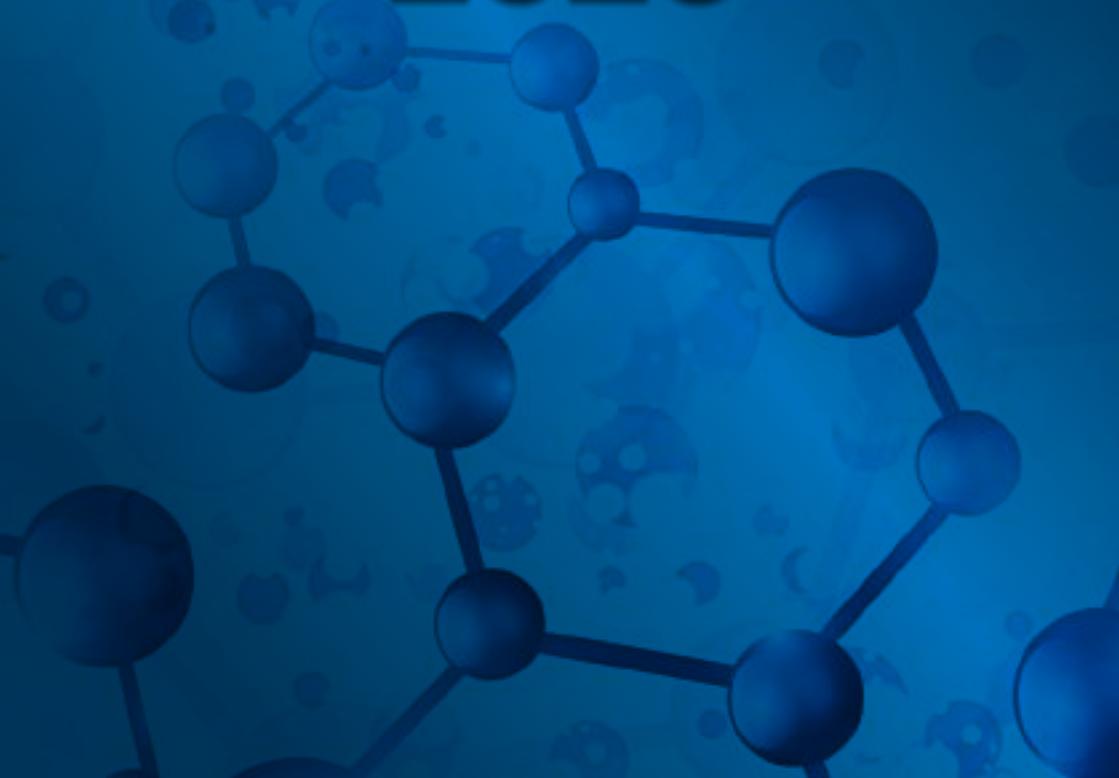


Curriculum for

# Polymer Engineering

## Bachelor of Engineering Program

# 2020



Pakistan Engineering Council  
&  
Higher Education Commission  
Islamabad







**CURRICULUM  
OF  
POLYMER ENGINEERING**

**Bachelor of Engineering Program**

**2020**

**Pakistan Engineering Council  
&  
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Islamabad**

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## **PREFCE**

The curriculum, with varying definitions, is said to be a roadmap or plan of teaching-learning process that students of an academic program are required to undergo. It includes objectives and learning outcomes, course contents, scheme of studies, teaching approaches, and assessment methodologies. Since knowledge in all fields and sectors is expanding at a faster pace and new disciplines are also emerging; it is imperative that curricula should be dynamic having regular review and updation.

The University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vides 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 HEC has been undertaking the development of curricula for new/ emerging fields and revision of curricula after regular intervals through respective National Curriculum Revision Committees (NCRCs) until 2018.

As a policy change and expanding higher education base under HEC, the curriculum review and development task has been shifted to the respective regulators and HEIs. PEC also having mandate under its Act of Parliament and especially after attaining Washington Accord full signatory status and IPEA licensing authority, took up the challenge to review and develop the curricula for engineering programs based on Outcome-Based Education (OBE) System. PEC has therefore constituted an Engineering Curriculum Review and Development (ECRDC) and also subject ECRDCs comprising of eminent engineers and professionals from academia and industry to take up the task of curricula review and updation, while taking all relevant stakeholders on board. Nevertheless, the basic templates developed by HEC NCRCs have been followed as guidelines.

Under OBE based curriculum review and development framework, PEC held national and regional levels stakeholders and industrial consultation workshops engaging HEIs, industry, technical and consulting organizations. The experts' feedback and suggestions were translated into the curriculum review process taking into consideration of the dynamics of technological advancement, industrial needs and management-cum-soft skills for engineering graduates.

This curriculum document would serve as a guideline whereas allowing HEIs to tame/ change within the framework by introducing courses in support of local/ required industrial demand as well as satisfying 12 GAs (Graduate Attributes) covering core and elective courses, considered as beauty of OBE system in the international environment. At the same time, this curriculum framework would fulfill our national, social and economic needs leading towards attainment of Sustainable Development Goals (SDGs- 2030). It would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards.

## **1. Engineering Curriculum Review & Development Committee (ECRDC)**

PEC in its efforts towards quality engineering education, took up the challenge of curriculum review and development for engineering programs after due consent of HEC. A high level Engineering Curriculum Review and Development Committee (ECRDC), led by Prof Engr Dr Fazal Ahmad Khalid, Chairman Punjab HEC/ Vice Chairman PEC, was constituted whereas other eminent members are from industry and academia to take up the task of curricula review and updation, besides developing curriculum for new/ emerging fields. The main responsibility of ECRDC is to oversee the entire curriculum review and development process while setting policies and guidelines for the subject ECRDCs working in their respective domains. The 1st meeting of main ECRDC was held on 29th June, 2018 at PEC HQ, Islamabad, wherein the Convener briefed the scope, objective and ToRs of the Committee and also formulated the subject ECRDCs comprising of eminent engineers and professionals from academia and industry.

- |   |          |
|---|----------|
| 1. Engr Prof Dr Fazal Ahmed Khalid<br>Convener, Metallurgy, Materials, Mining Engg & Allied Disciplines | Convener |
| 2. Engr Prof Dr Iftikhar Hussain<br>Convener Mechanical Engg & Allied Disciplines                       | Member   |
| 3. Engr Prof Dr M. Younus Javed<br>Convener Electrical Engg & Allied Disciplines                        |          |
| 4. Engr Malik Saleem Ullah Saeed<br>Convener Chemical Engg & Allied Disciplines                         | Member   |
| 5. Engr Dr Wasim Khalil<br>Convener, Civil Engg & Allied Discipline                                     | Member   |
| 6. Engr Dr Muhammad Ashraf<br>Convener, Agricultural Engg & Allied Disciplines                          | Member   |
| 7. Engr Prof Dr Jameel Ahmed<br>Convener, Common to All (Non-Engg Component)                            | Member   |

8. Engr Muhammad Raza Chohan Director General, HEC Member
9. Engr Dr Nasir Mahmood Khan Additional Registrar (Accreditation), PEC Member
10. Engr Dr Ashfaq Ahmed Sheikh, Additional Registrar, CPD Secretary

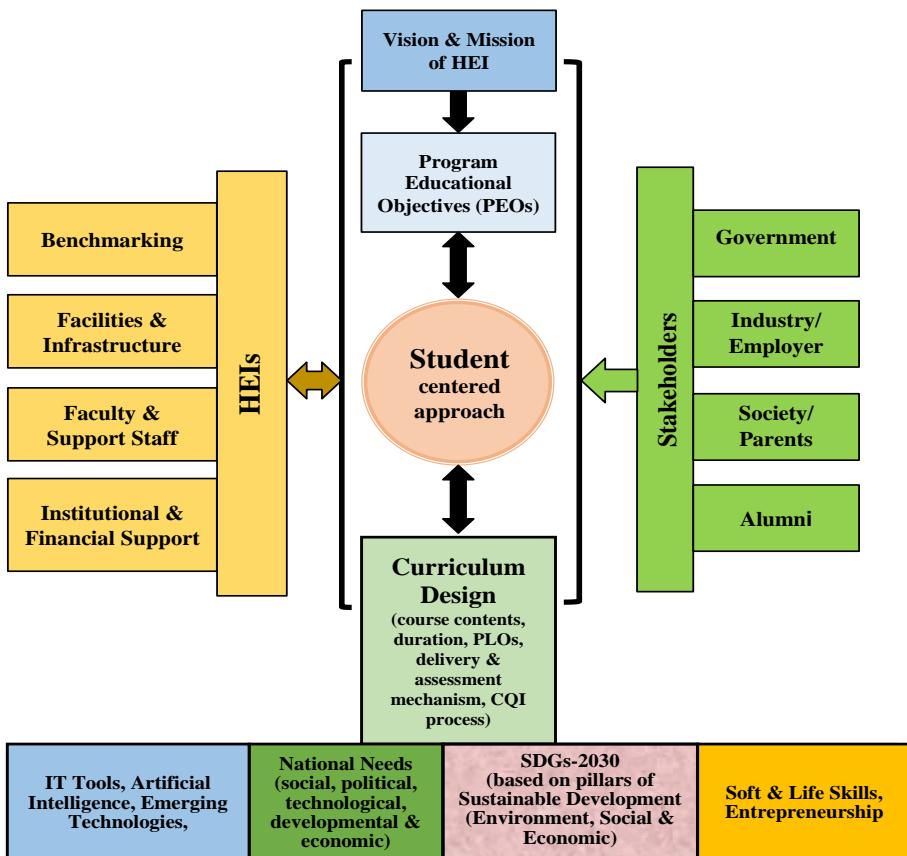
## **2. ECRDC Agenda**

- The ECRDC is responsible to oversee the overall working of curriculum review and development for all engineering programs in terms of strategy, guidance and progress and thereby submission to the relevant forum for adoption notification.
- Each member of ECRDC will also work in the capacity of a convener for the respective discipline as mentioned against his name and as per ToRs.

### 3. OBE-Based Curriculum Development Framework

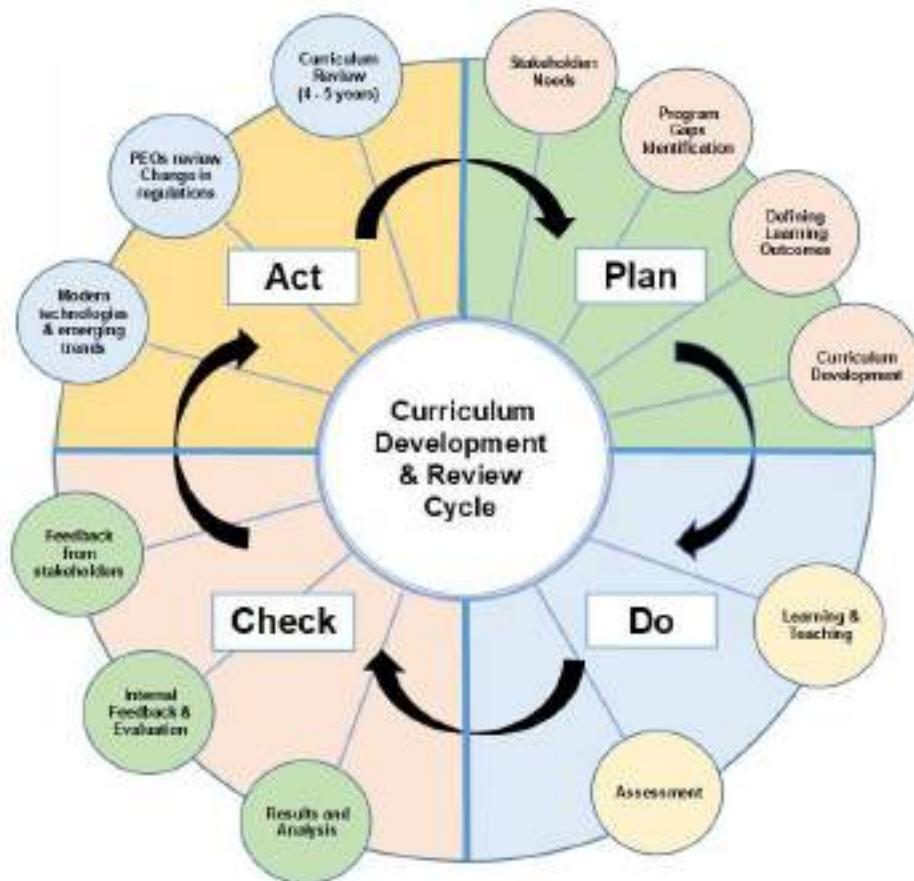
Outcome Based Education (OBE) is an approach of teaching and learning that focuses on what students should be able to attain at the end of the educational program. OBE is a student's centered system which concerns what the students will know and be able to do as learning outcomes. The curriculum development under OBE is therefore an integration of graduate attributes and stakeholders' feedback in cognizance with institution's Vision and Mission.

#### Outcome-Based Education (OBE) - Curriculum Development Framework



#### **4. PDCA Approach to Curriculum Design and Development**

The process of curriculum design and development constitutes various inter connected elements with the objective of achieving the intended purpose of the program. The Plan-Do-Check-Act approach (PDCA) as explained below has been followed in the curriculum development and review process.



**Plan.** This stage begins with an analysis of the stakeholders' needs of faculty, current and past students, employers and society in general. The stakeholders' needs are translated into human resource terminology i.e. graduate competencies which in turn translated into educational taxonomy and learning outcomes. Based on the learning outcomes, curriculum is designed backward to meet PLOs.

**Do.** The plan stage is implemented where curriculum is delivered and learning outcomes are assessed to gauge the achievement of PLOs.

**Check.** This stage involves the analysis of assessment results and feedback from students and faculty. Areas for improvement are identified.

**Act.** When the learning outcomes are achieved, the curriculum, learning and teaching strategies and assessment methods are standardized. Best practices are shared and improvement is made for the next cycle of PDCA.

## **5. ECRDC for Chemical and Allied Engineering**

The PEC Engineering Curriculum Review and Development Committee (ECRDC) of Chemical, Polymer, Textile and Allied Engineering disciplines took up the task to review and update the curriculum for Bachelor of Polymer Engineering degree program. The subject Committee had two meetings held on 13-09-2019 and 24-1-2020 at Lahore besides meetings of Sub-Groups for Polymer Engineering. The Committee comprised of following members:

- |   |   |          |
|---|---|----------|
| 1 | Engr. Malik Saleem Ullah Saeed<br>Chief Executive Officer<br>Water Engineering & Management Services (WEMS), Lahore   | Convener |
| 2 | Engr. Dr. Amjad Hussain Dilawari<br>Professor<br>UET, Lahore  | Member   |
| 3 | Engr. Dr. Syed Kamran Sami<br>Dean<br>Faculty of Engineering & Architecture<br>Balochistan University of Information Technology,<br>Engineering and Management Sciences (BUITEMS), Quetta | Member   |
| 4 | Engr. Prof. Dr. Asif Ali Qaiser<br>Professor/Chairman<br>Department of Polymer & Process Engineering<br>UET, Lahore   | Member   |

- 5 Engr. Prof. Dr. Syed Farman Ali Shah Member  
Professor  
Department of Chemical Engineering  
Mehran University of Engineering and Technology (MUET)  
Jamshoro
- 6 Engr. Prof. Dr. Mahmood Saleem Member  
Professor  
Institute of Chemical Engg. & Technology  
University of the Punjab, Lahore
- 7 Engr. Dr. Aqeel Ahmad Taimoor Member  
Associate Professor  
Faculty of Materials & Chemical Engg  
Ghulam Ishaq Khan Institute of  
Engineering Sciences and Technology, Swabi
- 8 Engr. Prof. Dr. Naveed Ramzan Member  
Professor  
Department of Chemical Engineering  
UET, Lahore
- 9 Engr. Dr. Rabia Nazar Member  
Assistant Professor  
Department of Polymer & Process Engineering  
UET, Lahore
- 10 Engr. Dr. Arshad Hussain Member  
Professor  
Chemical Engineering Department  
SCME, National University of Sciences and Technology(NUST)  
Islamabad
- 11 Engr Prof Dr Muddasar Habib Member  
Chairman  
Department of Chemical Engineering  
University of Engineering and Technology, Peshawar

- 12 Engr Muhammad Irshad Ramay Member  
Coordinator  
National Cleaner Production Center Refinery Morgah, Rawalpindi
- 13 Engr Asad Dawood Member  
Unit Manager  
HSE Fatima Fertilizer Ltd., Lahore
- 14 Engr Nasir Zaman Khan Member  
Department Manager  
United Energy Pakistan, Karachi
- 15 Engr Muhammad Akram Member  
Executive Director Operations  
Ibrahim Fibers Limited (Polyester Plant), Islamabad
- 16 Engr Muhammad Ramzan Member  
Plant Manager  
Rafhan Maize Products, Jaranwala
- 17 Engr Imran Ashraf Member  
CEO  
Brilliant Engineers, Lahore
- 18 Engr. Prof Dr Inayat Ali Memon Member  
Professor  
Department of Chemical Engineering NED-UET, Karachi
- 19 Engr. Prof. Dr. Javaid Rabbani Khan Member  
Professor  
GIKI, Swabi
- 20 Engr. Abdul Basit Member  
Field Manager  
Facilities Engineering Manager  
Orient Petroleum Ltd., Islamabad

- 21 Engr. Prof. Dr. Suleman Tahir Member  
Chairman  
Department of Chemical Engineering,  
University of Gujarat, Gujarat
- 22 Engr. Prof. Dr. Sadiq Hussain Member  
Chairman  
Chemical Engineering Department  
NFC-Institute of Engineering & Technology, Multan
- 23 Engr. Mubasher Mahmood Butt Member  
Manager HSE&Q  
Fauji Fertilizer Company, Rahimyar Khan
- 24 Engr. Dr. Nadeem Feroze Member  
Chairman/Professor  
Department of Chemical Engineering  
UET, Lahore
- 25 Engr. Liaquat Mahmood Member  
Professor (Rtd)  
ICET University of Punjab, Lahore
- 26 Engr. Amar Abbas Member  
Process Manager  
Pak Arab Refinery Company, Kot Addu
- 27 Mr. Hidayatullah Kasi Rep HEC  
Deputy Director  
Higher Education Commission, Islamabad
- 28 Engr. Dr. Ashfaq Ahmed Sheikh Member  
Additional Registrar-CPD  
Pakistan Engineering Council, Islamabad
- 29 Engr. Muhammad Kashif Ali AR-CPD  
Assistant Registrar-CPD  
Pakistan Engineering Council, Islamabad

## **5.1 Sub Group Polymer Engineering**

1. Engr. Dr. Asif Ali Qaiser Lead Sub-Group  
Professor/Chairman  
Department of Polymer & Process Engineering  
UET, Lahore
2. Engr. Dr Naveed Ramzan Member  
Professor  
Department of Chemical Engineering  
UET, Lahore
3. Engr. Liaqat Mahmood Member  
Professor (Rtd)  
ICET University of Punjab, Lahore
4. Engr. Dr. Rabia Nazar Member  
Assistant Professor  
Department of Polymer & Process Engineering  
UET, Lahore
5. Engr. Muhamamd Akram Member  
Executive Director Operations  
Ibrahim Fibers Limited (Polyester Plant), Islamabad
6. Engr.Dr Syed Kausar Ali Expert  
Chairman & Professor  
Department of Polymer & Petrochemical Engineering  
NED-UET, Karachi
7. Mr. Hidayatullah Kasi Rep HEC  
Deputy Director  
Higher Education Commission, Islamabad
8. Engr. Dr. Ashfaq Ahmad Sheikh Secretary  
Additional Registrar-CPD  
Pakistan Engineering Council, Islamabad
9. Engr. Muhammad Kashif Ali AR-CPD  
Assistant Registrar-CPD  
Pakistan Engineering Council, Islamabad

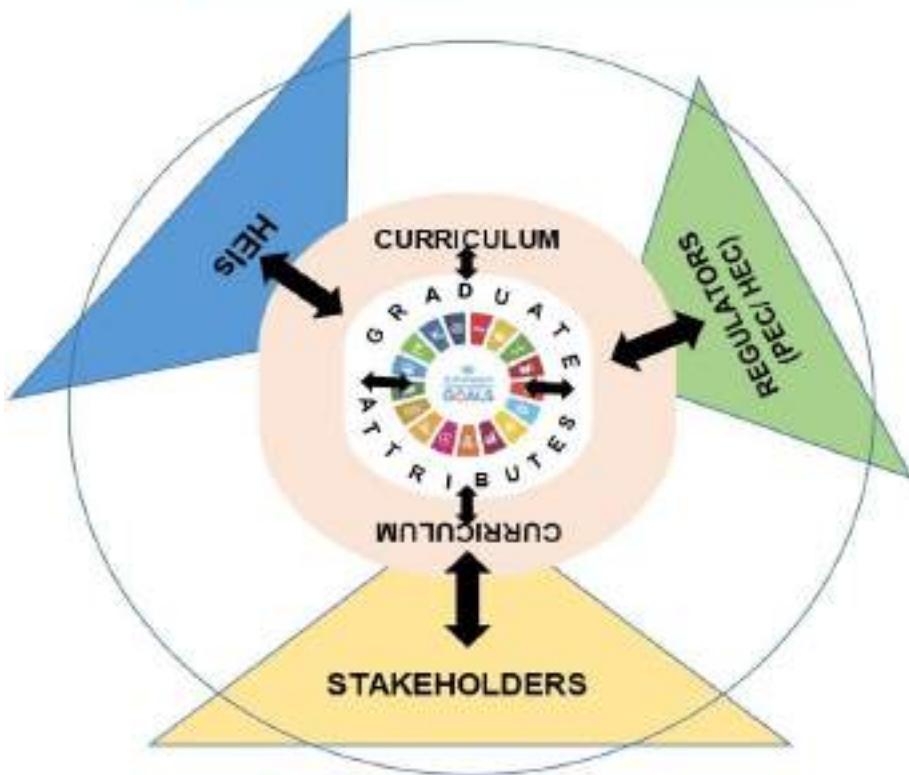
## **6. Agenda of ECRDC for Chemical and Allied Engineering Disciplines**

- The Subject ECRDC will work under the overall directions and supervision of main ECRDC comprising all Conveners.
- The key driving lines for the development of engineering curriculum for each discipline will be the overall policy of Pakistan Engineering Council in connection with international commitments (Washington Accord, IPEA etc.) and Government policies.
- Review of polices and stakeholders' feedback relating sector relevant to the respective discipline
- Comparative study of the curricula being offered at various engineering universities/institutions following the OBE-based system
- Development and finalization of complete scheme and curriculum for respective discipline including all aspects.

The Convener Engr Mailk Saleemullah Saeed highlighted the important benchmarks and international best practices to be considered for the development/ revision of the curriculum while taking into account the Outcome Based Education (OBE) system. He also suggested that the Committee comprising professors and experts from academia, industry and R&D institutions has provided a useful input and suggestions covering new developments to be incorporated in the curriculum. He also highlighted the importance of the field of Polymer Engineering for achieving sustainable developments while addressing socio-economic issues and challenges envisaged in Sustainable Development Goals-2030 as under and well-mapped with the courses;

- Goal-1: No Poverty
- Goal-2: Zero Hunger
- Goal-3: Good Health and Well-being
- Goal-4: Quality Education
- Goal-5: Gender Equality
- Goal-8: Decent Work and Economic Growth
- Goal-9: Industrial Innovation and Infrastructure
- Goal-12: Responsible Consumption and Production
- Goal-13: Climate Action

## OBE Curriculum towards SDGs-2030 Attainment



The curriculum therefore has been designed based on above SDGs translating into program objectives and mapped with the scheme of study

## **7. Program Objectives (PEOs) and Learning Outcomes (PLOs)**

As guidance, the sample Program Educational Objectives (PEOs) and Learning Outcomes (PLOs) are given below for a typical Polymer Engineering Program. The HEIs should have their own program objectives, PLOs and CLOs in line with the institution's Vision and Mission, in cognizance with industrial needs as well as national and international trends.

