Curriculum for

Chemical Engineering

Bachelor of Engineering Program

2023

Pakistan Engineering Council
&
Higher Education Commission
Islamabad

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Contents

PREFACE

The curriculum, with varying definitions, is considered as a roadmap or plan of teaching-learning process that students of an academic programme 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.

University Grants Commission (UGC) was the authorised 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 this provision, 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 Committee (ECRDC) comprising of eminent engineers and professionals from academia and industry to take up the task of curricula review and updation. Nevertheless, the basic templates developed by HEC NCRC have been followed as guidelines.

Under OBE based curriculum review and development framework, PEC held national and regional levels stakeholders and industrial consultation workshops by engaging HEIs, industry, technical and consulting organizations. The experts' feedback and suggestions were translated into the curriculum review process while 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 the revised 11 GAs (Graduate Attributes) and 13 PCs (Professional Competency) covering core and elective courses, considered as beauty of OBE system in the international arena. At the same time, this curriculum framework would fulfill the purpose of meeting 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.

While approving this curriculum in 10th meeting of ECRDC-Main, Engr. Lt. Gen (Retd.) Javed Mahmood Bukhari (Convener) appreciated and complemented the role of PEC by doing a great job in many endeavors. He lauded the PEC initiatives and accomplishments being made by the current Governing Body & Management Committee under the Leadership of Engr. Muhammad Najeeb Haroon (Chairman PEC) and Engineering Accreditation Board (EAB) under the Convener-ship of Engr. Dr. Niaz Ahmad Akhtar (Convener EAB/ Vice-Chairman Punjab) for promoting standards of engineering education as well as practice of engineering for ultimate achievement to promote rapid growth in socio-economic field of Pakistan.

He acknowledged the contribution and tangible input rendered by members/ experts of ECRDC-Main and respective discipline-wise Committees/ Sub-Groups and continued support of Engr. Dr. Nasir Mahmood Khan (Secretary/ Registrar-PEC) for developing these undergraduate engineering programs curricula and producing quality work output.

The Convener also expressed gratitude to PEC and HEC for collaborative efforts and synergy for uplifting the standards of education particularly in engineering field in the country. He praised the working of HEC on issuing Undergraduate Education Policy (UEP) to be implemented from Fall-2023 for all HEIs and Councils. In this regard, he appreciated PEC EAB working and notification of engineering education guidelines/ framework document, evolved based on the synthesis and mapping in the light of HEC UEP. He anticipated that these combined efforts will continue to achieve the Sustainable Development Goals (SDGs) of enhancing the quality of engineering education towards economic growth at national level.

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 Engr. Lt. Gen (Retd.) Javed Mahmood Bukhari, Member Governing Body/ Rector, NUST was constituted (for the term 2021-2024), whereas other eminent members from industry and academia were involved in 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 9th meeting of main ECRDC and first of this term, was held on 31st May 2022 at PEC Head Office Islamabad, wherein the Convener briefed the scope, objective and ToRs of the Committee and also endorsed the subject ECRDCs comprising of eminent engineers and professionals from academia and industry.

1.	Engr. Lt. Gen (Retd.) Javed Mahmood Bukhari Convener (ECRDC-Main)/ Member PEC Governing Body/ Rector NUST, Islamabad	Convener
2.	Engr. Prof. Dr. Altaf Mukati Vice President (Academics) SZABIST University, Karachi	Dy. Convener
3.	Engr. Prof. Dr. Bhawani Shankar Chowdhry Member, PEC Governing Body / Prof. Emeritus /Advisor MUET	Member
4.	Engr. Prof. Dr. Shahid Khattak Convener, Elect Engg & Allied Disciplines	Member
5.	Engr. Prof. Dr. Ehsan Ullah Khan Kakar Convener, Civil Engg & Allied Disciplines	Member

6.	Engr. Prof. Dr. Syed Mushtaq Shah Convener, Mechanical Engg & Allied Disciplines	Member
7.	Engr. Prof. Dr. Amanat Ali Bhatti Convener, Materials , Metallurgical, Mining and Petrogas & Allied Disciplines	Member
8.	Engr. Prof. Dr. Naveed Ramzan Convener, Chemical Engg & Allied Disciplines	Member
9.	Engr. Dr. Muhammad Ashraf Convener, Agricultural Engg. & Allied Disciplines	Member
10.	Engr. Muhammad Raza Chohan Convener, Common to All (Non-Engg Component)	Member
11.	Mr. Hidayatullah Kasi HEC Representative	Member
12.	Engr. Dr. Nasir Mahmood Khan	Secretary / Registrar, PEC
13.	Engr. Niaz Ahmed Khaskheli Sr. Additional Registrar, EAD	Secretary ECRDC

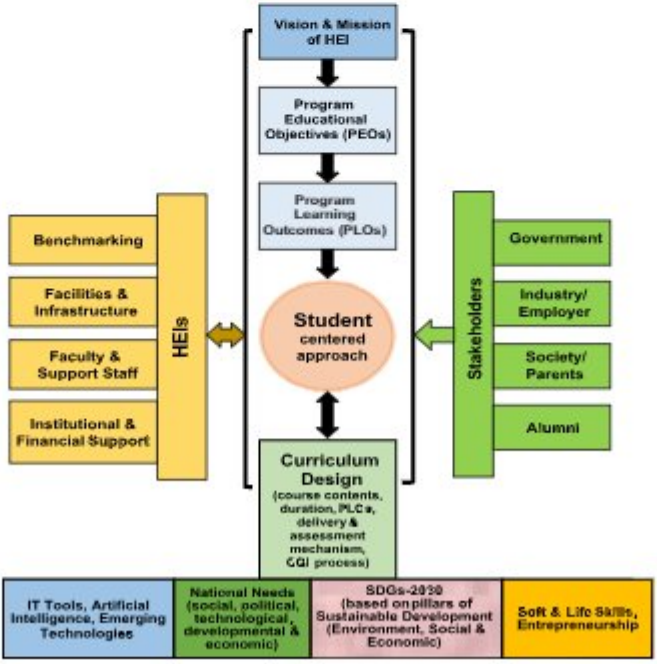
2. ECRDC Agenda

- The ECRDC is responsible to oversee the overall working of curriculum review and development for all engineering programs in terms of strategy, guidance & progress, and thereby submission to the relevant forum for adoption/ notification.
- Each Member of ECRDC will also work in the capacity of Convener for respective disciplines as mentioned against their names and as per their 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 graduates 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 interconnected 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 Do 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 also identified during this stage.

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 Disciplines

The PEC Engineering Curriculum Review and Development Committee (ECRDC) of Chemical and Allied Engineering Disciplines took up the task to review and update the curriculum for Chemical Engineering program. The subject Committee had several meetings besides multiple sessions of Sub-Groups and the concluding meeting of ECRDC (Chemical Engineering) was conducted on 11-1-2024 at PEC Head Office Islamabad. The Committee consisted of following members.

1. Engr. Dr. Naveed Ramzan — Convener
   Dean/ Professor, Department of Chemical Engineering
   University of Engineering & Technology, Lahore

2. Engr. Dr. Saeed Gul — Member
   Professor, Department of Chemical Engineering
   University of Engineering & Technology, Lahore

3. Engr. Dr. Sadiq Hussain — Member
   HoD/ Professor, Department of Chemical Engineering
   NFC-IET, Multan

4. Engr. Dr. Khadija Qureshi — Member
   Chairperson/ Professor, Department of Chemical Engineering
   Mehran University of Engineering & Technology
   Jamshoro

5. Engr. Dr. Tanveer Iqbal — Co-opted Member
   Chairman/ Campus Coordinator/ Professor
   Department of Chemical Engineering
   UET (New Campus), Lahore

6. Engr. Dr. Syed Kamran Sami — Co-opted Member
   Dean/ Professor, Faculty of Engineering & Architecture
   BUITEMS, Quetta

7.	Engr. Dr. Muhammad Zafar Noon Former Professor, UET Lahore	Co-opted Member
8.	Engr. Liaquat Mahmood Professor (Rtd.), Punjab University, Lahore	Co-opted Member
9.	Engr. Muhammad Ramzan Plant Manager, Rafhan Maize, Faisalabad	Co-opted Member
10.	Engr. Mubashir Mahmood Butt Manager HSE&Q Fauji Fertilizer Corporation Company Sadiqabad, Rahim Yar Khan	Co-opted Member
11.	Engr. Ammar Abbas Process Manager, Pak Arab Refinery Company (PARCO), Kot Addu	Co-opted Member
12.	Engr. Habib ur Rehman Managing Director, Madina Glass Processing	Co-opted Member
13.	Engr. Imdad Hussain Brohi Former Process Engineer Saindak Metals Pvt Ltd, Ministry of Energy (Petroleum Division)	Co-opted Member
14.	Mr. Hidayatullah Kasi HEC Representative	Co-opted Member
15.	Engr. Niaz Ahmed Khaskheli Sr. Additional Registrar/ HoD-EAD	Secretary ECRDC
16.	Engr. Osaf Mahmood Malik Section Head (Curriculum & Development)	Additional Registrar-EAD
17.	Engr. Syed Haider Abbas Bokhari	Assistant Registrar-EAD
18.	Mr. Muhammad Irfan	Office Superintendent-EAD

The working on curriculum development of Chemical Engineering was initiated in 2022 by previous EAD team comprising of Engr. Dr. Ashfaq Ahmed Sheikh (Sr. Additional Registrar), Engr. Ghulam Karim (Additional Registrar) and Engr. Daniyal Hameed (Assistant Registrar). The contribution of previous as well as current EAD team was highly acknowledged and appreciated by the Convener ECRDC Chemical and Allied Engineering Disciplines.

