mechanical equipment. 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

Solid-Liquid mixing; types of mixing and mixing mechanism. Equipment for solid-liquid mixing

Flow through porous media, Carman-Kozney equation

Electrostatic Precipitation: Basic operating principles, the physics of precipitation, factors effecting the design and performance of electrostatic precipitators.

Powder, ultra-fine and nanoparticles technology

Lab Outline:

Practical exercises relating to the topics covered in theory.

Recommended Books:

1. McCabe Warren L, Smith Julian C, Harriott Peter., "Unit Operations, 7th Edition, 2010, McGraw-Hill Inc.
2. Coulson J. M, Richardson J. F., "Chemical Engineering- Particle technology and separation processes" Vol 2, 5th Ed. 2007, Pergamon Press.
3. Martin Rhodes, "Introduction to Particle Technology, 2nd Ed. 2008, John Wiley & Sons, Ltd.
4. Richard G. Holdich, "Fundamentals of particle technology", 2002, Midland Information Technology and Publishing.
5. Enrique Ortega-Rivas, "Unit Operations of Particulate Solids: Theory and Practice" 2012, CRC Press.
6. Particle Technology, Hans Rumpf–4th Edition. 2013.

FLUID MECHANICS-II

Credit hours: 2 (2,0,0) Prerequisites: 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 Outline:

Flow of Compressible Newtonian Fluids

Flow through porous media; Fluidization and types of fluidized beds and

their use in chemical engineering, Particle and Regime classification, minimum fluidization and particulate fluidization, entrainment and elutriation, concept of hydrodynamic characteristics of fluidized beds, bubbling fluidization, turbulent fluidization, slurry bed fluidization. Industrial application of fluidization.

Introduction to non-Newtonian fluids

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 Turbo-machinery and its classifications. Compressors, their classification, characteristics and selection. Turbines, their classification and selection. Compressible flow and its application in chemical engineering, concept of choked flow.

Lab Outline:

Practical exercises relating to the topics covered in theory.

Recommended Books:

1. Holland, F. A. Bragg, R. "Fluid flow for Chemical Engineers", 2nd Ed., Butterworth & Heinemann. 1995.
2. White, F.M. "Fluid Mechanics", 7th Ed., McGraw-Hill. 2011.
3. Noel-de-Nevers "Fluid Mechanics for Chemical Engineers" McGraw-Hill, 2004
4. McCabe Warren L., Smith Julian C., Harriott peter "Unit Operations of Chemical Engineering" 7th Ed., 2010. McGraw-Hill Inc.
5. Coulson J.M., Richardson J.F. "Chemical Engineering" Vol-I, 6th 1999. Butterworth, Elsevier.
6. Munson B.R., Huebsch W.W., Rothmayer A.P. "Fundamental of Fluid Mechanics" Wiley; 7th Ed., 2012
7. Seppo A. Korpela, " Principles of Turbomachinery", 2012, Wiley.

PROCESS SAFETY MANAGEMENT

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the Course:

Familiarization of international standards & the importance of safety and the occupational health viz-a –viz environment related to chemical industries

Course Outline:

Importance of safety with increased productivity, Overall safety of plant and personnel; Accident and loss statistics. Accident analysis and prevention. Types of accidents in chemical industry. Regulations and standards for industrial safety. Difference between accident and incident. Accident rate calculations and economics of accident prevention. Safety management. Hazard and risk assessment. Accident investigation and case history. Fires and explosions. Fire triangles. Flammability characteristics. Safety

equipment, fire-fighting equipment and their uses. Occupational diseases related to chemical industry.

Environmental impacts and quality standards

Recommended Books:

1. Crowl D.Y., Louvar J.F., “Chemical Process Safety Fundamentals with Applications”, 1990, Prentice Hall.
2. Marc J. Assael and Konstantinos E. Kakosimos, “ Fires, Explosion and Toxic Gas Dispersion”, 2010, CRC Press.
3. Charles E. Thomas, Process Technology: Safety, Health, and Environment By Charles E. Thomas 3rd Edition, 2005.
4. Reynold L. Hoover, Health, Safety, and Environmental Control, 2nd Edition 2000.
5. Stephen Asbury ,Health and Safety, Environment and Quality Audits: A Risk-based Approach, 2nd Edition.1999.
6. By Elearn ,Managing Health, Safety and Working Environment, 2nd Edition.

SEMESTER 5

MASS TRANSFER

Credit hours: 3 (2,3,0) Prerequisites: N/A

Objectives of the Course:

To impart knowledge of fundamental laws of mass transfer their applications for stage operations

Course Outline:

Classification of mass transfer operations; the choice of mass transfer methods; Design principles. Molecular Diffusion in fluids and solids; Fick’s law of Diffusion; steady state diffusion in fluids at rest or in laminar motion. Concept of mass transfer coefficients, their calculation in laminar and turbulent flows; Interphase mass transfer; Equilibrium and diffusion across the interface and the concept of stages. Phase equilibrium in Mass transfer.

Distillation: The fractionating column. Lewis-Sorel; McCabe-Thiele methods. Importance of the reflux ratio; Calculation of minimum reflux ratio; Number of plates at total reflux; Underwood and Fenske methods; 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. Enthalpy-concentration method.

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; Numerical examples of multi- component separation problems; Side streams and partial condensers. Column Design: Tray design; hydraulics and performance.

Batch distillation: operation at constant product composition or constant reflux ratio. Calculation of column diameter and height.

Lab Outline:

Practical exercises relating to the topics covered in theory.

Recommended Books:

1. McCabe Warren L., Smith Julian C., Harriott Peter "Unit Operations of Chemical Engineering" 7th Ed. 2005. McGraw-Hill Inc.
2. Coulson J.M., Richardson J. F. "Chemical Engineering" Vol-II, 5th Ed. 2002. The English Book Society and Pergamon Press.
3. Incropera Frank P., De Witt David P. "Fundamentals of Heat and Mass Transfer" 3rd Ed. 1990. John Wiley and Sons.
4. Treybal Robert E. "Mass Transfer Operations", 1981, McGraw-Hill Book Company.
5. Schweitzer, "Handbook of Separation Techniques for Chemical Engineers", 1979, McGraw-Hill Book Co.
6. Coulson J. M., Richardson J. F. "Chemical Engineering" Vol-I, 1999. The English Book Society and Pergamon Press
7. Alan S. Foust, Leonard A. Wenzel "Principles of Unit Operations" 2nd Ed.1980. John Wiley & Sons.
8. Diran Basmadjian. "Mass Transfer and Separation Process (Principles and Applications) CRC Press Taylor and Francis Group. 2007.

CHEMICAL REACTION ENGINEERING

Credit hours: 4 (3,3,0)

Prerequisites: Chemical Engineering Thermodynamics, Physical & Analytical Chemistry.

Objectives of the Course:

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

Course Outline:

Kinetics of homogeneous reactions: Rate of reaction, variables affecting the rate of reaction, order of reaction, rate constant; searching for a mechanism of reaction, 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 reactors: Batch, Mixed flow, Plug flow reactors, Comparison of single reactor, multiple reactor systems in parallel/series. Temperature and pressure effects, Adiabatic and non-adiabatic operations.

Design of heterogeneous reactors: Surface phenomenon and catalysis, adsorption/desorption isotherms, Heterogeneous reaction systems, Rate equations for heterogeneous reactions, Determination of rate controlling steps. Kinetics of solid catalyzed reactions. Catalyst deactivation and

regeneration. Design of fixed bed and fluidized bed catalytic reactors.

Lab Outline:

Practical exercises relating to the topics covered in theory.

Recommended Books:

1. H. Scott Fogler "Elements of Chemical Reaction Engineering" 4th Edition, Prentice Hall; 2005
2. Levenspiel Octave. "Chemical Reaction Engineering" 3rd Ed. 2006, John Wiley & Sons Inc.
3. Smith J. M. "Chemical Engineering Kinetics" 2001, McGraw-Hill Book Co.
4. E Bruce Nauman "Chemical Reactor Design, Optimization and Scale up" McGraw-Hill 2002.
5. Charles and Thatcher "Introduction to Chemical Engineering Kinetics and Reactor Design" Second Ed. 2014 John Wiley

ENGINEERING MATERIALS

Credit hours: 2 (2,0,0) Prerequisites: N/A.

Objectives of the Course:

To impart knowledge of engineering materials, their characteristics, testing and applications.

Course Outline:

Stress, strain, modulus, elastic and plastic behaviour of materials. Physical, mechanical, thermal properties and characterization. Properties, classification and application of materials of construction such as Iron, steel, stainless steel, Nickel, haste alloy, copper alloys, Aluminium and its alloys, lead, titanium and tantalum, PVC, Teflon, poly-olefins, PTFE glass, stone ware, acid resistant bricks and tiles. Biomaterials, Composites, Ablatives and thermal insulation materials. Electrical and optical properties of materials, biodegradable materials and recyclable materials.

Nature, types and rate of corrosion, corrosion protection, surface treatment, heat treatment. Material selection; Material testing (destructive and non-destructive testing); International standards for material testing.
Introduction to nano-materials.

Lab Outline: N/A

Recommended Books:

1. William D. Callister, D. G. R. (2014). Materials Science and Engineering: An Introduction (9th Ed.). John Wiley & Sons, Inc.
2. Srivastava C. M., Srinivasan C. "Science of Engineering Materials" 2nd Ed.2000, New Age International (PRACTICALS) Limited, Publishers.
3. Varnon John. "Introduction of Engineering Materials" MacMillan.
4. William F. Smith. "Principles of Materials Science and Engineering" McGraw-Hill.
5. R. A. Flinn and P. K. Trjan "Engineering Materials and Their Applications" Jaico.

6. Ijaz Hussain Khan. “Corrosion Technology”, Vol-I and 2, Institute of Chemical Engineering, University of the Punjab, Lahore, Pakistan.

HEAT TRANSFER

Credit hours: 4 (3,3,0) Prerequisites: N/A

Objectives of the Course:

To develop understanding of the governing laws of heat transfer for designing heat transfer equipment.

Course Outline:

Difference between thermodynamics and heat transfer; modes of heat transfer: Conduction; Fourier’s law of heat conduction, steady state one dimensional heat conduction without and with heat generation, conduction in multi layers geometries and its application in insulation. Unsteady state heat conduction; Introduction to heat conduction in two dimensions.

Convection; concept of free and forced convection; concept of heat transfer coefficient and Newton’s law of cooling; forced convection in laminar and turbulent flows in pipes and on flat plates; Use of dimensional analysis in convection, concept of overall heat transfer coefficient; Concept of thermal boundary layer and its analogy with momentum boundary layer.