### **7.1 Program Educational Objectives (PEOs)**

The program aims at imparting quality education to Polymer Engineering graduates for contributing to the society through modern technologies and practices in line with SDGs especially Goal-1, Goal-2, Goal-3, Goal-4, Goal-5, Goal-8, Goal-9, Goal-12, and Goal-13.

The graduates of the program will able to:

- i. Graduates demonstrate sound engineering knowledge and skills.
- ii. Graduates execute and manage teamwork, interpersonal skills and professional growth.
- iii. Graduates conduct professional practice considering socio-economical, environmental, ethical, health and safety and cultural aspects.

### **7.2 Program Learning Outcomes (PLOs)**

Program outcomes are the narrower statements that describe what students are expected to know and be able to do by the time of graduation. These relate to the knowledge, skills and attitude that the students acquire while progressing through the program. Specifically, it is to be demonstrated that the students have acquired the following graduate attributes (GAs):

**PLO1 Engineering Knowledge:** An ability to apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

**PLO2 Problem Analysis:** An ability to identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

**PLO3 Design/Development of Solutions:** An ability to design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

**PLO4 Investigation:** An ability to investigate complex engineering problems in a methodical way including literature survey, design and conduct of experiments, analysis and interpretation of experimental data, and synthesis of information to derive valid conclusions.

**PLO5 Modern Tool Usage:** An ability to create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities, with an understanding of the limitations.

**PLO6 The Engineer and Society:** An ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solution to complex engineering problems.

**PLO7 Environment and Sustainability:** An ability to understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of, and need for, sustainable development.

**PLO8 Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

**PLO9 Individual and Team Work:** An ability to work effectively, as an individual or in a team, on multifaceted and/or multidisciplinary settings.

**PLO10 Communication:** An ability to communicate effectively, orally as well as in writing, on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

**PLO11 Project Management:** An ability to demonstrate management skills and apply engineering principles to one's own work, as a member and/or leader in a team, to manage projects in a multidisciplinary environment.

**PLO12 Lifelong Learning:** An ability to recognize importance of, and pursue lifelong learning in the broader context of innovation and technological developments.

## **8. Program Salient Features**

The undergraduate engineering program has been based on the following salient features:

- **Duration:** 4 years
- **Number of Semesters:** 8
- **Total number of credit hours:** 130 – 136
  - Engineering Domain: minimum 85 Credit Hours
  - Non-Engineering Domain: minimum 30 Credit Hours

(HEIs have flexibility of 15-21 Credit Hours to add courses either in Engineering, Non-Engineering or both Domains to fulfill the program objectives in line with the overall Vision/ Mission of the Institute concerned).
- **Additional Course or Credit Hours Requirements:** Any addition of course or credit hour requirements as per direction or policy of the Government (Provincial or Federal), HEIs have leverage to cater such needs over and above the prescribed requirements in this document.
- **Number of weeks per semester:** 15 - 18
- **Number of credit hours per semester:** 15 - 18
- **Curriculum:** The engineering curriculum is the most important instrument for grooming the students based on 12 Graduate Attributes (GAs) encompassed under the Program Learning Outcomes (PLOs). In order to inculcate different dimensions of thinking – mathematical, computational, design and creative – among students in Cognitive, Psychomotor and Affective domains, the curriculum is based on the following knowledge profiles:

**WK1 - Natural Sciences:** A systematic theory-based understanding of natural sciences applicable to the discipline.

**WK2 - Mathematics and Computing:** The concept-based mathematical thinking, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modeling applicable to the discipline.

- WK3 - Engineering Fundamentals:** A systematic, theory-based formulation of engineering fundamentals required in an engineering discipline.
- WK4 - Engineering Specialization:** The knowledge of engineering specialization that provides theoretical frameworks and bodies of knowledge for the accepted practice areas that are at the forefront in a discipline.
- WK5 - Engineering Design:** The Design Thinking Knowledge that supports engineering design in a practice area of an engineering discipline.
- WK6 - Engineering Practice:** The Knowledge of engineering practices (technology) in different practice areas of an engineering discipline.
- WK7 - Engineering in Society:** A systematic, comprehension-based knowledge of the role of engineers in a society and the professional issues related to practicing engineering profession in a discipline: ethics and the professional responsibility of an engineer to public safety including the impact of an engineering activity i.e. economic, social, cultural, environmental and sustainability.
- WK8 - Research Literature:** Engagement with selected knowledge in the research literature of the discipline.

The curriculum matrix covering above knowledge profiles should therefore be composed of non-engineering domain (humanities, math, management and natural sciences), and engineering domain with computer science, foundation, breadth, depth and multidisciplinary courses (including safety) so that different streams could be encouraged within each discipline, enabling students to undertake a range of Complex Problem Solving and Complex Engineering Activities. The students may select electives from any of the streams with guidelines from their respective advisors.

## *Curriculum of Polymer Engineering*

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<b>Knowledge Profile*</b> <b>(WK-1 to WK-8)*</b>	<b>Knowledge Area</b>	<b>Sub-Area</b>	<b>Courses</b>	<b>Credit Hours</b>	
<b>Non-Engineering Domain</b>					
WK-2	Natural Science	Math	As per program requirements	12 – 15	
WK-1		Physics	Applied Physics	6 – 9	
		Chemistry	Applied Chemistry		
		Natural Science/ Math Elective	As per program requirements		
WK-7	Humanities	English	Written, communication and presentation skills	4 – 7	
		Culture	Islamic Studies and Ethics	2	
			Pakistan Studies and Global Perspective	2	
		Social Science	Social and soft skills	2 – 6	
	Management Sciences	Professional Practice	Professional and Project Management	2 – 6	
<b>Total (Non-Engineering Domain)</b>				<b>min 30</b>	
<b>Engineering Domain</b>					
WK-2/ WK-4/ WK-5/ WK-6	Computer and Information Sciences	ICT/AI/ Data Science/ Cyber Security		6 – 9	
WK-3/ WK-2	Foundation Engg Courses		Specific to program objectives and outcomes	22 – 24	
WK-4/ WK-2/ WK-1	Core Breadth of Engg discipline		Specific to program objectives and outcomes	23 – 24	
WK-5/ WK-6	Core Depth of Engg Discipline		Specific to program objectives and outcome	22 – 24	

WK-3/ WK-4/ WK-2/ WK-1	Multidisciplinary Engg Courses		Specific to program objectives and outcome	6 – 12
			Occupational Health and Safety (mandatory- 01 Cr Hr)	
WK-6/ WK-8/ WK-7	Final Year Design Project (FYDP)/ Capstone	Integration of innovative, creative, technical, management and presentation skills of a graduate towards final year.		6
WK-6/ WK-7	Industrial Training	at least 6 - 8 weeks internship		Qualifying
WK-4/ WK-5/ WK-6/ WK-7/ WK-8/ WK-2	<b>Innovative and Critical Thinking (under relevant courses):</b> <ul style="list-style-type: none"> <li>- Complex Problem Solving</li> <li>- Complex Engineering Activities</li> <li>- Semester Project</li> <li>- Case Studies</li> <li>- Open Ended Labs</li> <li>- Problem Based Learning (PBL)</li> </ul>			
<b>Total (Engineering domain)</b>			<b>min 85</b>	
<b>Total (Credit Hours)</b>			<b>130 – 136</b>	

\* As a specific or more than one knowledge profile to be covered

- **Industrial Training:** Internship of at least 6 - 8 weeks is mandatory part of degree requirements towards 3rd to 4th year of program; must be supervised, monitored, evaluated, and reflected in the transcripts under a prescribed mechanism and with defined and mapped rubrics with program objectives;
  - Selection of internship in line with elective subjects/ specific streams
  - Qualifying weightage:
    - At least 75% attendance is mandatory 10%
    - Assessment report from the employer 50%
    - Evaluation at relevant HEIs/ Deptt – presentation 40%
- **Final Year Design Project (FYDP)/ Capstone:** FYDP aims to challenge innovative, creative, technical, management and presentation skills of a graduate to bring together the learning over the degree program.

- A final year design project (FYDP) is the confluence of an engineering program. Undertaking a final year design project is a compulsory requirement. It should mainly comprise literature search, individual analysis, modeling and simulation, AI (Artificial Intelligence) and computational data analytics, design and putting together various hardware, software, firmware and Algorithm Engineering / Informatics related to the program to demonstrate a functional concept including rapid prototyping, where applicable.
- The FYDP shall include complex engineering problems and design systems, components or processes integrating core areas and meeting specific needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
- A project of this nature should invariably lead to an integration of the knowledge and practical skills as mandated in the program outcomes. In this context, projects of multidisciplinary nature should be encouraged.
- The FYDP should span over two consecutive semesters, i.e. semester 7 & 8, totaling 6-credit hours and should be fully supervised, assessed and reflected in the transcripts under a prescribed mechanism so as to prepare for joining industry after graduation.
- **Faculty:** The faculty must be trained for the Outcome-Based Education (OBE) system. Their familiarity with the program objectives and outcomes, understanding of the Outcome-Based Assessment (OBA) cycle, enthusiasm for developing an effective program, and the ability to become an active player in this regard are the keys to ensure the attainment of program objectives. The faculty is expected to have the ability to ensure proper implementation of the program, and to develop processes for evaluation, assessment and CQI. A formal training program to groom the faculty should be instituted to become effective instructors in applying pedagogical skills in all aspects of Teaching, Learning and Assessment covering all domains of Knowledge, Skills and Attitude.
- **Personal Grooming:** Personal Grooming of young faculty members and students is very important in order to develop and support their professional skills. Therefore, it is required that HEIs should conduct/arrange sessions or counseling hours on regular basis to provide guidance for personal grooming. Personal Grooming is important for positive self-image and increasing the confidence level of the individuals. It would help in enhancing students' self-

esteem and would go a long way in developing an attractive personality by adopting habits like personal hygiene, clothing, appearance, interaction and expressive skills, etc. The students should be motivated and equipped to be entrepreneurs in their relevant field.

- **Presentation and Communication Skills:** Special focus should be given to inculcate communication and presentation skills amongst the graduates through individual and group presentations, technical writing and discussions, throughout the program as a regular feature.

This curriculum has been designed to guide and facilitate the universities and departments to formulate their own programs according to the industrial needs, emerging trends and recent developments in the field of Polymer Engineering. The HEIs have flexibility to incorporate changes in the proposed curriculum within given range of credit hours for engineering and non-engineering domain.

## 9. Framework for Bachelor of Polymer Engineering

Knowledge Profile (WK-1 to WK-8)	Knowledge Area	Sub Area	Name of Course	Theory	Lab	Total		
				Credit Hours				
<b>Non-Engineering Domain</b>								
WK-7	Humanities	English	Functional English	2	0	2		
			Communicational Skills	2	0	2		
			Technical Writing & Presentation Skills	2	1	3		
	Culture		Islamic Studies and Ethics	2	0	2		
			Pakistan Studies and Global Perspectives	2	0	2		
	Social Sciences	Professional Ethics	Social Science Elective-I	2	0	2		
			Social Science Elective-II	2	0	2		
	Management Sciences	Professional Practice	Management Science Elective –I (Entrepreneurial Management)	2	0	2		
			Management Science Elective –II (Total Quality Management)	3	0	3		
WK-2 WK-1	Natural Sciences	Mathematics	Calculus and Analytic Geometry	3	0	3		
			Linear Algebra	3	0	3		
			Probability & Statistics	3	0	3		
	Physics		Applied Physics	2	1	3		
			Polymer Chemistry-I	2	1	3		
<b>Total (Non- Engineering Domain)</b>				<b>32</b>	<b>3</b>	<b>35</b>		
<b>Engineering Domain</b>								
WK-2/ WK-4/ WK-5/ WK-6	Computer and Information Sciences	ICT/AI/ Data Science/ Cyber Security	Information and Communication Technologies (ICT)	2	1	3		
			Artificial Intelligence	2	1	3		
WK-3/ WK-2	Engineering Foundation	--	Industrial Stoichiometry	3	0	3		
			Thermodynamics	3	0	3		
			Engineering & Polymer Materials	3	0	3		
			Particle Technology	2	1	3		

			Polymer Analysis & Characterization	3	1	4
			Fundamentals of Polymer Engineering	2	1	3
			Fluid Flow	3	1	4
			Mechanical Properties of Polymers	3	0	3
			Workshop Practice	0	1	1
			Engineering Drawing and Graphics	1	1	2
			Heat Transfer	2	1	3
WK-4/ WK-2/ WK-1	Major Based Core (Breadth)		Polymer Structures & Synthesis	2	1	3
			Transport Phenomena	3	0	3
			Polymer Processing Operations	2	1	3
			Polymer Compounding & Blending	3	0	3
			Mass Transfer	2	1	3
			Polymer Composites	3	0	3
			Process Plant Design	2	1	3
			Polymer Reaction Engineering	2	1	3
WK-5/ WK-6	Major Based Core (Depth)		Polymer Processing Design & Simulation	2	1	3
			Polymer Product Design	3	0	3
			Polymer Rheology	3	0	3
			Elective-I	3	0	3
			Elective-II	3	0	3
			Elective-III	3	0	3
			Elective-IV	3	0	3
WK-1/ WK-2/ WK-3/ WK-4	Multi-Disciplinary Engineering Electives		MDE-I (Chemical & Petrochemical Industries)	3	0	3
			MDE-II (Instrumentation and Control)	2	1	3
			Environmental Engineering & Process Safety	3	0	3
			Occupational Health and Safety	1	0	1
WK-6/ WK-7/ WK-8	Final Year Project (FYP)/Creative Project	Industrial/ Innovative/ Creative Project	FYDP (Part-I)	0	3	6
			FYDP (Part-II)	0	3	

## *Curriculum of Polymer Engineering*

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WK-6/ WK-7	Industrial Training	At least 6 weeks mandatory internship	0	0	0
WK-2/ WK-4/ WK-5/ WK-6/ WK-7/ WK-8	<b>Innovative and Critical Thinking (under relevant courses)</b> <ul style="list-style-type: none"><li>- Complex Problem Solving</li><li>- Complex Engineering Activities</li><li>- Semester Project</li><li>- Case Studies</li><li>- Open Ended Lab</li><li>- Problem Based Learning (PBL)</li></ul>				
<b>Total (Engineering Domain)</b>		<b>77</b>	<b>22</b>	<b>99</b>	
<b>Total Credit Hours</b>		<b>110</b>	<b>25</b>	<b>134</b>	

## **10. Scheme of Studies for Bachelor of Polymer Engineering**

Course Title	Theory	Lab	Total	Course Title	Theory	Lab	Total
<b>First Year</b>							
<b>Semester 1</b>				<b>Semester 2</b>			
Functional English	2	0	2	Communicational Skills	2	0	2
Information and Communication Technologies (ICT)	2	1	3	Engineering & Polymer Materials	2	1	3
Calculus and Analytical Geometry	3	0	3	Fundamentals of Polymer Engineering	2	1	3
Polymer Chemistry-	2	1	3	Industrial Stoichiometry	3	0	3
Islamic Studies	2	0	2	Particle Technology	2	1	3
Applied Physics	2	1	3	Linear Algebra	3	0	3
Engineering Drawing	1	1	2	Workshop Practice	0	1	1
<b>Total</b>	<b>14</b>	<b>4</b>	<b>18</b>	<b>Total</b>	<b>14</b>	<b>4</b>	<b>18</b>
<b>Second Year</b>							
<b>Semester 3</b>				<b>Semester 4</b>			
Fluid Flow	3	1	4	Technical Writing & Presentation Skills	2	1	3
Polymer Structures & Synthesis	2	1	3	Heat Transfer	2	1	3
Chemical & Petrochemical Industries	3	0	3	Environmental Engineering & Process Safety	3	0	3
Thermodynamics	3	0	3	Polymer Processing Operations	2	1	3
Pakistan Studies	2	0	2	Probability and Statistics	3	0	3
Process Engineering Computing	2	1	3	Social Sci Elective-II (Engineering Economics)	2	0	2

## ***Curriculum of Polymer Engineering***

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Total	15	3	18	Total	14	3	17
<b>Third Year</b>							
<b>Semester 5</b>				<b>Semester 6</b>			
Mass Transfer	2	1	3	Polymer Analysis & Characterization	3	1	4
Mechanical Properties of Polymers	3	0	3	Instrumentation & Control	2	1	3
Polymer Reaction Engineering	2	1	3	Polymer Composites	2	1	3
Polymer Compounding & Blending	3	0	3	Management Sciences Elective-II (Total Quality Management)	3	0	3
Transport Phenomena	3	0	3	Polymer Rheology	3	0	3
Social Science Elective-I	2	0	2		0	0	0
<b>Total</b>	<b>15</b>	<b>2</b>	<b>17</b>	<b>Total</b>	<b>13</b>	<b>3</b>	<b>16</b>
<b>Fourth Year</b>							
<b>Semester 7</b>				<b>Semester 8</b>			
Management Sciences Elective-I (Entrepreneurial Management)	2	0	2	Polymer Product Design	3	0	3
Process Plant Design	2	1	3	Polymer Processing Design & Simulation	2	1	3
Elective-I	3	0	3	Elective-III	3	0	3
Elective-II	3	0	3	Elective-IV	3	0	3
FYDP-I	0	3	3	FYDP-II	0	3	3
<b>Total</b>	<b>10</b>	<b>4</b>	<b>14</b>	<b>Total</b>	<b>11</b>	<b>4</b>	<b>15</b>
Compulsory industrial internship of 6 weeks during summer holidays					Qualify		
<b>Total Credits Hours</b>					<b>134</b>		

\* Course on OSH (1-0) should be taught during 1<sup>st</sup> year of program.

### **Proposed List of Electives for Polymer Engineering**

- Elastomeric Materials
- Smart Polymers
- Mold Design & Fabrication
- Polymers in Energy Applications
- Nanotechnology
- Polymer Packaging
- Polymer Coating & Adhesives
- Industrial Membranes Technology
- Recycling & Waste Management
- Polymers in Automotive Applications
- Fiber Technology
- Additive Manufacturing
- Biopolymers
- Polymeric Foams

### **Electives for Social Science**

- Sociology for Engineers
- Professional Ethics
- Economics for Engineers
- Sociology
- Social Anthropology
- Understanding Psychology and Human
- Social Psychology
- Organizational Behavior
- Critical Thinking
- Philosophy
- Human Resource Development
- Culture and Society
- Engineering Law

### **Electives for Management Sciences**

- Entrepreneurship
- Entrepreneurship and Marketing
- Engineering Project Management
- Principle of Management
- Engineering Management
- Quality Management Systems
- Textile Marketing
- Industrial Engineering and Management
- Total Quality Management
- Supply Chain Management
- Production Management

### **Courses for Computer Sciences**

- Information and Communication Technologies (ICT)
- Artificial Intelligence
- Cyber Security
- Data Science
- Modelling and Simulation
- Computer Programming and Design

## **11. Program Specific Lab**

The following labs specific to engineering discipline be ensured to cover relevant knowledge domains but not limited to;

- Polymer Texting Lab
- Polymer Processing & Application Lab
- Polymer Pilot Plant Lab
- Polymer Characterization Lab
- Polymer Structure & Synthesis Lab
- Polymer Composites Lab
- Conducting Polymers and Membrane Lab
- Plastic and Rubber Compounding Lab
- Process Engineering Lab
- Process Heat Transfer Lab
- Fluid Flow Lab
- Mass Transfer Lab
- Instrumentation and Control Lab
- Thermodynamics Lab

## **12. Course Details and Teaching-Assessment Approaches**

In the following sections, Course Outline and teaching-assessment approaches are given for guidance based on a typical semester system. The instructors may adopt or adapt accordingly defining CLOs, course delivery plan, innovative teaching approaches and assessment techniques.

### **12.1 Engineering Domains**

#### **Computer and Information Sciences Courses**

##### **Information and Communication Technologies (ICT)**

#### **Course Outline:**

##### **Introducing Computer Systems: Basic Definitions**

- Computer and Communication Technology
- The applications of ICT - particularly for Engineers

##### **Basic Operations and Components of a Generic Computer System**

- Basic operations: Input, Processing, Output, Storage Basic components: Hardware, Software, Data, Users
- Types of storage devices

##### **Processing Data**

- Transforming data into information
- How computers represent and process data
- Processing Devices
- CPU architectures

##### **The Internet**

- The Internet and the World Wide Web- browsers, HTML
- URLs/ How DNS works
- Email and other programs

## **Introduction to Embedded Systems**

- What is an Embedded System
- Applications
- Components
- Programming Languages
- Popular Development Platforms

## **Networking Basics**

- Uses of networks
- Common types of networks (LAN, WAN, MAN etc.)
- Introduction to OSI Model
- Future of Networks

## **Database Management**

- Hierarchy of Data
- Maintaining Data
- Database Management Systems

## **Exposure to ICT Tools and Blogs (Student Assignment)**

### **Protecting your privacy, your computer and your data**

- Basic Security Concepts
- Threats to users
- Threats to hardware
- Threats to Data

## **ICT in Education**

### **Future Trends in ICT**

### **Final Presentations**

### **Tools / Software Requirement**

Microsoft Office, Windows, Virtual Box, Netbeans

**Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Industrial/ Field Visits, Group discussion, Report Writing

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- “Introduction to Computers”, Peter Norton, 7th Edition, 2013, McGraw-Hill.
- “Computing Essentials”, Timothy O’Leary and Linda O’Leary, 2010, McGraw-Hill.
- Using Information Technology: A Practical Introduction to Computers & Communications”, Williams Sawyer, 6th Edition, 2005, McGraw-Hill.
- “Discovering Computers, Complete: Your Interactive Guide to the Digital World. Cengage Learning” Shelly GB, Vermaat ME, 2012 Ed.

**Computer Programming and Design**

**Course Outline:**

- Introduction to Programming and languages
- Algorithms, Flowcharts and pseudocode
- Overview of programming (C, C+, Python)
- Writing, compiling and debugging
- Coding style
- Statements
- Variables and datatypes
- Operators and expressions
- Selection
- Relational operators
- Conditional Statements
- Conditional operators
- Switch, break, continue

- Logical operators
- Modular programming
- Structures in functions and Arrays
- File pointers
- Error handling
- Revision
- Project Demos

#### **Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Industrial/ Field Visits, Group discussion, Report Writing

#### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

#### **Suggested Books:**

- Paul J. Deitel and Harvey M. Deitel, C: How to Program, Prentice Hall, 2010.
- The C Programming Language (2nd Ed.) by Kernighan and Ritchie, 1988.
- Code Complete (2nd Ed.) by Steve McConnell, 2004.
- The Art of Computer Programming (TAOCP) by Donald E. Knut

## **Computer Aided Design**

#### **Course Outline:**

- Introduction to AutoCAD
- Use basic drawing and text commands
- Use basic editing commands (move, copy, erase, etc.)
- Use advanced editing commands (mirror, fillet, etc.)
- Dimensioning capabilities of Auto CAD
- Create and use layers
- Print or plot a drawing
- Create and using blocks
- Be familiar with hatching capabilities of Auto CAD

- Curves
- 3D modeling
- Multiple Lines
- Geometric Shapes
- Isometric drawings
- Polar Arrays

**Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Industrial/ Field Visits, Group discussion, Report Writing

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Mastering AutoCAD 2017 and AutoCAD LT 2017 by George Omura with Brian Benton, (latest edition), 2016.
- AutoCAD® 2015 And AutoCAD Lt® 2015 No Experience required by Donnie Gladfelter.

**Introduction to Modeling and Simulation**

**Course Outline:**

**Simulation**

- Prepare Model Inputs and Outputs
- Configure Simulation Conditions
- Run Simulations
- View and Analyze Simulation Results
- Test and Debug Simulations
- Optimize Performance
- Simulation Guidelines & Best Practices

## **Modeling**

- Design Model Architecture
- Manage Design Data
- Design Model Behavior
- Configure Signals, States, and Parameters
- Configure Inputs and Visualizations
- Analyze and Remodel Design
- Test Model Components
- Modeling Guidelines & Best Practices

## **Tools/ Software Requirement**

- Matlab

## **Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Industrial/ Field Visits, Group discussion, Report Writing

## **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

## **Suggested Books:**

- Introduction to Matlab for Engineering Students by David Houcque, Northwestern University.
- <https://www.mathworks.com/help/simulink/simulation.html>
- <https://www.mathworks.com/help/simulink/modeling.html>

## **Artificial Intelligence**

### **Course Outline**

This course gives a broad overview of the fundamental theories and techniques of Artificial Intelligence.