Sub-Group Chemical Engineering

1.	Engr. Prof. Dr. Naveed Ramzan	Convener
2.	Engr. Ammar Abbas	Lead Sub-Group
3.	Engr. Mubashir Mehmood Butt	Co-Lead
4.	Engr. Prof. Dr. Muhammad Zafar Noon	Member
5.	Engr. Prof. Dr. Khadija Qureshi	Member
6.	Engr. Prof. Dr. Saeed Gul	Member
7.	Engr. Prof. Dr. Tanveer Iqbal	Member
8.	Engr. Prof. Dr. Sadiq Hussain	Member
9.	Engr. Prof. Dr. Javaid Rabbani Khan	Member
10	Engr. Prof. Dr. Syed Kamran Sami	Member
11	Engr. Prof. Dr. Rafiullah Khan	Member
12	Engr. Prof. Dr. Abdul Waheed Bhutto	Member
13	Engr. Osaf Mahmood Malik	Secretary Sub-Group

The ECRDC Chemical and Allied Engineering Disciplines appreciated the extra-ordinary efforts and contribution of Engr. Prof. Dr. Naveed Ramzan (Convener) as well as his UET Lahore Team, Engr. Prof. Dr. Kamran Sami (Member) & Engr. Osaf Mahmood Malik (Secretary Sub-Group) for compilation of course contents and proof reading of this curriculum booklet.

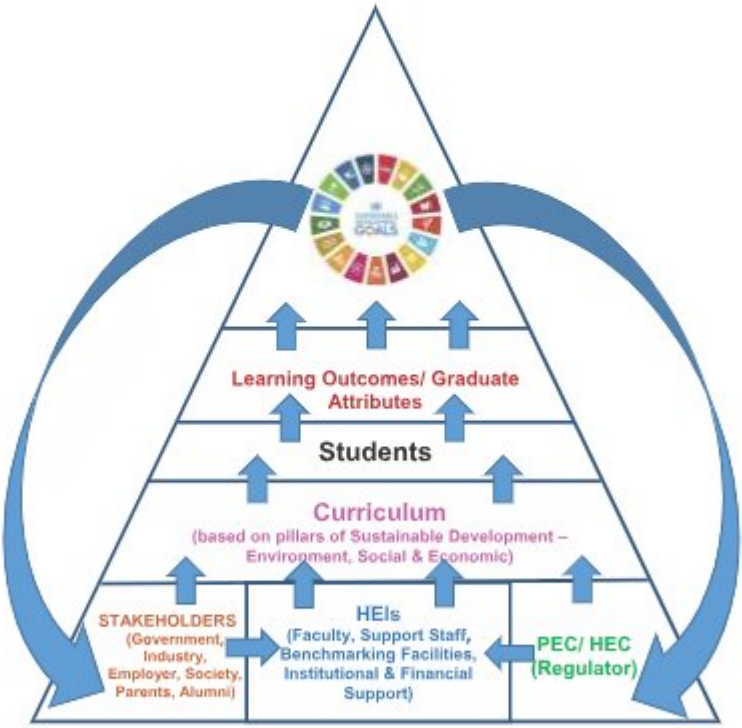
6. Agenda of ECRDC for Chemical and Allied Engineering Disciplines

- 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 conjunction with international commitments (Washington Accord, IPEA etc.) and Government policies/ HEC.
- Review of polices and stakeholders' feedback for the sector(s) relevant to the respective discipline.
- Comparative study of the curricula being offered at various engineering universities/institutions already following the OBE-based system.
- Development and finalization of complete scheme and curriculum for respective discipline including all aspects.

The Convener Engr. Dr. Naveed Ramzan 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 have provided a useful input and suggestions covering new developments to be incorporated in the curriculum. He also highlighted the importance of the field of Chemical Engineering for achieving sustainable developments while addressing socio-economic issues and challenges envisaged in Goal-4 of the Sustainable Development Goals-2030.

- Goal-1: No Poverty
- Goal-2: Zero Hunger
- Goal-3: Good Health and Well-being
- Goal-4: Quality Education
- Goal-5: Gender Equality
- Goal-6: Clean Water and Sanitation
- Goal-7: Affordable and Clean Energy
- Goal-8: Decent Work and Economic Growth
- Goal-9: Industrial Innovation and Infrastructure

- Goal-10: Reduced Inequalities
- Goal-11: Sustainable Cities and Communities
- Goal-12: Responsible Consumption and Production
- Goal-13: Climate Action
- Goal-14: Life Below Water
- Goal-15: Life on Land
- Goal-16: Peace, Justice and Strong Institution
- Goal-17: Partnerships for the Goals



The curriculum therefore has been designed based upon the above SDGs alongside their mapping strategy with program mission, objectives, learning attributes and the scheme of study.

7. Attainment of Graduate Attribute and Professional Competencies

The development of an engineering professional is an ongoing process with important identified stages. The first stage is the attainment of an accredited educational qualification i.e., the graduate stage. The fundamental purpose of engineering education is to build a knowledge base and attributes to enable the graduate to continue learning and to proceed to formative development that will develop the competence required for independent practice. The second stage, following a period of formative development, is professional registration. The fundamental purpose of formative development is to build on the educational base to develop the competencies required for independent practice in which the graduate works with engineering practitioners and progresses from an assisting role to taking more responsibility as an individual and as a team member until competence can be demonstrated at this level required for registration. Once registered, the practitioner must maintain and expand competence.

The baseline for developing the curriculum of engineering program and setting the graduate attributes are the defined set of Knowledge and Attitude Profiles approved by International Engineering Alliance (IEA) in version 4.0.

7.1 Knowledge and Attitude Profile

In order to inculcate different dimensions of thinking mathematical, computational, design and creativeness among students in Cognitive, Psychomotor and Affective domains, the curriculum is designed to cover the following 9x knowledge and attitude profiles. These profiles reflect an indicated volume of learning and the work attitude against which graduates must be able to perform.

- **WK1:** A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.

- **WK2:** Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.

- **WK3:** A systematic, theory-based formulation of engineering fundamentals required in the relevant engineering discipline.

- **WK4:** Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

- **WK5:** Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.

- **WK6:** Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.

- **WK7:** Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development (Represented by the 17 UN Sustainable Development Goals (UN-SDG).

- **Wk8:** Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

- **WK9:** Ethics, inclusive behavior and conduct; Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability, etc. with mutual understanding and respect, and of inclusive attitudes.

7.2 Graduate Attribute Profiles (GAs)/ Program Learning Outcomes (PLOs)

Graduate attributes (GAs) form a set of individually assessable outcomes that are the components indicative of the graduate's potential to acquire competence to practice at the appropriate level. The graduate attributes are exemplars of the attributes expected from a graduate of an accredited program. Graduate attributes are clear, succinct statements of the expected capability, qualified if necessary, by a range indication appropriate to the type of program. The GAs have been revised in version 4.0 of IEA with distinctive change being the merger of GA-6 Engineer

and Society; and GA-7 Environment and Sustainability as the single GA of 'The Engineer and the World'. There are also minor changes in the statements of revised GAs approved as version 4.0 of IEA.

The engineering curriculum is the most important instrument for grooming the students based on 11x Graduate Attributes (GAs) encompassed under the Program Learning Outcomes (PLOs). Program outcomes are the narrower statements that describe what students are expected to know and be able to do at the time of graduation. These PLOs mainly relate to the knowledge, skills and attitudes that students acquire while progressing through the program. Specifically, it is to be demonstrated that the students have acquired the defined GAs. The program must demonstrate that by the time of graduation, the students have attained a certain set of knowledge, skills and behavioral traits, at-least to some acceptable minimum level. This minimum threshold value (i.e., KPI for PLO attainment) should not be less than 50% even to begin with; however, as the program progresses through its evolution, it is expected that this minimum threshold value would subsequently be raised to higher values through program's CQI. Specifically, it is to be demonstrated that all students of a batch to be accredited have acquired the following graduate attributes (GAs) set according to the revised framework of International Engineering Alliance (IEA) version-4.0:

- **PLO-1 Engineering Knowledge:** Apply knowledge of mathematics, natural science, engineering fundamentals and Engineering specialization to the solution of complex engineering problems (WK-1-WK-4).

- **PLO-2 Problem Analysis:** Identify, formulate, conduct research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences (WK-1-WK-4).

- **PLO-3 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 (WK-5).

- **PLO-4 Investigation:** Conduct investigation of complex Engineering problems using research-based knowledge and research methods, including design of experiments, analysis and interpretation of data, and synthesis of

information to provide valid conclusions (WK-8).

- **PLO-5 Tool Usage**: Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex Engineering problems, with an understanding of the limitations (WK-2 and WK-6).

- **PLO-6 The Engineer and the World:** Analyze and evaluate sustainable development impacts to society, the economy, sustainability, health and safety, legal frameworks, and the environment while solving complex engineering problems (WK-1, WK-5, and WK-7).

- **PLO-7 Ethics:** Apply ethical principles and commit to professional ethics and norms of engineering practice and adhere to relevant national and international laws. Demonstrate an understanding of the need for diversity and inclusion (WK-9).

- **PLO-8 Individual and Collaborative Team Work:** Function effectively as an individual, and as a member or leader in diverse and inclusive teams and in multi-disciplinary, face-to-face, remote and distributed settings (WK-9).

- **PLO-9 Communication:** Communicate effectively and inclusively 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, and make effective presentations, taking into account cultural, language, and learning differences (WK-1 and WK-9).

- **PLO-10 Project Management and Finance:** Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, to manage projects in multidisciplinary environments (WK-2 and WK-5).