Radiation heat transfer; laws of radiation, radiation surface behaviour concept of shape factor for black body and non-black body radiation.

Heat transfer equipment, types and selection criteria; types of heat exchangers and design; heat transfer with phase change; boiling and condensation; the boiling curve; evaporators and their design. International standards, e.g. TEMA and IPS standards shall be followed.

Lab Outline:

Practical exercises relating to the topics covered in theory.

Recommended Books:

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

NUMERICAL METHODS AND SOFTWARE APPLICATIONS

Credit hours: 3 (2,3,0) Prerequisites: N/A

Objectives of the Course:

To enable students to use structured programming techniques in suitable programming languages and implement numerical solutions using software tools e.g. MATLAB, MATHEMATICA etc.

Course Outline:

Linear Algebra: Matrix and First-order Linear Systems. Eigen values and Eigen vectors. Finite difference and theory of interpolation; Iterative methods; Taylor, Newton Series etc. Approximation zeros (roots); numerical integration and differentiation. Iterative methods for solution of linear systems, design value problems, numerical solutions of ordinary differential equations.

Linear algebra applications: matrix calculations, solution of linear equations, Eigen value calculation. Numerical solution/calculation of integrals, derivatives and differential equations. Transfer function manipulation and study of transient response of various first and second order systems, plotting Bode and Root Locus diagrams. Introduction to simulations using software tools.

Lab Outline:

Practical exercises relating to the topics covered in theory using software tools e.g. MATLAB, MATHEMATICA etc.

Recommended Books:

1. Zhilin Li, Lubin & Vulkov, Jerzy Wasniewski, “Numerical analysis and its applications”, Springer, 2005, ISBN 3540249370.
2. Michelle Schatzman, “Numerical Analysis” Oxford University Press, 2002, ISBN 0198508522.
3. Steven T. Karris, “Numerical Analysis” Orchard Publications, 2004, ISBN 0974423912.

Probability & Statistics

Credits: 2 (2,0,0) Prerequisite: N/A

Objectives of the Course:

To prepare the students for the statistical analysis of data to quantify the errors

Course Outline:

Statistical treatment of data. Probability analysis and distribution including random variables, binomial distribution, poisson approximation to binomial distribution, Probability density function. Sampling distribution. Regression analysis. Scientific notation and significant figures. Types of errors in experimental measurements. Units in different systems. Graphical Techniques (Log, semi-log and other non-linear graphs). Applications of statistical analysis

software i.e. SPSS, STATA, R, etc.

Recommended Books:

1. Kenneth. Lange, “Statistical Methods”, Springer, 2002, ISBN 0387953892.
2. Montgomery, D.C., and Runger, G.C., “Applied Statistics and Probability for Engineers”, John Wiley & Sons, 2001.

SEMESTER 6

INSTRUMENTATION & PROCESS CONTROL

Credit hours: 4 (3,3,0) Prerequisites: N/A

Objectives of the Course:

To impart knowledge of instruments and control in order to design control systems for chemical process industry.

Course Outline:

Study of scientific principles employed in instruments; sensors, modifiers, recorders etc. Dynamic and static properties of instruments; selection and calibration of instruments; error analysis of process measurement; Instrument Identification and Line Symbols; Available technology of instrumentation for temperature, flow, level, weight, load, pressure, composition and pH measurement. Transducers; advanced measurement devices employing piezoelectric current, ultrasonic, laser, microwave etc. final control elements; Installation of different types of sensors with economic considerations; Types of Controller, Design and Hardware elements of control Case studies based on installation and commissioning of different types of sensors on the basis of economics and technology.

Introduction and significance of control; Feedback and feed forward control; Design and Hardware elements of control; Dynamics of first and second order systems; Overall transfer function testability; Controllers (P, PI, PID etc.), final control elements; Dynamic behavior of feedback controlled processes, Representation of control systems; Multiple control loops; cascade, ratio, over-riding etc. Introduction to stability of chemical processes, tuning of feedback control loops; introduction to frequency response methods /techniques; Routh's criteria, Bode plots, Nyquit method; Computer control, Introduction to Distributed Control Systems; Case study: Development of control scheme of complete plant. Development of P & ID. Safety instrumented system.

Lab Outline:

Practical exercises relating to the topics covered in theory.

Recommended Books:

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

Oxford University Press, 1997.
4. Coughanowr, D. R. and S. E. LeBlanc,, Process system Analysis & Control, 3rd Edition, 2009, McGraw-Hill.
5. Process Control Instrumentation Technology, Curtis D. Johnson, Pearson Education 2003.
6. Chemical Process Control, G. Stephanupolos, Prentice Hall 2002
7. Essentials of Process Control, W.L. Luyben McGraw-Hill 1997.

FUELS & ENERGY

Credit hours: 4 (3,3,0) Prerequisites: N/A

Objectives of the Course:

To provide in-depth knowledge of selection and efficient utilization of fossil fuels and alternate & sustainable energy resources.

Course Outline:

Survey of available energy resources. Introduction and survey of locally available fuels, industrial fuels: Classification and storage of solids, liquids and gaseous fuels: Criteria and characterization for the selection of fuels for industrial purposes; Carbonization, liquefaction and gasification of coal; Synthetic fuels; Petroleum refining, natural gas processing & syngas production Fuel up gradation, Fishertrops process and clean coal technology

Furnaces, Burners and their performance Biomass Sources, Pretreatment of biomass for thermo-chemical conversion, methods of production of fuels from biomass, Gasification and liquefaction of forest products, Biomass volatilization, Kinetics of gasification, Ethanol and Methanol production from biomass.

Nuclear and Solar energy, hydel power, wind and tidal energy, geothermal energy. Energy conservation, methodologies of selected systems.

Lab Outline:

Practical exercises relating to the topics covered in theory.

Recommended Books:

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

CHEMICAL ENGINEERING ECONOMICS

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the Course:

To familiarize students with the importance of economics and its application in chemical engineering design for the purpose of cost estimation, profitability and economic feasibility.

Course Outline:

Engineering economy basics: Measures of financial effectiveness; Non-monetary factors and multiple objectives; principles of engineering economy.

Consumer and producer goods; Measures of economic worth; Price, Supply and Demand relationship; Production; Factors of production; Laws of return , Taxation & Insurance

Depreciation calculation Sunk and opportunity costs; Fixed, variable, and incremental costs; Recurring and nonrecurring costs; Direct, indirect, and overhead costs; Standard costs; Breakeven analysis; Unit cost of production; Cost-benefit analysis; Feasibility studies; Value analysis in designing and purchasing.

Economic evaluation of processes and equipment; Payback period method; Present worth method; Uniform annual cost method; Rate of return method (including Internal Rate of Return).

Manufacturing lead time; Production rate; Capacity; Utilization; Availability; Work in process; WIP and TIP ratios.

Types of ownership; types of stock; Partnership & joint stock companies; Banking and specialized credit institutions.

Islamic and Contemporary financing systems and their use in cost estimation.

Recommended Books:

1. Leland Blank, and Anthony Tarquin, “Engineering Economy”, 6th Edition, McGraw-Hill, 2005.
2. G. J. Thuesen, and W. J. Fabrycky, “Engineering Economy”, 9th Edition, Prentice Hall of India, 2005.
3. Ted G. Eschenbach, “Engineering Economy”, 2nd Edition, Oxford University Press, 2003.
4. James L. Riggs, David D. Bedworth, and Sabah U. Randhawa, ”Engineering Economics”, 4th Edition, Tata McGraw-Hill, 1996.
5. James L. Riggs, and Thomas M. West, “Essentials of Engineering Economics”, 2nd Edition, McGraw-Hill, 1986
6. Engineering Economy (9th Edition, 2008) by Gerald J. Thuesen and W.J. Fabrycky, Prentice Hall.
7. Engineering Economy (7th Edition, 2011) by Leland Blank and Anthony Tarquin, McGraw-Hill.
8. Engineering Economy (3rd Edition, 2010) by Ted G. Eschenbach, Oxford University Press.
9. Engineering Economics (4th Edition,1996) by James L. Riggs and David D. Bedworth, McGraw-Hill.
10. Process Engineering Economics (Chemical Industries) (1st Edition, 2003) by James R. Couper ,CRC Press.
11. Engineering Economy (16th Edition, 2014) by William G. Sullivan & C. Patrick koelling, Prentice Hall. mes L. Riggs, and Thomas M. West, “Essentials of Engineering Economics”, 2nd Edition, McGraw-Hill, 1986

Separation Processes I

Equipment for gas liquid operations; Equipment where the gas is dispersed; sparged vessels column, tray towers; Equipment where liquid is dispersed, packed towers, venturi scrubbers. Equipment for liquid operations; mixer settlers and pulse columns. Equipment for solid fluid operations; leaching, drying, adsorption and ion exchange.

Absorption: Extension of design techniques to absorption.
Liquid-Liquid extraction: Introduction, Extraction Processes, Equilibrium data, Calculation of the number of theoretical stages for various cases of countercurrent and co-current operations.

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: Basic principles, types, features and operation of various cooling towers. Cooling tower design; Alternative sinks for waste heat. Design of equipment based on worst case scenarios. Water and air based systems. Environmental effects.

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.

Recommended Books:

1. McCabe Warren L., Smith Julian C., Harriott Peter "Unit Operations of Chemical Engineering" 7th Ed. 2005. McGraw-Hill Inc.
2. Coulson J.M., Richardson J. F. "Chemical Engineering" Vol-II, 5th Ed. 2002. The English Book Society and Pergamon Press.
3. Incropera Frank P., De Witt David P. "Fundamentals of Heat and Mass Transfer" 3rd Ed. 1990. John Wiley and Sons.
4. Treybal Robert E. "Mass Transfer Operations", 1981, McGraw-Hill Book Company.
5. Schweitzer, "Handbook of Separation Techniques for Chemical Engineers", 1979, McGraw-Hill Book Co.
6. Coulson J. M., Richardson J. F. "Chemical Engineering" Vol-I, 1999. The English Book Society and Pergamon Press
7. Alan S. Foust, Leonard A. Wenzel "Principles of Unit Operations" 2nd Ed. 1980. John Wiley & Sons.
8. Diran Basmadjian. "Mass Transfer and Separation Process (Principles and Applications) CRC Press Taylor and Francis Group. 2007.

TRANSPORT PHENOMENA

Credit hours: 3 (3,0,0) Prerequisites: Fluid Mechanics-I.