- Overview of AI Problems;

- Intelligent Behavior: Turing Test, Rationale versus Non-rationale Reasoning;
- Problem Characteristics: Fully versus Partially Observable,
- Single versus Multi agent; Intelligent Agents: reactive, deliberative, goal-driven, utility-driven, and learning agents; Uninformed Search: Depth First, Breadth First, Depth First with Iterative Deepening;
- Informed Search: Hill climbing, A\*- Search and their Time and Space Complexity, Local Search, Genetic Algorithm; Game Playing: Minimax, Evaluation functions, Alpha-beta pruning; Propositional and Predicate Logic; Resolution and Theorem Proving; Forward and Backward Chaining;
- Machine Learning: Introduction,
- Supervised learning: Instance based learning, Decision tree, Artificial neural networks, Unsupervised Learning: K-means Clustering, Reinforcement Learning.

#### **Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written assignments/Quizzes, Case Studies relevant to Engg. disciplines, Semester project, Guest speaker, Industrial/Field visits, Group discussion, Report Writing.

#### **Assessment:**

Mid-term, Report writing/Presentation, Assignment, Project report, Quizzes, Final exam.

#### **Suggested Books:**

- Stuart J. Russell and Peter Norvig, “Artificial Intelligence: A Modern Approach”, latest Edition, Prentice Hall, ISBN-13: 978-0136042594.
- Elaine Rich and Kevin Knight, “Artificial Intelligence”, latest Edition, McGraw-Hill, ISBN-13: 978-0070522633.
- R. J. Schalkoff, “Artificial Intelligence in Engineering Approach”, latest edition, McGraw Hill, ISBN-13: 978-0070550841.
- Peter Jackson, “Introduction to Expert Systems”, latest Edition, Addison Wesley, ISBN-13: 978-0201876864.
- Ivan Bratko, “Prolog Programming for Artificial Intelligence”, latest Edition, Addison Wesley, ISBN-13: 978-0321417466.

## **Engineering Foundation Courses**

### **Engineering & Polymer Materials**

#### **Course Outline:**

- Introduction to materials and their properties: Selection of materials, mechanical properties of materials, physical properties of materials, engineering materials, composite materials, factors affecting material properties, composition
- Basic science of materials: Molecules and lattices, crystals, allotropy, grain structure, crystal growth, solidification defects, semiconductor materials, polymeric materials, polymer building blocks, crystallinity in polymers, orientation, melting points in polymers, glass transition temperature, the effect of temperature on polymer applications, memory effects
- Alloying of metals: Alloys, alloying elements, solubility, solid solutions, intermetallic compounds, cooling curves, phase, alloy types, phase equilibrium diagrams (eutectic type, solid solution type, combination type), coring
- Plain carbon steels: Ferrous metals, the iron-carbon system, critical change points, the effect of carbon on the properties of plain carbon steel, plain carbon steels
- Heat treatment of plain carbon steels: Heat treatment processes, annealing processes, normalizing, quench hardening, quenching media, tempering, mass effect, case hardening, localized case hardening, surface hardening
- Cast irons and their heat treatment: The iron-carbon system for cast iron, alloying elements and impurities, heat treatment of grey cast iron, malleable cast iron, alloying cast irons, properties and uses of white and grey cast irons, specifications of grey iron castings, properties uses of malleable cast irons, specifications of malleable cast irons, compositions
- Non-ferrous metals their alloys and their heat treatment: Non-ferrous metals, aluminum, aluminum alloys, copper, high copper content alloys, brass alloys, tin-bronze alloys, aluminum-bronze alloys, cupro-nickel alloys, magnesium alloys, zinc alloys, tin-lead alloys
- Introduction and classification of polymeric materials
- Shaping and joining materials: Molding polymeric materials, welding plastic materials, adhesive bonding, thermoplastic adhesives, impact adhesives, thermosetting adhesives, safety in the use of adhesives

- Materials testing (non-destructive): The need for non-destructive testing, visual examination, ultrasonic testing, magnetic testing, radiography
- Materials in service: Allowable working stress, creep in polymeric materials, fatigue, factors affecting fatigue of metals and polymers, the corrosion of metals, types of corrosion factors affecting corrosion, prevention from corrosion, plastic degradation.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- R. L. Timings, Engineering Materials, Volume 1, 2nd Edition, Longman, 1998 (ISBN-13: 978-0582319288)

**Fundamentals of Polymer Engineering**

**Course Outline**

- Types of polymers: Thermoplastics and thermosets, chemistry of synthesis, structure
- Molecular structure of polymers: Types of bonds, bond distances and strengths, bonding and response to temperature, action of solvents, bonding and molecular structure, stereoisomerism
- Polymer morphology: Amorphous and crystalline polymers, the effect of polymer structure, temperature, and solvent on crystallinity, the effect of crystallinity on polymer density, the effect of crystallinity on mechanical properties, the effect of crystallinity on optical properties, models for the crystalline structure of polymers, extended chain crystals, liquid crystal polymers

- Characterization of molecular weight: Average molecular weights, determination of average molecular weights, molecular weight distributions, gel permeation (or size-exclusion) chromatography (GPC, SEC)
- Thermal transitions in polymers: The glass transition, molecular motions in an amorphous polymer, determination of T<sub>g</sub>, factors that influence T<sub>g</sub>, the effect of copolymerization on T<sub>g</sub>, the thermodynamics of melting, the metastable amorphous state, the influence of copolymerization on thermal properties, effect of additives on thermal properties, effects of crosslinking, thermal degradation of polymers
- Rheological behavior of polymers and viscoelasticity: Relations between shear force and shear rate, polymer melts and solutions, power law for non-Newtonian fluids, temperature dependence of flow properties, influence of molecular weight on flow properties, the effects of pressure on viscosity, viscous energy dissipation, introduction to linear viscoelasticity
- Mechanical properties of polymers: Introduction to mechanical properties of polymers
- Introduction to polymer processing
- Polymer applications: Plastics and plastic additives, rubbers and thermoplastic elastomers, synthetic fibers, surface finishes and coatings, adhesives
- Analytical tests: Density and specific gravity, water absorption, moisture analysis, sieve analysis, pourability of plastic materials
- Material characterization tests: melt flow index (MFI), viscometer
- Mechanical tests: Tensile testing, flexural testing, creep and stress relaxation, impact testing, hardness
- Thermal properties: Heat deflection temperature, Vicat softening point, melting point, thermal conductivity, thermal expansion, brittleness temperature
- Electrical properties: Dielectric strength, dielectric constant and dissipation factor
- Weathering properties: Accelerated weathering and out-door weathering
- Optical properties: Refractive index, luminous transmittance and haze, color, gloss
- Chemical properties: Immersion tests, solvent stress-cracking resistance, environmental stress-cracking resistance.

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

### **Suggested Books:**

- C. S. Brazel, S. L. Rosen, Fundamental Principles of Polymeric Materials, Third Edition, John Wiley & Sons, Inc., 2012 (ISBN-13: 978-0470505427)
- Naranjo et. al., Plastic Testing and Characterization: Industrial Applications, Carl Hanser Verlag, Munich, 2008 (ISBN-13: 978-1569904251)
- V. Shah, Handbook of Plastics Testing and Failure Analysis, 3rd Edition, John Wiley & Sons, Inc., 2007 (ISBN13: 978-0471671893)

## **Industrial Stoichiometry**

### **Course Outline**

- Dimensions, units and their conversion
- Moles, Density and Concentration
- Choosing a basis
- Temperature
- Pressure
- Introduction to material balances: The concept of a material balance, open and closed system, steady state and unsteady state systems, multiple component systems, accounting for chemical reactions in material balances , material balance for batch and semi-batch processes
- A general strategy for solving material balance problems: Problem solving, the strategy for solving problems
- Solving material balance problems for single units without reactions: Main concepts regarding solving material balance problems for single units without reactions

- The chemical reaction equation and stoichiometry: Stoichiometry, terminology for applications of stoichiometry (e) Material balances for processes involving reactions
- Material balance problems involving multiple units
- Recycle, bypass, purge and the industrial application of material balances
- Energy terminology, concepts and units: The terminology associated with energy balances, types of energy
- Introduction to energy balances for processes without reaction: The concept of the conservation of energy, energy balances for closed steady state and unsteady state systems, energy balances for open steady state and unsteady state systems
- Calculation of enthalpy changes: Phase transitions, heat capacity equations, tables and charts to retrieve enthalpy values, computer databases
- Energy balances: How to account for chemical reaction: The standard heat of formation, the heat of reaction, merging the heat of formation with the sensible heat of a compound in making energy balance, the heat of combustion

#### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

#### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

#### **Suggested Books:**

- D. M. Himmelblau, J. B. Riggs, Basic Principles and Calculations in Chemical Engineering, 8th Edition, Prentice Hall, 2012 (ISBN-13: 978-0132346603)
- O. A. Hougen, K. M. Watson, and R. A. Ragatz, Chemical Process Principles- Part 1, Material and Energy Balances., 2nd Edition, John Wiley & Sons, Inc., 1954
- R. M. Felder, R. W. Rousseau, Elementary Principles of Chemical Processes, 3rd Edition, Wiley, 2005 (ISBN-13: 978-0471720638)

## **Particle Technology**

### **Course Outline**

- Characterization of solid particles
- Properties of masses of particles: Storage and conveying of solids
- Mixing of solids: Mixing performance, mixers for Non-cohesive solids, mixers for cohesive solids
- Mixing techniques and mixers for polymers and elastomers: Mixer extruder, muller mixer, mixing effectiveness, axial mixing
- Introduction to crushing, grinding and size separation: Characteristic of comminuted products, energy and power requirements in comminution, crushing laws and work index
- Equipment for size reduction: Crushers and types, grinders and types, roller mill, attrition mill, tumbling mill, ultrafine grinders, classifying hammer mill, fluid energy mill, agitated mill, colloid mill, cutting machines, energy consumption, size enlargement
- Screening: Screening equipment, vibrating screens, screen capacity
- Filtration: General considerations
- Cake filters: Centrifugal filters, filter media, filter aids, Principles of cake filtration, washing filter cakes
- Clarifying filters: Liquid clarification, gas cleaning, principles of clarification
- Crossflow filtration: Membrane filters, types of membranes, premeate flux for ultrafiltration, concentration polarization, applications of ultrafiltration, diafiltration, microfiltration
- Gravity sedimentation processes
- Centrifugal sedimentation processes
- Crystal geometry
- Equilibria and yields
- Nucleation
- Crystal growth
- Origins of crystals in crystallizers
- Crystallization equipment
- Crystallizer design: Crystal size distribution
- Crystallization from melts

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

### **Suggested Books:**

- W. L. McCabe, J. Smith, P. Harriott, Unit Operations of Chemical Engineering, 7th Edition, McGraw-Hill, 2004 (ISBN-13: 978-0072848236)
- R. G. Holdich, Fundamentals of Particle Technology, Midland Information Technology and Publishing, 2002 (ISBN: 0954388100)
- E. L. Paul, V. A. Atiemo-Obeng, S. M. Kresta, Handbook of Industrial Mixing: Science and Practice, John Wiley & Sons, Inc., 2003 (ISBN: 978-0-471-26919-9)
- J. H. Harker, J. R. Backhurst, J. F. Richardson, Coulson and Richardson's Chemical Engineering Volume 2, 5th Edition, Butterworth-Heinemann, 2002 (ISBN-10: 0750644451)

## **Fluid Flow**

### **Course Outline**

- Introduction: Basic properties of fluids, introduction to fluid flow, fluid and solid, molecular structures of fluid and solid, classification of fluids, dimensions associated with common physical quantities, an application of fluid flow, introduction to fluid statics, basics of hydrostatic equilibrium
- Fluid flow phenomena: Ideal fluid and potential flow, the velocity field, one-dimensional flow, the shear stress field, viscosity, kinematic viscosity, turbulence, viscosity and momentum flux, characteristics of turbulent flows, turbulence & boundary layers, nature of turbulence, deviating velocities in turbulence flow, eddy viscosity, flow in boundary layers, development of

- turbulent boundary layer on a flat plate, boundary-layer formation in straight tubes, boundary-layer separation and wake formation, numerical and examples
- Basic equations of fluid flow: Mass balance in a flowing fluid, macroscopic momentum balance, momentum correction factor, Bernoulli's equation without friction, correction of Bernoulli's eq. for fluid friction, skin and form friction, pump work in Bernoulli's equation
  - Flow of incompressible fluids in conduits and in thin layers: Incompressible flow in pipes and channels, shear stress and skin friction in pipes, relation between skin friction and wall shear, the friction factor, relation between skin friction parameters, laminar flow in pipes, Hagen-Poiseuille eq., effect of roughness, drag reduction in turbulent flow, friction from changes in velocity or direction, numerical and problems
  - Flow of compressible fluids: Processes of compressible flow, flow through variable area conduits, adiabatic frictional flow, isothermal frictional flow
  - Flow past immersed bodies: Friction in flow through beds of solids, motion of particles through fluids, fluidization
  - Transportation and metering of fluids: Pipes, fittings and valves, fluid-moving machinery: pumps, positive displacement pumps, centrifugal pumps, fans, blowers and compressors, measurements of flowing fluids: full-bore meters, insertion meters
  - Agitation and mixing of liquids: Agitation of liquids, circulation, velocities and power consumption in agitation vessels, blending and mixing, suspension of solid particles, dispersion operations

#### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

#### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- W. L. McCabe, J. Smith, P. Harriott, Unit Operations of Chemical Engineering, 7th Edition, McGraw-Hill, 2004 (ISBN-13: 978-0072848236)

## **Thermodynamics**

### **Course Outline**

- Introduction: The scope of thermodynamics, dimensions and units, measures of amount or size, force, temperature, pressure, energy, heat
- The first law and related concepts: Internal energy, the first law of thermodynamics, the energy balance for closed systems, the thermodynamic state and state functions, equilibrium, the phase rule, the reversible process, enthalpy, heat capacity, mass and energy balances for open systems
- The second law of thermodynamics: Statements of the second law, heat engines, entropy, entropy changes of an ideal gas, mathematical statement of the second law, entropy balance for open systems, the third law of thermodynamics, entropy from the microscopic viewpoint
- Volumetric properties of pure fluids: PVT behavior of pure substances, virial equations of state, the ideal gas, application of the virial equations, cubic equations of state.
- Vapor/liquid equilibrium: The nature of equilibrium, the phase rule: Duhem's theorem, VLE: qualitative behavior, simple models for vapor/liquid equilibrium, VLE by modified Raoult's Law, VLE from K-value correlations
- Production of power from heat transfer: The steam power plant, internal – combustion engine.
- Refrigeration and liquefaction: The Carnot refrigerator, the vapor compression cycle, the choice of refrigeration, heat pump, liquefaction processes
- Thermodynamic properties of fluids (constant composition): Property relations for homogeneous phases, residual properties.
- Theory of solution thermodynamics: Fundamental property relation, the chemical potential and phase equilibria, partial properties, fugacity and fugacity coefficient: pure species, fugacity and fugacity coefficient: species in solution, the ideal solution, excess properties
- Applications of solution thermodynamics: Liquid-phase properties from VLE data, models for the excess Gibbs energy, property changes of mixing.

- Polymer solution thermodynamics:
  - a. General rules for polymer solubility, typical phase behavior in polymer–solvent systems, the thermodynamic basis of polymer solubility, the solubility parameter, the Flory–Huggins theory, properties of dilute solutions, polymer solutions, suspensions, and emulsions, concentrated solutions: plasticizers.
  - b. Pure polymer PVT behavior and equation of states related to polymer solutions.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- J. M. Smith, H. Van Ness, M. Abbott, Introduction to Chemical Engineering Thermodynamics, 8th Edition, McGraw-Hill, 2017 (ISBN-13: 978-1259696527)
- R. P. Danner, M. S. High, Handbook of Polymer Solution Thermodynamics, Wiley-AIChE, 1993 (ISBN-13: 9780816905799)
- C. S. Brazel, S. L. Rosen, Fundamental Principles of Polymeric Materials, 3rd Edition, John Wiley & Sons, Inc., 2012 (ISBN-13: 978-0470505427)
- J. W. Tester, M. Modell, Thermodynamics and Its Applications, 3rd Edition, Prentice Hall, 1996 (ISBN-13: 9780139153563)
- M. A. van Dijk, A. Wakker, Concepts in Polymer Thermodynamics, CRC Press, 1998 (ISBN-13: 9781566766234)

## **Heat Transfer**

### **Course Outline**

- Introduction: Modes of heat transfer and their governing equations
- Heat transfer by conduction in solids: Basic law of conduction, thermal conductivity, steady state conduction and unsteady state conduction
- Principles of heat flow in fluids: Typical heat exchange equipment, heat flux and heat transfer coefficients
- Heat transfer to fluids without phase change: Boundary layers, heat transfer by forced convection in turbulent flow, effect of roughness, natural convection and heating and cooling of fluids in forced convection
- Heat transfer to fluids with phase change: Heat transfer from condensing vapors, drop-wise and film type condensation, Nusselt equations, heat transfer to boiling liquids, sub-cooled boiling, pool boiling, thermo-siphon re-boilers and forced circulation re-boilers
- Heat-exchange equipment: General design of heat exchange equipment, shell and tube heat exchangers, 1-1 exchanger, tube and tube sheets, shell and baffles, multi-pass exchangers and 2-4 exchangers
- Correlations of LMTD in multi-pass exchangers: Heat transfer coefficients in shell and tube exchangers, choice of tube side fluid, cross-flow exchangers
- Types of heat exchangers: Plate type exchangers, extended surface equipment, type of extended surface and scraped surface exchangers
- Design of Heat Exchangers: Counter-flow double pipe exchanger, 1-2 Parallel-counterflow shell and tube exchanger
- The Effectiveness-NTU method
- Condensers and vaporizers
- Evaporation: Types of evaporators, single effect and multiple effect evaporators, performance of tubular evaporators, methods of feeding and vapor recompression

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- W. L. McCabe, J. Smith, P. Harriott, Unit Operations of Chemical Engineering, 7th Edition, McGraw-Hill, 2004 (ISBN-13: 978-0072848236)
- D. Q. Kern, Process Heat Transfer, McGraw-Hill, 1950 (ISBN: 9780074632178)
- Y. A. Cengel, Heat Transfer: A Practical Approach, 2nd Edition, McGraw-Hill, 2002 (ISBN-13: 978-0072458930)
- J. M. Coulson and J. F. Richardson, Coulson & Richardson's Chemical Engineering: Fluid Flow, Heat Transfer, and Mass Transfer, 6th Edition, Butterworth-Heinemann, 1999 (ISBN: 9780750644440)

## **Mechanical Properties of Polymers**

**Outline**

- The mechanical properties of polymers: General considerations, different types of mechanical behavior, elastic solid and behavior of polymers, stress and strain, state of stress, state of strain, generalized Hooke's law, generalized definition of strain, stress tensor, stress-strain relationships, strain energy functions
- Principles of linear viscoelasticity: Linear viscoelastic behavior, creep, stress relaxation, Boltzmann superposition principle, stress relaxation modulus, mechanical models, retardation and relaxation time spectra, dynamic mechanical measurements: the complex modulus and complex compliance, Alfrey approximation
- Measurement of viscoelastic behavior including creep and stress relaxation, dynamic mechanical measurements, wave-propagation methods
- Experimental studies of linear viscoelastic behavior as a function of frequency and temperature: Time- temperature equivalence, flexible molecular chain models

- Relaxation transitions: Experimental behavior and molecular interpretation, amorphous polymers, factors affecting the glass transition in amorphous polymers, relaxation transitions in crystalline polymers
- Creep, stress relaxation and non-linear viscoelasticity, Eyring equation
- Yielding and instability in polymers: Discussion of load–elongation curves in tensile testing, ideal plastic behavior, cold-drawing, molecular interpretations of yield and cold-drawing
- Breaking phenomena: Principles of brittle fracture of polymers, crazing in glassy polymers, impact strength of polymers, fatigue in polymers.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- M. Ward, John Sweeney, Mechanical Properties of Solid Polymers, 3rd Edition, John Wiley & Sons, Inc., 2013 (ISBN-13: 978-1444319507)
- L. E. Nielsen, Mechanical Properties of Polymers, Van Nostrand Reinhold, 1962 (ISBN-13: 978-1258246884)
- G. M. Swallowe, Mechanical Properties and Testing of Polymers: An A-Z Reference, Springer, 1999 (ISBN-13: 978-9048140244)
- F. W. Billmeyer, Textbook of Polymer Science, John Wiley & Sons, 2007 (ISBN-13: 978-047103196)

## **Polymer Analysis & Characterization**

### **Course Outline**

- Fourier transform infrared spectroscopy (FTIR) spectroscopy
- UV spectroscopy
- Introductory level Raman spectroscopy, energy dispersive X-ray spectroscopy (EDS), mass spectroscopy, Nuclear magnetic resonance spectroscopy (NMR), atomic absorption spectroscopy (AAS)
- Differential scanning calorimetry (DSC)
- Thermogravimetric analysis (TGA)
- Dynamic mechanical analyzer (DMA)
- Thermo-mechanical analyzer (TMA)
- Size exclusion chromatography (SEC) with emphasis on gel permeation chromatography (GPC)
- High performance liquid chromatography (HPLC)
- Gas chromatography (GC)
- Torque rheometers
- Rotational rheometers and viscometers
- Capillary rheometer
- Optical microscopy
- Electron microscopy including transmission electron microscope (TEM) and scanning electron microscope (SEM)
- Scanning probe microscopy
- Atomic force microscopy
- Open circuit voltammetry
- Cyclic voltammetry
- Linear polarization
- Electrochemical impedance spectroscopy (EIS)

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Wiley, Characterization and Analysis of Polymers, Wiley-Interscience, 2008 (ISBN-13: 978-0470233009) 2. A. Naranjo, M. P. Noriega, T. A. Osswald, A. Roldán-Alzate, J. D. Sierra, Plastic Testing and Characterization: Industrial Applications, Carl Hanser Verlag, Munich, 2008 (ISBN-13: 978-1569904251)
- H. Lobo (Editor), Jose V. Bonilla (Editor), Handbook of Plastics Analysis, CRC Press, 2003 (ISBN-13: 9780824707088)
- J. D. Menczel (Editor), R. B. Prime (Editor), Thermal Analysis of Polymers: Fundamentals and Applications, Wiley, 2009 (ISBN-13: 978-0471769170)

**Engineering Drawing and Graphics**

**Course Outline:**

- Introduction, types of lines, lettering, dimensioning, use of pencil and drawing instruments, planning of drawing sheet,
- Projections, types of projections, orthographic projections, plane of projections,
- Four quadrants, Isometric and pictorial projections of solids/machine parts,
- Making of freehand sketches from solid objects and from orthographic projections,
- Sections of joints, screw thread system, nuts and bolts, key and cotter,
- Coupling and simple bearing, pipe connections and engine details,
- Preparation of assembly drawings.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written assignments/Quizzes, Case Studies relevant to Engg. disciplines, Semester project, Guest speaker, Industrial/Field visits, Group discussion, Report Writing.

**Assessment:**

Mid-term, Report writing/Presentation, Assignment, Project report, Quizzes, Final term

**Suggested Books:**

- N. D. Bhatt, N.D. 1990. Elementary Engineering Drawing Plane And Solid Geometry”, 30th Edition, Charotar Publishing House.
- Parkinson, A.C. 1939. A First Year Engineering Drawing”, Pitman, London.
- Luzjader, W.J. Fundamentals of Engineering Drawing: With an Introduction to Interactive Computer Graphics for Design and Production.
- Baker, A.L. 1893. The Elements of Solid Geometry”, Boston, MA: Ginn and Co.