- **PLO-11 Lifelong Learning:** Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change (WK-8 and WK-9).

The graduate attributes are stated generically and are applicable to all engineering disciplines. In interpreting the statements within a disciplinary context, individual statements may be amplified and given particular emphasis but they must neither be altered in substance nor individual elements ignored. HEI is expected to prepare the PLO mapping with the whole curriculum as per their OBE design.

7.3 Professional Competence Profiles

A professionally or occupationally competent person has the attributes necessary to perform the activities within the profession or occupation to the standards expected in independent employment or practice. The professional competence profiles for each professional category record the elements of competence necessary for performance that the professional is expected to be able to demonstrate in a holistic way at the stage of attaining registration.

Professional competence can be described using a set of attributes corresponding largely to the graduate attributes, but with different emphases. For example, at the professional level, the ability to take responsibility in a real-life situation is essential. Unlike the graduate attributes, professional competence is more than a set of attributes that can be demonstrated individually. Rather, competence must be assessed holistically. Thirteen elements of professional competence as approved by the IEA for global benchmarking are mentioned as follows:

- **EC1 Comprehend and apply universal knowledge:** Comprehend and apply advanced Engineering knowledge of the widely-applied principles underpinning good practices.

- **EC2 Comprehend and apply local knowledge:** Comprehend and apply advanced Engineering knowledge of the widely-applied principles underpinning good practice specific to the jurisdiction of practices.

- **EC3 Problem analysis:** Define, investigate and analyze complex Engineering problems using data and information technologies where applicable.

- **EC4 Design and development of solutions:** Design or develop solutions to complex Engineering problems considering a variety of perspectives and taking account of stakeholder views.

- **EC5 Evaluation:** Evaluate the outcomes and impacts of complex Engineering activities.

- **EC6 Protection of society:** Recognize the foreseeable economic, social, and environmental effects of complex Engineering activities and seek to achieve sustainable outcomes.

- **EC7 Legal, regulatory, and cultural:** Meet all legal, regulatory, and cultural requirements and protect public health and safety in the course of all Engineering activities.

- **EC8 Ethics:** Conduct Engineering activities ethically.

- **EC9 Manage engineering activities:** Manage part or all of one or more complex Engineering activities.

- **EC10 Communication and Collaboration:** Communicate and collaborate using multiple media clearly and inclusively with a broad range of stakeholders in the course of all Engineering activities.

- **EC11 Continuing Professional Development (CPD) and Lifelong learning:** Undertake CPD activities to maintain and extend competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work.

- **EC12 Judgement:** Recognize complexity and assess alternatives in light of competing requirements and incomplete knowledge. Exercise sound judgement in the course of all complex Engineering activities.

- **EC13 Responsibility for decisions:** Be responsible for making decisions on part or all of the complex Engineering activities.

The professional competence profiles are stated generically and are applicable to all engineering disciplines. The application of a competence profile may require amplification in different regulatory, disciplinary, occupational or environmental contexts. In interpreting the statements within a particular context, individual statements may be amplified and given particular emphasis but must not be altered in substance or ignored.

8. Mapping of Bachelors of Engineering Program with UN SDGs

The Engineering Programs are vital for achieving the sustainable development while addressing socio-economic issues and challenges envisaged in United Nation's Sustainable Development Goals i.e. UN SDGs (Figure 1) as under;

Figure 1: United Nation's Sustainable Development Goals (UN SDGs)

Therefore, the UN SDGs have been considered in curriculum design (Figure 2). The Bachelors of Engineering Program may be mapped with the UN SDGs keeping in mind its curriculum, other pre-requisites (if any) e.g. survey camp, internship, community service etc., co- and extra- curricular activities as well as theHEI's charter (having emphasis on the particular program). The mapping can be done (through the key phrases in SDGs) on the basis of low, medium and/or high emphasis as well as direct/indirect relevance. The non-exhausted list of considered key phrases of UN SDGs for the purpose of mapping is available in Annexure A (Note: HEI may get it shortened or lengthened as per the need of the respective engineering program). The purpose of emphasizing the SDGs is to (i) join hands with the Provincial/Federal government in playing their effective role from HEI point of view and (ii) to educate/aware the student population about the challenges of the world to be overcome in their professional careers with the help of these UN SDGs. For mapping with curriculum, mapping may be targeted through course description, objectives, learning outcomes, course contents and/or class activities. Similarly, other pre-requites can be mapped. For mapping of co-

and extra- curricular activities, the nature of activities may be designed keeping in mind the relevant SDGs. For mapping of HEI's charter (having emphasis on the particular program) with the SDGs, the vision and mission of the HEI may be considered.

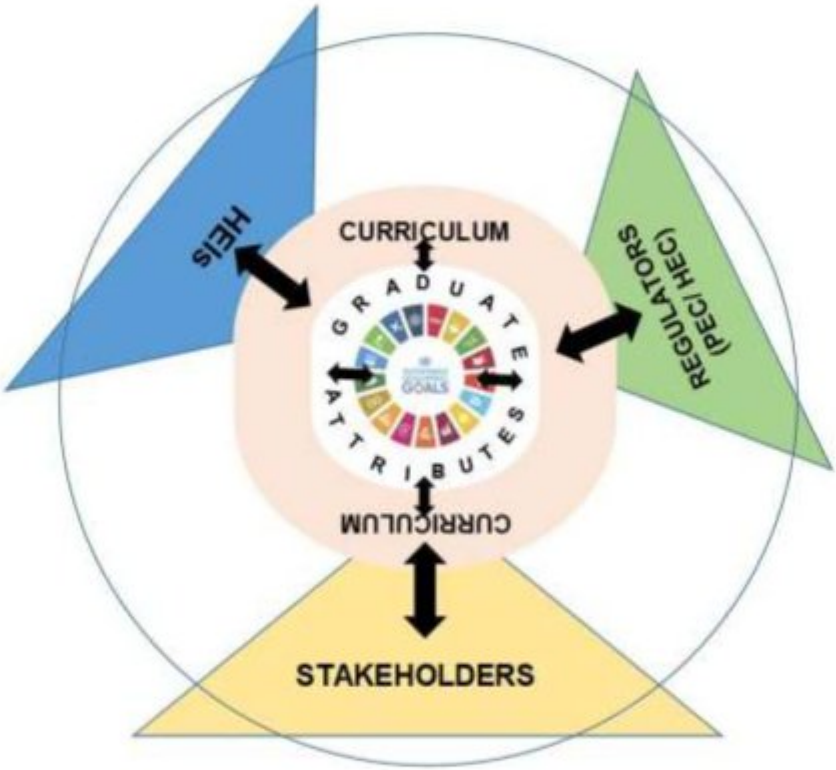


Figure 2: Consideration of UN SDGs in curriculum design

The following template may be adopted for the mapping of the bachelors of engineering program with the United Nation's Sustainable Development Goals (UN SDGs):

Ser	Description	UN SDGs																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	HEI vision and mission with focus on specific engineering program																	
2	Bachelor of Engineering Curriculum (Engg. & Non-Engg. Courses)																	
3	Final Year Design Project (FYDP)																	
4	Other pre-requisite activities (Internship, Community service, Survey camp, etc)																	
5	Co- and Extra-Curricular Activities																	

Note: The ticks "√" may be placed in cells where mapping is being considered by the HEI.

As an example, a non engineering course (Sociology for Engineers) has been mapped with the UN SDGs for the guidance purpose (Annexure B) and included in course outline section. HEI is expected to design the mapping considering the defined strategy.

9. Correlation Matrix PLOs-ECs-WKs-SDGs

A correlation matrix has been established to link Program Learning Outcomes (PLOs) with the corresponding engineering competencies, knowledge and attitude profiles, as well as the targeted UN Sustainable Development Goals (SDGs) by 2030. This mapping has been developed in accordance with the revised definitions of Graduate Attributes and Professional Competences (GAPCs) approved in version 4.0 of the International Engineering Alliance (IEA).

PLOs	ECs **	WKs	SDGs (Proposed)
PLO-1 **Engineering Knowledge:** Breadth, depth and type of knowledge, both theoretical and practical	**EC-1** **Comprehend and apply universal knowledge** **& EC-2** **Comprehend and apply local knowledge**	(WK-1, WK-2, WK-3 & WK-4) **WK-1** **Natural sciences** and awareness of relevant **social sciences** **WK-2** **Mathematics & computing** **WK-3** **Engineering fundamentals** **WK-4** **Engineering specialist knowledge**	SDG-9
PLO-2 **Problem Analysis**: Complexity of analysis	**EC-3** **Problem analysis**	(WK-1, WK-2, WK-3 &WK-4) **WK-1** **Natural sciences** and awareness of relevant **social sciences** **WK-2** **Mathematics & computing** **WK-3** **Engineering fundamentals** **WK-4** **Engineering specialist knowledge**	Selected SDGs from SDG-1 to 17 (relevance as per curriculum)
PLO-3 **Design/Development of Solutions:** Breadth and uniqueness of engineering problems i.e., the extent to which problems are original and to which solutions have not previously been identified or codified	**EC-4** **Design and development of solutions**	**WK-5** **Engineeringdesign and operations**	SDG-1, 2, 3, 6, 10, 11, 12, 13, 14 (relevance as per curriculum)