Objectives of the Course:

To develop comprehensive models of chemical engineering operations based on the theories of momentum, mass, and energy transport.

Course Outline:

Transfer processes: A review of the mechanisms of momentum, energy and mass transport.

Momentum transport: Derivation of equations of continuity and motion (Navier- Stoke's equation). Application in laminar and turbulent flow problems.

Energy transport: Derivation of energy equation. Application to heat transfer problems involving conduction, forced and free convection. Application in laminar and turbulent flow problems.

Mass transport: Derivation of species conservation equations for binary and multi- component mixtures. Application to mass transfer problems with and without chemical reaction. Application in laminar and turbulent flow problems.

Recommended Books:

1. Bennett C. O., Myers J. E. "Momentum, Heat & Mass Transfer" 3rd Ed. 1983. McGraw-Hill Book Company.
2. Bird R. Byron, S Warren E., Lightfoot Edwin N. "Transport Phenomena" , Revised 2nd Edition, 2007, John Wiley & Sons Inc.
3. B Robert S., Hershey Harry C. "Transport Phenomena–A Unified Approach", 1988, McGraw-Hill International Editions.
4. Incropera Frank P., De Witt David P. "Fundamentals of Heat and Mass Transfer" 3rd Ed. 1990. John Wiley and Sons.
5. James Welty, Charles E. Wicks, Gregory L. Rorrer, Robert E. Wilson, Fundamentals of Momentum, Heat and Mass Transfer, 5th Edition, 2008, Wiley.

TECHNICAL REPORT WRITING & PRESENTATION SKILLS

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the Course:

To enhance the report writing & presentation skills and develop interpersonal communication expertise

Course Outline:

Presentation skills

Introduction to basic concepts; features of effective presentation, best practices.

Essay writing

Descriptive, narrative, discursive, argumentative.

Academic writing

How to write a proposal for research paper/term paper.
How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency).

Technical Report writing

Introduction to basic concepts, important aspects of technical reports and documentation, best practices.

Recommended Books:

1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
2. College Writing Skills by John Langan. McGraw-Hill Higher Education. 2004.
3. Patterns of College Writing (4th Edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.

SEMESTER 7

SEPARATION PROCESSES II

Credit hours: 3 (2,3,0)

Prerequisites: Heat Transfer, Mass Transfer.

Objectives of the Course:

To provide understanding of design strategies of separation equipment involving simultaneous heat and mass transfer operations.

Course Outline:

Adsorption: Introduction, The nature of adsorbents, Adsorption equilibria, Adsorption from liquids, structure of adsorbents, Adsorption equipment and regeneration of spent adsorbents.

Ion exchange: principles, applications and equipment. Membrane Separation Processes.

Leaching: General principles, Factors influencing the rate of extraction, Mass transfer in leaching operations, Equipment for leaching, Calculation of the number of stages by graphical methods.

Crystallization: Growth and properties of crystals, saturation and nucleation, crystallization rate, impurities, effect of temperature on solubility. Solubility and phase diagram, fractional crystallization, caking, crystallizers, principles of construction and operations.

Azeotropic and Extractive distillation: Heterogeneous azeotropes; Illustrative examples of azeotropic distillation. Reactive distillation.

Lab Outline:
Practical exercises relating to the topics covered in theory.

Recommended Books:

1. McCabe Warren L., Smith Julian C., Harriott peter "Unit Operations of Chemical Engineering" 7th Ed. 2005. McGraw-Hill Inc.
2. Coulson J. M., Richardson J. F. "Chemical Engineering" Vol-II, 5th Ed. 2002. The English Book Society and Pergamon Press.
3. Coulson J. M., Richardson J. F. "Chemical Engineering" Vol-I, 1999. The English Book Society and Pergamon Press
4. 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.
5. Incropera Frank P., De Witt David P. "Fundamentals of Heat and Mass Transfer" 3rd Ed. 1990. John Wiley and Sons.
6. Treybal Robert E. "Mass Transfer Operations", 1981, McGraw-Hill Book Company
7. Christie J. Geankoplis, "Transport Processes and Unit Operations", 4th Ed., 2003, Prentice Hall Professional Technical Reference

INDUSTRIAL MANAGEMENT

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the Course:

To provide understanding of the principles and techniques of industrial management.

Course Outline:

Introduction to Industrial Management; Productivity, Plant Layout; Product & Process layout analysis and comparison; Material handling considerations in layout. Production planning methods, material requirement planning, material resource planning. Capacity planning and control; Production control systems; Job shop scheduling; Quality Control; Production control charts; Scheduling techniques; Purchasing and procurement. Inventory control; EOQ/EPQ models (calculations based on EOQ). Time and Motion study.

Organizational structure, Human resource management. Project management principles, PERT/CPM, total quality management, ISO standards, labour and engineering laws. Labour problems; Labour organizations; Prevention & settlement of disputes.

Recommended Books:

1. Harold Kerzner, "Project Management: A Systems Approach to Planning, Scheduling, and Controlling", Ninth Edition, John Wiley & Sons, 2006.
2. Jay Heizer and Barry Render, "Principles of Operations Management", 3rd Edition, Prentice Hall, 1999.
3. Jay Heizer and Barry Render, "Operations Management", 5th Edition, Prentice Hall, 2000.

4. Industrial Management Methods Ronald Hurst.
5. Industrial Organization & Management BETHEL.
6. Principles of Management Design Robert E. Parr.
7. Operations Management (11th Edition, 2013) by Jay Heizer and Barry Render, Prentice Hall.
8. Principles of Operations Management (9th Edition,2013) by Jay Heizer and Barry Render, Prentice Hall.
9. Fundamentals of Project Management (4th Edition, 2011) by Joseph Heagney , Amacom.

CHEMICAL PLANT DESIGN

Credit hours: 3 (3,0,0)

Prerequisites: Heat Transfer, Mass Transfer.

Objectives of the Course:

To integrate applications of design practices and techniques by using international codes and standards for chemical plants

Course Outline:

Process design and development. General design considerations. Design codes, standards & materials selection.

Vessel design: Low, medium and high pressure storage and transportation vessels; Cryogenic vessels

Design of mass transfer equipment; material transport; material handling. Heat transfer equipment including furnaces and refrigeration units. Piping and pipeline design.

Basic Concepts of Cost Indexing & Optimization: Optimization of Unconstrained Functions; Linear Programming Applications; Non-Linear Programming with Constraints.

Engineering Ethics; Local, Global Impact Analysis.

Recommended Books:

1. Peters Max S., Timmerhaus Klaus D. “Plant Design and Economics for Chemical Engineers” 4th Ed. 1991. McGraw-Hill Inc.
2. Ludwig Ernest E. “Applied Process Design for Chemical and Petrochemical Plants” Vol 1, 2 & 3, 3rd Ed. 2002, Gulf Publishing Company.
3. Walas Stanley M. “Chemical Process Equipment Selection and Design “Butterworth Heinemann” 1999.
4. Coulson J. M, and Richardson, “Chemical Engineering”, Vol VI, “Butterworth Heinemann” 1999.
5. Wells G. L. Rose L. M. “The art of Chemical Process Design” 1986. Elsevier.
6. Smith Robin “Chemical Process Design” 1995. McGraw-Hill Inc.

7. Backhurst & Harker, “Chemical Process Design, John Wiley
8. Evans, “Handbook of Chemical Equipment Design”
9. E. L. Cussler and G. D. Moggridge, “Chemical Product Design”, 2001, Cambridge University Press.
10. Special Issue of Chemical Engineering Research and Design, Part A 80 (A1), 2002 on “Process and Product Development”
11. James Wel, Molecular Structure and Property: Product Engineering, Ind. Engg. Chem. Res. 41(8) 1917-1919 (2002)
12. Robbin Smith, “ Chemical Process : Design and Integration,” 2005, Wiley.

DESIGN PROJECT- Part I

Credit hours: 3 (0,9,0)

ELECTIVE-I

Credit hours: 3 (3,0,0)

PROCESS ANALYSIS & OPTIMIZATION

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To impart knowledge of various models used for process and performance analysis for optimization in process industry.

Course Outline:

Use of models in process engineering: Model as a working description of a system. Types and function of model: mechanistic, empirical, stochastic, procedural and qualitative. Reasoning for using models. Strategy for model building: Relationship between engineering and mathematical approximations. Example of dynamic delay of air heater. Conceptual models. Formulation of functional – mechanistic models based on conservation equations. Coordinate free methods based on vector/matrix notation. Models for complex and irregular geometry. Case study examples for heat exchanger and tubular reactor definition of system parameters consistent with the model. Averaging and model reduction techniques. Numerical procedures based on weighted residuals.

Adaptive models: Empirical models based on non-linear regressive adaptive refinement of models. State variables models and matrix differential equations. Filtering and continuous up-dating of models. State estimation and adaptive control. Population balance models: Description of process in terms of distribution functions based on principal attributes. Age distribution. Process vessel characteristics in terms or residence time distribution functions. Standard models based on plug flow, CSTR and dead space. Mixing and age distribution. Application to reaction systems and liquid-liquid extraction. Quantitative models: Diagnostics procedures. Signal flow graphs. Reasoning with qualitative models.

Models for process simulation: Analysis of systems behavior for process optimization, flexibility and safety. Stability and multiple states. Optimization methods; Analytical/numerical techniques for single variable and multi variable (constrained and unconstrained) functions; linear programming; PERT and CPM project and its organization.

Recommended Books:

1. Taha Hamdy A. “Operation Research-An Introduction” Prentice Hall (Pvt) Limited.
2. Edgar T. F., Himmelblau D.M. “Optimization of Chemical Processes” 1989 McGraw-Hill Inc.
3. B. V. Babu “Process Plant Simulation”, 2004 Oxford University Press.
4. E. Bruce Nauman, “Chemical Reactor Design, Optimization and Scaleup”, 2002 McGraw-Hill.
5. Robbin Smith, “ Chemical Process : Design and Integration,” 2005, Wiley.

SEMESTER 8

Entrepreneurship

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the course:

To provide and understanding of basic principles and concepts to analyze the theories of entrepreneurship

Course Outline:

Introduction: The concept of entrepreneurship; The economist view of entrepreneurship; The sociologist view; Behavioural approach; Entrepreneurship and Management

The Practice of Entrepreneurship: The process of entrepreneurship; Entrepreneurial Management; The entrepreneurial business; Entrepreneurship in service institutions; The new venture.

Entrepreneurship and Innovation: The innovation concepts; Importance of innovation for entrepreneurship; Sources of innovative opportunities; The innovation process; Risks involved in innovation.