**Workshop Practice**

**Course Outline:**

**Machine Shop:**

Detailed study of center lathe and accessories. Plain and Taper turning. Basic lathe operations including turning, facing, simple screw cutting/treading, knurling, grooving (drilling and boring), cutting tools and their grinding. Brief Introduction of shaper, milling sharing and surface and grinding machine, Assigning of practical jobs.

**Fitting and Fabrication Shop:**

The use and care of fitter’s tools. Marking out of job. Practice in Metal filing, Sawing, Drilling, Dyeing, Tapping and reaming. Brief introduction and use of power Hack Saw, Arbor Press, Sheet Sharing Machine, Sheet Rolling Machine, Punching Machine and Drilling Machine. Assigning of practical Jobs.

**Carpentry Shops:**

The use and care of tools. Type of Timber, its defect and preservation methods practice in planning and sawing. Different types of wood joints. Study of sawing planning, turning mortise and tenon machines. Assigning of Practical jobs.

**Electrical Shop:**

Electric shocks and treatment. The use and care of tools used by Electrician. Types and uses of cable and electrical accessories for house wiring, practice in simple house wiring, testing methods. Switch gear used on domestic installation and DB system. Earthing System. Assigning of Wiring arrangement practical.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written assignments/Quizzes, Case Studies relevant to Engg. disciplines, Semester project, Guest speaker, Industrial/Field visits, Group discussion, Report Writing.

**Assessment:**

Mid-term, Report writing/Presentation, Assignment, Project report, Quizzes, Final term.

**Suggested Books:**

- Chapman, W.A.J. Workshop Technology Part-1 An Introductory Course, Edward Arnold.

## **Engineering Breadth Courses**

### **Polymer Structures & Synthesis**

#### **Course Outline**

- Macromolecules in solution
- Macromolecules in the molten state
- Macromolecules in the solid state: Macromolecules in the elastomeric state, macromolecules in the amorphous (glassy), macromolecules in the crystalline state
- Methods for synthesis of polymers: Chain growth polymerizations, step growth polymerizations, modification of polymers
- Techniques for manufacturing of polymers: Particularities in the preparation of polymers, polyreactions in bulk, homogeneous polyreactions in bulk, heterogeneous polyreactions in bulk, polyreactions in solution, polyreactions in dispersion, polyreactions in suspension, polyreactions in emulsion
- General laboratory techniques for the preparation of polymers
- Correlations of structure and morphology with the properties of polymers
- Radical homopolymerization
- Ionic homopolymerization
- Ring-opening polymerization
- Metal-catalyzed polymerization including polymerization with Ziegler-Natta-catalysts (e) Copolymerization
- Kinetics of chain growth polymerization
- Condensation polymerization (poly-condensation): Polyesters, polyamides, phenol-formaldehyde resins, urea- and melamine-formaldehyde condensation products
- Stepwise addition polymerization (poly-addition): Polyurethanes, epoxy resins  
(c) Kinetics of step growth polymerization
- Chemical conversion of macromolecules
- Crosslinking of macromolecular substances
- Degradation of macromolecular substances
- Modification of polymers by additives
- Mixtures of polymers (polymer blends)
- Stretching and foaming of polymers

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

### **Suggested Books:**

- D. Braun, H. Cherdron, M. Rehahn, H. Ritter, B. Voit, Polymer Synthesis: Theory and Practice: Fundamentals, Methods, Experiments, 5th Edition, Springer, 2013 (ISBN-13: 978-3642289798)
- G. Odian, Principles of Polymerization, Fourth Edition, Wiley-Interscience, 2004 (ISBN-13: 978-0471274001)
- Stanley R. Sandler, Wolf Karo, JoAnne Bonesteel, Eli M. Pearce, Polymer Synthesis and Characterization Manual, Academic Press, 1998 (ISBN-13: 978-0126182408)

## **Polymer Processing Operations**

### **Course Outline**

- Extrusion: Introduction, equipment, normal operations and control of the process, extrusion problems and troubleshooting, special extrusion processes and products, case studies
- Injection molding: Introduction, equipment, normal operations and control of the process, critical operational parameters and techniques, injection molding problems and troubleshooting, case studies
- Blow molding: Introduction, extrusion blow molding, injection blow molding, blow molding problems and troubleshooting, case studies
- Thermoforming: Forming processes, equipment, plant considerations, normal operations and control, thermoforming problems and troubleshooting, film thermoforming processes and products, case studies

- Foaming: Introduction, creating foams in resins, shaping and solidifying foams, re-bond, applications, case studies
- Rotational molding: Introduction, equipment, operation and control of process, troubleshooting, design for rotomolding, case study-trash cart manufacturing
- Casting: Introduction, casting processes, equipment, operation and control of the casting process, casting process and troubleshooting, design for casting, case study- casting a polyester thermoset part in a silicone mold
- Compression molding, transfer molding and related processes: Introduction, compression molding, transfer molding, design for compression and transfer molding, control and operation, reaction injection molding (RIM).

#### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

#### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

#### **Suggested Books:**

- B. Strong, Plastics: Materials and Processing, 3rd Edition, Prentice Hall, 2005 (ISBN-13: 978-0131145580)
- H. Balofsky, Plastic: Product Design and Process Engineering, Hanser Publications, 1995 (ISBN-3-446-18155-5)

## **Mass Transfer**

#### **Course Outline**

- Mass transfer and application: Introduction and types of separation processes, Distillation, Gas absorption, Humidification operations, Leaching and extraction, Drying of Solids, Membrane separation processes, dialysis, pervaporation, reverse osmosis
- Principles of diffusion and mass transfer between phases: Phase equilibria, theory of diffusion, Fick's law of diffusion, equimolar diffusion, one

component mass transfer, prediction of diffusivities in different materials, mass transfer theories, film theory, boundary layer theory, penetration theory and two film theory

- Gas absorption: Principle of absorption, types of packing and packed tower
- Equilibrium stage operations: Typical distillation equipment, typical leaching equipment, principles of stage processes, graphical methods for two component systems, operating line diagrams, determination of ideal contact stages
- Distillation: Flash distillation, continuous distillation with reflux, rectification and stripping, number of ideal plates by McCabe-Thiele method, conditions of feed, feed line, construction of operating line, feed plate location, minimum number of plates, minimum reflux, optimum reflux ratio, normal operations of sieve plates, valve trays column, types of plate efficiency, Murphree efficiency, distillation in packed columns, introduction to multicomponent distillation, batch distillation, azeotropic and extractive distillation
- Leaching and extraction: Leaching, leaching equipment, principles of countercurrent leaching, liquid extraction, extraction equipment, principles of extractions, phase equilibrium and special extraction techniques.

#### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

#### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

#### **Suggested Books:**

- E. J. Henley, J. D. Seader and D. K. Roper, Separation Process Principles, Wiley, 2011( ISBN: 9780470646113)
- W. L. McCabe, J. Smith, Peter Harriott, Unit Operations of Chemical Engineering, 7th Edition, McGraw-Hill, 2004 (ISBN-13: 978-0072848236)
- D. Basmadjian, Mass Transfer: Principles and Applications, Taylor & Francis, 2003 (ISBN: 9780203503140)

- J. M. Coulson and J. F. Richardson , Coulson & Richardson's Chemical Engineering: Fluid Flow, Heat Transfer, and Mass Transfer, 6th Edition, Butterworth-Heinemann, 1999 (ISBN: 9780750644440)

## **Polymer Reaction Engineering**

### **Course Outline**

- Overview of chemical reaction engineering
- Kinetics of homogeneous reactions: Concentration-dependent term of a rate equation, temperature-dependent term of a rate equation, searching for a mechanism, predictability of reaction rate from theory
- Interpretation of batch reactor data: Constant-volume batch reactor, varying-volume batch reactor, temperature and reaction rate, the search for a rate equation (c) Introduction to reactor design
- Ideal reactors for a single reaction: Ideal batch reactors, steady-state mixed flow reactors, steady-state plug flow reactors
- Design for single reactions: Size comparison of single reactors, multiple-reactor systems, recycle reactor, autocatalytic reactions
- Design for parallel reactions
- Potpourri of multiple reactions: Irreversible first-order reactions in series, first-order followed by zero-order reaction, zero-order followed by first-order reaction, successive irreversible reactions of different orders, reversible reactions, irreversible series-parallel reactions, the Denbigh reaction and its special cases
- Introduction to polymerization processes: Polymerization techniques, polymerization reactors
- Coordination polymerization: polyolefin types: Microstructural classification and analytical techniques, catalysts for olefin polymerization, industrial olefin polymerization reactors
- Free-radical polymerization: Homogeneous systems: polymer reaction engineering aspects
- Case studies of free-radical polymerization: Heterogeneous systems: high-impact polystyrene, vinyl chloride monomer bulk polymerization
- Case studies of step-growth polymerization: Poly (ethylene terephthalate) production, polyamide production processes.

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

### **Suggested Books:**

- J. Asua (Editor), Polymer Reaction Engineering, Wiley-Blackwell, 2007 (ISBN: 978-1405144421)
- O. Levenspiel, Chemical Reaction Engineering, Third Edition, Wiley, 1998 (ISBN-13: 978-0471254249)

## **Polymer Compounding & Blending**

### **Course Outline**

- An overview of additives
- Types of additive and the main technical trends: Current lines of development, special additives, multi-functional formulations, masterbatches, dendritic polymers
- The world market: World consumption of additives, the market for masterbatch, overall commercial trends, growth of specialist compounders, regional factors
- Mechanical properties — fillers: Effect of fillers, factors for compounding, types of fillers, surface modification, nano-technology
- Mechanical properties – reinforcements: Types of reinforcing fibers
- Appearance - colorants, pigments, dyes, special effects: Main types of pigment and colorant, dyes, liquid colors, pigments for special effects, thermo-chromic and photochromic pigments, laser marking, pigment dispersants, multi-functional systems, pigments for engineering plastics, the effect of pigments on dimensions, colorants for food and medicals, recent developments, color

strength, weathering, natural effects, surface treatment. types of black and white pigments and masterbatches

- Appearance - black and white pigmentation
- Resistance to heat – heat stabilizers: Heat stabilizers, antioxidants, anti-ozonants
- Resistance to light – UV stabilizers
- Modifying specific properties: flammability – flame retardants: Types of flame retardants (halogen, phosphorus, and other halogen free and metal flame retardants), synergistic reactions
- Conductivity - antistatic/conductive additives: Antistatic agents, conductive additives, ESD (electrostatic discharge) compounds, EMI (electromagnetic interference) compounds, metallic additives, coated polymers, intrinsically conductive material
- Curing and crosslinking: Curing agent, accelerators, inhibitors, curing agent for epoxy, selecting a cure system, UV cure system
- Coupling, compatibilizing agents
- Plasticizers: Types of plasticizers, extender and secondary plasticizer, health and safety of plasticizer, reducing the loading of plasticizer
- Blowing agents: Physical and chemical blowing agent, structural foam and syntactic structural foam, replacement of CFCs
- Modifiers and processing aids: Impact modifier, elastomer modifier, processing aids, lubricants, mold release agents, anti-blocking and anti-slip agents, antibacterial and biocides, degradation additives, shrinkage modifier, barrier modifiers, antifogging agents
- Lubricants, mold, release agents, anti-slip and anti-blocking
- Miscellaneous additives
- Additives for rubber
- Additives for recycling: stabilizers, properties modifier, melt flow/viscosity modifier, compatibilizers
- Pre-compounding operations: Feeders, pre-blending, pre-conditioning
- Compounder types: Screw nomenclature and geometry, batch-type compounders, extruders for compounding, types of twin-screw extruder
- Unit operations for polymer compounding
- Case studies for setting up of formulations (PVC, PE, PP, and expendable PS)
- Introduction to polymer blending

- Equilibrium phase behavior
- Compatibilization: Post-compounding operations, reactive compatibilization
- Preparation and phase structure development: Methods of blend preparation, phase structure development in molten state, binary polymer blends, blends containing a compatibilizer, structure determination of polymer blends
- Physical properties of polymer blends: Toughness of polymer blends
- Commercially important polymer blends.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- J. Murphy, Additives for Plastics Handbook, 2nd Edition, Elsevier, 2001 (ISBN-13: 978-1856173704)
- R. H. Wildi, Christian Maier, Understanding Compounding, Hanser Gardner, 1998 (ISBN-13: 978-1569902288)
- H. F. Mark, Polymer Blends in Encyclopedia of Polymer Science and Technology, 3rd Edition, Wiley-Interscience, 2004 (ISBN-13: 978-0471275077)

**Transport Phenomena**

**Course Outline**

- Viscosity and the mechanisms of momentum transport: Newton's law of viscosity, generalized Newton's law of viscosity, pressure and temperature dependence of viscosity, molecular theory of viscosity of gas at low density, molecular theory of viscosity of emulsions, convective momentum transport

- Shell momentum balances and velocity distributions in laminar flow: Shell momentum balance and boundary conditions, flow of a falling film, flow through a circular tube, flow through annulus, flow through adjacent immiscible fluids, creeping flow around a sphere
- The equations of change for isothermal systems: The equation of continuity, the equation of motion, the equation of mechanical energy, the equation of angular momentum
- Thermal conductivity and the mechanisms of energy transport: Fourier's law of heat conduction, temperature and pressure dependence of heat conductivity, theory of thermal conductivity of gases at low density, theory of thermal conductivity of liquids, thermal conductivity of solids, effective thermal conductivity of composite solids, convective transport of energy
- Shell energy balances and temperature distributions in solids and laminar flow: Shell energy balance boundary conditions, heat conduction with a chemical heat source, heat conduction through a composite wall
- Diffusivity and the mechanisms of mass transport: Fick's law of binary diffusion, temperature and pressure dependence of diffusivities, theory of diffusivity of gases at low density, theory of diffusion in binary liquids, theory of diffusion in colloidal suspensions, theory of diffusion of polymers, mass and molar transport by convection, the Maxwell-Stefan equations for multicomponent diffusion in gases at low density.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- R. B. Bird, Warren E. Stewart, Edwin N. Lightfoot, Transport Phenomena, 2nd Edition, John Wiley & Sons, Inc., 2006 (ISBN-13: 978-0470115398)

## Polymer Composites

### Course Outline

- Introduction: Definition, general characteristics, applications, material selection process
- Materials, fibers, thermoset & thermoplastic matrices, fiber surface treatments, fillers and other additives, incorporation of fibers into matrix, prepregs, sheet-molding compounds, incorporation of fibers into thermoplastic resins, fiber content, density, and void content, fiber architecture
- Manufacturing: Fundamentals, bag-molding process, compression molding, pultrusion, filament winding, liquid composite molding process, other manufacturing processes, manufacturing processes for thermoplastic matrix composites, quality inspection methods
- Mechanics: Fiber–matrix interactions in a unidirectional lamina, characteristics of a fiber-reinforced lamina, laminated structure, elastic deformation of laminates, stresses and distortions
- Performance, multiply laminates, balanced and symmetric laminates, cross-ply laminates, multidirectional laminates, woven fabric laminates, sheet-molding compounds, interply hybrid laminates, compressive properties, flexural properties, in-plane shear properties, interlaminar shear strength, the interface region, bonding mechanisms, experimental measurements of bond strength at fiber/ matrix interphase, control of bond strength
- Strength of composites: Failure modes of long fiber composites, failure of laminates under off axis load, strength of laminates, composite failure criteria, maximum stress criteria, maximum strain criteria, Tsai hill criteria, TsaiWu criteria, Hashin criteria, Puck's criteria, fracture mechanics of composite materials
- Polymer nanocomposites: Nanoclay, carbon nanofibers, carbon nanotubes, structure, production of carbon nanotubes, functionalization of carbon nanotubes, mechanical properties of carbon nanotubes, carbon nanotube–polymer composites, properties of carbon nanotube–polymer composites
- Recycling of polymer composites material selection
- Latest research trends in polymer composites.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- D. Hull & T.W. Clyne, An Introduction to Composite Materials, 2nd Edition, Cambridge University Press, 1997 (ISBN-13: 978-0521388559)
- P. K. Mallick, Fiber Reinforced Composites: Materials, Manufacturing, and Design, 3rd Edition, CRC Press, 2007 (ISBN-13: 978-0849342059)

## **Process Plant Design**

**Course Outline**

- Introduction: Chemical engineering plant design, general overall design considerations, practical considerations in design, engineering ethics in design
- General design considerations: Health and safety hazards, loss prevention, environmental protection, plant location, plant layout, plant operation and control
- Process design development: Development of design database, process creation, process design, process flow diagrams, piping and instrumentation diagrams, equipment design and specifications, the preliminary design
- Flowsheet synthesis and development: Flowsheet synthesis and development, process information, input/output structure, functions diagram, operations diagram, process flowsheet, software use in flowsheet synthesis
- Optimum design and design strategy: Defining the optimization problem, selecting an objective function, suboptimization, programming optimization problems, optimization solution methodologies, optimization applications

- Materials and fabrication selection: Factors contributing to corrosion, combating corrosion, properties of materials, tabulated data for selecting materials of construction, selection of materials, fabrication of equipment
- Materials-handling equipment—design and costs: Review of the materials-handling equipment design
- Reactor equipment—design and costs: Review of the reactor equipment design
- Heat-transfer equipment—design and costs: Review of the heat-transfer equipment design 10. Separation equipment—design and costs: Review of the separation equipment design.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- M. Peters, K. Timmerhaus, R. West, Plant Design and Economics for Chemical Engineers, 5th Edition, McGrawHill, 2002 (ISBN-13: 978-0072392661) Reference book:
- G. Towler, R. K. Sinnott, Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design, 2nd Edition, Butterworth-Heinemann, 2012 (ISBN-13: 978-0080966595)

## **Engineering Depth Courses**

### **Polymer Product Design**

#### **Course Outline:**

- Introduction to Plastics Materials: History of Plastics, Definition of Plastics, Thermoplastics, and Thermosets, General Plastics Properties, Plastics Feedstocks and Volumes
- Properties of Plastics: Molecular Weight and Molecular Weight Distribution, Melt Flow Index, Molecular Structure of Polymers, Thermal Properties of Plastics, Physical Properties of Plastics, Electrical Properties, Flammability
- Overview of Plastics Materials: Polyethylene, Polypropylene, Polystyrene, Polyvinyl Chloride, Engineering Plastics, Thermoplastic Elastomers, Biopolymers, Thermosets, Fillers and Reinforcements
- Process Overviews, Advantages and Constraints: Extrusion, Injection Molding, Extrusion Blow Molding,
- Injection Blow Molding and Stretch Blow Molding, Compression Molding, Transfer Molding, Rotational Molding, Reaction Injection Molding, Thermoforming, Filament Winding, Pultrusion, Additive Manufacturing
- (3D Printing), Other Prototyping Processes
- General Design Considerations: Shrinkage, Dimensional Tolerances, Draft, Gating, Coring and Holes, Rib Design, Color and Appearance, Chemical Resistance, Weathering and Environmental Effects, Recycling and Recycling Codes
- Design of Structural Components: Rigidity and Strength, Creep, Fatigue, Torsion, Impact, Other Elevated Temperature Considerations
- Design of products: Enclosures, Packaging and Containers, Snap Fits and Hinges, Plastic Gears, Bearings, Pressure Vessels and Pipes, Plastic Optics
- Joining Techniques: Threads and Threading, Self-Tapping Screws, Metal Inserts, Ultrasonic, Welding, Vibration and Hot Plate Welding, Spin Welding, Solvent and Adhesive Bonding, Bolt and Screw Assembly
- Product Design Process: Design Process, Material Selection, Design Services
- Costing of Injection Molding Process.

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

### **Suggested Books:**

- P. F. Mastro, Plastics Product Design, John Wiley & Sons Inc., 2016 (ISBN-13: 978-1118842713)
- B. Strong, Designing with Plastics in Plastics: Materials and Processes, 3rd Ed., Pearson Prentice Hall, 2005 (ISBN-13: 978-0131145580)
- J. Gordon, Industrial Design of Plastics Products, John Wiley & Sons, Inc., 2002 (ISBN-13: 978-0471231516)

## **Polymer Processing Design & Simulation**

### **Course Outline**

- Single dimensional analysis and scaling: Dimensional analysis, dimensional analysis by matrix transformation, problems with non-linear material properties, scaling and similarity
- Balance equations
- Model simplification: Reduction in dimensionality, lubrication approximation
- Simple Models in Polymer Processing: Pressure driven flow of a Newtonian fluid through a slit, flow of a power law fluid in a straight circular tube (Hagen-Poiseuille equation), flow of a power law fluid in a slightly tapered tube, volumetric flow rate of a power law fluid in axial annular flow, radial flow between two parallel discs – Newtonian model, the Hele-Shaw model, cooling or heating in polymer processing
- Single screw extrusion–isothermal flow problems: Newtonian flow in the metering section of a single screw extruder, cross channel flow in a single screw extruder, Newtonian isothermal screw and die characteristic curves

- Extrusion dies–isothermal flow problems: End-fed sheeting die: coat hanger die, extrusion die with variable die land thicknesses, pressure flow of two immiscible fluids with different viscosities, fiber, spinning, viscoelastic fiber spinning model
- Processes that involve membrane stretching: Film blowing, thermoforming
- Coating processes: Wire coating die, roll coating
- Injection molding – isothermal flow problems: Balancing the runner system in multi-cavity injection molds, radial flow between two parallel discs
- Melting and solidification: Melting with pressure flow melt removal, melting with drag flow melt removal, melting zone in a plasticating single screw extruder
- Mixing – isothermal flow problems: Effect of orientation on distributive mixing – Erwin’s ideal mixer, predicting the striation thickness in a Couette flow system – shear thinning model, residence time, distribution of a fluid inside a tube, residence time distribution inside the ideal mixer (h) Curing reactions during processing
- Introduction to polymer processing simulation
- Major software packages used in polymer processing

#### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

#### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

#### **Suggested Books:**

- T. A. Osswald, J. P. Hernández-Ortiz, *Polymer Processing: Modeling and Simulation*, Hanser, 2006 (ISBN-13: 978-1569903988)
- Z. Tadmor, C. G. Gogos, *Principles of Polymer Processing*, 2nd Edition, Wiley-Interscience, 2006 (ISBN-13: 9780471387701)
- D. G. Baird, D. I. Collias, *Polymer Processing: Principles and Design*, 2nd Edition, Wiley, 2014 (ISBN-13: 9780470930588)

## **Polymer Rheology**

### **Course Outline**

- Introduction to rheology: Polymers and the importance of rheology, rheology in its simplest form, types of fluids, application to processing
- Stress, strain, velocity and rate of deformation: Stress and pressure, stress tensor, velocity gradients, rate of deformation tensor, continuity equation
- Continuum mechanics: Concept of continuum, various time derivatives, equation of motion
- Newtonian and Generalized Newtonian Fluids (GNF): Definition of Newtonian behavior, need of GNF, generalized GNF for 3D, inventing GNF relationship and parameters from data
- Normal stresses: Types and origin of normal stresses, the second normal stress difference, normal-stress coefficients and empirical findings, transient rheological functions, temperature effects and superposition of steady-flow data
- Analysis of simple flow: Poiseuille flow, drag flow
- Experimental methods of rheological characterization: Measurement of viscosity, normal stresses from shearing flows, extensional rheology, specialized geometries, flow visualization and other rheo-optical methods, micro and nano rheology, velocity-profile correction for non-Newtonian fluids, the Mooney correction
- Elementary polymer processing concepts: Simple laboratory processing methods, elementary extrusion concepts, a downstream process—spinning
- Rheology and molecular structure: Introduction and qualitative overview of molecular theory, molecular weight dependence of zero shear viscosity, compliance and first normal stress difference, shear rate dependence of viscosity, temperature and pressure dependence, effects of long chain branching
- Solution rheology: Polymer chain conformation, zero-shear viscosity.