PLO-4 **Investigation:** Breadth and depth of investigation and experimentation	**EC-5** **Evaluation**	**WK-8** **Research literature**	SDG-9
PLO-5 **Tool Usage:** Level of understanding of the appropriateness of technologies andtools	**EC-3** **Problem analysis** **& EC-5** **Evaluation**	(WK-2 & WK-6) **WK-2** **Mathematics & computing** **& WK-6** **Engineering practice**	SDG-9
PLO-6 **The Engineer and the World:** Level of knowledge and responsibility for sustainable development	**EC-6** **Protection of society** **& EC-7** **Legal, regulatory, and cultural**	(WK-1, WK-5 & WK-7) **WK1** **Natural sciences** and awareness of relevant **social sciences** **WK-5** **Engineeringdesign and operations** **& WK7** **Engineering in Society**	Selected SDGs from SDG - 1 to 17 (relevance as per curriculum)
PLO-7 **Ethics:** Understanding and level of practice	**EC-8** **Ethics:** No differentiation in this characteristic	**WK-9** **Ethics, inclusive behavior and conduct**	SDG- 5, 10, 16
PLO-8 **Individual and Collaborative Team work:** Role inand diversity of team	**EC-10** **Communication and Collaboration**	**WK-9** **Ethics, inclusive behavior and conduct**	SDG- 5, 10, 16
PLO-9 **Communication:** Level of communication according to type of activities performed	**EC-10** **Communication and Collaboration**	(WK-1 & WK-9) **WK-1** **Natural sciences and awareness of relevant social sciences** **& WK-9** **Ethics, inclusive behavior and conduct**	SDG- 5, 10, 16

PLO-10 **Project Management and Finance:** Level of management required for differing types of activity	**EC-9** **Manage engineering activities**	(WK-2 & WK-5) **WK-2** **Mathematics & computing** **& WK-5** **Engineering** **design and operations**	SDG-9
PLO-11 **Lifelong Learning:** Duration and manner	**EC-11** **Continuing Professional Development (CPD) and lifelong learning** **EC-12** **Judgement** **EC-13** **Responsibility for decisions**	**WK-8** **Research literature**	SDG-9, 13

** Engineering Competencies (ECs) are expected to be demonstrated by graduates during their practical experiences, which have been mapped with PLOs to reflect integration in the designed curriculum.

The relationship matrix has been generically designed as a guiding framework for HEIs and is applicable to all engineering disciplines. When interpreting the matrix within a specific context, revisions or amplifications may be incorporated to highlight particular emphasis or compliance with rationalized program requirements.

10. 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
    - o General Education for Engineering Discipline: Minimum 38 Credit Hours
    - o Engineering Domain (including computer courses, foundation, breadth, depth/major courses): Minimum 72 Credit Hours
    - o FYDP/ Capstone Project: 06 Credit Hours
    - o Multidisciplinary Engineering/Specialty Courses: Minimum 06 Credit Hours
    - o HEIs have flexibility of 8-14 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.
- **Number of Weeks per Semester:** 15 - 18
- **Number of Credit Hours per Semester:** 15 - 18

The curriculum matrix covering the defined knowledge and attitude profiles should therefore be composed of non-engineering domain (humanities, math, management and natural sciences), and engineering domain with Chemical Engineering, 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. The knowledge areas of Non-Engineering and Engineering domains have been broadly mapped with 11x PLOs and 9x WKs using the guiding framework of IEA version 4.0 in the following table:

Knowledge Profile (WK-1 to WK-9)	Knowledge Area	Sub-Area	Courses	Credit Hours
General Education/ Non-Engineering Domain				
WK-1/ WK-2	**Natural Sciences**	Math	As per program requirements	12-15
		Physics	***Applied Physics	3-9
		Chemistry	***Applied Chemistry	
		Natural Science/ Math Elective	*** Math Elective	
WK-1/ WK-5/ WK-7/ WK-9	**Humanities**	English	**Functional English	3
			** Expository Writing	3
		Culture	** Islamic Studies or Ethics	2
			**Ideology & constitution of Pakistan	2
			*Arts & Humanities Elective (Languages or study of religion)	2
		Social Science	***Social Science Elective	2
			** Civics and Community Engagement	2
	Management Sciences	Professional Practice	***Project Management	2
			**Entrepreneurship	2
	Computer Sciences	Basic Computing	**Applications of ICT	3

Engineering Domain				
Knowledge Profile (WK-1 to WK-9)	**Knowledge Area**	**Sub-Area**	**Courses**	**Credit Hours**
WK-2/ WK-4/ WK-5/	Advanced Computer and Information Science(s)	ICT/AI/ Data Science/ Cyber Security		6-9
WK-2/ WK-3	Foundation Engg Courses		Specific to Program Objectives and outcome	22-24
WK-1/ WK-2/ WK-4	Core Breadth of Engg Disciplines		Specific to Program Objectives and outcome	22-24
WK-5/ WK-6	Core Depth of Engg Disciplines		Specific to Program Objectives and outcome	22-24
				Min 72
WK-1/ WK-2/ WK-3/ WK-4/ WK-7/ WK-9	Multi disciplinary Engg Courses		Specific to Program Objectives and outcome Occupational Health and Safety (Mandatory 01 credit hours)	6
WK-4/ WK-5/ WK-6/ WK-7/ WK-8/ WK-9	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/ WK-9	Industrial Training	Internship (06-08 Weeks)		Mandatory & Qualifying

WK-2/ WK-4/ WK-5/ WK-6/ WK-7/ WK-8	**Innovative and Critical Thinking (under relevant courses):** - Complex Problem Solving - Complex Engineering Activities - Semester Project - Case Studies - Open Ended Labs - Problem-Based Learning (PBL)	
	(Flexible Engineering/ Non-Engineering) Courses may be adjusted as per the requirements	8-14
	Total (Credit Hours)	**130-136**

Note: * University may offer any course within the specific broader subject domain/ cluster to meet the given credits.
** HEC designed model courses may be used by the university.
*** PEC ECRDC designed courses.

- **Industrial Training:** Internship of at least 6 - 8 weeks is a mandatory part of degree requirements to be carried out during 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 outcomes. The assessment phase should focus about;
  - Selection of internship inline with elective subjects/ specific streams
  - Qualifying weightage: 70%
    - 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 of infrastructure, 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 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 towards its overall implementation are the key factors for ensuring

the attainment of program objectives. The faculty is expected to have the ability to ensure proper implementation of the program, and develop processes for evaluation, assessment and CQI. A formal training program to groom the faculty should be instituted so as they 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 as it 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 department to formulate their own programs according to the industrial needs, emerging trends and recent developments in the field of Chemical Engineering. The HEIs have flexibility to incorporate changes in the proposed curriculum within given range of credit hours for engineering and non-engineering domain.

11. Framework for Bachelor of Chemical Engineering Curriculum

Knowledge Profile (WK-1 to WK-9)	Knowledge Area	Sub Area	Course Title	Theory	Lab	Credit Hours	Total
General Education Domain/ Non-Engineering Domain							
WK-1/ WK-5/ WK-7/ WK-9	**Humanities**	English	Functional English **	3	0	3	6
			Expository Writing **	3	0	3	
		Culture	Ideology and Constitution of Pakistan **	2	0	2	6
			Islamic Studies/ Ethics**	2	0	2	
			Arts & Humanities Elective*	2	0	2	
		Social Sciences	Social Science Elective***	2	0	2	4
			Civics & Community Engagements **	2	0	2	
	Management Sciences	Professional Practice	Project Management ***	2	0	2	4
			Entrepreneurship **	2	0	2	
	Computer Sciences	Basic Computing	Applications of ICT **	2	1	3	3
WK-1/ WK-2	**Natural Sciences**	Mathematics	Quantitative Reasoning-I**	3	0	3	6
			Quantitative Reasoning-II**	3	0	3	
			Calculus & Analytical Geometry	3	0	3	6
			Linear Algebra & Differential Equations	3	0	3	
		Chemistry	Inorganic & Organic Chemistry	2	1	3	6
		Physics	Applied Physics***	2	1	3	
Total (General Education Domain/ Non-Engineering Domain)							**41**

Note: * University may offer any course within the specific broader subject domain/ cluster to meet the given credits.

** HEC designed model courses may be used by the university.

*** PEC ECRDC designed courses.

Engineering Domain							
Knowledge Profile (WK-1 to WK-8)	**Knowledge Area**	**Sub Area**	**Course Title**	**Theory**	**Lab**	**Credit Hours**	**Total**
WK-2 WK-4 WK-5 WK-6	Advanced Computer and Information Science(s)	ICT/AI/ Data Science/ Cyber Security	Programming and Data Science	2	1	3	6
			Numerical Methods with Software Application	2	1	3	
WK-2/ WK-3	Engineering Foundation Courses		Chemical Engineering Thermodynamics-I	2	1	3	22
			Engineering Drawing & Graphics	0	1	1	
			Mass Transfer	3	1	4	
			Chemical Process Industries	3	0	3	
			Fluid Mechanics-I	2	1	3	
			Heat Transfer	3	1	4	
			Chemical Engineering Principles-I	2	0	2	
			Chemical Engineering Principles-II	2	0	2	
WK-1 WK-2 WK-4	Engineering Breadth Courses		Instrumentation and Process Control	3	1	4	24
			Fluid Mechanics-II	2	0	2	
			Transport Phenomena	3	0	3	
			Particulate Technology	3	1	4	
			Integrated Management Systems	3	0	3	
			Fuels & Energy	2	1	3	
			Chemical Engineering Thermodynamics- II	2	0	2	
			Environmental Engineering	2	1	3	

WK-5 WK-6	Major Based Core (Depth)		Elective-I	2	0	2	22
			Elective-II	2	0	2	
			Elective-III	2	0	2	
			Separation Processes	3	1	4	
			Chemical Reaction Engineering	3	1	4	
			Process Modelling, Simulation and Optimization	3	1	4	
			Chemical Plant Design	3	0	3	
			Chemical Process Safety	1	0	1	
WK-1/ WK-2/ WK-3/ WK-4	Multi-Disciplinary Engineering Breadth		Workshop Practices	0	1	1	4
			Engineering Materials	2	0	2	
			Occupational Health & Safety	1	0	1	
WK-6 WK-7/ WK-8	Final Year Design Project (FYDP)		FYDP Part-I	0	3	3	6
			FYDP Part-II	0	3	3	
WK-6 WK-7	Industrial Training	6-8 weeks industrial training (Non-Credit)				**Mandatory & Qualifying**	
Total (Engineering Domain)						**84**	
WK-1/ WK-2 WK-3 WK-4	Flexible (Engineering/ Non-Engineering) Courses		Probability & Statistics	3	0	3	11
			Physical & Analytical Chemistry	2	1	3	
			Maintenance & Utility Engineering	2	0	2	
			Applied Electrical Engineering	2	1	3	
Total (Flexible Courses)							**11**
Total (Credit Hours)							**136**

Note: Quran Translation (QT) Credits will be allowed as over and above 136 Cr. Hrs.