Developing Entrepreneur: Entrepreneurial profile; Trait approach to understanding entrepreneurship; Factors influencing entrepreneurship; The environment; Socio cultural factors; Support systems.

Entrepreneurship Organization: Team work; Networking organization; Motivation and compensation; Value system.

Entrepreneurship and SMES: Defining SMEs; Scope of SMEs; Entrepreneurial managers of SME; Financial and marketing problems of SMEs.

Entrepreneurial Marketing: Framework for developing entrepreneurial marketing; Devising entrepreneurial marketing plan; Entrepreneurial

marketing strategies; Product quality and design.

Entrepreneurship and Economic Development: Role of entrepreneur in the economic development generation of services; Employment creation and training, Ideas, knowledge and skill development; The Japanese experience. Case Studies of Successful Entrepreneurs.

Recommended Books:

1. Paul Burns and Jim Dew Hurst: Small Business and Entrepreneurship
2. P. N. Singh: Entrepreneurship for Economic Growth
3. Peter F. Drucker: Innovation and Entrepreneurship Peter F. Drucker
4. John B. Miner: Entrepreneurial Success

ELECTIVE-II

Credit hours: 3 (3,0,0)

ELECTIVE-III

Credit hours: 3 (3,0,0)

PROCESS DESIGN & SIMULATION

Credit hours: 3 (2,3,0)

Prerequisites: Engineering Thermodynamics.

Objectives of the Course:

To impart knowledge of the principles of process design and application of simulation tools for synthesis of flow sheets for chemical processes.

Course Outline:

Hierarchy of process design; Process synthesis and design strategy. Pinch design method. Heat and power integration. Reactor network design. Separation system selection and design. Design of heat exchanger networks. Optimization.

Introduction to various design and simulation software. Development of process flow diagrams for various process industries and de-bottlenecking using simulation software such as HYSYS/ASPEN. Economic evaluation of processes. Strategies for decision making.

Lab Outline:

Practical exercises relating to the topics covered in theory.

Recommended Books:

1. HYSYS (or Chem CAD) User and Tutorial Guides.
2. Chau, Pao C. “Process Control: A First Course with MATLAB”, Cambridge University Press, 2002.
3. Davis, Timothy A. and Sigmon, Kermit, “MATLAB Primer, 7th Ed.” Chapman & Hall/CRC, 2004.
4. Smith, R, “Chemical Process Design and Integration” 2005, John Wiley & Sons.

DESIGN PROJECT- Part II

Credit hours: 3 (0,9,0)

MAINTENANCE & UTILITY ENGINEERING

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the Course:

To equip students with the know-how of maintenance of process plants & utilities handlings & operation

Course Outline:

Types of maintenance: Preventive, predictive and corrective, break down and total productive maintenance. Individual versus group replacement; Internal versus external maintenance. Scheduling and planning of maintenance. Organization of maintenance force. Design considerations; Layout and construction. Maintenance of rotary and stationery equipment, inspection techniques; Non-destructive testing techniques. Lubrication and lubricants.

Importance of utilities in process industries, its types, selection criteria and economical utilization. Flare network , Instrument & Plant Air, Boiler feed water, Cooling water supply, Fire fighting system, Fuel gas supply, etc.

Recommended Books:

1. Maintenance Manager's Standard Manual by Thomas A. Wester-Kamp, Prentice-Hall.
2. A Guide to Effective Industrial Safety by Jack W. Boley, Gulf Publishing Company.

ELECTIVES

COMPUTATIONAL FLUID DYNAMICS

Credit hours: 3 (3,0,0)

Prerequisites: Fluid Mechanics-I, Fluid Mechanics-II.

Objectives of the Course:

To impart knowledge of the numerical solution of the comprehensive models of chemical engineering operations based on the theories of momentum, mass, and energy transport using commercial CFD packages.

Course Outline:

Scope and limitations of experimental, analytical and numerical methods in transport processes. The Continuity Equation and governing equations for Momentum, Heat and Mass transport in a continuum; The General Transport Equation.

Discretization; basic concepts and methods. Discretized forms and solution methodologies for steady and unsteady-state one-dimensional heat conduction; Extension of discretization concepts to two- and three-dimensional domains. Modeling of Convection and Diffusion terms using

various discretization schemes; Calculation of flow field using SIMPLE algorithm.

Case studies: Simulation of various one- and two-dimensional laminar flow situations covered in the course of Transport Phenomena using a CFD software and comparison of results with analytical solutions.

Recommended Books:

1. Patankar. S. V., Numerical heat transfer and fluid flow, Hemisphere, 1980.
2. Versteeg, H. and Malalasekra, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2nd Ed., Prentice Hall, 2007.

MINERAL PROCESSING

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To provide knowledge about art and science of beneficiating ores and minerals with the aim to yield marketable value added products.

Course Outline:

Introduction to Mineralogy; Objectives of mineral processing. Mine-mill interface. Properties of minerals and ores. Sampling and evaluation. Comminution: fracture, liberation, size criteria, energy-size relationships. Crushing and grinding. Screening and classifying. Concentration processes: density and other physical processes. Interfacial phenomena. Flotation. Liquid-solid separation: flocculation, thickening, filtration. Washability curves. Partition curves. Material balances. Performance prediction. Applications of biotechnology in mineral processing.

Recommended Books:

1. Jones, Meurig P., Applied Mineralogy: A Quantitative Approach, John Wiley & Sons, 1987
2. Kelly, Errol G. and Spottiswood, David J., Introduction to Mineral Processing, John Wiley & Sons, 1989
3. Wills, B. A., Mineral Processing Technology, Pergamon Press. 1985

NUCLEAR ENGINEERING

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To acquaint students with the field of nuclear engineering.

Course Outline:

Role and importance of nuclear energy; Nuclear cross-sections; Reaction Rates; Nuclear fission and chain reaction; Criticality conditions; Conversion and breading; Reactor components and their characteristics; Classification and design features of research, production and power reactors; Introduction to fast and fusion reactor systems.

Different types of fuel cycles; Core and feed–material preparations; Uranium enrichment; Fabrication of fuel; Reprocessing of Irradiated fuel; Fuel cycle performance of commercially available reactors; In-core fuel management and fuel management strategies.

Nuclear radiation hazards and nuclear waste management.

Recommended Book:

1. Lamarsh, J. R, Introduction to Nuclear Engineering, 3rd Edition, Prentice Hall, 2001.

NOVEL SEPARATION PROCESSES

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To impart knowledge about fundamentals, theory and design of Novel separation processes.

Course Outline:

General theory of multistage separations based upon equilibrium and rate processes. Theory, design and analysis of ion exchange processes along with their industrial applications. Mass transfer processes through membranes: separation of chemical species using osmosis, reverse osmosis, electro-dialysis and molecular sieves. Adsorption, desorption and other surface phenomena, design and operation of adsorption columns. Chromatographic separation technology and its application to chemical and biochemical separations.

Recommended Books:

1. Seader, J. D., and Ernest J. Henley. Separation Process Principles. New York, NY: Wiley, 1998.
2. King, C. J. Separation Processes. 2nd Edition, New York, NY: McGraw-Hill, 1980
3. Manson Benedict, Nuclear Chemical Engineering, 2nd Edition, McGraw-Hill, 1981
4. Treybal, R. E. Mass Transfer Operations. 3rd Edition, New York, NY: McGraw-Hill, 1980.

SCIENCE OF ENERGETIC MATERIALS

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To develop an understanding of chemistry and ballistics of propellants, primary and high explosives and pyrotechnics.

Course Outline:

Propellants: Solid and liquid propellants, main families and use of solid propellants, double base propellants, composite propellants, advanced

energetic binder propellants. Liquid mono and bi-propellants. Hybrid propellants, safety characteristics and hazards, green propellant fuels.

Explosives: History of explosives and types of explosions, the chemistry of explosives, deflagration, detonation and explosion, explosive classifications, explosive initiation.

Pyrotechnics: Principles and applications of pyrotechnics, production of noise, smoke, light, colour etc. Non-military applications of propellants and explosives.

Recommended Books:

1. A. Bailey, G. S Murray " Explosives, Propellants and Pyrotechnics"
2. Alain Davenas, Solid Rocket Propulsion Technology" Pergamon Press.
3. Urbanski, Chemistry and Technology of Explosives"

ROCKET PROPULSION

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To develop an understanding of theory and engineering of rocket propulsion, basic design principles of solid and liquid rocket engines.

Course Outline:

Background and History of Rocket Propulsion, Classification, Applications, Thrust, Exhaust Velocity, Energy and Efficiencies, Nozzle Theory and Thermodynamic Relations, Chemical Rocket Propellant Performance Analysis, Solid Propellant Rocket Fundamentals, Propellant Burning Rate, Combustion Models, Basic Performance Relations, Propellant Grain and Grain Configurations, Solid Propellant Classification, Propellant Characteristics, Hazards, Propellant Ingredients, Propellant Processing and Manufacture, Propellant Grain Mechanical Properties, Solid Rocket Components and Motor Design, Introduction to Liquid Propellant Rocket Engines, Liquid Propellants.

Recommended Books:

1. Elements of Rocket Propulsion; George P. Sutton, 7th Edition
2. Solid Rocket Propulsion Technology, Alain Davenas
3. Space Propulsion Analysis and Design; Humble, Hennry and Larson
4. Rocket Propulsion, M. Barriere
5. Modern Engineering for Design of Liquid Propellant Rocket Engines, D. K. Huzel, D. H. Huang

EXPLOSIVE FORMULATION, MANUFACTURING & FILLING

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To develop an understanding with manufacturing technologies of explosives

and energetic materials

Course Outline:

Manufacture of energetic materials, TNT, RDX, HMX, Tetryl, PETN, NC, NG, Lead azide, Lead Styphnate etc. Formulation and filling of explosives, casting, projectile preparations, Effects of casting, porosity, cavitation, crystal size, uniformity of composition, standard casting procedures, pellet casting, vacuum melting and casting, vibration and centrifugal casting, controlled cooling and extrusion, Pressing, standard procedures and measurement of explosive charges, direct pressing in casing, palletizing, vacuum pressing, hot pressing, hydrostatic and iso-static pressing, machining of explosives, quality controls in explosive charging, density, cracks, cavities, composition variations.