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

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**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- M. T. Shaw, Introduction to Polymer Rheology, Wiley, 2012 (ISBN-13: 978-0470388440)
- J. M Dealy, J. Wang, Melt Rheology and its Applications in the Plastics Industry, 2nd Edition, Springer, 2013
- (ASIN: B00CRU9KMK)
- J. R. Fried, Polymer Science and Technology, 3rd Edition, Prentice Hall, 2014 (ISBN-13: 978-0137039555)

## **Engineering Depth Electives**

### **Elastomeric Materials**

#### **Course Outline:**

- Natural rubber: Introduction, natural rubber, production of natural rubber, grades of natural rubber, special purpose natural rubber, application of natural rubber
- General and special purpose elastomers: Styrene butadiene rubber (SBR), polybutadiene rubber (BR), polyisoprene (IR)
- Specialty elastomers: Polychloroprene (CR), acrylonitrile butadiene rubber (NBR), butyl rubber (IIR), ethylene propylene rubber (EPM, EPDM), silicone rubber (MQ), polysulfide rubber, chlorosulphonated polyethylene (CSM), acrylic rubber (ACM), fluorocarbon rubber (FKM), urethane rubber
- Fillers for rubber: Carbon black, and silica
- General compounding and vulcanization: Curing agent, accelerators, activators, anti-degradants, antioxidants, anti-ozoneants, waxes, processing aids, homogenizers, tackifiers, peptizers, lubricants, plasticizers, resins, retarders, blowing agent
- Introduction, application overview, segmental block copolymers TPEs, thermoplastic polyurethane, styrenic block copolymer, and thermoplastic vulcanizates.

#### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

#### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

#### **Suggested Books:**

- B. Rodger, Rubber Compounding Chemistry and Application, Marcel Dekker Inc., 2004 (ISBN 0-8247-4871-9)

## **Smart Polymers**

### **Course Outline:**

- Introduction to smart polymers and their applications: Types of smart polymer, applications of smart polymers
- Intrinsically conducting polymers (ICPs)
- Temperature-responsive polymers: Basic principles of temperature-responsive polymers in aqueous solution, Key types of temperature-responsive polymers in aqueous solution, selected applications of thermo-responsive polymers
- PH-responsive polymers: Key types and properties of pH-responsive polymers, synthesis of pH-responsive polymers, applications
- Photo-responsive polymers: Chromophores and their light-induced molecular response, Key types and properties of photo-responsive polymers, applications
- Magnetically responsive polymer gels and elastomers: Preparation of magnetically responsive polymer gels and elastomeric materials, magnetic properties of filler-loaded polymers, Elastic behavior of magnetic gels and elastomers
- Enzyme-responsive polymers: Key types and properties of enzyme-responsive polymers, preparation of enzymeresponsive polymers, Characterization of enzyme-responsive polymers, applications
- Shape memory polymers: Characterizing shape memory effects in polymeric materials, classifying shape memory polymers, main applications
- Self-healing polymer systems: Types of self-healing, self-healing and recovery of functionality in materials, applications
- Smart instructive polymer substrates for tissue engineering
- The use of smart polymers in medical devices for minimally invasive surgery, diagnosis and other applications
- Smart polymers for bio-separation and other biotechnology applications
- Smart polymers for textile applications
- Biopolymers for food packaging applications
- Smart polymers for optical data storage.

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits,

Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- M. R. Aguilar, J. S. Roman, Smart Polymer and their Applications, 2nd Edition, Woodhead Publishing, 2019 (ISBN-13: 978-0081024164)
- L. Dai, Intelligent Macromolecules for Smart Devices: From Materials Synthesis to Device Applications, Springer, 2004 (ISBN-13: 978-1852335106)

## **Mold Design & Fabrication**

**Course Outline**

- Introduction and mold types: Simple Open/Close Mold, Molds with Moving Elements, Molds for threads, Multicomponent injection molds
- Preparation: CAD systems for mold design, Material selection, Demolding, Split line face, Injection and ventilation
- Components of a mold: Simple Mold inserts and cores, Slides, Ejectors, Cooling System, Components and Marking, Surface, Systematic Design Approach
- Assembly
- The finished mold: Mold validation, Labels on the mold
- Maintenance and repair: Simple Maintenance schedule, Welding, Complement replacement
- Manufacturing technologies: Milling, EDM, Grinding, Drilling, Turning, New technologies, Polishing
- Practical guidelines: Design check list, design color chart, Sequential function chart, maintenance schedule, formulas and calculations.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- R. Dangel, Injection Moulds for Beginners, Hanser Publishers, Munich, 2016 (ISBN-13: 978-1-56990-631-6)
- D. O. Kazmer (Editor), Injection Mold Design Engineering, 2nd Edition, Hanser Publishers, Munich, 2016 (ISBN13: 978-1569904176)

### **Polymers in Energy Applications**

**Course Outline:**

- General introduction: Polymers as key components for energy challenges
- Nanomaterials and nanofluids for energy applications
- Electrically conductive polymers
- Ionically conducting polymers
- Piezoelectric, dielectric, and ferroelectric materials
- Thermoelectricity
- Polymers for photovoltaic cells
- Polymers for batteries and super-capacitors
- Energy saving in buildings.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- V. Mittal (Editor), Polymers for Energy Storage and Conversion, Wiley-Scrivener, 2013 (ISBN-13: 9781118344545)
- M. Moeller (Editor), Krzysztof Matyjaszewski (Editor), Polymer Science: A Comprehensive Reference, Volume 10, Section: Polymers in Energy Applications, Elsevier Science, 2012 (ISBN-13: 978-0444533494)

**Nano-Technology**

**Course Outline:**

- Introduction to Nanotechnology: What is nanotechnology? History of nanotechnology Classification of different areas of nanotechnology, Top-down Approach & Bottom-up Approach, The interdisciplinary nature of nanotechnology, What does nanotechnology offer for our future, Nanotechnology and the Converging Technologies.
- Nanotechnology and the Nanosciences, Why does one use the term Nanotechnology rather than Nano-sciences, Nano-Physics and Nano-Chemistry, Nanobiology, Nanomedicine.
- Nanostructures, Aerogels, Fullerenes: Buckyballs, Analysis of the Bonding in C<sub>60</sub>, Carbon Nanotubes, Nanowires, Dendrimers (Organic Nanoparticles)
- Synthesis of nanomaterials: Methods based on evaporation, Sputter deposition, Chemical vapor deposition, Solgel methods, Microemulsions, Sonochemical synthesis, Microwave synthesis
- Analysis techniques: Electron /microscope, Scanning Probe /microscopes, Diffraction techniques, Spectroscopies
- Applications: Electronics, Energy, Automobiles, Sports and toys, Textiles, Cosmetics, Nanotechnology and environment.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits,

Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- S. K. Kulkarni, Nanotechnology, Principles and Practices, 3rd Edition, Springer, 2014 (ISBN:81-85589-54-2)
- C. P. Poole, F. J. Owens, Introduction to Nanotechnology, Wiley, 2003 (ISBN: 978-81-265-1099-3)
- T. Pradeep, A Textbook of Nanoscience and Nanotechnology, McGraw Hill, 2016 (ISBN: 978-1-25-900732-3)

## **Polymer Packaging**

**Course Outline:**

- Introduction to Polymer Packaging: Role of Plastics in Packaging, Barrier Properties, Surfaces and Adhesion, Optical Characteristics, Plastics Identification.
- Major Plastics in Packaging: Branched Polyethylenes, Linear Polyethylenes, Polypropylene, Polyvinyl Chloride, Vinylidene Chloride Copolymers, Polystyrene, Polyvinyl Alcohol (PVOH) and Ethylene Vinyl Alcohol (EVOH), Nylon,
- Polyester, Polycarbonate, Fluoropolymers, Styrene-Butadiene Copolymers, Acrylonitrile Copolymers, Cyclic Olefin Copolymers, Liquid Crystal Polymers, Conductive Polymers, Thermoplastic Elastomers, Biobased Plastics, Polymer Blends, Polymer Nanocomposites, Comparison Chart of Major Plastics.
- Additives and Compounding: Additives to Modify Surface Attractions, Colorants, Antifogging Agents, Nucleating Agents, Antistatic Agents, Antimicrobials or Biocides, Nanoclays and Related Additives.
- Packaging Manufacturing Techniques: Extrusion and Extruders, Cast Film and Sheet, Blown Film, Stretch and Shrink Wrap, Film and Sheet Coextrusion,

Surface Treatment, Yield of Film, Thermoforming, Injection Molding, Closures, Rotational Molding, Compression Molding, Blow Molding and Bottles.

- Converting, Lamination and Coating: Extrusion Coating and Laminating, Hot Melt Lamination or Coating, Adhesive Lamination, Thermal Laminating, Metallized Film, Silicon Oxide Films, Other Inorganic Barrier Coatings, Building Multilayer Structures
- Flexible Packaging: Characteristics of Flexible Packaging, Pouch Styles, Pillow Pouches, Three-Side Seal Pouches, Four-Side Seal Pouches, Stand-Up Pouches, Forming Pouches, Retort Pouches, Bulk and Heavy-Duty Bags.
- Printing and labelling of polymer packaging: Introduction to the printing of plastic films, Gravure printing, Flexographic printing, Digital printing, Printing and labelling of rigid plastic containers, In-mould labelling, Labelling, Dry offset printing, Silk screen printing, Heat transfer printing.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- S.E.M. Selke, J.D. Culter, Plastics Packaging, Properties, Processing, Applications, and Regulations, 3rd Edition, Hanser Publishers, Germany, 2016 (ISBN-13: 978-1569904435)
- Ghosh, Technology of Polymer Packaging, Hanser Publishers, Germany, 2015 (ISBN-13: 978-1-56990-576-0)
- R. Coles, D. McDowell, M. J. Kirwan, Food Packaging Technology, CRC Press, Blackwell Publishing, UK 2003 (ISBN 1-84127-221-3)

## **Polymer Coating & Adhesives**

### **Course Outline:**

- Introduction to Coatings: The importance of polymer coatings, The general constitution of Polymer coatings, Economics of coatings, The application methods of coatings, Global markets for polymeric coatings
- Rheological Aspects of coatings: The importance of rheology, Rheological characterization, Hydrodynamic interactions, Rheological control of paints and powder coatings, Thickening in waterborne paints, Viscosity of paints during curing
- Basic Coating Formulations: Coating compositions in general, Solvent borne formulations, Solvent borne high solids formulations, Chemistries of solvent borne high solids formulations, Waterborne formulations, Chemistries of water borne formulations, Challenges and applications of water borne formulations, Radiation curing formulations, Photo-initiators, Chemistries of radiation curing formulations, Chemistries of powder Coating Formulations, Pros and cons of radiation curing.
- Additives and Particulates: Types of Additives, Thickeners, Inorganic Thickeners, Organic Thickeners, Surface Active Agents, Wetting and Dispersing Agents, Antifoaming Agents, Adhesion Promoters, Surface Modifiers,
- Leveling and Coalescing Agents, Catalytically Active Additives, Dryers, Special Effect Additives, Particulates
- Introduction to adhesives: Basic Definitions, Advantages and Disadvantages of Adhesive Bonding, Uses of Adhesive Bonding in Modern Industry, Economics of Adhesive Technology.
- The Relationship of Surface Science and Adhesion Science: Rationalizations of Adhesion Phenomena, Electrostatic Theory of Adhesion, Diffusion Theory of Adhesion, Mechanical Interlocking and Adhesion,
- Wettability and Adhesion, Acid-Base Interactions at Interfaces, Covalent Bonding at Interfaces, The Relationship of Fundamental Forces of Adhesion and Practical Adhesion, The Weak Boundary Layer
- The Surface Preparation of Adherends for Adhesive Bonding: Plastic Surface Preparation, Metal Surface Preparation, Anodization Treatments for Adhesive Bonding of Aluminum, General Techniques for the Surface Preparation of Metals.

- The Chemistry and Physical Properties of Structural Adhesives: Introduction to Structural Adhesives, Chemistry of Base Resins Used in Structural Adhesives, Formulation of Structural Adhesives for Optimum Performance, Pressure-sensitive Adhesives, Rubber-Based, Contact Bond and other Elastomeric Adhesives, Hot Melt Adhesives.
- Mechanical Tests of Adhesive Bond Performance: Failure Modes and the Definition of Practical Adhesion, Tensile Testing of Adhesive Bonds, Shear Loading of Adhesive Bonds, Cleavage Loading of Adhesive Bonds, Peel Tests.

#### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

#### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

#### **Suggested Books:**

- G. de With, Polymer Coatings, Wiley-VCH Verlag GmbH & Co. KGaA, Germany, 2018 (ISBN: 978-3-52734210-5)
- V. Pocius, Adhesion and Adhesives Technology, 3rd Edition, Carl Hanser Verlag GmbH & Co. KG, Germany, 2012 (ISBN: 978-3-446-43177-5)

## **Industrial Membrane Technology**

#### **Course Outline:**

- Overview of separation processes: Principle of membrane separation, classification of membranes, classification of membrane separation processes, Pressure driven processes, concentration driven processes, Temperature driven processes, Electrically driven processes.
- Advantages and disadvantages of membranes: Energy efficient, Simple design, product specific, open domain, flexible, Clean technology, Concentration polarization, Fouling, feed composition, Selectivity, Life

- Application of membranes in various fields: Drinking water and desalination, Industrial waste water treatment, Municipal wastewater treatment, Food industry, Tenny Industry, Biotechnology, pharmaceutical, Automobile industry, Oil-Water emulsion, Nuclear Industry wastewater, Process Water. Dairy Industry, Biotechnological, applications, Electrodialysis, pervaporation, gas permeation, Temperature responsive membranes, PH responsive membranes, Light responsive membranes, Magnetic field responsive membranes
- Transport mechanism and membrane separation processes: Transport mechanism Knudsen flow, viscous flow, Surface flow, capillary condensation, Molecular sieving, Driving forces for permeation
- Membrane separation processes: Introduction, Osmosis, Microfiltration, ultrafiltration, Nanofiltration, Reverse osmosis, Gas separation Pervaporation, Carrier mediated transport, Liquid membranes, Dialysis, electrodialysis Ion exchange membranes, Membrane distillation
- Membranes contactors: Gas Liquid contactors, Liquid Contactors, Non-porous membrane contactors, Concentration polarization and membrane fouling
- Membrane Modules and process design: Introduction, plate and frame module, spiral wound model, Tubular, capillary, hollow fiber, Module configuration comparison, Cross flow operation , hybrid and cascade operation
- Membrane preparation techniques: Introduction, Membrane precursor and their role, polymeric membrane preparation methods, Phase inversion method, Thermally induced phase separation, Drying-Induced Phase
- Separation, Vapor-Induced Phase Separation, Stretching, Deep Coating Method, Track-Etching Method, Template Leaching, Interfacial Polymerization Method, Plasma Polymerization, Polymeric Tubular Membranes, Mixed Matrix Membranes, Ceramic Membrane Preparation Methods, Sol-Gel Method, Dip Coating, Pressing,
- Extrusion, Slip Casting, Tape Casting, Chemical Vapor Deposition, Sintering, Presintering, Thermolysis,
- Final Sintering, Ceramic Hollow Fiber, Membranes, Polymeric Ceramic Composite Membranes, Zeolite Membranes, Glass Membranes, Dense Membranes, Membrane Cost
- Polymeric Membranes and Their Applications: Introduction, , Advantages Over Ceramic Membranes, Polymeric Membrane Applications in Various Fields, Desalination, Wastewater Treatment, Textile Industry, Sugar Industry,

Food Industry, Tannery Industry, Biotechnology and Health Care, Protein Purification, Hemodialysis, Separation of Racemic and Azeotropic Mixtures, Gas Separation, Air Separation, Hydrogen Production, Carbon Dioxide Separation, Gas–Vapor Separation, Fuel Cells, Proton Exchange Membrane Fuel Cell, Challenges for Fuel Cell Membranes, Osmotic Power Plants, Stimuli-Responsive Polymeric Membranes, Temperature-Responsive Membranes, pH-Responsive Membranes, Light-Responsive Membranes, Magnetic Field Responsive Membranes, Chemical-Responsive Membranes

- Fouling mechanism and remedies: Flux decline mechanism, Concentration polarization model, Resistance in series model, Osmotic pressure control model
- Membrane fouling reduction techniques: Cross flow, Turbulence over membrane surface, Polymer-enhanced filtration. Membrane surface charge
- Current trends and future perspective: Current Trends in Membrane Science, Introduction, Development of Artificial Organs, Artificial Kidney. Developments in Dialysis Membrane Material, Artificial Lung, Artificial Liver, Artificial Pancreas, Conductive Membranes in Textiles, Microencapsulation Technology in Textiles, Breathable Fabrics, Shape-Memory Fabrics, Phase Change Materials, Smart Flame-Retardant Fabrics, Conductive Textiles, Role of Membranes in Military Warfare, Water Supply, Clothing, Membrane Reactors, Monitoring and Sensing, Energy, Future Perspectives of Membrane Science
- Introduction to future perspective: Advanced Materials for Membranes, Superhydrophilic, Hydrophobic, Oleophilic, Oleophobic Materials and Membranes, Smart Gating Membranes: Smart Separations, Health Care: Smart Wound Healing and Advanced Drug Delivery Systems, Membrane Sensors, Bioinspired and Biomimetic Membranes, Membranes for Smart Textiles.

#### **Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- M. K. Purkit, Randeep Singh, Membrane Technology in Separation Science, Taylor & Francis, 2018 (ISBN 13: 978-1-138-62626-3)
- M. Mulder, Basic Principles of Membrane Technology, 2nd Edition, Kluwer Academic publishers, 1997 (ISBN: 07923-4247-X)
- M. C. Porter, Handbook of Industrial Membrane Technology, Noyes Publications, 1991 (ISBN O-8155-1205-8)

**Recycling & Waste Management**

**Course Outline:**

- Introduction to Recycling and Waste Management: Why Recycling, Sources of Waste, Recycling of Plastics, Municipal Solid Waste, Various Stages of Recycling Plastic Wastes, Additives, Mixed Plastics, Composites.
- Methods of Recycling of Polymers: Addition Polymers: Primary Recycling, Mechanical Recycling (or Secondary Recycling), Chemical or Feedstock Recycling (Tertiary Recycling), Energy Recovery (Quaternary Recycling),
- Chemical Recycling of Polyethylene (LDPE and HDPE), Thermolysis Schemes and Technologies, Reactor Types, Polyolefin Thermal Cracking, Catalytic Degradation, Chemical Recycling of Polypropylene, Pyrolysis, Copyrolysis, Catalytic Cracking, Chemical Recycling of Polystyrene, Recycling Methods for Polystyrene Products, Future Prospects, Chemical Recycling of Poly(vinyl chloride), Mixed Plastic Recycling Processes, Mixed PVC Wastes World Initiatives, The BASF Feedstock Recycling Process, Veba Combi Cracking Process, Chemical Recycling of Poly(methyl methacrylate), Dissolution/Reprecipitation, Chemical/Feedstock Recycling.
- Methods of Recycling of Polymers: Condensation Polymers: Chemical Recycling of Nylon, Recycling Methods,
- Chemical Recycling Involving Depolymerization of Nylons Which Can Be Carried Out by Hydrolysis or

- Ammonolysis of Nylon 6,6 and Nylon 6, Hydrolysis of Nylon 6, Hydrolysis of Nylon 6,6 and Nylon 4,6,
- Ammonolysis of Nylon 6,6, Recovery of Nylon 6,6 Monomers, Catalytic Pyrolysis, Applications of Depolymerized Nylon 6, Chemical Recycling of Polycarbonate, Recycling Techniques, Advantages of Recycling and Reuse of Polymers.
- Plastic Waste Management: Plastic Waste Management Scenario, Ways of Recycling, Reuse, Mechanical Recycling, Chemical Recycling, Poly (Lactic Acid), Poly (Vinyl Chloride), Polyethylene, Polypropylene, Polystyrene, Poly (Ethylene Terephthalate), Applications.
- Recycling of Rubber: Introduction, Recycling of Rubber Products, Chemical Process, Physical Methods, Mechanochemical Techniques, Microwave Technique, Ultrasonic Technique, Twin-Screw Extruder, Biological Process, Applications of Recycled Rubber, Sound-Insulation Materials, Civil Engineering Applications, Oil Absorbent, Energy Production, Zinc Fertilizer.
- Recycling of Polymer Blends and Composites: Introduction, Polymer Blends and Composites, Methods of Recycling, Mechanical Recycling, Chemical Recycling, Thermal Recycling, Characterization and Application of Recyclates.
- Toxic or Environmental Effects of Recycled Polymers: Will Recycling Reduce the Amount of Waste? Recycling of Waste Electrical and Electronic Equipment (WEEE), Recycling of Tires, Recycling of Plastics, Recycling of Polymers, Health Problems, Recycling by Polymer Incineration.

#### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

#### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Francis, Recycling of Polymers: Methods, Characterization and Applications, Wiley-VCH Verlag GmbH, 2017 (ISBN: 978-3-527-33848-1)

### **Polymers in Automotive Applications**

**Course Outline:**

- The importance of polymers in automotive applications
- Plastics in the Interior of the Vehicle
- Plastics in Horizontal and Vertical Body Panels
- Plastics in the Exterior of the Vehicle
- Plastics in the Powertrain
- Plastics in Fuel Systems
- Plastics in Lighting and Wheel Systems
- The Future of Plastics in Automotive Applications
- Competition Between Plastics and Composites and Other Materials
- Environmental and Safety Requirements and Customer Demand (k) Recycling and Disposal.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- K. Sehanobish, Engineering Plastics and Plastic Composites in Automotive Applications, SAE International, USA, 2009 (ISBN-13: 978-0-7680-1933-9)
- D. Mann, J. C. Van den Bos, A. Way, Automotive Plastics & Composites: Worldwide Markets and Trends to 2007, Reinforced Plastics Magazine Series, Elsevier Advanced Technology, 2007.

## **Fiber Technology**

### **Course Outline:**

- Introduction: Definition and classification, Evolution of manufactured fibers, Fiber-forming processes, Fiber products and properties, Production trends, Application areas.
- Structural principles of polymeric fibers: Molecular size and interaction, Molecular orientation and crystallinity in fibers, Polymers as fibers, plastics and rubbers, Fiber morphology, Thermal transitions
- Basic principles of fluid flow during fiber spinning: Shear flow, Elongational flow, Molecular theories of fluid flow, Spinnability and flow instabilities
- Melt-spinning processes: The melt-spinning line, Melt-spinning variables and conditions for continuous spinning, Special features of high speed spinning, The role of some critical parameters and their variation along the spinline, Structure formation during spinning, Integrated spin-draw process
- Solution-spinning processes: The process variables for solution-spinning, Dry-spinning, Wet-spinning, Development of structure and morphology during solution-spinning, some salient comparative features of the spinning processes.
- Spin finishes for manufactured fibers: Properties of spin finishes, Role of spin finishes, Spin finish components, Spin finish application techniques, Spin finishes for staple fiber production and processing, Spin finishes for filament yarns, Influence of spin finish on dyeing of yarn/fabric, Analysis of spin finish formulations, Problems encountered in finish application.
- Poly (ethylene terephthalate) fibers: Polymer production, Fiber production, Structure and mechanical properties of fibers, Application areas
- Nylon 6 and nylon 66 fibers: Nylon 6 polymer production, Nylon 66 polymer production, Degradation reactions, Additives, Fiber production, Post-spinning operations, Glass transition temperature and fiber structure, Mechanical behavior, Applications.
- Speciality polyamide and polyester yarns: Production of modified polymers for making yarns with different dyeability characteristics, Antistatic nylon and polyester yarns, Flame retardant yarns, Polyester yams with microgrooves, microvoids and microcraters, Super micro filament yams by conjugated bicomponent yam spinning, Fibers with non-circular cross-section and hollow fibers.