12. Scheme of Study for Bachelor of Chemical Engineering

1st Year				
First Semester				
S. No.	**Course Title**	**(Credit Hours)**		**Total**
		Theory	**Lab**	**Cr. Hrs.**
1	Functional English	3	0	3
2	Islamic Studies/ Ethics	2	0	2
3	Chemical Engg Principles-I	2	0	2
4	Engineering Drawing and Graphics	0	1	1
5	Inorganic & Organic Chemistry	2	1	3
6	Calculus & Analytical Geometry	3	0	3
7	Application of Information and Communication Technology	2	1	3
	Total	**14**	**3**	**17**
Second Semester				
S. No.	**Course Title**	**(Credit Hours)**		**Total**
		Theory	**Lab**	**Cr. Hrs.**
1	Physical and Analytical Chemistry	2	1	3
2	Ideology and Constitution of Pakistan	2	0	2
3	Applied Physics	2	1	3
4	Quantitative Reasoning -I	3	0	3
5	Expository Writing	3	0	3
6	Workshop Practice	0	1	1
7	Chemical Process Industries	3	0	3
	Total	**15**	**3**	**18**

2nd Year				
Third Semester				
S. No.	**Course Title**	**(Credit Hours)**		**Total Cr. Hrs.**
		Theory	**Lab**	
1	Linear Algebra & Differential Equation	3	0	3
2	Chemical Engg Principles-II	2	0	2
3	Chemical Engineering Thermodynamics-I	2	1	3
4	Engineering Materials	2	0	2
5	Fluid Mechanics-I	2	1	3
6	Programming and Data Science	2	1	3
7	Civic and Community Engagement	2	0	2
	Total	**15**	**3**	**18**
Fourth Semester				
S. No.	**Course Title**	**(Credit Hours)**		**Total Cr. Hrs.**
		Theory	**Lab**	
1	Quantitative Reasoning -II	3	0	3
2	Chemical Engineering Thermodynamics-II	2	0	2
3	Heat Transfer	3	1	4
4	Particulate Technology	3	1	4
5	Arts & Humanities Elective *	2	0	2
6	Occupational Health and Safety (OSH)	1	0	1
7	Social Science Elective **	2	0	2
	Total	**16**	**2**	**18**

3rd Year				
Fifth Semester				
S. No.	**Course Title**	**(Credit Hours)**		**Total Cr. Hrs.**
		Theory	**Lab**	
1	Mass Transfer	3	1	4
2	Fuels & Energy	2	1	3
3	Fluid Mechanics II	2	0	2
4	Applied Electrical Engineering	2	1	3
5	Numerical Methods with Software Application	2	1	3
6	Transport Phenomena	3	0	3
	Total	**14**	**4**	**18**
Sixth Semester				
S. No.	**Course Title**	**(Credit Hours)**		**Total Cr. Hrs.**
		Theory	**Lab**	
1	Instrumentation & Process Control	3	1	4
2	Chemical Reaction Engineering	3	1	4
3	Integrated Management System (IMS)	3	0	3
4	Environmental Engineering	2	1	3
5	Probability & Statistics	2	0	2
	Total	**13**	**3**	**16**

Final Year				
Seven Semester				
S. No.	**Course Title**	**(Credit Hours)**		**Total**
		Theory	**Lab**	**Cr. Hrs.**
1	Separation Processes	3	1	4
2	Project Management	2	0	2
3	Chemical Plant Design	3	0	3
4	Depth Elective-I ***	2	0	2
5	Process Modelling, Simulation and Optimization	3	1	4
6	FYDP (Part-I)	0	3	3
	Total	**13**	**5**	**18**
Eight Semester				
S. No.	**Course Title**	**(Credit Hours)**		**Total**
		Theory	**Lab**	**Cr. Hrs.**
1	Entrepreneurship	2	0	2
2	Depth Elective-II ***	2	0	2
3	Depth Elective-III ***	2	0	2
4	Chemical Process Safety	1	0	1
5	Maintenance & Utility Engineering	3	0	3
6	FYDP (Part-II)	0	3	3
	Total	**10**	**3**	**13**

* List of Arts and Humanities Electives (2+0)	** List of Social Science Electives (2+0)
• Communication and Presentation Skills • Beginners Spanish • Elementary Arabic • Elementary French • Elementary Chinese • History • Philosophy • Professional Ethics • Any other relevant course / language decided by the HEI as per requirement.	• Sociology for Engineers • Sociology • Social phycology • Critical Thinking • Human Resource Management • Organizational Behavior • Engineering Law • Engineering Economics • Any other relevant course decided by the HEI as per requirement.

*** Proposed Streams / Electives for Chemical Engineering (2+0)		
A - Chemical Engineering	**B - Design Engineering**	**C - Oil & Gas Engineering**
A-1: Polymer Engineering **A-2:** Novel Separation Processes **A-3:** Mineral Processing Technology **A-4:** Nanotechnology Engineering **A-5:** Chemical process design and Simulation **A-6:** Industrial Safety and Hazardous Waste Management	**B-1:** Computational Fluid Dynamics (CFD) **B-2:** Experimental Design and Data Analytics **B-3:** Advanced Machine learning technology **B-4:** Operation Management and Risk Assessment	**C-1:** Petroleum Refinery Engineering **C-2:** Gas Processing & Transmission **C-3:** Petrochemical Engineering **C-4:** Fuel and energy Management **C-5:** Advanced Fuel Technology **C-6:** Drilling Engineering **C-7:** Natural Gas Processing & Pipeline Management **C-8:** Field Operations and Production **C-9:** Reservoir Engineering Management **C-10:** Principles of Enhanced Oil Recovery

*** Proposed Streams / Electives for Chemical Engineering (2+0)		
D - Biochemical Engineering	**E - Green Engineering**	**F - Nuclear Engineering**
D-1: Biochemical Engineering **D-2:** Biochemical Operation and Kinetics **D-3:** Bio-Separations **D-4:** Biomaterials Engineering **D-5:** Bioreactor Design **D-6:** Biofuels and Biorefineries **D-7**: Biochemical Treatment of Wastes	**E-1:** Green Technologies & sustainable Development **E-2:** Industrial Ecology **E-3:** Environment Impact Assessment **E-4:** Sustainability in Process & Energy Systems	**F-1:** Introduction to Nuclear Engineering **F-2:** Nuclear Physics & Reactor Theory **F-3:** Nuclear Materials & Fuels **F-4:** Radiation detection and measurement **F-5:** Nuclear Waste Assessment & Management

*** Proposed Streams / Electives for Chemical Engineering (2+0)		
G - Process Engineering	**H - Energetic Materials**	**I - Energy & Power**
G-1: Chemical Process Design, Analysis and Optimization **G-2:** Chemical Wet Processing of Textiles **G-3:** Food Processing Engineering **G-4:** Advanced Process Control **G-5:** Computer-Aided Process Synthesis **G-6:** Process Intensification **G-7:** Advanced Process Safety	**H-1:** Thermodynamics of energetic Materials **H-2:** Material Characterization techniques **H-3:** Polymer & composites **H-4:** Alloy Processing and Characterization **H-5:** Corrosion Engineering **H-6:** Computer Aided Design and Manufacturing	**I-1:** Industrial Energy Systems **I-2:** Energy Auditing and Management **I-3:** Fuel Cell, and Sustainable Energy Technologies **I-4:** Internal Combustion Engines **I-5:** Clean Coal Technology and Co-Generation **I-6:** Combustion Engineering

Note: New area/subjects can also be included according to the specialization/availability of the faculty and facilities besides need of the market.

13. Program Specific Labs

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

1. Heat Transfer Lab
2. Mass Transfer Lab
3. Fluid Mechanics Lab
4. Particulate Technology Lab
5. Fuels and Combustion Lab
6. Environmental Engineering Lab
7. Chemical Engineering Thermodynamics Lab
8. Instrumentation and Control Lab
9. Chemical Reaction Engineering Lab
10. Physical and Analytical Chemistry Lab

- ***"Labs/ Practical: The course practical/ labs should be defined and synchronized with the course outline (Theory part)."***

- ***"All safety protocols, manuals and log books etc. should be maintained and complied by each lab."***

14. Courses Details and Teaching-Assessment Approaches

In the following sections, Course Outlines 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.

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

Further, assessment may be carried out through Mid Term, Report writing/ Presentation, Assignments, Term Project, Quizzes and Final Term Exam etc.