Recommendation Books:

1. Paul Cooper, “Explosive Engineering”
2. A. Bailey, G. S Murray “Explosives, Propellants and Pyrotechnics”
3. Urbanski, Chemistry and Technology of Explosives”

POLYMER ENGINEERING

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the course:

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

Course Outline:

Detailed account of raw materials used; advanced treatment of methods of polymerization and co-polymerization; principles of polymers formation; thermal cleavage of covalent bonds; radical production by photochemical; high energy radiation and oxidation-reduction processes; flow properties of polymers, classification of melt flow behavior, rheological properties, structure and properties of polymer; analysis and testing of polymers; production and properties of commercially important polymers; detailed account of polymer processing; design of equipment and machinery used; recent advances in polymer technology.

Recommended Books:

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

CHEMICAL WET PROCESSING OF TEXTILES

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To impart knowledge of wet processing in textile industry

Course Outline:

Chemistry of textile processing; processes and machines for desizing, scouring, bleaching and mercerization. Pretreatments; Application of reactive vat and another classes of dyestuff on various machines. Dying of cotton, viscous rayon and blend fibres. Printing, exposing print paste, pigment and reactive types. thickening.

Rotary printing machine on curing process. Objective and service performance of chemical finishing of soft and hard finishing agents. Printing flexibility using CAD/CAM system; Treatment of effluent from Textile Industry; Recovery of chemicals and their sustainable aspects.

Recommended Books:

1. Tyron. L. Vigo, Textile Processing and properties, 1994 Elsevier.
2. S. Kawabek, Objective Parameters of fabric, 1999, Textile Machinery Society Kyoto.
3. E. R. Trotman, Hodder & Stoughton, Dyeing & Chemical Technology of Textile Fibres, 1993 Charles Griffin & Co.
4. A. J. Hall, The Standard Handbook of Textiles, 2004, Wood head Publishing Co.

PETROLEUM REFINERY ENGINEERING

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To impart knowledge of processes and operations in petroleum refining industry.

Course Outline:

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, hydrocracking. Auxiliary processes and operations; 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.

Recommended Books:

1. W. L. Nelson, Petroleum Refinery Engineering, 1991, McGraw-Hill.
2. G. D. Hobson, Modern Petroleum technology, 1991, Applied Sc. Publisher.
3. J. H. Gary and G.E Handwerk, Petroleum Refinery Technology & Economics, 2001, Dekker.
4. S. Parkash, Refining Processes Handbook, 2003, Elsevier/GPP.

GAS PROCESSING

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To provide an understanding of the processes and operations in hydrocarbon gas processing plants.

Course Outline:

Introduction to natural gas industry, gas production, testing of well fluid; Test separator, Multiphase flow meters, establishing GOR; Gas-liquid separation design and configurations. Acid gas sweetening; Chemical and Physical solvent processes. Membrane/molecular sieve processes, Cryogenic separation, solvent regeneration. Dehydration of Natural Gas, LPG recovery and condensate stabilization, LNG and CNG. Gas processing facilities, process flow schemes and product specifications.

Disposal of gas field emissions, effluent, produced water (EOR, Re-injection, flaring) Design, metallurgy and corrosion protection of gas pipelines and equipment. Sludge handling. Gas compression; compressors types, selection between centrifugal and reciprocating compressor, design considerations. Energy conservation in gas processing facilities. Flare system design; PSVs, blow down, flare/vent stack sizing.

Recommended Books:

1. Ken Arnold, Maurice Stewart, Design of Gas Handling Systems and Facilities, Volume 2, 1989, Gulf Publishing Company
2. Stephen A. Newman, Acid and Sour Gas Treating Processes,1985, Gulf Publishing Company
3. Donald L. Katz , Handbook of Natural Gas Engineering,1990, McGraw-Hill
4. M. Saeed, Handbook of Natural Gas Transmission and Processing, 2006, Gulf Publishing Company
5. E. J. Hoffman, Membrane Separation Technology, 2003, Gulf Publishing Company
6. GPSA Engineering Data Book 13th Ed. 2012, Gas Processors Supplier Association.
7. Tarek Ahmed, “Reservoir_Engineering_Handbook”, 4E , 2010, Gulf Professional Publishing.
8. Charles R. Smith, G. W. Tracy, and R. Lance Farrar, “Applied Reservoir Engineering”, Vol 1 and Vol 2 – Smith, Oil & Gas Consultants International.
9. Boyan Guo and Ali Ghalambor, “Natural Gas Engineering Handbook”, 2nd Edition , 2005, Gulf Publishing Company

PETROCHEMICALS

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To develop knowledge about unit operations and processes used for production of valuable products from petroleum.

Course Outline:

Recent trends in Petrochemical industries. Hydrocarbon Sources and Raw materials; their characterization, availability and pricing. Processes for the production of ethylene, acetylene, and other monomers. Polymerization of monomers into useful plastics.

Synthesis gas production, separation and purification, ammonia synthesis.

BTX production, separation and purification.

Recommended Books:

1. Austin George T. "Shreve's Chemical Processes Industries" 6th Ed. 1997, McGraw-Hill International Edition.
2. Robert A. Meyers, Handbook of Petrochemical Production Processes, 2005, McGraw-Hill.
3. A. C. Waddems, Chemicals from Petroleum 978, John Murrey.
4. S. Strelzoff, Technology and Manufacture of Ammonia, 1982, Inter Science Publishers.
5. Kirk Othmer, Encyclopedia of Chemical Technology, 1999, Intoosc Publishers.

RISK MANAGEMENT & SAFETY

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To provide understanding of plant safety by identifying risks, controlling and managing them.

Course Outline:

Major hazard accidents; Basic concepts of risk; Hazard identification procedures and techniques; What-if; HAZOP; FMEA. Consequence analysis concerning release of chemical hazards including discharge models, dispersion and effect models.

Fire and explosion models, effect models. Estimation of incident frequencies (estimation of incident frequencies from historical data, frequency modeling techniques, FTA and ETA).

Human factors in risk analysis; Risk of chemical reactions, e. g. chemical reactivity and run away, active and passive safety in the design of equipment and systems.

Emergency planning and responses; Storage and transportation of hazardous

materials. Introduction to International safety standards (e.g. OSHA etc.) A specific case study

Recommended Book:

1. Fullwood R. R., “Pobabilitistic Safety Assessment in Chemical and Nuclear Industries”. 1999.

INDUSTRIAL WASTE MANAGEMENT

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To impart the knowledge about the sources of waste, its treatment and disposal according to international/national standards, policies and regulations.

Course Outline:

Environmental Management; ISO 14001; EMAS; Environmental auditing; Responsible Care; Environmental Policies and regulations. Different types of eco- labeling.

Material Recycling: recycling of metals, recycling of polymeric materials.
Treatment of liquid waste streams: mechanical, biological and chemical methods. Production of bio-gas. Anaerobic digestion and other stabilization methods. Dewatering. Drying.

Treatment of solid waste: separation, incineration, composting. Separation; Incineration. Other methods for disposal of solid waste (e.g. composting and landfilling). Treatment and use of ash products. Treatment of radioactive waste. Air and noise pollution and its control.

Recommended Book:

1. Cheremisinoff, “Handbook of water and waste water treatment technologies”, 2002.

ENVIRONMENTAL ENGINEERING

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To impart knowledge of environmental pollution, its control considering the national and international standards, and its impact on environment and ecology.

Course Outline:

Introduction to environment and ecology, pollution concept, types of pollution. 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, water pollution control technologies, water

treatment technologies, soil 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.

Recommended Book:

1. Cheremisinoff, “Handbook of air pollution prevention and control”, 2002.

RENEWABLE ENERGY RESOURCES

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To provide in-depth knowledge of renewable energy resources and their production to meet the energy needs of the country.

Course Outline:

Biomass Sources; Pretreatment of biomass for thermo-chemical conversion, methods of production of fuels from biomass; Gasification and liquefaction of forest products; Biomass volatilization; Pyrolytic reactions and products of biomass; Kinetics of wood gasification; Characterization of peat and biomass liquids; Fermentation to Ethanol and Biogas; Ethanol and Methanol production; Social, economical, and environmental implications; Applied Solar energy; Current status of wind and Tidal energy; Economics of Tidal power; Wind turbines.

Recommended Books:

1. Overand R. P, Milne T. A, and Mudge L. K, “Fundamentals of Thermo-chemical Biomass Conversion”, 1985, Elsevier Applied Science publishers, NY, USA, ISBN 0 85334 306 3.
2. Palz W, Chartier P, and Hall D. O. “Energy from Biomass”, 1981, Proceedings of First EC Conference, Applied sciences publishers Ltd. London, UK, ISBN 0 85334 970 3.
3. Hobson P. N, Bousfield S, and Summers R, “Methane production from Agricultural and Domestic waste”, 1981, Applied sciences publishers Ltd. London, UK, ISBN 0 85334 924-X.
4. Report of National Research Council, Committee on Technology Innovation, Board on Science and Technology for International Development, USA, “Alcohol Fuels-Options for Developing Countries”, 1983, National Academy Press, Washington DC, ISBN 0309 03386 1.
5. Meinel B Aden, and Meinel P. Marjorie, “Applied Solar Energy – an Introduction”, 1976, Addison Wesley publishing Co. London, UK, ISBN 0 201 04719 5.
6. Roger Henri Charlier,” Tidal Energy” 1982, Van Nostrand Reinhold Co. NY, USA, ISBN 0 442 24425 8.
7. Bhadra S. N, Kastha D, and Banerjee S, “Wind Electrical Systems”, 2005,

Oxford University Press, ISBN 0 195 67093 0.

INDUSTRIAL ENERGY SYSTEMS

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To impart knowledge of energy systems in the process industry.

Course Outline:

Introduction to industrial process energy systems: concepts, heat balances, heat distribution systems; local heating vs. central heating systems; illustrative example from the pulping industry.

An overview of energy conversion technologies in industrial energy systems. Process integration: Basics of process integration methodologies with emphasis on Pinch analysis (Pinch temperature, minimum process heating and cooling requirements, composite curves and grand composite curves, targeting for minimum number of heat exchanger units). Design of heat exchanger networks for maximum heat recovery. Process integration principles for high-efficiency energy conversion technologies (heat pumps and combined heat and power units) and energy-intensive chemical separation operations (distillation, evaporation). Energy efficiency and economic performance evaluation of process integration measures. Process integration methodologies for retrofit applications in existing industrial energy systems. Impact of reduced steam demand on electricity production for an industrial process equipped with a steam turbine, CHP unit. Economics of energy conversion in industrial energy systems: characteristics of heat pumps and combined heat and power (CHP) units (performance, investment costs). Influence of operating conditions on performance. Optimization of size and various design parameters based on process integration principles. Methodology for identifying the cost-optimal mix of technologies for satisfying a process heat demand, accounting for heat load variation over the course of the year.