- Acrylic fibers: Polymer manufacture, Influence of polymerization conditions on properties of acrylic polymer, Characterization of acrylonitrile polymers, spinning processes, Tow processing, Mechanical properties of acrylic fibers, Speciality fibers.
- Polypropylene fibers: Polymerization, Stabilization against degradation, Fiber production, Structure development during solidification, Fiber properties, Application areas.
- Rayon fibers: The viscose process, Advances in viscose rayon technology, Viscose fiber variants, Alternatives to the viscose process.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- V. B. Gupta, V. K. Kothari (auth.), V. B. Gupta, V. K. Kothari (eds.), Manufactured Fibre Technology, 1st Edition, Springer Netherlands, 1997 (ISBN-978-94-011-5854-1)
- H. A. Krassig, Fiber Technology: From Film to Fiber, 1st Edition, CRC Press, 1984 (ISBN-13: 9780824770976).
- J. E. McIntyre, Synthetic Fibers, 1st Edition, Elsevier Science, 2004 (ISBN-9781855735880)

## **Additive Manufacturing**

### **Course Outline:**

- Introduction to additive manufacturing: Various additive manufacturing techniques, history, current development and fundamental engineering aspects
- Polymer additive manufacturing: Current additive manufacturing techniques for printing polymers, printing mechanisms, advantages and limitations
- Additive manufacturing process optimization: Principles and strategies for additive manufacturing process optimization
- Additive manufacturing applications: Current industrial applications, link to other manufacturing techniques
- Future of additive manufacturing: Potentials of additive manufacturing, new additive manufacturing techniques, limitations, development plans in many countries and industries.

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

### **Suggested Books:**

- J. Zhang, Y-G. Jung, Additive Manufacturing: Materials, Processes, Quantifications and Applications, Butterworth-Heinemann, 2018 (ISBN 978-0128-1232-70)
- Bandyopadhyay, S. Bose, Additive Manufacturing, 2015 (ISBN-13: 978-1482223590)

## Bio-Polymers

### Course Outline:

- Detailed knowledge of the structure, function, and properties of biopolymers: Structure-property relationships in biological materials, biological materials: scale, heterogeneity, representative volume elements, fibers: the key building blocks for performance and versatility, design and function of structural biological materials, design for stiffness and design for strength.
- Case study of some biological materials:
  - Proteins: Amino acids and their polymerization, primary structure, conformation secondary structure, structural proteins, coping with strain energy
  - Sugars and fillers: Fibers, structural polysaccharides in plants water, the invisible support, mucus
  - Bone: Composition of bone, integration and organization levels, mechanical properties of the cortical of bone
  - Soft tissue engineering: Structure-properties of soft tissues. articular cartilage, structure and composition, bio-mechanics of articular cartilage, cell seeded repair systems, bio-artificial implants: design and tissue engineering
  - Silk fibers: Origins, nature and consequences of structure, mechanical properties of spider silks, hierarchical microstructure of silk fibers, spinning - the origins of silk fiber microstructure
- Introduction to biomedical materials and bio-mimicking with smart polymers: Biological ceramics calcium salts or silica, problems with mechanical tests, the functional design of bone, teeth, eggshell, echinoderms, implementing ideas gleaned from biology biomimetic products, quasi-biomimetic products, techniques for biomimetics
- Synthetic biopolymers: Poly(alpha-esters) etc., Structure, composition and processing
- Environmental issues when using biopolymers and synthetic polymers, the use of biopolymers like sugar based, cellulose based, starch based biopolymers in different application areas e.g. textile, food packaging etc.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- J. Vincent, Structural Biomaterials, Third Edition, Princeton University Press, 2012 (ISBN: 978-1-4008-4278-0)
- M. Elices, Structural Biological Materials, Volume 4: Design and Structure-Property Relationships, Pergamon, 2000 (ISBN-13: 978-0444552389)
- S. Kumbar. C. T. Laurencin, M. Deng, Natural and Synthetic Biomedical Polymers, 1st Edition, 2014 (ISBN 9780123969835)
- S. Kalia, L. Avérous, Biopolymers: Biomedical and Environmental Applications, 2011 (ISBN: 978-0-470-639238).

## Polymer Foams

### Course Outline:

- Introduction: Polymeric Foams, Mechanisms, and Materials
- Melt Elasticity of Polyolefins: Impact of Elastic Properties on Foam Processing
- Fundamentals of Bubble Nucleation and Growth in Polymers
- Material Properties Affecting Extrusion Foaming
- Foam Stability in Flexible Polyurethane Foam Systems
- Flexible Polyurethane Foams
- Rigid Polyurethane Foams
- Microcellular Polypropylene Foam
- Innovative PLA Bead Foam Technology
- Nanocellular Foams
- Recent Innovations in Thermoplastic Foams.

### Teaching Methodology (Proposed as applicable):

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

### Assessment:

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

### Suggested Books:

- S. T. Lee, N. S. Ramesh, Polymeric Foams: Mechanisms and Materials, CRC Press LLC, 2014 (ISBN: 0-84931728-2/04)
- S. T. Lee (Editor) Polymeric Foams: Innovations in Processes, Technologies, and Products, CRC Press LLC, 2017 (ISBN: 9781498738873)

## **Multidisciplinary Engineering Courses**

### **Chemical & Petrochemical Industries**

#### **Course Outline**

- Batch versus continuous processing
- Chemical process control and instrumentation
- Process flow sheeting
- Chemical process economics
- Water treatment industries: Types of impurities in water from various resources
- Fertilizer industries: Synthetic ammonia, phosphate rock, super phosphate, potassium sulfate, potassium chloride, ammonium nitrate, ammonium sulfate, ammonium sulfate and Urea manufacturing processes
- Explosives and propellants industries: Types and characteristics of explosives, industrial explosives, propellants for rockets, military explosives
- Pulp and paper industries: Manufacturing of pulp, manufacturing of paper, manufacturing of structural boards
- Food and food by-products processing industries: Types of food processing, pasteurization and sterilization, food by-products, food processing equipment
- Sugar and starch industries: Manufacture of sugar, cane-sugar refining processes, starches and related products, manufacturing of starch, dextrin, and dextrose from corn
- Glass Industries: Methods of manufacture, Manufacture of special glasses, raw material, types and composition of glass
- Surface and coating industries: Paints, pigments, varnishes, industrial coatings, antifouling coatings, printing inks and industrial polishes.
- Petroleum Processing: Constituents of petroleum, Feedstock and Products of refining, Processing or refining, Crude distillation, Thermal cracking, catalytic cracking, hydrocracking, Lube oil processing, propane deasphalting, dewaxing, hydro-finishing
- Primary raw materials for petrochemicals: Natural gas, crude oils, coal, oil shale, tar sand, and gas hydrates
- Hydrocarbon intermediates: Paraffinic hydrocarbons, olefinic hydrocarbons, dienes, aromatic hydrocarbons

- Chemical based on Methane: Chemicals based on direct reactions on methane, chemicals based on synthesis gas
- Ethane and higher paraffins based chemicals: Ethane chemicals, propane chemicals, n butane chemicals, isobutene chemicals, naphtha based chemicals
- Chemicals based on ethylene: Oxidation of ethylene, chlorination of ethylene, alkylation using ethylene
- Chemicals based on propylene: Oxidation of propylene, Chlorination of Propylene, Alkylation of propylene
- C4 Olefins and Di-olefins based chemicals: Chemicals based on n-butenes, isobutylenes and butadiene
- Chemicals based on benzene, toluene and xylene: Reactions and chemicals of benzene , toluene and xylenes
- Synthetic petroleum based polymers: Thermoplastics and engineering resins, thermoplastic plastics, synthetic rubber, synthetic rubbers.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- G. T. Austin, Shreve's Chemical Process Industries, 5th Edition, McGraw-Hill Professional, 1998 (ISBN-13: 9780071350112)
- J. H. Gary, G. E. Handwerk, M. J. Kaiser, Petroleum Refining: Technology and Economics, 5th Edition, CRC Press, 2007 (ISBN-13: 978-0849370380)
- S. Matar, Lewis F. Hatch, Chemistry of Petrochemical Processes, 2nd Edition, Gulf Professional Publishing, 2001 (ISBN-13: 978-0884153153)

## **Environmental Engineering & Process Safety**

### **Course Outline**

- Air pollution: Effects of air pollutants, origins and fates of air pollutants, acid rain, ozone depletion, global warming, air pollution meteorology, atmospheric dispersion
- Water pollution: Causes of water pollution, water treatment, water quality and standards, water plant waste management, water pollution sources, biological oxygen demand
- Environmental issues related to the plastics industry
- The polymer waste problem
- Legislation
- Disposing of post-consumer plastics
- Life-cycle assessment
- Plastics recovery and recycling
- Mechanical recycling
- Reprocessing of mixed plastics wastes
- Energy recovery by incineration
- Liquid fuel and feedstock recovery
- Management of urban waste
- Importance of safety and health for engineers: Occupational safety and health, environmental problems
- Toxicology: Effects of toxicants on biological organisms, relative toxicity, threshold limit values
- Industrial hygiene: Laws and regulations, OSHA: process safety management, risk management, industrial hygiene identification, evaluation and control
- Fire and explosions: Hazards related to fire and explosions, designs to prevent fires and explosions
- Hazard Identification: Process hazard check list, hazard surveys, hazard and operability study, other methods (f) Risk management and assessment: Identification, analysis, elimination, financing.

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits,

Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- M. Davis, D. Cornwell, Introduction to Environmental Engineering, 5th Edition, McGraw-Hill, 2012 (ISBN-13: 978-0073401140)
- G. Scott, Polymers and the Environment, Royal Society of Chemistry, 1999 (ISBN-13: 978-0854045785)
- D. A. Crowl, J. F. Louvar, Chemical Process Safety: Fundamentals with Applications, 3rd Edition, Prentice Hall, 2011 (ISBN-13: 978-0131382268)
- L. Lundquist , Y. Leterrier, P. Sunderland, J. A. E. Manson, Life Cycle Engineering of Plastics: Technology, Economy and Environment, Elsevier Science, 2001 (ISBN-13: 978-0080438863)

## **Instrumentation & Control**

### **Course Outline**

- Incentives for chemical process control
- Design aspects of a process control system: Classification of variables in a chemical process, design element of a control system, control aspects of a complete chemical plant
- Hardware for a process control system: Hardware elements of a control system
- Modelling the dynamic and static behavior of chemical processes: The need of a mathematical model for a process control, elements of mathematical model. modelling difficulties (b) The input-output models
- Review of Laplace transform: Laplace transform of basic functions, integrals, derivatives, final value theorem, initial value theorem, linearization, inversion of Laplace transform
- Transfer function of a process with single output, with multiple outputs, qualitative analysis of the response of a system

- Dynamic behavior of first-, second- and higher-order systems and their dynamics: Introduction, processes modelled as first, second and nth order system, dynamic response of pure capacitive system, dynamic response of first order lag system, multi-capacity processes as second order systems, inherently second order processes, second order system caused by the presence of controllers, dynamic system with dead time, dynamic systems with inverse response, overall transfer function testability; introduction of frequency response techniques
- Introduction to feedback control: Concept of feedback control, types of feedback controllers, measuring devices, transmission lines, final control elements
- Dynamic behavior of feedback controlled processes: Block diagram and the closed-loop response, effect of proportional control on the response of a controlled process, effect of integral control action, effect of derivative control action, effect of composite control actions
- Stability analysis of feedback systems: Notion of stability, the characteristic equation, Routh-Hurwitz criterion for stability, Root-Locus analysis
- Theoretical and practical controllers
- Final control elements
- Process control using computers
- Measuring instruments for temperature, pressure, and level
- Control of heat exchangers and distillation columns
- Control of polymerization reactors

#### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

#### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- G. Stephanopoulos, Chemical Process Control: An Introduction to Theory and Practice, PTR Prentice Hall, 1984 (ISBN-13: 978-0131286290)
- J. Asua (Editor), Polymer Reaction Engineering, Wiley-Blackwell, 2007 (ISBN: 978-1405144421)

**Occupational Health and Safety**

**Course Description:**

This course introduces the student to the study of workplace occupational health and safety. The student will learn safe work practices in offices, industry and construction as well as how to identify and prevent or correct problems associated with occupational safety and health in these locations as well as in the home.

**Learning Outcomes:**

Upon successful completion of this course, the student will be able to:

- Identify hazards in the home, laboratory and workplace that pose a danger or threat to their safety or health, or that of others.
- Control unsafe or unhealthy hazards and propose methods to eliminate the hazard.
- Present a coherent analysis of a potential safety or health hazard both verbally and in writing, citing the Ontario Occupational Health and Safety Regulations as well as supported legislation.
- Demonstrate a comprehension of the changes created by WHMIS and OSHA legislation in everyday life.

**Course Outline:**

**Health and Safety Foundations**

- Nature and scope of health and safety
- Reasons/benefits and barriers for good practices of health and safety
- Legal frame work and OHS Management System

## **Fostering a Safety Culture**

- Four principles of safety- RAMP (Recognize, Assess, Minimize, Prepare)
- Re-thinking safety-learning from incidents
- Safety ethics and rules
- Roles and responsibilities towards safety
- Building positive attitude towards safety
- Safety cultures in academic institutions

## **Recognizing and Communicating Hazards**

- Hazards and Risk
- Types of hazards: Physical (mechanical and non-mechanical), Chemical (Toxic and biological agents), electrical, fire, construction, heat and temperature, noise and vibration, falling and lifting etc.
- Learning the language of safety: Signs, symbols and labels

## **Finding Hazard Information**

- Material safety data sheets
- Safety data sheets and the GHS (Globally Harmonized Systems)

## **Accidents & Their Effect on Industry**

- Costs of accidents
- Time lost
- Work injuries, parts of the body injured on the job
- Chemical burn injuries
- Construction injuries
- Fire injuries

## **Assessing and Minimizing the Risks from Hazards**

- Risk Concept and Terminology
- Risk assessment procedure
- Risk Metric's
- Risk Estimation and Acceptability Criteria
- Principles of risk prevention
- Selection and implementation of appropriate Risk controls
- Hierarchy of controls

## **Preparing for Emergency Response Procedures**

- Fire
- Chemical Spill
- First Aid
- Safety Drills / Trainings:
  - Firefighting
  - Evacuation in case of emergency

## **Stress and Safety at Work environment**

- Workplace stress and sources
- Human reaction to workplace stress
- Measurement of workplace stress
- Shift work, stress and safety
- Improving safety by reducing stress
- Stress in safety managers
- Stress and workers compensation

## **Incident Investigation**

- Importance of investigation
- Recording and reporting
- Techniques of investigation
- Monitoring
- Review
- Auditing Health and Safety

## **Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), written assignments/quizzes, tutorials, case studies relevant to engineering disciplines, semester project, guest speaker, industrial/field visits, group discussion, report writing

## **Assessment:**

Mid-semester exam, report writing/presentation, assignment, project report, quizzes, end-semester exam

**Suggested Books:**

- The A-Z of health and safety by Jeremy Stranks, 2006.
- The Manager's Guide to Health & Safety at Work by Jeremy Stranks, 8th edition, 2006.
- Occupational safety and health law handbook by Ogletree, Deakins, Nash, Smoak and Stewarts, second edition, 2008.

## **12.2 Non-Engineering Domain**

### **English Courses**

#### **Functional English**

**Area Scope:**

The knowledge units in this area collectively encompass the following:

- Follow English vocabulary and skills to use it in professional life.
- Identify common errors usually made by the Learners of English as second language
- Practice English correctly in speaking and writing

**Course Outline:**

- Public Speaking
- The Art of Creating a Power Point Presentation.
- Interacting with the Opposite Gender
- Classroom Etiquettes and Teachers' Expectations
- Articles
- Prepositions
- Homophones
- Punctuation
- Tenses in English Grammar
- Formal Letter Writing
- Summary writing
- Organizing and planning your writing
- Sensory Perception in writing

- Critical thinking
- Final Term Project

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio./video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

### **Suggested Books:**

- P. C. Wren & H. Martin “High School English Grammar & Composition”.
- Colin W. Davis & Andrew J. Watts New Expressway For English 1 (New Edition)
- Herta A. Murphy & Herbert William Hildebrandt. Effective Business Communications
- Diana Hacker. A Writer’s Reference
- Sadat Ali Shah. Exploring The World Of English
- J. Thomson and A. V. Martinet. Practical English Grammar, “University Physics”, 13th Edition

## **Communication Skills**

### **Area Scope:**

The knowledge units in this area collectively encompass the following:

- Communicate effectively using intermediate- to-advanced level English while developing the understanding of essentials of communication skills.
- Participate in group discussions by attentive listening, questioning to clarify ideas, eliciting responses, or disagreeing in a constructive way.

### **Course Outline:**

By the end of the semester students will have skills including:

## **Writing Skills**

- Vocabulary Building
- Writing Skills: Essays and Letters
- Common Writing Errors
- Purposeful Writing

## **Reading Skills**

- Skimming and Scanning
- Critical Reading
- Reading for Understanding
- Techniques and strategies to develop sound vocabulary.

## **Listening Skills**

- Introduction to Communication Process
- Seven Cs of Communication
- Types of Listening
- Listening for Comprehension

## **Speaking Skills**

- Verbal and Non-Verbal Communication
- Basics of Presentation Skills
- Presentation Strategies and public speaking skills.
- Use of Audio-Visual Aids
- Basics of Group Communication
- Listening Skills
- Communicate effectively in job interviews.

## **Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Anchor in English-II (Lessons 1-5), A SPELT Publication
- Christopher Fry, “Summary Writing (Book-I)”, Oxford University Press
- College Essays by John Langland
- Barron’s TOFFL iBT Edition
- Communication Skills for Engineers by Sunita Marshal and C.Muralikrishna

**Technical Writing and Presentation Skills**

**Area Scope:**

The knowledge units in this area collectively encompass the following:

- The students will be able to write technically correct statements, assignments, final year project report, project proposal, short report and research paper
- The students would be able to their write CV, cover letter and business/ professional Correspondence meeting all criteria
- The students would be able to present their work/ research at a technical forum.

**Course Outline:**

- Introduction to Technical writing
- Proposal write-up and improvement strategies Introduction to research and research types choosing research problems and research advisors How to carry out research
- Formulation – Problem statement, Literature
- Review
- Design - Methodology
- Analysis - Data analysis and interpretation Good writing style techniques
- Uses of correct words
- Presenting and publishing research
- Write business/professional correspondence, cover letter and CV
- Writing meeting minutes

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Writing for Computer science by Justin Zobel Research Methodologies – A step by step guide for beginners, Ranjit Kumar.

## **Mathematics Courses**

### **Linear Algebra**

#### **Area Scope:**

The knowledge units in this area collectively encompass the following:

- To comprehend basic concepts of Linear Algebra and optimization
- To apply techniques of Linear Algebra and optimization for solution of engineering problems

#### **Course Outline:**

##### **System of Linear Equations and Applications**

- Overview of linear system of equations, Cases of unique solution, No solution and infinite solutions,
- Echelon form, Gauss elimination method, Inversion of matrix in the context of solution of system of equations, LU factorization, Row space and column space
- Relevant engineering case studies such as Network analysis, Traffic Flows, Balancing chemical reaction, Leontief Input-output model, Finding max stress in compound cylinder, Applications of linear systems in force balancing of structures, Markov process

##### **Vector Spaces and Transformations**

- Vector Spaces: Real vector spaces, Subspaces, Basis and dimension, Rank, Nullity
- Gram-Schmidt process for finding orthonormal basis
- Linear Transformation, Kernel of Transformation, Range of Transformation, Matrix of Transformation,
- Applications: Cryptography, Coding and decoding, Breaking of codes, Robotic Applications of linear transformations

##### **Eigenvalues and Eigen Vectors**

- Eigenvalues, Eigenvectors, Similar matrices, Diagonalization,
- Quadratic forms, Positive definite Matrices, Singular Value Decomposition, Inner product Spaces

- Applications of linear Algebra: Constructing curves and surfaces, Computer graphics, Genetics

## **Linear Programming**

- Solution Introduction to linear programming, Optimization, Graphical method, Simplex method, Optimization problems in engineering and economics
- Dual simplex methods, Duality theory, Primal and dual problems, transportation models, north-west corner, least-cost and Vogel's approximations methods,
- Assignment model, the transshipment model and other relevant engineering case studies

## **Application of Linear Algebra in Dynamical Systems**

- Numerical System of linear ODEs, Eigenvalue problems, Homogeneous and nonhomogeneous system of ODE.
- Dynamical systems, Population dynamics, Prey-Predator models, Stability analysis

## **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

## **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

## **Suggested Books:**

- Introductory Linear Algebra: By Bernard Kolman and David R. Hill, Latest Edition.
- Elementary Linear Algebra: By Howard Anton and Chris Rorres, Latest Edition.

## **Calculus and Analytical Geometry**

### **Area Scope:**

- To develop a clear understanding of fundamental concepts of single variable calculus
- To apply concepts of differentiation and integration to solve complex engineering problems

### **Course Outline:**

#### **Analytical Geometry:**

- Review of vectors, scalars and vector products.
- Three dimensional coordinate system and equation of straight line and plane

#### **Functions Limit and Continuity:**

- Review of functions and graphs,
- Limits & Continuity,
- Techniques of Finding Limits,
- Discontinuity,
- Limits of Sine and Cosine and Exponential Functions

#### **Differentiation:**

- Introduction to Derivatives
- Examples of Derivatives
- Derivative as Rate of Change
- Derivative's Rules
- Implicit Differentiation
- Higher order derivatives
- Leibnitz Theorem

#### **Applications of Derivatives:**

- Applications of Derivatives
- Monotonic functions
- Optimization problems
- Relative and Absolute extrema
- First and second derivative tests

- Point of inflection
- Concavity
- Curvature
- Indeterminate Forms and L' Hospital rule
- Differentials

### **Integration:**

- Integrals and Properties of Integrals
- Techniques of Integration
- Integration by Parts
- Definite Integrals
- Integration of Trigonometric
- Exponential and Inverse Functions
- Integration by Partial Fractions
- Reduction Rules

### **Applications of Integration:**

- Applications of Integration
- Area under the curve
- Area between curves
- Solids of Revolution
- Volume of Solids of revolution by disk washer, Cylindrical shell & Cross Section Methods
- Center of Pressure and Depth of Center of Pressure
- Center of mass
- Arc length

### **Improper Integrals:**

- Improper Integrall
- Integrals and Singularities
- Convergence of improper integrals

### **Infinite Sequence and Series:**

- Sequence and Infinite Series
- Convergence and Divergence of sequences and series

- Positive Term Series
- Integral Test
- Basic Comparison Test
- Limit Comparison Test
- Ratio and Root tests
- Alternating series
- Absolute and Conditional Convergence

**Power and Taylor Series:**

- Power series
- Maclaurin and Taylor Series and its Applications

**Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Thomas' Calculus by George B. Thomas, Jr., Maurice D. Weir, Joel R. Hass, Pearson, USA.
- Swokowski, Onlinick & Pence: Calculus
- Robert T. Smith & Roland B. Minton: Calculus
- Calculus: Early Transcendentals by James Stewart. Brooks/Cole USA.

## **Differential Equations**

### **Area Scope:**

The knowledge units in this area collectively encompass the following:

- To define basic mathematical concepts related to differential equations
- To describe different types of analytical methods for solution of differential equations
- To formulate different engineering problems in the form of differential equations

### **Course Outline:**

#### **Basic Concepts and Modeling**

- Linear Differential equations, Non-Linear, Differential equations, Solutions of differential equations, General solutions, Particular solutions, Initial and boundary value problems, Degree and order of ODEs
- Formulation of first-order ODEs: Case studies related to finding age of fossils, Mixing problems and free fall motion, Finding temperature of a building, RL, RC circuits, Airplane take-off problem, Population dynamics and logistic equations etc.

#### **Analytical Methods of Solution for First-order ODEs**

- Variable separable method, Reduction to variable separable form, Homogeneous equations, Differential equations reducible to homogeneous form, Solution of the related ODE models by these methods
- Exact equations, Integrating factors, Linear equations and related examples, Bernoulli's equations, Orthogonal trajectories and solution of the related ODE models by these methods

#### **Mathematical Models Based on Second-order ODEs**

- Formulation of a single RLC circuit, Spring mass systems, Earthquake model of a single story building
- Bungee Jumper model, Bridge collapse problem etc.