14.1 Non-Engineering Domain

FUNCTIONAL ENGLISH

UGE Policy V1.1: General Education Course

Credits: 03
Pre-Requisite: Nil

DESCRIPTION

This course is designed to equip students with essential language skills for effective communication in diverse real-world scenarios. It focuses on developing proficiency in English language usage: word choices, grammar and sentence structure. In addition, the course will enable students to grasp nuanced messages and tailor their communication effectively through application of comprehension and analytical skills in listening and reading. Moreover, the course encompasses a range of practical communication aspects including professional writing, public speaking, and everyday conversation, ensuring that students are equipped for both academic and professional spheres. An integral part of the course is fostering a deeper understanding of the impact of language on diverse audiences. Students will learn to communicate inclusively and display a strong commitment to cultural awareness in their language use. Additionally, the course will enable them to navigate the globalized world with ease and efficacy, making a positive impact in their functional interactions.

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Apply enhanced English communication skills through effective use of word choices, grammar and sentence structure.
2. Comprehend a variety of literary / non-literary written and spoken texts in English.
3. Effectively express information, ideas and opinions in written and spoken English.
4. Recognize inter-cultural variations in the use of English language and to effectively adapt their communication style and content based on diverse cultural and social contexts.

COURSE OUTLINE

1. **Foundations of Functional English:**
   - Vocabulary building (contextual usage, synonyms, antonyms and idiomatic expressions)
   - Communicative grammar (subject-verb-agreement, verb tenses, fragments, run-ons, modifiers, articles, word classes, etc.)

- Word formation (affixation, compounding, clipping, back formation, etc.)
- Sentence structure (simple, compound, complex and compound-complex)
- Sound production and pronunciation.

2. **Comprehension and Analysis:**
   - Understanding purpose, audience and context.
   - Contextual interpretation (tones, biases, stereotypes, assumptions, inferences, etc.).
   - Reading strategies (skimming, scanning, SQ4R, critical reading, etc.).
   - Active listening (overcoming listening barriers, focused listening, etc.).
3. **Effective Communication:**
   - Principles of communication (clarity, coherence, conciseness, courteousness, correctness, etc.).
   - Structuring documents (introduction, body, conclusion and formatting).
   - Inclusivity in communication (gender-neutral language, stereotypes, cross-cultural communication, etc.).
   - Public speaking (overcoming stage fright, voice modulation and body language).
   - Presentation skills (organization content, visual aids and engaging the audience).
   - Informal communication (small talk, networking and conversational skills).
   - Professional writing (business e-mails, memos, reports, formal letters, etc.).

PRACTICAL REQUIREMENT

As part of the overall learning requirements, students will also be exposed to relevant simulations, role-plays and real-life scenarios and will be required to apply skills acquired throughout the course in the form of a final project.

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. "Understanding and Using English Grammar" by Betty Schrampfer Azar.
2. "English Grammar in Use" by Raymond Murphy.
3. "The Blue Book of Grammar and Punctuation" by Jane Straus.
4. "English for Specific Purposes: A Learning-Centered Approach" by Tom Hutchinson and Alan Waters.
5. "Cambridge English for Job-hunting" by Colm Downes.
6. "Practical English Usage" by Michael Swan.

7. "Reading Literature and Writing Argument" by Missy James and Alan P. Merickel.
8. "Improving Reading: Strategies, Resources, and Common Core Connections" by Jerry Johns and Susan Lenski.
9. "Comprehension: A Paradigm for Cognition" by Walter Kintsch.
10. “Communication Skills for Business Professionals” by J.P Verma and Meenakshi Raman.

EXPOSITORY WRITING

UGE Policy V1.1: General Education Course

Credits: 03
Pre-Requisite: Functional English

DESCRIPTION

Expository Writing is a sequential undergraduate course aimed at refining writing skills in various contexts. Building upon the foundation of the pre-requisite course, Functional English, this course will enhance students' abilities of producing clear, concise and coherent written texts in English. The course will also enable students to dissect intricate ideas, to amalgamate information and to express their views and opinions through well-organized essays. The students will further be able to refine their analytical skills to substantiate their viewpoints using credible sources while adhering to established ethical writing norms. Additionally, the course will highlight the significance of critical thinking enabling students to produce original and engaging written texts.

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Understand the essentials of the writing process integrating pre-writing, drafting, editing and proof reading to produce well-structured essays.
2. Demonstrate mastery of diverse expository types to address different purposes and audiences.
3. Uphold ethical practices to maintain originality in expository writing.

COURSE OUTLINE

1. **Introduction to Expository Writing:**
   - Understanding expository writing (definition, types, purpose and applications)
   - Characteristics of effective expository writing (clarity, coherence and organization)
   - Introduction to paragraph writing
2. **The Writing Process:**
   - Pre-writing techniques (brainstorming, free-writing, mind-mapping, listing, questioning and outlining etc.)
   - Drafting (three stage process of drafting techniques)
   - Revising and editing (ensuring correct grammar, clarity, coherence, conciseness etc.)
   - Proof reading (fine-tuning of the draft)

- Peer review and feedback (providing and receiving critique)

3. **Essay Organization and Structure:**
   - Introduction and hook (engaging readers and introducing the topic)
   - Thesis statement (crafting a clear and focused central idea)
   - Body Paragraphs (topic sentences, supporting evidence and transitional devices)
   - Conclusion (types of concluding paragraphs and leaving an impact)
   - Ensuring cohesion and coherence (creating seamless connections between paragraphs)
4. **Different Types of Expository Writing:**
   - Description
   - Illustration
   - Classification
   - Cause and effect (exploring causal relationships and outcomes)
   - Process analysis (explaining step-by-step procedures)
   - Comparative analysis (analyzing similarities and differences)
5. **Writing for Specific Purposes and Audiences:**
   - Different types of purposes (to inform, to analyze, to persuade, to entertain etc.)
   - Writing for academic audiences (formality, objectivity, and academic conventions)
   - Writing for public audiences (engaging, informative and persuasive language)
   - Different tones and styles for specific purposes and audiences
6. **Ethical Considerations:**
   - Ensuring original writing (finding credible sources, evaluating information etc.)
   - Proper citation and referencing (APA, MLA, or other citation styles)
   - Integrating quotes and evidences (quoting, paraphrasing, and summarizing)
   - Avoiding plagiarism (ethical considerations and best practices)

PRACTICAL APLICATIONS AND CAPSTONE PROJECT

As part of the overall learning requirements, students will be required to build a writing portfolio having a variety of expository texts and present the same at the end of the course showcasing proficiency in expository writing.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. "The St. Martin's Guide to Writing" by Rise B. Axelrod and Charles R. Cooper.

2. "They Say / I Say: The Moves That Matter in Academic Writing" by Gerald Graff and Cathy Birkenstein.
3. "Writing Analytically" by David Rosenwasser and Jill Stephen.
4. "Style: Lessons in Clarity and Grace" by Joseph M. Williams and Joseph Bizup.
5. "The Elements of Style" by William Strunk Jr. and E.B. White.
6. "Good Reasons with Contemporary Arguments" by Lester Faigley and Jack Selzer.
7. "Writing to Learn: How to Write - and Think - Clearly About Any Subject at All" by William Zinsser.
8. "The Norton Field Guide to Writing" by Richard Bullock, Maureen Daly Goggin, and Francine Weinberg.
9. "The Art of Styling Sentences" by Ann Longknife and K.D. Sullivan.
10. "Writing Today" by Richard Johnson-Sheehan and Charles Paine

IDEOLOGY AND CONSTITUTION OF PAKISTAN

UGE Policy V1.1: General Education Course

Credits: 02
Pre-Requisite: Nil

DESCRIPTION

This course is designed to provide students with a fundamental exploration of the ideology and the constitution of Pakistan. The course focuses on the underlying principles, beliefs, and aspirations that have been instrumental in shaping the creation and development of Pakistan as a sovereign state. Moreover, the course will enable students to understand the core provisions of the Constitution of the Islamic Republic of Pakistan concerning the fundamental rights and responsibilities of Pakistani citizens to enable them function in a socially responsible manner.

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Demonstrate enhanced knowledge of the basis of the ideology of Pakistan with special reference to the contributions of the founding fathers of Pakistan.
2. Demonstrate fundamental knowledge about the Constitution of Pakistan 1973 and its evolution with special reference to state structure.
3. Explain about the guiding principles on rights and responsibilities of Pakistani citizens as enshrined in the Constitution of Pakistan 1973.

COURSE OUTLINE

1. **Introduction to the Ideology of Pakistan:**
   - Definition and significance of ideology.
   - Historical context of the creation of Pakistan (with emphasis on socio-political, religious, and cultural dynamics of British India between 1857 till 1947).
   - Contributions of founding fathers of Pakistan in the freedom movement including but not limited to Allama Muhammad Iqbal, Muhammad Ali Jinnah., etc.
   - Contributions of women and students in the freedom movement for separate homeland for Muslims of British India.
2. **Two-Nation Theory:**
   - Evolution of the Two-Nation Theory (Urdu-Hindi controversy, Partition of Bengal, Simla Deputation 1906, Allama Iqbal's Presidential Address 1930, Congress Ministries 1937, Lahore Resolution 1940).

- Role of communalism and religious differences.