Recommended Books:

1. Putman, R. E., “Industrial Energy Systems: Analysis, Optimization, and Control.
2. Smith, R., “Chemical Process Design and Integration” 2005, John Wiley & Sons.

BIOCHEMICAL ENGINEERING

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To develop an understanding of design and construction of unit processes that involve biological organisms or molecules.

Course Outline:

Introduction to biochemical engineering; Enzyme Classification; Enzyme reaction kinetics (Single-substrate Reactions) and energy patterns in biological systems; Enzyme Inhibition; Non-ideal Enzyme Kinetics, Isolation of enzymes and immobilized enzyme technology; Applications of Enzyme Catalysis (Bio-catalysis); Transport phenomenon in microbial system; Design and analysis of biochemical reactors (fermentors); Anaerobic and aerobic metabolism photosynthesis and bio synthesis; biochemical and microbiological applications.

Recommended Books:

1. Shuler, Michael L., and Fikret Kargi. Bioprocess Engineering: Basic Concepts. 2nd Edition. Upper Saddle River, NJ: Prentice Hall PTR, 2001.
2. Blanch, Harvey W., and D. S. Clark, eds. Biochemical Engineering. New York, NY: Marcel Dekker Incorporated, 1997.
3. Bailey, James E., and David F. Ollis. Biochemical Engineering Fundamentals. 2nd Edition, McGraw-Hill, Inc., New York, 1986.
4. Lovitt, R., and Jones, M. Biochemical reaction engineering, Coulson and Richardson's Chemical Engineering, Richardson, J.F., and Peacock, D.G (Eds.), 3rd Edition, Vol-3, Pergamon Press, London. 1994.
5. Levenspiel, O. Chemical Reaction Engineering. 3rd Edition 2006, John Wiley & Sons.

BIOCHEMICAL SEPARATIONS

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To study the techniques involved in the purification, or recovery, of product obtained through biochemical reactions.

Course Outline:

Introduction to the fundamental principles of separation operations for the recovery of products from biological processes; Mass transfer coefficients; Supercritical fluids. Flocculation and coagulation. Membrane filtration, chromatography, centrifugation, crystallization, drying, cell disruption. Protein refolding, extraction. Process design for recovery of products from biological processes. Application of bio-technology to energy conversion, solid waste and water treatment etc.

Recommended Books:

1. Bailey, James E., and David F. Ollis. Biochemical Engineering Fundamentals. 2nd Edition, McGraw-Hill, Inc., New York, 1986.
2. Lovitt, R., and Jones, M. Biochemical Reaction Engineering, Coulson and Richardson's Chemical Engineering, Richardson, J.F., and Peacock, D.G (Eds.), 3rd Edition, Vol-3, Pergamon Press, London. 1994.
3. Tutunjian, R. S. "Ultrafiltration Processes in Biotechnology." In Comprehensive Biotechnology. Vol. 2, The Principles of Biotechnology: Engineering Considerations. Edited by C. L. Cooney, and A. E.

Humphrey. Elmsford, NY: Pergamon Press Ltd., 1985.

BIOCHEMICAL PROCESSES AND PRODUCTS

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To apply the knowledge in biochemical engineering to develop processes and products.

Course Outline:

Application of biotechnology in Chemical Industry: Bio-degradation; Bio mass productivity and activity; Aerobic and anaerobic processes; Bio-chemical processes involved in the production of food products, beverages, organic acids, industrial solvents, various pharmaceutical products and antibiotic and commercial enzymes. Fermentation Industries: Industrial alcohol, Biodiesel and industrial solvents. Biodegradable Plastics and other related products. Treatment of waste from food and pharmaceutical Industry; Bio-remediation; Food preservation; Health hazards; Hygiene and sanitation. Important food industries in Pakistan. Food legislation: Concept and significance; Food legislation in Pakistan in relation to international laws. Bio-safety regulations

Recommended Books:

1. Bailey, James E., and David F. Ollis. Biochemical Engineering Fundamentals. 2nd Edition, McGraw-Hill, Inc., New York, 1986.
2. Austin George T. Shreve's Chemical Processes Industries. 6th Ed., McGraw Hill International Edition. 1997
3. Kirk Othmer Encyclopaedia of Chemical Technology. Inter Science Publishers. 1999.
4. Government of Pakistan. "Prospects of Chemical Industry in Pakistan" 2003, Export Advisory cell, Ministry of Industries and Production, Islamabad.

PRODUCTION & OPERATIONS MANAGEMENT

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To familiarize students with the techniques of management

Course Outline:

Introduction to Evaluation of Management Science: Entrepreneurship, SMEs. Nature & scope of Operation Management: Introduction to production management functions and classification of production systems. Production Operation Strategies, Goals tactics and mission.

Decision Making: The decision process, characterization of operation decision ; General approach to decision making. Decision Environmental; Decision Models. Resource Allocation- Linear Programming: Model Formulation Types/ Classification of Models; Analysis of linear programming model, Graphics approach, Simplex method, Application of linear programming.

Forecasting: Forecasting Environments & their modeling. Design of Work System: Facilities layout basic types, line balancing, Waiting Lines Goal, measuring system performance Quening Models Infinite Source, Finite Source. Reliability & Liability. Product Life Cycle. Process selection & capacity planning; Breakeven Analysis, Linear & Non-Linear. Cost volume analysis.

Capacity Management: the meaning of capacity; Capacity planning; Inventory Management/types & EOQ model, quantity Discount models.
Project Management: PERT CPM Analysis, Queuing Analysis/waiting lines

Recommended Books:

1. Bufa e. S., (1980), 'Elements of Production: Operations Management', New York: John Wiley & Sons.
2. Stevenson, W.J., (1986), 'Production operation Management', 8th Edition.
3. Chase Richard B. Aquilano, Nicholas, J. (1973), 'Production of operations management: a lifecycle approach'. Homewood, III: R. D. Irwin.
4. Stevenson W.J., (2005), 'Production operations Management', 8th Edition, McGraw-Hill Irwiv.\
5. John V. C. Lawrence R. P. Reavil A. C. Payne (2004), Management of Engineers, Scientists & Technologists', 2nd Edition, Wiley & Son

SOCIAL SCIENCES & MANAGEMENT COURSES
SOCIAL SCIENCES COURSES

ENGINEERING ECONOMICS

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the Course:

To familiarize students with the concepts of economics and their application in chemical engineering design for the purpose of cost estimation and profitability analysis.

Course Outline:

Engineering economy defined; Measures of financial effectiveness; Non-monetary factors and multiple objectives; principles of engineering economy.

Consumer and producer goods; Measures of economic worth; Price, Supply and demand relationship; Production; Factors of production; Laws of return.

Sunk and opportunity costs; Fixed, variable, and incremental costs; Recurring and non-recurring costs; Direct, indirect, and overhead costs; Standard costs; Breakeven analysis; Unit cost of production; Cost-benefit analysis; Feasibility studies; Value analysis in designing and purchasing.

Islamic and Contemporary financing system and their use in cost estimation. Depreciation accounting.

Economic evaluation of processes and equipment; Payback period method; Present worth method; Uniform annual cost method; Rate of return method.

Manufacturing lead time; Production rate; Capacity; Utilization; Availability; Work in process; WIP and TIP ratios.

Types of ownership; Types of stock; Partnership and joint stock companies; Banking and specialized credit institutions.

Recommended Books:

1. Leland Blank, and Anthony Tarquin, “Engineering Economy”, 6th Edition, McGraw-Hill, 2005
2. G. J. Thuesen, and W. J. Fabrycky, “Engineering Economy”, 9th Edition, Prentice Hall of India, 2005.
3. Ted G. Eschenbach, “Engineering Economy”, 2nd Edition, Oxford University Press, 2003.
4. James L. Riggs, David D. Bedworth, and Sabah U. Randhawa, ”Engineering Economics”, 4th Edition, Tata McGraw-Hill, 1996.
5. James L. Riggs, and Thomas M. West, “Essentials of Engineering Economics”, 2nd Edition, McGraw-Hill, 1986.

SOCIOLOGY AND DEVELOPMENT

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the Course:

To apprise potential engineers about social factors that contribute towards enhancing their professional performance for the good of society and the country.

Course Outline:

Introduction to Sociology

What is sociology? Nature, scope, and importance of sociology, social interactions, social groups, social institutions.

Culture and Related Concepts

Definition of culture, types of culture, elements of culture, role of culture in organization, socialization and personality.

Interpersonal Relations

Interpersonal behaviour, formation of personal attitudes, language and communication, motivations and emotions, public opinion.

Social Stratification

Factors of social stratification, caste and class, power, prestige, and authority, social mobility, migration.

Human Ecology

Ecological processes, ecosystem andenergy, ecosystem and physical environment, solid waste disposal, pollution.

Population Dynamics

World population growth and distribution, population dynamics in Pakistan, causes and consequences of urbanization, population policy in Pakistan, population and development.

Community Development

Meaning, scope, and subject matter of community development, processes of community development, community development programs in Pakistan, community organization and related services, cooperation and conflict in community development.

Deviance and Crime

Crime as a social and cultural phenomenon, crime and social organization, organized crime, culture based crime, economics of crime.

Sociology of Change and Development

What is social change and development? dynamics of social change, role of NGOs in development; World system and development, gender and development.

Recommended Books:

1. Allport, G. W. (1985). The Historical Background of Modern Social Psychology. New York, Random House.
2. Bernard, A. and T. Burgess (2004). Sociology. Cambridge University

Press.
3. DuBrin, A. J. (2007). Human Relations: Interpersonal Job Oriented Skills. New York, Prentice Hall.
4. Gardezi, H. N., Ed. (1991). Understanding Pakistan: The Colonial Factor in Societal Development. Lahore, Maktaba Fikr-o-Danish.
5. Hafeez, S. (1991). Changing Pakistan Society. Karachi, Royal Book Company. Gardezi, H. N., Ed. (1991).
6. Jones, G. W. (2005). "Why are Population and Development Issues not Given Priority?" Asia-Pacific Population Journal 20(1).
7. Macionis, J. J. (1999). Sociology 7th Edition, National Book Foundation, Islamabad
8. Maser, C. (1997). Sustainable Community Development: Principles and Concepts. Plorida St. Lucie Press.
9. Nelson, N. and S. Wright (1995). Power and Participatory Development: Theory and Practice. London, Intermediate Technology Publications.
10. Syed, S. H. (2003). The State of Migration and Multiculturalism in Pakistan: The Need for Policy and Strategy. Islamabad, UNESCO**:** 1-30.
11. Utton, A. E. (1976). Human Ecology, West View Press.
12. Webster, A. (1990). Introduction to Sociology of Development. London, Macmillan Education Ltd.
13. Weiss, A. M. (2001). Power and civil society in Pakistan, Oxford University press.