### **Analytical Methods of Solution for Second-order ODEs**

- Homogeneous linear ODEs, Method of reduction order, Wronskian determinant to check independence of the solution, and related examples
- Cauchy-Euler equations and related examples, Non-homogeneous linear ODEs, Method of undetermined coefficients
- Method of variation of parameters and related example
- Analytical solution of the related ODE models by these methods

### **Series Solution for Second-order ODEs**

- Series solution of ODEs and convergence tests
- Series solution of Legendre equation, Frobenious method of solution for Bessel equation and related applications

### **Laplace Transform**

- Laplace Transform, Derivation of Basic formulae, Inverse Laplace Transform, First shift theorem
- Laplace transform of integrals and derivative, Solution of second order ODEs by Laplace Transform, Unit step function and its Laplace transform, Second shift theorem, Convolution
- Application of Laplace transform to a system of ODEs and related applications

### **Partial Differential Equations**

- Partial Differential Equations and their types, Applications of partial differential equations in Engineering
- Method of Separation of Variables Method (MSVM) and solution of wave equation by the MSVM
- Method of Separation of Variables Method (MSVM) and solution of heat equation by the MSVM

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Advanced Engineering Mathematics by Erwin Kreyzig, John Wiley & Sons Inc. Latest Edition.
- Differential Equation with Boundary Value problems by D. G. Zill, M. R Cullen Latest Edition, Brooks/Cole Publishers.
- A First Course on Differential Equations with Modelling Applications by D. G. Zill, Latest Edition, Brooks/Cole Publishers.
- An Introduction to Mathematical Modelling by Bender, E.A., Latest Edition, Wiley, New York.

**Numerical Analysis**

**Area Scope:**

The knowledge units in this area collectively encompass the following:

- To comprehend different numerical techniques such as: error propagation, interpolation, differentiation, integration, eigenvalues and solution of algebraic and differential equations
- To apply the numerical techniques to different linear and nonlinear engineering problems

**Course Outline**

**Error Analysis and Interpolation**

- Error analysis, Types of error, Sources of error, Norms of vectors and matrices, Computer arithmetic, Condition number of a matrix, Significant digits and loss of significant digits, Floating point arithmetic, Binary and decimal representation, Single and double precision
- Interpolation: Newton forward and backward difference formula for interpolation, Central difference interpolation formulae, Lagrange's interpolation, Error in interpolation, Linear least square approximation,

Interpolation versus least square approximation, Relevant engineering case studies

### **Numerical Differentiation and Integration**

- Derivation of numerical differentiation of first order and second order derivatives using two points, three points, and five points formulas along with its application in engineering, Relevant case studies
- Numerical integration: Trapezoidal rule, Simpson's rules, Composite Trapezoidal Simpson Rules and Romberg integration, Applications of numerical in engineering, Relevant case studies

### **Methods of Solution a System of Linear Equations**

- Solution of system of linear algebraic equations, Gauss elimination method
- LU factorization, Tridiagonal solver
- Applications of these methods in engineering disciplines, Relevant case studies

### **Iterative Methods for Linear and Nonlinear Equations**

- Numerical Solution of nonlinear equations: Bisection method, Newton's method, Secant method, Convergence analysis of these methods
- Newton's method for system of nonlinear equations
- Solution of system of linear equations by Jacobi, Gauss Seidel and SOR methods, Applications of these methods in engineering disciplines, Relevant case studies

### **Numerical Methods for IVPs and BVPs**

- Euler's method and its variations, Taylor's higher order methods, Error analysis, Consistency, stability and convergence
- Runge-Kutta methods of order 2, 3, and 4, Stiff ODEs, Consistency, stability and convergence
- Linear multistep methods, Numerical solution of system of ODEs
- Numerical solution of BVPs by Finite Difference Method
- Applications in engineering: Some relevant case studies

### **Numerical Methods for Computing Eigenvalues**

- Eigenvalues and Eigenvectors of matrix: power method,
- Inverse power method, Shifted inverse power method.

- Applications of eigenvalues in engineering disciplines.

### **Numerical Optimization**

- Unconstrained Optimization,
- Golden search ratio, Lagrange Multipliers,
- Method of steepest descent
- Applications of optimization in engineering disciplines

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

### **Suggested Books:**

- Numerical Analysis: By Richard L. Burden, J. Douglas Faires, Latest Edition
- Numerical methods for scientist and engineers by R.W. Hamming (Latest Edition)
- Numerical methods for Engineers by Steven C. Chapra and R. P. Canale (Latest Edition).

## **Probability & Statistics**

### **Area Scope:**

The knowledge units in this area collectively encompass the following:

- To understand the basic concept of Statistics and Probability and their need in engineering.
- To Describe properties and classifications of probability density functions, regression analysis and interval estimation
- To Apply different probability and statistics techniques in engineering problems

## **Course Outline**

### **Basic Statistics**

- Statistics, Branches of Statistics, Importance of statistics, population, sample, observation, variables, measurement of variable, Data, primary data, secondary data

### **Data Presentation**

- Frequency distribution (grouped, ungrouped), stem and leaf display, histogram, frequency polygon, cumulative frequency polygon, Simple & Multiple Bar diagrams

### **Measure of Central Tendency**

- Arithmetic Mean (A.M), Geometric Mean (G.M), Harmonic Mean (H.M), Quantiles (Median, Quartiles, Deciles, Percentiles), Mode, Applications of Averages

### **Measure of Dispersion**

- Background, Range, Quartile deviation, Mean deviation, Variance, Standard deviation, Coefficient of variation, Moments, Moments ratios, Skewness, Kurtosis
- Applications in different Engineering Disciplines

### **Simple Regression, Correlation and Curve Fitting**

- Introduction to regression theory, Simple linear regression line, Line fitting by least square methods, Coefficient of determination,
- Simple correlation, coefficient of correlation, fitting of a first and second degree curve, fitting of exponential and logarithmic Curves, related problems.
- Principle of least squares.

### **Probability and Random Variables**

- Probability review, Laws of probability, Conditional probability, Bayesian theorem, independent, dependent events.
- Random variables, Discrete and Continuous random variables, Probability mass and density functions, Distribution functions, Mathematical expectation,

- Variance of random variable, Bivariate distribution, Joint probability distribution, Moment generating function

### **Probability Distributions**

- Discrete distributions:
- Bernoulli distribution, Binomial, Geometric, Negative binomial, Hypergeometric, Poisson distribution, Properties and application of these distributions.
- Continuous Distributions: Uniform Distribution, Exponential distribution, Normal distribution, Applications

### **Sampling and Sampling Distributions**

- Introduction, Population, Parameter & Statistic, Objects of sampling, Sampling distribution of Mean, Standard errors, Sampling & Non-Sampling Errors,
- Random Sampling, Sampling with & without replacement, Sequential Sampling, Central limit theorem.
- Applications in relevant engineering discipline

### **Statistical Inference and Testing of Hypothesis**

- Introduction to inferential statistics, Estimation, hypothesis testing of population mean, proportion,
- Variance, Applications in Engineering

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

### **Suggested Books:**

- Introduction to Statistical theory part 1, by Sher Muhammad Chuadary (Latest Edition)
- Advanced Engineering Mathematics, by Erwin Kreyszig (Latest Edition)
- Probability and Statistics for Engineers and Scientists, by Antony Hayter.
- Elementary Statistics, by Bluman.

## **Complex Variables & Transforms**

### **Area Scope:**

The knowledge units in this area collectively encompass the following:

- Explain the concept of complex number system, complex function, limit, continuity, differentiability and integral of complex valued functions
- Utilize the theory of complex integration and power series (Taylor series, Laurent series) to solve problems from the area of residue calculus
- Apply various transforms to solve complex integration.

### **Course Outline**

#### **Introduction**

- Review of complex numbers, Complex valued functions, Elementary functions (exponential and logarithmic functions, Trigonometric and hyperbolic functions and theirs inverses),
- Limits and continuity,
- Applications in Engineering

#### **Complex Differentiation and Integration**

- Derivatives of complex valued functions, Differentiability,
- Analyticity, Cauchy Riemann Equations, Harmonic Functions,
- Complex integrals, Cauchy-Goursat Theorem, Independence of Path, Cauchy's Integral Formulas and Their Consequences, Applications

## **Power Series**

- Taylor Series, Laurent Series, Singularities, Zeros and poles, Residue integration method, Residue theorem,
- Conformal mapping

## **Laplace Transformation**

- Linearity, Scaling, First shifting theorem, Heaviside's Shifting theorem,
- Inverse Laplace transformation, Properties of inverse Laplace,
- Convolution theorem, Applications in relevant engineering discipline

## **Special functions and Fourier Transforms**

- (Gamma, Beta functions, Periodic functions, Error function),
- Fourier Series, Fourier Sine and Cosine series,
- Fourier transform, Fourier cosine and sine transform, properties.
- Applications in relevant engineering discipline

## **Z-Transformation**

- Z-transform, Properties of Z-transform, linearity and scaling, Standard Z-transform, Inverse Z-transform,
- Inverse Z- transform by using residue, convolution theorem of Z-transform,
- Formation of difference equation and its solution using Z-transform.

## **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

## **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

## **Suggested Books:**

- Advanced Engineering Mathematics, by Erwin Kreyszing, Latest Edition
- Complex Variables and Applications by Churchill, Latest Edition

- R. J. Beerends, Fourier and Laplace Transform, Cambridge University Press, Latest Edition.
- Jeffry A, Advanced Engineering Mathematics, Elsevier, Latest Edition

## **Multivariate Calculus**

### **Area Scope:**

The knowledge units in this area collectively encompass the following:

- To develop a clear understanding of fundamental concepts of multivariable variable calculus
- To describe of the concept of gradient, multiple integrals in rectangular, polar, cylindrical and spherical coordinates, directional derivatives, and optimization problems
- To apply the concepts line integrals, surface integrals, volume integrals, Green's, Stokes', Gauss theorems to different engineering problems

### **Course Outline:**

#### **Geometry of Space:**

Analytical Space Geometry, Cylindrical and Spherical coordinates, Lines in space, Intersection of Line and a Plane

#### **Vector-Valued Functions and Motion in Space:**

Functions of several variables, their limits and continuity, Quadratic Surfaces, Parametric representation of curves, Velocity and Acceleration, Arc length, Tangent, Normal, Bi-normal, Curvature & Torsion

#### **Partial Differentiation:**

Partial derivatives, Total Differentials, Chain Rule with More Variables, Directional derivatives

#### **Applications of Partial Derivatives:**

Optimization Problems, Extrema of functions of several variables, Conditional extrema, Lagrange Multipliers and Example

### **Multiple Integrals:**

Double Integration, Order of Integration, Double Integrals in Polar Coordinates, Applications: Mass and Average Value, Moment of Inertia, Triple Integrals, Rectangular and Cylindrical Coordinates, Applications and Examples, Triple Integrals in Spherical Coordinates

### **Vectors in 3 Space:**

Introduction to vectors, Scalar and vector product, Volume of parallelepiped and tetrahedron, Gradient of a Scalar Field, Divergence of a Vector Field, Curl of a Vector Field

### **Integration in Vector Fields:**

Line Integral, Integration Around Closed Curves. Work Done, Potential and Related Examples, Conservative and non-Conservative Fields, Green's Theorem, Divergence Theorem, Stoke's Theorem, Applications of Double and Triple integrals

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

### **Suggested Books:**

- Thomas' Calculus by George B. Thomas, Jr., Maurice D. Weir, Joel R. Hass. Pearson, USA.
- George B. Thomas, Jr. and Ross L. Finney, Calculus and Analytic Geometry
- Swokowski, Onlinick & Pence: Calculus
- Robert T. Smith & Roland B. Minton: Calculus
- Calculus: Early Transcendental by James Stewart, Brooks/Cole USA.

## **Applied Physics**

### **Course Outline:**

#### **Vectors:**

Review of vectors, Ordinary Differentiation of Vector, Gradient of Scalar field, Divergence and Curl of Vector Field, Line, surface and volume integrals with their applications.

#### **Electricity & Magnetism:**

Electric field due to Discrete and Continuous Charge Distributions, Electrostatic Potential of discrete and Continuous charges, Gauss's Law and its Applications, Lorentz Force and Hall Effect, Ampere's Law, Maxwell's Equations, Magnetic Field due to current element (Circular Current Loop and Solenoid), Faraday's Law.

#### **Waves & Oscillations:**

Types of Waves and Superposition Principle, Wave Speed on a stretched string, Wave equation, Energy & Power of a Wave, Principle of Superposition and Standing Waves. Simple Harmonic oscillations. Forced & damped oscillations.

#### **Optics and Lasers:**

Huygens Principle, Two-slit interference, Single-Slit Diffraction, resolving power of Optical Instruments, Lasers and laser light, Working principle of lasers

#### **Atomic and Nuclear Physics:**

Atomic Nucleus and Properties of Nucleus, Radioactive Decay and Radioactive Dating. Nuclear Reactions, Nuclear Reactor, Thermonuclear Process, Controlled Thermonuclear Fusion, Radioactive Decay and Radioactive Dating, Radiation Detection Instruments,

#### **Thermodynamics:**

Laws of thermodynamics and Heat Transfer Mechanisms, Heat and Work, Kinetic Theory of gases, Ideal gases, Mean Free path, distribution of molecular speeds, Change in Entropy and Irreversible processes

**Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), written assignments/quizzes, tutorials, case studies relevant to engineering disciplines, semester project, guest speaker, industrial/field visits, group discussion, report writing

**Assessment:**

Mid-semester exam, report writing/presentation, assignments, project report, quizzes, end semester exam

**Suggested Books:**

- Halliday, Resnick and Walker, “Fundamentals of Physics” 10th Edition Extended
- Hugh D. Young and R.A. Freedman, University Physics. 12th Edition
- Raymond A Serway and John W. Jawett, Jr. Physics for Scientists and Engineers with modern Physics, 09th Edition.

**Polymer Chemistry**

**Area Scope:**

The knowledge units in this area collectively encompass the following:

- To know Reaction mechanism and industrial applications of organic compounds and their reactions
- To understand chemical process industry, Industrial Chemical Analysis and primary raw materials used in various industries
- To infer the knowledge of synthesis and basic reactions of polymers
- To learn Synthesis characterization and applications of Paints, pigments, dyes and coating

**Course Outline:**

- Industrial Aspects of Inorganic Chemistry, study of selected inorganic industries, Sulfur industry, Industry dealing with nitrogen, phosphorus, chloralkaline and titanium oxide.
- Reaction mechanism and industrial applications of organic reactions such as sulfonation, Nitration, Hydrogenation, Amination, Halogenation, oxidation, polymerization.

- An overview of chemical process industry and primary raw material, Industrial Pollution Prevention, Industrial Chemical Analysis, Chemical Explosives and propellants, Synthetic polymers, Polymeric materials, Corrosion, chemical analyses of materials, Improved Paints pigments and industrial coatings, Dye: Chemistry and Applications, Chemical manufacturing processes and production methods

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Applied Chemistry and Chemical Engineering” A. K. Haghi, Devrim Balkose, Omari V.
- Mukbaniani, Andrew G. Mercader, Apple Academic Press, 2018
- Comprehensive Analytical Chemistry; Molecular Characterization and Analysis of
- Polymer, John M. Chalmers, Robert J. Meier, Elsevier (2008)
- Green Chemistry in industry Mark Anthony Benvenuto, Heinz Plaumann, De Gruyter,
- Volume 3, 2018
- Polymers, Polymer Blends, Polymer Composites and Filled Polymers, G. E. Zaikov,
- Nova (2006)
- Biodegradable Polymer Blends and Composites from Renewable Resources, Long Yu, Wiley (2008)
- Sustainable Industrial Chemistry: Principles, Tools and Industrial Examples.
- Fabrizio cavani, Gabriele Centi, Siglinda Perathoner , Wiley Publishshers, 2009

- Pavia, Lampman, Introduction to Spectroscopy, 4th edition, Brooks/Cole, 2009
- H. Kuhn, Principles of Physical Chemistry, 2nd edition, Wiley, 2009
- G.D. Christian, Analytical Chemistry, 7th edition, 2014, Wiley
- D. W. H. Rankin, Norbert Mitzel, Carole Morrison, Structural Methods in Molecular Inorganic chemistry, Wiley, (2013)
- Gary Wulfsberg, Foundations of Inorganic Chemistry, University Science Books, 2017 David Klein, Organic Chemistry , Wiley, 2017

## **Social Sciences Courses**

### **Sociology for Engineers**

#### **Area Scope:**

This course is meant to provide engineering students, with an opportunity to view the discipline of sociology from the engineering perspective and will highlight its application to engineering profession. This will also enable the engineers to fit their technical ideas into a socially acceptable product /project in a more successful manner. The knowledge units in this area collectively encompass the following:

- To introduce to the methods and philosophy of the social science to help their understanding of the socio-cultural dimension of human existence as a fundamental reality in engineering projects etc.
- To provide opportunity for students to begin the process of considering social problems/ issues while designing engineering products.
- To allow engineers to play a pro-active role in critical discussions of social issues specifically.
- To demonstrate comprehension of roles and functions of various social institutions, state organizations, Professional bodies and relationships for analyzing their social impact Assessment.

#### **Course Outline:**

#### **Fundamental Concepts and Importance of Sociology for Engineers**

What is sociology? Nature, Scope, and Importance of Sociology, Sociological Perspectives and Theories, Social Interactions, Social Groups/ Social Institutions & their interface with Engineering Project/services, Sociology & Impact of Technology & Engineering Products/Projects on Society.

#### **Cultural Impacts of Engineering Projects on Society**

Definition of Culture, Types of Culture & Elements of Culture, Culture & Power, Authority, Dominance Socialization and Personality, Role of Engineering Projects on Culture, social norms and values of Society, Cultural Infusion of Engineers in Society

## **Theoretical Perspective of Sociology: Diffusion and Innovation; Adoption and Adaptation; Social development; Community Development**

Community Development & Social consequences of Industrialization, Development Processes of Societal Development, Cooperation and Conflict in Community Development in Engineering Context.

## **Understanding of Societal & Ethical Norms and Values for Engineers**

Engineering Ethics, Engineering product/services for Less privileged, Role of Engg & Technology in addressing Social inequality, Core Social Values/Norms affecting Engg Performance

## **Organizational Social Responsibility (OSR) of Engineers**

- Extent to which development intends to sensitize societal and under-privileged needs
- Gender inclusiveness and balance
- Special and Disadvantaged Community of the Area
- Planning for community inclusiveness
- Societal Obligation of Engineers

## **Engineers, Society and Sustainability**

Social System and Concept of Sustainable Development Technology and Development, Population Dynamics in Pakistan, Causes and Consequences of Unplanned Urbanization, Community Development, Programs in Pakistan, Community Organization & Engineering Projects, Population, Technological & Industrial expansion and Development with focus on social/human/ethical dimensions.

## **Industrial & Organizational Psychology**

Interpersonal Relations, Interpersonal Behavior, Formation of Personal Attitudes, Language and Communication, Motivations and Emotions, Impact of Technology on human feelings and level of Sensitivity

## **Climate Change and Ecological Friendliness from Engineering Perspective**

Ecological Processes, Ecosystem and Energy, Impact of Engineering Projects on Eco System & Human Ecology, Industrial & Environmental impact on Population & General Masses, Technological Intervention, Ecosystem and Physical Environment,

Social Impact of Technology & Engineering Products & Services (Solid Waste Disposal, Pollution control etc.).

**Social Approaches and Methodologies for Development Administration & Stakeholders Analysis:**

All Phases of the Project (pre, post and execution) Structured, Focused Group, Stakeholder Consultative Dialogues etc. Dynamics of Social Change, Sociology of Change and Industrial Development, Social Change due to Technology Driven Economic Growth.

**SIA (Social Impact Assessment):**

Base line and need-assessment, evaluation and impact assessment surveys of the development projects. Role of Engg & Technology for Creating Social Cohesiveness & Societal Integration. Technology Based change in Collective Behavior, Social Audit of Engineering Projects.

**Engineering Intervention for Social Stratification:**

Factors of Social Stratification, Engineering Interventions for addressing Social Stratification, Social Mobilization through Technological Innovation.

**Case Studies of Different Development Projects in Social Context**

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Godhade, J. B., and S.T. Hunderkari. 2018. Social Responsibility of Engineers. International Journal of Academic Research and Development. Vol. 03; Special Issue. March, 2018.

- Nichols, S.P. and Weldon, W.F. 2017. Professional Responsibility: The Role of Engineering in Society Center for Electro-mechanics, The University of Texas at Austin, USA.
- Aslaksen, E.W. 2016. The Relationship between Engineers and Society: is it currently fulfilling its potential? Journal and Proceedings of the Royal Society of New SouthWales, Vol.148.Nos.455-456. Gumbooya Pty Lte, Allambie Heights, Australia.
- Bell, S. Engineers, Society and Sustainability. Synthesis Lectures on Engineers, Technology, and Society. Edited by Caroline Baillie, University of Western Australia. Morgan and Claypool Publishers
- Jamison, A., Christensen, S.H., and Lars, B. 2011. A Hybrid Imagination: Science and Technology in Cultural Perspective.
- Vermaas, P., Kroes, P., Poet, I., and Houkes, W. 2011. A Philosophy of Technology: From Technical Artefacts to Socio technical systems.
- Mitcham, C., and Munoz, D. 2010. Humanitarian Engineering. Morganand Claypool Publishers.
- Riley, D. 2008. Engineering and Social Justice. Morgan and Claypool Publishers.
- Bugliarello, G. 1991. The Social Functions of Engineering: A Current Assessment, A Chapter in “Engineering as A Social Enterprise”.

## **Sociology**

### **Area Scope:**

The knowledge units in this area collectively encompass the following:

- To introduce the necessary subject knowledge and understanding required for the successful study of Sociology and related Social Science disciplines at undergraduate.
- To develop skills of application, analysis and evaluation in the context of the study of Social Science.
- To develop a knowledge and understanding of sociology both at a global and national level.
- To introduce the planning and organization skills necessary to develop as independent, autonomous learners.

- To develop the confidence and competence of the students as learners and to assist them in taking some responsibility for their own learning through directed study and reading.

**Course Outline:**

- Introduction: Sociological Perspective,
- The Development of Sociology,
- The Role of Values in Sociology, Prejudice In Early Sociology,
- Theoretical Perspective in Sociology. Culture: Components of Symbolic Culture, Subcultures and Counter Cultures, Cultural Universals, Animals and Culture,
- Technology and Global Village, Sociology and New Technology.
- Socialization: Social Development of Self, Mind, and Emotions,
- Socialization into Gender Social Structure and Interaction,
- Social Institutions. Research in Sociology: Research Model, Research Methods. Experiments, Ethics,
- Bureaucracy and Formal Organizations, Rationalization of Society, Formal Organizations and Bureaucracy,
- Voluntary Associations Social Classes, Economy, Politics, Power and Authority, Family, Medicine, Health and Illness, Population and Urbanization, Social Movements
- Social Psychology with special reference to attitudes, attributions and behavior, Emotions, Cognition and Thinking, Reasoning, Problem- Solving and Creativity, Personality, Intelligence, and Abnormal Behavior, etc.
- Introduction to the Field of Organizational Behaviour
- Conflict and Negotiation in the Workplace
- Leadership in Organizational Settings and Organizational Culture
- Ethics: In General an introduction and the development of ethical theory.
- Ethics in Islam, a comprehensive view with different ethics approaches and Ethics Theories
- Research Methods for Society and Sociology

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits,

Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Henslin, Sociology: A Down-to-Earth Approach, 11th edition.
- D. Kendall, Sociology in our Times. Wadsworth Pub Co.

## **Social Psychology**

**Area Scope:**

To impart knowledge of social psychology of attraction; attitudes and prejudice; altruism and aggression; personal and social identities; conformity; group influence and their applications in the real world.

**Course Outline:**

- Principles of sociology and psychology with emphasis on the individual and his/her reciprocal interaction with groups,
- Basic psychological factors, attribution and perception of others, attitudes and attitudinal change, social attitudes, altruism, helping others, aggression, hurting others, prejudice, disliking others, discrimination and stereotypes,
- Language and communication, society and cultures, culture and personality, small groups and their relation to the individual, leadership and group dynamics. Attraction, attitudes and prejudice; altruism and aggression; personal and social identities, conformity, group influence, moral and ethical issues, harassment,
- Corruption and its control, thinking processes and decision making.

**Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engineering disciplines, Semester Project, Guest Speaker, Industrial/ Field Visits, Group discussion, Report Writing

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Edward Alsworth Ross, “Social Psychology”, Macmillan, 2006
- Emory Stephen Bogardus, “Essentials of Social Psychology”, Univ. of Southern, California Press, 2006
- Hewstone, M., & Stroebe, W. (Eds.), “Introduction to Social Psychology”, 3rd ed., Oxford: Blackwell Publishers, 2006
- Lesko, W.A. “Readings in social psychology General, classic, and contemporary selections, 6th ed., 2006

**Community Services**

**Area Scope:**

Community service-learning provides a variety of benefits to the students and the community service has a unique way of developing an individual's leadership skills, sense of community, civic ethic, self-esteem, and other personal characteristics. Every service activity benefits a specific individual or group. Whether it is building homes for the poor, serving victims of chronic or terminal illness, tutoring children, addressing environmental needs or any other service, there is a person or group who ultimately benefits from your time. Finally, the organization where you conduct your service benefits enormously. Volunteers can make important contributions to Community benefit agencies (nonprofit) and government programs in their attempt to deal with the complex and growing needs of society.

**Course Outline:**

- Develop and implement service programs
- Develop workplace communication strategies
- Analyze impacts of sociological factors on clients in community work and services
- Manage and promote diversity
- Manage legal and ethical compliance
- Facilitate workplace debriefing and support processes

- Reflect on and improve own professional practice
- Manage work health and safety
- Assess co-existing needs
- Coordinate complex case requirements
- Develop, facilitate and review all aspects of case management
- Provide case management supervision
- Undertake project work
- Lead and manage team effectiveness
- Manage personal work priorities and professional development
- Manage meetings

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Schools and Community: The Communitarian Agenda in Education By James Arthur; Richard Bailey, Falmer Press, 2000.
- Studying Service-Learning: Innovations in Education Research Methodology by Shelley H. Billig, Alan S. Waterman , Lawrence Erlbaum Associates, 2003

## **Organizational Behavior**

### **Course Outline:**

#### **Introduction to Organizational Behavior**

- Organizational Disciplines and topics
- Psychological Perspective
- Social-Psychological Perspectives

#### **Structure and Control in Organization**

- Introduction of 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

#### **Group and Work**

- Social Interaction
- Dramaturgy and impression Management
- Social Skill

## **Group and Inter group Behavior**

- Group Structure & Norms
- Group Processes
- How throne Studies

## **Leadership**

- Leadership as an attribute
- Leadership Style

## **Patterns of Work**

- Work-the classical approach
- Marx, Weber, & The critique of labor
- Foucault & Disciplinary Power
- Conflict and Consent in Work
- The labor 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

## **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

## **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

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

**Engineering Economics**

**Area Scope:**

- Apply the appropriate engineering economics analysis method(s) for problem solving i.e. present worth, annual cost, rate of return, payback, break-even, benefit-cost ratio
- Evaluate the cost effectiveness of individual projects using the methods learnt, draw inferences for investment decisions, and compare the life cycle cost of multiple projects.
- Compute the depreciation of an asset using standard depreciation techniques to assess its impact on present or future value

**Course outline**

**Engineering Economics**

- Role of engineers in business
- Economic decisions v/s design decisions
- Large scale engineering projects and types of strategic economic decisions
- Fundamental principles of engineering economics

**Interest Rate and Economic Equivalence**

- Interest: The Cost of Money
- Economic Equivalence
- Development of Formulas for Equivalence Calculation
- Unconventional Equivalence Calculations

## **Understanding Money and Its Management**

- Nominal and Effective Interest Rates
- Equivalence Calculations with Effective Interest Rates and with Continuous Payments
- Changing Interest Rates
- Debt Management
- Investing in Financial Assets

## **Present-Worth Analysis**

- Project Cash Flows
- Initial Project Screening Methods: payback Screening and Discounted Cash Flow Analysis
- Variations of Present-Worth Analysis
- Comparing Mutually Exclusive Alternatives

## **Annual Equivalent-Worth Analysis**

- Annual Equivalent-Worth Criterion
- Capital Costs versus Operating Costs
- Applying Annual-Worth Analysis
- Life-Cycle Cost Analysis
- Design Economics

## **Rate-of-Return Analysis**

- Rate of Return and Methods of Finding It
- Internal Rate-of-Return Criterion
- Mutually Exclusive Alternatives

## **Cost Concepts Relevant to Decision Making**

- General Cost Terms; Classifying Costs for Financial Statements
- Cost Classifications for Predicting Cost Behavior
- Future Costs for Business Decisions
- Estimating Profit from Production

## **Depreciation and Corporate Taxes**

- Asset Depreciation: Economic versus Accounting
- Book and Tax Depreciation Methods (MACRS)
- Depletion
- Income Tax Rate to be used in Economic Analysis
- The Need for cash Flow in Engineering Economic Analysis

## **Developing Project Cash Flows**

- Cost-Benefit Estimation for Engineering Projects
- Developing Cash Flow Statements

## **Project Risk and Uncertainty**

- Origins of Project Risk
- Methods of Describing Project Risk: Sensitivity, Break-Even and Scenario Analysis

## **Special Topics in Engineering Economics**

- Replacement Decisions
- Capital Budgeting Decisions
- Economic Analysis in the Service Sector

## **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

## **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Contemporary Engineering Economics by Chan S. Park, 6th edition, Pearson 2015, ISBN: 9780134105598
- Engineering Economic Analysis by Donal G. Newnan, Jerome P. Lavelle, Ted G. Eschenbach, 12th edition, Oxford University Press, ISBN: 978-0199339273
- Engineering Economy by Leland T. Blank and Anthony Tarquin.

## **Professional Ethics**

### **Area Scope:**

The objective of this course is to grasp ideals and principles as they have been spelled out in a variety of traditional ethical systems and to apply these conceptual structures and guidelines to major problems and dilemmas of engineering practices in a corporate culture.

### **Course Outline:**

- Engineering Ethics, Ethical concepts, and Types
- Moral Autonomy, Kohlberg's & Gilligan's Theory
- Profession and Professionalism
- Moral Reasoning, Ethical Theories
- Critique codes of ethics
- Moral frameworks, Personal commitments and professional life
- Engineering as social experimentation
- Involving the public in the design process, Case studies for engineering as social experimentation
- Assessment of safety and risk, Design considerations, uncertainty
- Risk-benefit analysis, Safe-exit and fail safe systems
- Case Studies for the Design Process Case studies in impact of safety/risk on design
- Employee/employer rights and responsibilities
- Confidentiality and conflict of interest
- Whistle-blowing, case studies on professional behavior/policies on the job
- Environment, sustainable development, Multinational corporations, globalization of engineering

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Industrial/ Field Visits, Group discussion, Report Writing

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Ethics in Engineering 4th edition, by Mike W. Martin, Roland Schinzinger, McGraw-Hill, New York, 2005.
- Fundamentals of Engineering Economics, 3rd ed., by Chan S. Park
- Engineering Ethics: Concepts and Cases,4th edition, by Charles E. Harris, Michael S. Pritchard, Michael J. Rabins, Wadsworth, 2008.
- The Seven Habits of Highly effective people by Stephan r. Covey
- Principle Centered Leadership Stephan r. Covey
- Change your lens change your life by (Faiez H. Seyal)
- How to Manage by Ray Wild
- Happiness by Richard Layard

## **Cultural Courses**

### **Islamic Studies and Ethics**

#### **Course Description:**

The Islam is a religion of peace and harmony for all humans based on knowledge and guidance in the Holy Quran. The basic teachings of Islam are comprehensive, practicable and universal. Therefore, this course briefly presents the vision of life and applied aspects of ethical system.

#### **Area Scope:**

- To enhance understanding of Islamic Culture and Civilization
- To understand values and social system in Islam
- To improve students' ethical and professional skill and critical thinking

#### **Course Outline:**

##### **Islam – Religion of Peace and Harmony**

- Basic Concepts – Islam, Quran and Hadith
- Faith and Religious Life
  - Selected Verses of Surah Al-Baqara Related to Faith (Verse No-284-286)
  - Selected Verses of Surah Al-Mumanoon Related to Characteristics of Faithful (Verse No-1-11)

##### **Islamic Culture and Civilization**

- Basic Concepts and of Characteristics of Islamic Culture and Civilization
- Education System of Islam
- Political System of Islam – Dynamics, Sovereignty and Institutions
- Economic System of Islam – Principles, Riba, Trade and Commerce
- Acceptance of Other Religions – Interfaith Harmony
- Foreign Policy

##### **Social System of Islam**

- Basic Concepts of Social System in Islam
- Elements of Family and their Rights - Parents, Women, Husband & Wife, Children
- Inheritance – Rights and Laws

- Social Rights – Neighbors, Relatives and Society
- Equality and Brotherhood
  - Selected Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
- Concept of Welfare State – Period of Khilafat-e-Rashida

### **Professional Ethics and Morality**

- Basic Concepts - Islam and Ethics
  - Selected Verses of Surah Al-Inam Related to Ihkam (Verse No-152-154)
- Profession and Professionalism in Islam
- Characteristics of a Professional
  - Truthfulness, Honesty, Sincerity, Patience, Gratitude, Meditation and Research
- Role for Human Safety and Environment
- Time Management
- Prophet Muhammad (PBUH) – Role Model
  - Selected Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
  - Selected Verses of Surah Al-Ihzab Related to Adab Al-Nabi (Verse No. 6, 21, 40, 56, 57, 58)

### **Islam and Science**

- Islam and Science
- Role of Muslims in Science and Education
- Critical Thinking and Innovation
  - Selected Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
  - Selected Verses of Surah Al-Saf Related to Tafakar, Tadabar (Verse No1,14)

**Note:** All topics should be taught/covered in the light of relevant Verses from Holy Quran and Ahadiths.

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Industrial/ Field Visits, Group discussion, Report Writing

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Al-Qur'ān (selected text).
- Sayyid Tāhir Rasūl Qādri دروس قرآن 52 (Karachi: Islamic Research Academy, 7<sup>th</sup> ed., 2017).
- Sayyid Hasan-uddin Ahmad، تعلیمات قرآنی 2-vols., (Karachi: Jasarat Publications, 1998).
- Muhammad Shaffi، معارف القرآن (Karachi: Dar-ul-Isha'at, 2000).
- Sayyid Abu'l A'lä Mawdūdī، تفہیم القرآن 6vols., (Lahore: Islamic Publications, 1998). [Preambles of all (114) chapters.]
- Amin Ahsan Islahi، تبیر القرآن (Lahore: Farān Publications, 2005).
- Khawaja Abdul Waheed، موضوعات قرآن و انسانی زندگی (Islamabad: Islamic Research Institute, 3<sup>rd</sup> ed., 1997).
- Khurram Murad, رب کا پیغام (Lahore: Manshūrat, Mansoora, 2000)
- Hameed ullah Muhammad, "Emergence of Islam", Islamic Research Institute (IRI), Islamabad
- Hameed ullah Muhammad, "Muslim Conduct of State" Sh Muhammad Ashraf, Kashmir Bazar, India (Latest Edition)
- Hameed ullah Muhammad, "Introduction to Islam" Compiled by The CSS Point, [www.thecsspoint.com](http://www.thecsspoint.com)
- Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication Islamabad, Pakistan, (Latest Edition).
- H.S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep & Deep Publications New Delhi (1989).
- Islamic Education by A. S. Bukhari & M. D Zafar, Latest Edition.
- Muslim's character by M. Al-Ghazali, Latest Edition.

## **Pakistan Studies and Global Perspective**

### **Area Scope:**

The knowledge units in this area collectively encompass the following:

- Have a better understanding of the rationale for the creation of Pakistan.
- Enable students to contribute in social, political and economic growth of Pakistan.
- Become a part of strong nation with a sense of ownership and responsibility towards Pakistan
- Play an active role toward sustainable development of Pakistan in global perspective.

### **Course Outline:**

**Time Duration**

#### **Historical and Ideological Perspective**

**5 hrs**

- a. Pakistan Movement
  - Aligarh Movement
  - Two Nations Theory
- b. Founders of Pakistan
  - Allama Muhammad Iqbal
  - Quaid-e-Azam Muhammad Ali Jinnah
  - Other Leaders (Women and other Pakistan Movement Leaders)
- c. Quaid's Vision for Pakistan
- d. Kashmir – An unfinished Agenda of Partition

#### **Constitution of Pakistan**

**4 hrs**

- a. An overview of constitutional development in Pakistan
- b. Salient features of the Constitution of 1973
- c. Constitutional Amendments
- d. Fundamental Rights and Responsibilities of Citizens

#### **Contemporary Pakistan**

**4 hrs**

- a. Pakistan's society, culture and demography – celebrating diversity
- b. Current Challenges: social, economic, environmental, political and external
- c. Nation's resilience in War on Terror

<b>Economy of Pakistan</b>	<b>4 hrs</b>
a. An overview of Economy	
b. Services, Manufacturing and Agricultural Profile of Pakistan	
c. Regional Economic Cooperation	
d. One Belt One Road (OBOR) – CPEC	
<b>Land of Opportunities</b>	<b>4 hrs</b>
a. Physical features: diversity and beauty	
b. Natural resources - mineral, water, energy, agriculture & livestock, and marine resources	
c. Tourism and Culture	
<b>Pakistan's Foreign Policy</b>	<b>5 hrs</b>
a. Foreign Policy – Principles and Objectives	
b. Relations with Neighbors	
c. Major Economies	
d. Muslim World	
e. Geo-political and strategic significance of Pakistan in Regional and Global Politics	
<b>Pakistan in pursuit of Global Agenda</b>	<b>4 hrs</b>
a. SDGs-2030 - Pakistan Goals	
b. Commitments on Climate Change	
c. Peace and Security	

**Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Industrial/ Field Visits, Group discussion, Report Writing

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Khalid B. Sayeed, Pakistan: The Formative Phase 1857 – 1948, Pakistan Publishing House, 1960
- Gulam Allana, Quaid-e-Azam: the story of Pakistan, Ferozsons, 1967.
- Shahid M. Amin, Pakistan's Foreign Policy: A Reappraisal, Oxford University Press, 2010.
- S. Akbar Zaidi, Issues in Pakistan's economy, Oxford University Press, 2003.
- Hamid Khan, Constitutional & political history of Pakistan, Oxford University Press, 2003
- Rafi Raza, *Pakistan in Perspective 1947-1997*, Oxford University Press, 2003
- Sharif-ul-Mujahid, *The Ideology of Pakistan*, Progressive Publishers, 1974.
- Ziring Lawrence, *Pakistan in the Twentieth Century*, Oxford University Press, 1997 -
- Burke S. M. & Ziring Lawrence, *Pakistan's Foreign Policy*, Oxford University Press, 1973. Mohammad Qadeer , Pakistan
- Climate Change Policies-Ministry of Climate Change, Islamabad-  
<http://mocc.gov.pk/>
- Sustainable Development Goals (SDGs)- [www.pc.gov.web/sdg/sdgpak](http://www.pc.gov.web/sdg/sdgpak)
- Economic Survey of Pakistan- [http://finance.gov.pk/survey\\_1617.html](http://finance.gov.pk/survey_1617.html)
- Foreign Policies- Ministry of Foreign Affairs, Pakistan <http://mofa.gov.pk/>
- Population Census of Pakistan- Economic Survey of Pakistan  
[http://finance.gov.pk/survey\\_1617.html](http://finance.gov.pk/survey_1617.html)
- Issues in Pakistan's Economy by S. Akbar Zaidi, ISBN: 0195790529.
- Pakistan's Foreign Policy: A Reappraisal by Shahid M. Amin. ISBN: 0195798015
- Newspapers editorial and selected journalistic writings on current affairs.
- Pakistan (Lands, Peoples, & Cultures) by Carolyn Black, Bobbie Kalman. ISBN: 0778797147

## **Management Sciences Courses**

### **Engineering Project Management**

#### **Area Scope:**

The primary objective of this course is to get the fair understanding of core issues pertaining to Engineering Project Management. This course is aimed at providing both basic and some advanced exposure to emerging trends in the field of Project Management, so as to enable the engineering professionals of tomorrow to successfully complete sophisticated projects within the constraints of capital, time, and other resources with due regards to stakeholders set of expectations. Engineering students will learn key Project Management skills and strategies and will be able to face emerging challenges.

Core Objectives of this course are:

- To develop competencies in project costing, budgeting, and financial appraisal;
- To gain exposure to project Planning Control and Management, using standard tools and schedule variance analysis;
- To appreciate the elements of risk and quality in hi-tech projects;
- To learn Project Management by “practice”, through the medium of “End of Semester Group Project”; and
- To appreciate and understand the use of computers in Project Management, especially a tool like MS Project & Primavera etc.

#### **Course Outline:**

#### **Project Management Concepts**

History of Project Management, Introduction to Project Management, Project, Program & Portfolio Management, Project characteristics, Objectives& Requirements, Project Phases/Stages, Project Life Cycle, Project Environment, Project Scope & Project Charter, Project Manager, Project Stakeholder Analysis.

#### **Project Proposal Development**

Project Proposal, Characteristics of good proposal, Types of Proposals, Request for Proposal, Request for Quotation etc.). Proposal Templates etc.

## **Project Feasibility**

Brief review of various aspects of Project Feasibility like Technical, Social, Managerial, Economic, Financial & Marketing, Administrative etc.

## **Project Selection Criteria (Economic Analysis of Engineering Projects)**

Using Break Even Analysis, Cost Benefit Ratio, Internal Rate of Return, Net Present Value etc.

## **Project Contract & Procurement Management**

Engineering contracts, Type of contracts, understanding of procurement Process & Cycle, PPRA Rules

## **Project Planning and Scheduling**

Project Planning (Resource & HR Planning), Work Breakdown Structure, Project Network & Scheduling, Manning Schedule and Activity Charts, Critical Path Method (CPM)/Project Evaluation & Review Techniques

## **Project Costing & Estimation**

Cost Estimation in Projects, Cost components in projects and methods for cost estimation in projects, Cost Control in Projects, Estimation of Outstanding Work, Earned Value Management, Schedule & cost variance analysis

## **Project HRM & Communication Management**

Effective organization and communication for Successful Projects, Project Organizational Structures (Project matrix and project based organizations), Project HR Plan preparation, HR Need Assessment and HR Matrix, Building and Managing effective project team, Selection & control mechanism of HRM in Projects, Effective Communication Plan.

## **Project Risk Management**

Definitions Project Risk, Project Risk Management Tools, Types of Project Risk, Project Risk Assessment, Risk Identification and Mitigation, Monitoring & Controlling Risk, Generic Risk Management Strategies & Technique.

## **Computer Application in Project Management**

Basic/Elementary Introduction and hands on basic exposure of use of MS Project & Primavera P6 Software in Project Management

## **Project Quality Management**

Defining Quality, Quality Assurance, Quality Management, 7 Quality Improvement Tools as applied to Project Management, Project Quality Management Plan, Quality Management Processes and Strategies

## **Project Closure & Termination**

Project Evaluation, defining project success, Project Completion Criteria, Project Audit, Project Termination & When to close a project, the termination process, Project Close Up & lesson learnt, & Project Archive

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

### **Suggested Books:**

- Project Management: A system Approach to Planning, Scheduling and Controlling 11th Edition, Harold Kerzner
- Bennett, F. Lawrence. 1996. The management of engineering. New York: Wiley.
- Cleland, David. Field guide to project management. New York: Wiley.
- Eisner, H. Essentials of project management and systems engineering management. New York: Wiley.
- Frame, J. D. Managing projects in organizations. San Francisco: Jossey-Bass
- Goldratt, Eliyahu. Critical chain. North River Press.
- Haynes, M.E. Project management: From idea to implementation. Los Altos, CA: Crisp Publications.
- Lewis, James, Project planning, scheduling & control. New York: McGraw-Hill

- Lewis, James, P. 1998. Mastering project management. New York: McGraw-Hill
- Lientz, Bennet & Rea, Kathryn. 1995. Project management for the 21st century. San Diego: Academic Press.
- Miller, Roger & Lessard, Donald. 2000. The strategic management of large engineering projects. Cambridge, MA: MIT Press.
- Nicholas, J.M. Managing business & engineering projects. Englewood Cliffs, NJ: Prentice Hall.
- Shtub, Avraham, Bard, Jonathan, & Globerson, Shlomo. 1994. Project management: Engineering, technology, and implementation. Englewood Cliffs, Prentice-Hall.
- Project Management by Adrienne Watt
- J.R. Meredith and S.J. Mantel. Project Management: A Managerial Approach. John Wiley and Sons. New York. 2019. (Reference).

## **Entrepreneurship**

### **Area Scope:**

- Develop a business plan with an appropriate business model
- Demonstrate the ability to provide a self-analysis in the context of an entrepreneurial career
- Demonstrate the ability to find an attractive market that can be reached economically

### **Course Outline**

- Basic Concept-Entrepreneurship
- Innovation and Entrepreneurship
- Basic Plan Development Cycle
- Intellectual Rights
- Financial and Legal Modalities
- Marketing
- Industrial Competitiveness
- Gap Analysis, Critical Thinking and Idea Generation
- Business Plan Development
- Successful Case Studies (local)

**Teaching Methodology (Proposed as applicable):**

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Project / Field Visits, Group discussion, Community Service, Report Writing, Social Impact Review and Social Audit of Engg Project

**Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

**Suggested Books:**

- Michael J Etzel, Bruce J Walker, William J Stanton, Marketing, McGraw-Hill 2010
- William D. Bygrave and Andrew Zacharak, Entrepreneurship 2nd Edition, Wiley, 2012.
- Entrepreneurship by Hisrich, McGraw- Hill, 2009
- Principles of Marketing, Cotrell McGraw- Hill 2012
- Paul Burns and Jim Dew Hurst: Small Business and Entrepreneurship
- P.N. Singh: Entrepreneurship for Economic Growth
- Peter F. Drucker: Innovation and Entrepreneurship Peter F. Drucker
- John B. Miner: Entrepreneurial Success
- “Marketing that Works: How Entrepreneurial Marketing Can Add Sustainable Value to Any Sized Company”, by Leonard Lodish, Howard Morgan, Shellye Archambeau and Jeffrey Babin, Pearson FT Press
- "Entrepreneurial Marketing," Lessons from Wharton's Pioneering MBA Course, Morgan, H. L., A. Kallianpur, and L. M. Lodish, John Wiley & Sons, 2001

## **Principles of Management**

### **Area Scope**

- The focus will be on the learning fundamental principles of management and of managing people and organization.
- Develop analytical and conceptual framework of how people are managed in small, medium and large public and private national and international organizations.

### **Course Contents:**

- 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, process and techniques of controlling
- Management and Society: future perspective

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Industrial/ Field Visits, Group discussion, Report Writing

### **Assessment:**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

### **Suggested Books:**

- Stephen P. Robins, Mary Coulter: Management, latest edition.
- H. Koontz Odonnel and H. Weihrich: Management, latest edition.
- Mc Farland: Management: Foundation and Practice, latest edition.
- Robert M. Fulmer: The New Management, latest edition.

## **Engineering Management**

### **Course Outline**

- Industrial networks
- Fundamentals of Product and Process development
- Business Community and New Generations of Managers
- Practical Skills Knowledge and Experience in Commercialization of New Technological Inventions
- Use of Multidisciplinary Science Based Knowledge,
- Problem Solving, Teamwork and Outreach Activity,
- Major steps in proof of concept to intellectual property protection,
- Prototype development
- Fabrication and assembly routes
- Materials procurement,
- Identification and creation of new markets
- Development of business plan
- Appropriate technology and marketing
- Distribution and financing
- Routes and strategies for specific technology under development.

### **Teaching Methodology (Proposed as applicable):**

Lectures (audio/video aids), Written Assignments/ Quizzes, Tutorials, Case Studies relevant to engg disciplines, Semester Project, Guest Speaker, Industrial/ Field Visits, Group discussion, Report Writing

### **Assessment**

Mid Term, Report writing/ Presentation, Assignments, Project Report, Quizzes, Final Term

### **Suggested Books:**

- R. A. Bulgelman, Strategic Management of Technology and innovation, latest Edition McGraw Hill.





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