3. **Introduction to the Constitution of Pakistan:**
   - Definition and importance of a constitution.
   - Ideological factors that shaped the Constitution(s) of Pakistan (Objectives Resolution 1949).
   - Overview of constitutional developments in Pakistan.
4. **Constitution and State Structure:**
   - Structure of Government (executive, legislature, and judiciary).
   - Distribution of powers between federal and provincial governments.
   - 18th Amendment and its impact on federalism.
5. **Fundamental Rights, Principles of Policy and Responsibilities:**
   - Overview of fundamental rights guaranteed to citizens by the Constitution of Pakistan 1973 (Articles 8-28).
   - Overview of Principles of Policy (Articles 29-40).
   - Responsibilities of the Pakistani citizens (Article 5).
6. **Constitutional Amendments:**
   - Procedures for amending the Constitution.
   - Notable constitutional amendments and their implications.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. "The Idea of Pakistan" by Stephen P. Cohen.
2. "Ideology of Pakistan" by Javed Iqbal.
3. "The Struggle for Pakistan" by I.H. Qureshi.
4. "Pakistan the Formative Phase" by Khalid Bin Sayeed.
5. "Pakistan: Political Roots and Development" by Safdar Mahmood.
6. "Ideology of Pakistan" by Sharif-ul-Mujahid.
7. "The Struggle for Pakistan: A Muslim Homeland and Global Politics" by Ayesha Jalal.
8. "Jinnah, Pakistan and Islamic Identity: The Search for Saladin" by Akbar S. Ahmed.
9. "The Making of Pakistan: A Study in Nationalism" by K.K. Aziz.
10. "Pakistan: A New History" by Ian Talbot.
11. "Pakistan in the Twentieth Century: A Political History" by Lawrence Ziring.
12. "The Constitution of Pakistan 1973". Original.
13. "Constitutional and Political Development of Pakistan" by Hamid Khan.
14. "The Parliament of Pakistan" by Mahboob Hussain.
15. "Constitutional Development in Pakistan " by G.W. Choudhury.
16. "Constitution-Making in Pakistan: The Dynamics of Political Order" by G.W. Choudhury.

ISLAMIC STUDIES

UGE Policy V1.1: General Education Course

Credits: 02
Pre-Requisite: Nil

DESCRIPTION

This course is designed to provide students with a comprehensive overview of the fundamental aspects of Islam, its beliefs, practices, history and influence on society. It will further familiarize students with a solid foundation in understanding the religion of Islam from an academic and cultural perspective. Through this course, students will have an enhanced understanding of Islam's multifaceted dimensions which will enable them to navigate complex discussions about Islam's historical and contemporary role, fostering empathy, respect, and informed dialogue.

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Demonstrate enhanced knowledge of Islamic foundational beliefs, practices, historical development, spiritual values and ethical principles.
2. Describe basic sources of Islamic law and their application in daily life.
3. Identify and discuss contemporary issues within the Muslim world including social challenges, gender roles and interfaith interactions.

COURSE OUTLINE

1. **Introduction to Islam:**
   - Definition of Islam and its core beliefs.
   - The Holy Quran (introduction, revelation and compilation).
   - Hadith and Sunnah (compilation, classification, and significance).
   - Key theological concepts and themes (Tawhid, Prophethood, Akhirah etc.).
2. **Sirah of the Holy Prophet (Peace Be Upon Him) as Uswa-i-Hasana:**
   - Life and legacy of the Holy Prophet PBUH
   - Diverse roles of the Holy Prophet PBUH (as an individual, educator, peace maker, leader etc.)
3. **Islamic History and Civilization:**
   - World before Islam.
   - The Rashidun Caliphate and expansion of Islamic rule.
   - Muslims contributions to philosophy, science, medicine, mathematics, and culture.

4. **Islamic Jurisprudence (Fiqh):**
   - Fundamental sources of Islamic jurisprudence.
   - Pillars of Islam and their significance.
   - Major schools of Islamic jurisprudence.
   - Significance and principles of Ijtihad.
5. **Family and Society in Islam:**
   - Status and rights of women in Islamic teachings.
   - Marriage, family, and gender roles in Muslim society.
   - Family structure and values in Muslim society.
6. **Islam in the Modern World:**
   - Relevance of Islam in the modern world (globalization, challenges and prospects).
   - Islamophobia, interfaith dialogue, and multiculturalism
   - Islamic responses to social, ethical, and technological changes
7. **Introduction to Islamic Trade and Finance:**
   - Islamic Financing Structures
   - The Stability of Islamic Financial System
   - Financial Engineering
   - Regulation of Islamic Financial Institutions

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. "The Five Pillars of Islam: A Journey Through the Divine Acts of Worship" by Muhammad Mustafa Al-Azami.
2. "The Five Pillars of Islam: A Framework for Islamic Values and Character Building" by Musharraf Hussain.
3. "Towards Understanding Islam" by Abul A' la Mawdudi.
4. "Islami Nazria e Hayat" by Khurshid Ahmad.
5. "An Introduction to Islamic Theology" by John Renard.
6. "Islamic Civilization Foundations Belief & Principles" by Abul A' la Mawdudi.
7. "Women and Social Justice: An Islamic Paradigm" by Dr. Anis Ahmad.
8. "Islam: Its Meaning and Message" by Khurshid Ahmad.

Note: This course is compulsory for Muslim and optional for non-Muslim undergraduate students. Non-Muslim students can opt for nay course of at least the same or more credits in subjects such as religious studies, ethics, theology, comparative religion, Christian ethics, etc.

*** List of Arts and Humanities Electives (2+0)**

- Communication and Presentation Skills
- Beginners Spanish
- Elementary Arabic
- Elementary French
- Elementary Chinese
- History
- Philosophy
- Professional Ethics

COMMUNICATION AND PRESENTATION SKILLS

Credits: 02
Pre-Requisite: Nil

COURSE LEARNING OUTCOME

By the end of the course, students will be able to:

1. Write clearly, concisely, and grammatically correctly in various forms, avoiding errors.
2. Read critically to understand information better and improve vocabulary.
3. Deliver engaging presentations with effective communication and visuals.
4. Adapt communication style to audience and context, demonstrating active listening.

COURSE OUTLINE:

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.

SUGGESTED TEACHING AND ASSESSMENT METHODS

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

ASSESSMENT:

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

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Anchor in English-II (Lessons 1-5), A SPELT Publication
2. Christopher Fry, "Summary Writing (Book-I)", Oxford University Press
3. College Essays by John Langlan
4. Barron's TOFFL iBT Edition
5. Communication Skills for Engineers by Sunita Marshal and C.Muralikrishna
6. Writing for Computer science by Justin Zobel Research Methodologies – A step by step guide for beginners, Ranjit Kumar.

BEGINNERS SPANISH

Credits: 02
Pre-Requisite: Nil

COURSE LEARNING OUTCOME

By the end of the course, students will be able to:

1. Greet and introduce yourself and others in basic Spanish, stating your profession, nationality, activities, and family members.
2. Comprehend the Spanish alphabet, numbers, telling the time, days of the week, months, and weather descriptions.
3. Describe people, places, your likes and dislikes, using basic vocabulary and simple sentence structures.
4. Communicate in basic Spanish for everyday situations like eating out, shopping, daily activities, and work, in both formal and informal settings.

COURSE OUTLINE:

- Greeting and introducing yourself and others: profession, nationality, activities and family
- the alphabet numbers, telling the time, days of the week, the months, the weather
- describing people and places, likes and dislikes
- Spanish in context: eating out, shopping, daily activities, work formal and informal situations
- describing past events
- expressing opinions.
- Grammatical structures: pronunciation, present tense: regular, irregular and reflexive verbs, personal pronouns, definite and indefinite articles, adjectives and nouns: gender and number, asking a question, demonstrative adjectives and pronoun, prepositions of place, verbs, adverbs of frequency, introduction to the past tense (pretérito indefinido).

SUGGESTED TEACHING AND ASSESSMENT METHODS

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Group discussion, Community Service, Report Writing, Social Impact Review

ASSESSMENT:

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

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Ele Actual A1 by Virgilio Boribio, Publisher: Editorial SM; ISBN: 978-84-675-4741

ELEMENTARY ARABIC

Credits: 02
Pre-Requisite: Nil

COURSE LEARNING OUTCOME

By the end of the course, students will be able to:

1. **Greet** and introduce yourself and others in basic Arabic, utilizing both formal and informal forms of address.
2. **Formulate** basic questions in Arabic using proper structure to inquire about everyday topics.
3. **Describe** yourself and others using relevant vocabulary and adhering to singular and plural noun/adjective formation and gender agreements.
4. **Construct** grammatically correct sentences in the present tense, incorporating conjugated verbs, definite and indefinite articles, and possessive adjectives.

COURSE OUTLINE:

Vocabulary

- Greetings and introductions
- Formal and informal address
- Question formation for asking basic questions
- Speaking about yourself and others
- Arabic numbers
- Everyday life vocabulary

Grammar

- Conjugating verbs in the present tense
- Formation of singular and plural nouns and adjectives
- Feminine and Masculine Forms
- Definite and indefinite articles
- Possessive adjectives (feminine and masculine)
- Adjectives and adjective agreements
- Sentence structure

SUGGESTED TEACHING AND ASSESSMENT METHODS

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Group discussion, Community Service, Report Writing, Social Impact Review.

ASSESSMENT:

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

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Al-Kitaab fii TaCallum al-Arabyya: A Textbook for Beginning Arabic (Part 1), 3rd Edition, Brustad, Al-Batal, AlTonsi, Georgetown University Press, 2011. ISBN: 978-1-58901-736-8

ELEMENTARY FRENCH

Credits: 02
Pre-Requisite: Nil

COURSE LEARNING OUTCOME

By the end of the course, students will be able to:

1. **Engage** in basic social interactions using greetings, numbers, and calendar expressions.
2. **Express** likes and dislikes on various topics, including weekend and school activities.
3. **Describe** aspects of your family, home, shopping experiences, and food preferences through basic vocabulary.
4. **Formulate** grammatically correct sentences in the present tense using regular and irregular verbs, subject pronouns, possessive adjectives, and the verbs "aller" and "venir" to express the future and immediate past.