SOCIAL ANTHROPOLOGY

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the course:

To provide understanding of anthropological skills for application by professional engineers and other related practitioners.

Course Outline:

I Introduction

1. Anthropology and social anthropology
2. Fields of anthropology
3. Anthropological research methods
4. Social anthropology and other social sciences
5. Significance of social anthropology

II Culture

1. Definition, properties and taxonomy
2. Evolution of growth and culture
3. Evolution of man: Religious and modern perspectives
4. Evolution of culture
5. Culture and personality

III Evolution and Growth of Culture

1. Evolution of man
2. Schools of thought in cultural anthropology

3. Acculturation
4. Enculturation
5. Ethnocentrism and xenocentrism

IV Language and Culture

1. Communication
2. Structural linguistics
3. Historical linguistics
4. Relationship between language and culture
5. Ethnography

V Economic System

1. Global economic system
2. The allocation of resources
3. The conversion of resources
4. The distribution of goods and services
5. Poverty and inequality

VII Marriage and Family

1. Marriage and mate selection
2. The family: Types and functions
3. Kinship system
4. Structure and function of family
5. Gender Relations

VIII Political Organization

1. Political sociology
2. Origin of political organization and organizational system
3. Types of political organizations
4. Power politics and factionalism in Pakistan
5. Resolution of conflict

IX Religion and Magic

1. The universality of religion
2. Comparative religions
3. Religion and society
4. Religious beliefs and practices
5. Witchcraft and sorcery

XI Culture Change

1. Forms of art
2. Expressive culture
3. Process of cultural change
4. Cultural change in the modern world
5. Cultural change in Pakistani society

Recommended Books:

1. Ahmad, Akbar S. 1990. Pakistani Society, Karachi, Royal Books Co.
2. Bernard, H. Russel. 1994. Research Methods in Anthropology, Qualitative and Quantitative Approaches. London: Sage Publications
3. Bodley, John H. 1994. Cultural Anthropology, California: Mayfield

Publishing Co.
4. Brogger, Jan. 1993. Social Anthropology and the Lonely Crowd. New Delhi: Reliance Publishing
5. Ember, Carol R. & Ember Melvin. 2005. Anthropology, 11th Ed. Englewood Cliffs: Prentice Hall, Ince. Harper and Row
6. Harris Marvin. 1987. Cultural Anthropology. New York: Harper and Row
7. Harris Marvin. 1985. Culture, People, nature; An Introduction to General Anthropology London: Harper and Row
8. Haviland, W. A. (2005). Anthropology: The Human Challenge. New York, Thomson Learning Inc.
9. Hertzler J. O. 1981. The Social Structure of Islam. Cambridge: Cambridge University Press.
10. Keesing, Roger M. 1998. Cultural Anthropology: A contemporary perspective. 3rd ed. New York: Harcourt Brace College Publishers.
11. Kottak, Conard Phillip. 2002. Anthropology: The Exploration of Human Diversity. 9th Ed. Boston: McGraw-Hill Higher Education.
12. Kennedy, Charles H. 1992. Pakistan London: Westview Press,.
13. Marron, Stanley. 1057. Pakistani Society and Culture. New Heaven
14. Wilson, Richard A. 1996. Human Rights, Culture and Context: Anthropological Perspective. London: Pluto Press.

UNDERSTANDING PSYCHOLOGY AND HUMAN BEHAVIOUR

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the Course:

To provide an understanding of human psychology and behaviour.

Course Outline:

- What is psychology?
- Nature, scope and application with special reference to Pakistan
- Different schools of psychology
- Methods of psychology
- Learning
- Intelligence and artificial intelligence
- Personality and its assessment
- Understanding mal-adjective behaviour
- Positive emotional states and processes
- Stress management and anger management

Recommended Books:

1. Atkinson R. C., Smith E. E. (2000), Introduction to Psychology (13th Ed.), Harcourt Brace College Publishers. Fernald, L. D., & Fernald, P. S. (2005), Introduction to Psychology, USA: WMC Brown Publishers.
2. Hergenhahn, B. R. (2001). An Introduction to the History of Psychology, New York: Wadsworth.
3. Goodwin, C. J, (2000) Research in Psychology: Methods and Design, (3rd E), New York: John Wiley & Sons.
4. Synder, C. R., Lopez, S. J. (2007) Positive Psychology, USA, Sage

Publications.
5. Allen, B. P. (1997), Personality Theories: Development, Growth and Diversity, (2nd Ed.), Boston: Allyn & Bacon.
6. Cohen, R. J., Swerdlik, M. E. (2005) Psychological Testing & Assessment (6th Ed.), New York: McGraw-Hill.
7. Corcini, R., (2000). Current Psychotherapies. London: Thompson & Co Publishers.
8. Comer, R. J. (2004). Abnormal Psychology, USA: Freeman & Company.
9. Schwartz, B., Wassernman, E., Robbins, S. (2002), Psychology of Learning and Behaviour, 5th Ed. Norton and Company.

PROFESSIONAL PSYCHOLOGY

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the Course:

To provide understanding of human psychology in the context of technical organizations and work environment.

Course Outline:

- Introduction to professional psychology
- Psychological testing
- Educational psychology
- Industrial/organizational psychology
- Social psychology
- Health psychology
- Clinical psychology
- Positive psychology
- Legal, ethical, and professional issues.

Recommended Books:

1. Crow, L., & Crow, A. (2000) Educational Psychology, New Delhi: Eurosia Publishing House Ltd.
2. Spiegel, P.K., Koocher, G.P. (1998), Ethics in Psychology, New York: Oxford University Press
3. Snyder, C. R., Lopez, S. J. (2000), Handbook of Positive Psychology, New York: Oxford University Press.
4. Compton, W. C. (2005), Introduction to Positive Psychology, USA, Thomson Wadsworth.
5. Debra, L. N. James Compbell Quick, (2000) Organizational Behaviour (3rd Ed), Cincinnati: South Western.
6. Fred Luthans, Alexander, D. S. Edwin, A. Locke (2000) (Eds), Handbook of Principles of Organizational Behaviour, London: Blackwell.
7. Brannon, L. Reist, J. (2000), Health Psychology: An Introduction to Behaviour and Health (4th Ed.), USA Wadsworth.
8. Donohue, W. Ferguson, K. (Eds), (2003), Handbook of Professional Ethics for Psychologists; Issues, Questions and Controversies, London: Sage Publications.
9. Meyers, D. (2005), Social Psychology, 8th Ed. McGraw-Hill Inc.

10. Cooper, J. Hogg, M. (2003) Handbook of Social Psychology, Sage Publications
11. Halgin, R. P., Whitbourne, S. K., Halgin, R. (2004), Abnormal Psychology: Clinical Perspectives on Psychological Disorders, New York: McGraw-Hill.
12. Thorndike R. L., Hage, E. P. (1995), Measurement and Evaluation in Psychology and Education (4th Ed), New York, McMillan.

Organizational Behaviour

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the Course:

To provide an understanding of organizational behaviour

Course Outline:

- Introduction to organizational behaviour Organizational disciplines and topics Psychological perspective
  - Social-psychological perspectives
- Structure and control in organization
  - Introduction
  - Bureaucracy
  - Managerial work
  - Contingency theory
  - Organizational design
- Individual and work learning
  - Learning theories
  - Learning and work
- Stress
  - Types of stress and work
  - Occupational stress management
- Individual differences
  - Personality and its factors
  - Personality dimensions and social learning
- Intelligence
- Motivation and job satisfaction
  - Needs at work
  - Theories of motivation and job satisfaction
  - Correlates of job satisfaction
  - Correlates of job satisfaction
- Group and work
  - Social interaction
  - Dramaturgy and impression management
  - Social skill
- Group and inter-group behaviour
  - Group structure and norms
  - Group processes
  - How throne studies

- Leadership
  - Leadership as an attribute
  - Leadership style
- Patterns of work
  - Work-the classical approach
  - Marx, Weber, and the critique of labor
  - Foucault and disciplinary power
- Conflict and consent in work
  - The labour process debate
  - Work place control and resistance
  - Industrial conflict and industrial relations
- Organizational culture
  - Organizational culture and strategic management
  - Exploring organizational culture
  - Evaluating concept of culture

Recommended Books:

1. Finchan, R., Rhodes, P. (2003), Principles of Organizational Behaviour, 3rd Oxford.
2. Noe, R., Hollenbeck, J. Gerhart, B., Wright, P. (2006), Human Resource Management, 5th Ed., McGraw-Hill.
3. Newstrom John W. (2007), Organizational Behaviour, (12th Ed), McGraw-Hill.
4. Luthan Fred, (2005), Organizational Behaviour, McGraw-Hill Inc.
5. Robins, Stephen, (2005), Organizational Behaviour, McGraw-Hill Inc.

INTRODUCTION TO SOCIOLOGY

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the course:

To provide an understanding of basic principles and concepts relating to sociology

Course Outline:

- The Nature of sociology
  - The study of social life
  - Exploring the global village
  - Sociology as a science
  - The sociological imagination
  - The development of sociology
  - Pioneers of sociology
  - Nature, scope and subject matter of sociology
  - Brief historical development of sociology
  - Society and community
  - Relationship with other social sciences
  - Social interaction processes

- Social groups
  - Definition and functions
  - Types of social groups
- Social institutions
  - Definition
  - Structure and function of social institutions
  - Inter-relationships among various social institutions
- Culture and related concepts
  - Definition and aspects of culture
  - Elements of culture
  - Organization of culture
  - Other concepts, cultural relativism, sub cultures, ethnocentrism, culture lag
- Socialization and personality
  - Role and status
  - Socialization
  - Culture and personality
- Deviance and social control
  - Definition and types of deviance
  - Juvenile delinquency
  - Formal and information methods of social control
- Social stratification
  - Approach to study social stratification
  - Caste class and race as basics of social stratification
- Major perspectives in sociology
  - Functionalist perspective
  - Conflict perspective
  - Interactionistic perspective
- Social control and deviance
  - Agencies of social control
- Social stratification
  - Determinants of social stratification
  - Social mobility, types and definition
  - Dynamics of social mobility
- Concept of social movement
  - Theories of social movement
  - Social and cultural change
- Social and cultural change
  - Definition of social change
  - Dynamics of social change
  - Impact of globalization on society and culture
  - Resistance to change
- Collective behaviour
  - Definition
  - Characteristics

- Causes
- Types
- Social movements
- Mob and crowd behaviour

Recommended Books:

1. Neulreck, Kenneth, J. 2005, Sociology: Diversity, Conflict and Change, Boston
2. Barnard, Andy. 2004. Sociology, Cambridge University Press
3. Giddens, Anthony, 2004, Sociology 4th Edition, Cambridge Polity Press
4. Albrow, Martin, 2003, Sociology, London Routledge.
5. Richard, T. Schaefer, 2003, Sociology 5th Edition, McGraw-Hill College
6. Kendall, Diana, 2004. Sociology in our Times, 4th Ed, Wadsworth
7. Tyler Melissa, Wallace Claire & Abbott Pamela, 2005, An Introduction to Sociology, 3rd Ed. Routledge.

LOGICAL & CRITICAL THINKING

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the Course:

To provide an understanding of basic principles and concepts relating to logical and critical thinking.

Course Outline:

- The Power of critical thinking
  - Claims and reasons
  - Reasons and arguments
  - Arguments in the rough
- The Environment of critical thinking
  - Perils of haunted mind
  - Self and the power of the group
  - Subjective and social relativism
  - Skepticism
- Making sense of arguments
  - Arguments basics
  - Patterns
  - Diagramming arguments
  - Assessing long arguments
- Reasons for belief and doubt
  - Conflict experts and evidence
  - Personal experience
  - Fooling ourselves
  - Claims in the news
- Faulty reasoning
  - Irrelevant premises
  - Genetic fallacy, composition, division
  - Appeal to the person, equivocation, appeal to popularity
  - Appeal to tradition, appeal to ignorance, appeal to emotion
  - Red herring, straw man

- Unacceptable premises
  - Begging the question, false dilemma o Slippery slope, hasty generalization o Faulty analogy
- Deductive reasoning: Propositional logic
  - Connectives and truth values
  - Conjunction, disjunction, negation
  - Conditional, checking for validity
  - Simple arguments, tricky arguments
  - Streamlined evaluation
- Deductive reasoning: Categorical logic
  - Statements and classes
  - Translations and standard form
  - Terms, quantifiers
  - Diagramming categorical statements
  - Sizing up categorical syllogisms
- Inductive reasons
  - Enumerative induction
  - Sample size, representativeness, opinion polls
  - Analogical induction
  - Casual arguments, testing for causes
  - Casual confusions
- Inference to the best explanation
  - Explanations and inference
  - Theories and consistency
  - Theories and criteria
  - Testability, fruitfulness, scope, simplicity
  - Conservatism
- Judging scientific theories
  - Science and not science
  - The scientific method, testing scientific theories
  - Judging scientific theories
  - Copernicus versus Ptolemy, evolution versus creationism
  - Science and weird theories
  - Making weird mistakes
  - Leaping to the weirdest theory, mixing what seems with what is
  - Misunderstanding the possibilities
  - Judging weird theories
  - Crop circles, talking with the dead

Recommended Books:

1. Vaughn Lewis, 2005, The Power of Critical Thinking, Oxford University Press.
2. Paulsen David W., Cederblom Jerry: 2000, Critical Reasoning, Wadsworth
3. Restall Greg. 2005, Logic: An Introduction, Routledge

INTRODUCTION TO PHILOSOPHY

Credit hours: 2 (2,0,0) Prerequisites: N/A

Objectives of the Course:

Course Outline:

- Definition and nature of philosophy
- Theory of knowledge
  - Opinion and knowledge
  - Plato, the republic selection
  - Knowledge through reason
  - Descartes meditation on first philosophy
  - Knowledge through experience
  - Hume an Inquiry concerning human understanding (Selection)
  - Experience structured by the mind
  - Kant critique of pure reason (Selection)
  - Knowing and doing
  - James pragmatism (Selection)
  - Knowledge and emotion
  - Jaggar love and knowledge (Selection)
- Philosophy of religion
  - Proving the existence of God
  - Anselm, Aquinas, Paley, Dawkins (Selection)
  - Justifying religious beliefs
  - Pascal Pensees (Selection)
  - James The will to believe selection
  - Freud The future of an illusion (Selection)
  - Confronting the problems of evil
  - Mackie Evil and omnipotence (Complete)
  - Hick Philosophy of religion (Selection)
- Metaphysics
  - Idealism and materialism
  - Berkeley Three dialogues between Hylas and Pholonous (Selection)
  - Armstrong Naturalism, materialism and first philosophy (Selection)
  - The mid-body problem
  - Descartes Meditations on first philosophy (Selection)
  - O'Hear Introduction to the philosophy of science (Selection)
  - Dennett The origins of selves (Complete)
  - Pali Canon (Selection)
  - Penelhum Religion and rationality (Selection)
- Freedom to Choose
  - Libertarianism
  - James The dilemma of determinism (Selection)
  - Taylor Metaphysics (Selection)
  - Determinism
  - Hospers Meaning and free will (Selection)
  - Skinner Walden Two (Selection)
  - Compatibilism
  - State Religion and the modern mind (Selection)

- Radhakrishnan Indian philosophy (Selection)

- Ethics
  - Fulfilling Human Nature
  - Aristotle Nicomachean Ethics (selection)
  - Loving God
  - Augustine The Morals of the Catholic Church and the City of God (Selection)
  - Following Natural Law
  - Aquinas Summa Theologiae (Selection)
  - Doing One's Duty
  - Kant Fundamental Principles of the Metaphysics of Morals (Selection)
  - Maximizing Utility
  - Mill Utilitarianism (Selection)
  - Turning Values of Upside Down
  - Nietzsche Human, All too Human and Beyond Good and Evil (Selection)
  - Creating Ourselves
  - Sartre Existentialism is a Humanism (Selection)
  - Hearing the Feminine Voice
  - Gilligan In a Different Voice (Selection)
  - Baier What do Women Want in a Moral Theory (Selection)

- Political and Social Philosophy
  - The State as Natural
  - Plato the Republic (Selection)
  - Aristotle Politics (Selection)
  - The State as a Social Contract
  - Hobbes Philosophical Rudiments Concerning Government and Society (Selection)
  - Locke the Second Treatise of Government (Selection)
  - Liberty of the Individual
  - Mill On Liberty (Selection)
  - Alienation in Capitalism
  - Marx Economic and Philosophic Manuscripts of 1844 (Selection)
  - Justice and Social Trust
  - Rawls A Theory of Justice (Selection)
  - Nozick Anarchy, State, and Utopia (Selection)
  - Held Rights and Goods (Selection)
  - Women in Society
  - Wollstonecraft A Vindication of the Rights of Women (Selection)
  - De Behaviour The Second Sex (Selection)
  - The Value of Philosophy
  - Russel The Problems of Philosophy (Selection)
  - Midgley Philosophical Plumbing (Selection)

Recommended Books:

1. Abel Donald C., Stumpf Samuel Enoch, 2002. Elements of Philosophy: An Introduction, 4th Ed. McGraw-Hill.
2. Scruton Roger, 2001. A short History of Modern Philosophy, 2nd Ed. Routledge.

MANAGEMENT COURSES

Principles of Management

Credit hours: 3 (2,0,0) Prerequisites: N/A

Objectives of the Course:

To provide an understanding of the fundamental principles of management and of managing people and organization in a historical as well as contemporary world.

Course Outline:

- Introduction, overview and scope of discipline
- The evolution and emergence of management thought
- Management functions
- Planning concepts, objectives, strategies and policies
- Decision making
- Organizing; departmentalization, line/staff authority, commitments and group decision making
- Staffing: principles of selection, performance, career planning
- Leading: Motivation, leadership, communication
- Controlling: the system and process and techniques of controlling
- Management and Society: future perspective

Recommended Books:

1. Stephen P. Robins, Mary Coulter: Management
2. H. Koontz Odonnel and H. Weihrich: Management
3. Mc Farland: Management: Foundation and Practice
4. Robert M. Fulmer: The New Management

INDUSTRIAL MANAGEMENT

Credit hours: 3 (3,0,0) Prerequisites: N/A

Objectives of the Course:

To provide understanding of the principles and techniques of industrial management

Course Outline:

Introduction to Industrial Management; Productivity, Plant Layout; Product and Process layout analysis and comparison; Material handling considerations in layout; Production planning methods, material requirement planning, material resource planning. Capacity planning and control; Production control systems; Job shop scheduling; Quality Control; Production control charts; Scheduling techniques; Purchasing and procurement; Inventory control; EOQ/EPQ models; Time and Motion study.

Organizational structure; Human resource management; Project

management principles; PERT/CPM; Total quality management; ISO standards; Labour and engineering laws; Labour problems; Labour organizations; Prevention and settlement of disputes.

Recommended Books:

1. Harold Kerzner, “Project Management: A Systems Approach to Planning, Scheduling, and Controlling”, Ninth Edition, John Wiley & Sons, 2006.
2. Jay Heizer and Barry Render, “Principles of Operations Management”, Third Edition, Prentice Hall, 1999.
3. Jay Heizer and Barry Render, “Operations Management”, Fifth Edition, Prentice Hall, 2000.
4. Industrial Management Methods. Ronald Hurst.
5. Industrial Organization & Management. BETHEL.
6. Principles of Management Design. Robert E. Parr.

RECOMMENDATIONS

1. All Chemical Engineering institutions should review their educational process and make it more sustainable.

2. The courses should be taught in a way to develop a more application based and research oriented approach.

3. The student assessment should be based on questions related with knowledge and understanding of subject including engineering analysis, investigation, engineering practices and transferable skills.

4. Latest software relating to chemical engineering subjects such as HYSYS, MATLAB, ANSYS, Auto CAD, Math, CAD, Pro-E should be made available at Institutions offering programmes in Chemical Engineering.

5. Faculty training in core disciplines should be arranged at Institutions offering programmes in Chemical Engineering.

6. Laboratory facilities should be strengthened to facilitate the lab work associated with theory courses.

7. All laboratories should be supervised and managed by qualified Lab Engineers.

8. Efforts should be made to strengthen academia-industry interaction.

9. Masters in Chemical Engineering by research is strongly recommended to be incorporated in the postgraduate programme.

10. The Practical/Lab work should comprise at least 20-30% of the total credit hours.

11. All the Universities/Institutions should make arrangements for practical training of their students in industrial organizations during summer.

12. To strengthen research capacity of HEIs, the honorarium for the postgraduate students, in engineering disciplines, is recommended to be equivalent to BPS- 17 salary.