COURSE OUTLINE:

- Social greetings, Number, Calendar and time, expressing likes and dislikes, Talking about weekend and school activities, Family and the home, Shopping, Food
- Grammatical structures:
  - Subject pronouns and the verb être
  - Present tense regular –er verbs
  - Agreement and placement of adjectives
  - The verb aller and its use in expressing the future
  - The verb venir and the immediate past
  - Possessive adjectives
  - Present tense irregular verbs
  - Interrogative pronouns qui and que
  - Partitive article

SUGGESTED TEACHING AND ASSESSMENT METHODS

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Group discussion, Community Service, Report Writing, Social Impact Review

ASSESSMENT:

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

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Débuts. Siskin, Williams-Gascon, Field. McGraw-Hill

ELEMENTARY CHINESE

Credits: 02
Pre-Requisite: Nil

COURSE LEARNING OUTCOME

By the end of the course, students will be able to:

1. **Utilize** Hanyu Pinyin to accurately sound and read Chinese characters, mastering standard pronunciation.
2. **Recognize** and write approximately 260 basic Chinese characters, applying them in simple communication.
3. **Construct** grammatically correct sentences by understanding fundamental word order and the usage of particles in Chinese.
4. **Formulate** different types of questions to effectively seek information in daily situations.

COURSE OUTLINE:

- Use Hànyǔ Pīnyīn to speak and read with standard Chinese pronunciation.
- Read and write about 260 Chinese characters.
- Understand the basic word order of Chinese sentences and the use of particles.
- Use different types of questions.
- Identify people and things
- Use time expressions and numbers.
- Use adjectives to describe people and things.
- Express possession and existence
- Express wishes, obligations, capabilities, possibilities and permissions.
- State likes and dislikes.
- Explain where something is located.
- Describe how an action is performed.

SUGGESTED TEACHING METHODS:

Lectures (audio,/video aids), Written Assignments/ Quizzes, Tutorials, Group discussion, Community Service, Report Writing, Social Impact Review

ASSESSMENT:

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

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Kung Fu (I): An Elementary Chinese Text. By John C. Jamieson and Lin Tao. Hong Kong:Chinese University Press, 2002

HISTORY

Credits: 02
Pre-Requisite: Nil

COURSE LEARNING OUTCOME

By the end of the course, students will be able to:

1. Define the concept of history, distinguishing its key characteristics and recognizing its evolving nature.
2. Describe the intricate relationship between memory, historical records, and the construction of history, critically examining their interconnected roles.
3. Evaluate the nature of historical inquiry, including its methods, limitations, and potential biases.
4. Explain the epistemological nature of history, including its methods of knowledge production and the challenges it faces.
5. Identify and categorize different forms of historical narratives based on their focus, methodology, and purpose.

COURSE OUTLINE:

- What is History?
- Memory, Record and History
- Nature of History:
- Utility, Benefits & importance of History:
- Epistemological nature of History:
- Forms and Classification of History

ASSESSMENT:

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

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Burke, Varieties of Cultural History, Cornell University Press, 1977
2. Carlo, Ginzburg. Clues. Myths, and the Historical Method, John Hopkins: University Press, 1992
3. Carr, E. H., What is History? Harmondsworth: Penguin, 1961
4. Cohn, Bernard. An Anthropologist among Historians and Other Essay, Oxford University Press, 1988

5. Collingwood, R. G. The Idea of History. Oxford: Oxford University Press, 1978.
6. Daniels, Studying History: How and Why, New Jersey, 1981.
7. Gertrude Himmalfarb. The New History and the Old, Cambridge: Harvard University Press, 1987
8. Govranski. History Meaning and Methods, USA, 1969
9. Hegel. Elements of the Philosophy of Right. Cambridge University Press, 1991

PHILOSOPHY

Credits: 02
Pre-Requisite: Nil

COURSE LEARNING OUTCOME

By the end of the course, students will be able to:

1. Examine the fundamental nature of philosophy, exploring its scope, purpose, and relevance to the engineering discipline.
2. Apply principles of arguments and logic in the context of philosophical analysis, developing the ability to construct and evaluate logical reasoning.
3. Examine different perspectives on knowledge within epistemology, relating these perspectives to engineering practices and the development of technological solutions.
4. Analyze the concept of induction, exploring its role in reasoning and its applications in the engineering field.
5. Compare and contrast the philosophical perspectives of rationalism and empiricism, considering their implications for the understanding of engineering phenomena.

COURSE OUTLINE:

- Introduction: The Nature of Philosophy
- Arguments and Logic in Philosophy
- Epistemology – Skepticism and Certainty
- Epistemology: The Scope and Limits of Knowledge
- Epistemology: Knowledge
- Induction
- Rationalism and Empiricism
- Philosophy and Meaning

ASSESSMENT:

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

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Hales, S. D. (2021). This is philosophy: An introduction. John Wiley & Sons.
2. Hospers, J. (2013). An introduction to philosophical analysis. Routledge.
3. Hurley, P. J. (2014). A concise introduction to logic. Cengage Learning.
4. Rachels, J., & Rachels, S. (1986). The elements of moral philosophy (p. 9). Philadelphia: Temple University Press.
5. Solomon, R. C., & Higgins, K. M. (2013). The big questions: A short introduction to philosophy. Cengage Learning.
6. Stewart, D. (2010). Fundamentals of Philosophy. 6th. Boston: Pearson

PROFESSIONAL ETHICS

Credits: 02
Pre-Requisite: Nil

COURSE LEARNING OUTCOME

By the end of the course, students will be able to:

1. Define key terms: profession, ethics, and their relation to law/morality.
2. Analyze ethical frameworks and their application in engineering. Identify desirable personality traits for ethical behaviour.
3. Explain ethical livelihood in engineering, including halal earning.
4. Describe professional ethics in engineering societies and codes of conduct.
5. Apply critical thinking and problem-solving in ethical situations.

COURSE OUTLINE

- Profession; What is a Profession? and Professional Ethics.
- Ethics; What is Ethics?, Why study Ethics?, Professional Ethics, Difference between Laws, morals, and Ethics: Character Ethics, Personality Ethics, Value &Virtue Ethics, and Characteristics of Code of Ethics
- Personality Traits, Desirable Personality Traits and Undesirable Personality Traits, Trust and Honesty, Sincerity, Truthfulness, Politeness, Respect & Etiquettes,
- Human values, values, morals and ethics, Moral Code of Islam, Struggle for Rizq e Halaal. To identify and adopt the legitimate, lawful and ethical sources of earning / livelihood.
- Moral development, moral dilemma, dealing with moral dilemma, moral autonomy, Fulfilment of Promise, Pride and Arrogance, Malpractice, Engineer's moral rights, right of professional conscience, professional rights and Ethical theories, intellectual property rights, patents, design, trademark etc.
- Professional ethics, role of professional bodies, Engineering code of ethics, Engineering ethics, training in preventive ethics, questionable

engineering practices, Micro and Macro ethics, examples of moral problems in engineering. Time management, Cooperation

- Inter-Personal Relations (Employer-Employee relationship), employee rights, professionalism and loyalty, right to protest, obligation of confidentiality, effect of change of job on confidentiality, conflict of interest. Grievances, Welfare, health & safety of personnel, whistleblowing and its features, types, procedures to be followed and conditions to be satisfied before whistle blowing
- Problem-Solving, Decision-Making, Engineers responsibilities towards society welfare, environment degradation, bio-centric ethics, Ecocentric ethics, Human centered environmental ethics, Global examples of catastrophic engineering incidents. Safety, responsibilities and rights; safety and risks, responsible engineering, cost of unsafe designed product, Moral thinking, tests in moral problems solving, problem solving in engineering ethics, case studies.

ASSESSMENT:

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

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Engineering Ethics: Concepts and Cases by Charles E. Harris Jr, 2018, 6th Ed., Cengage Learning, ISBN:978-1337554503
2. Ethics in Engineering by Mike Martin, 2022, 5th Ed., McGraw Hill, ISBN: 9781260721744
3. Attributes of Muslim Professionals in the Light of Quran & Sunnah by Akram Muhammad Zeki, 2021, Ilum Press, ISBN: 9789674911201

**** List of Social Science Electives (2+0)**

- Sociology for Engineers
- Sociology
- Social phycology
- Critical Thinking
- Human Resource Management
- Organizational Behavior
- Engineering Law
- Engineering Economics

SOCIOLOGY FOR ENGINEERS

Credits: 02
Pre-Requisite: Nil

DESCRIPTION

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.

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. 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.
2. To provide opportunity for students to begin the process of considering social problems/ issues while designing engineering products.
3. To allow engineers to play a pro-active role in critical discussions of social issues specifically.
4. To demonstrate comprehension of roles and functions of various social institutions, state organizations, Professional bodies and relationships for analyzing their social impact Assessment.

COURSE CONTENT

- **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 & heir 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 o 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.

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

SUGGESTED TEACHING METHODS:

Suggested Teaching Methods

Lectures (audio/video aids), Written Assignments/ Quizzes, ,Tutorials, Case Studies relevant to engineering 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 INSTRUCTIONAL/READING MATERIALS

1. 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.
2. Nichols,S.P.andWeldon,W.F.2017. Professional Responsibility: The Role of Engineering in Society Center for Electro-mechanics, The University of Texas at Austin, USA.
3. 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.
4. 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
5. Jamison,A.,Christensen,S.H.,andLars,B.2011.A Hybrid Imagination: Science and Technology in cultural perspective
6. Vermaas,P.,Kroes,P.,Poet,l.,andHoukes,W.2011.A Philosophy of Technology FromTechnical Artefacts to Socio technical systems.

7. Mitcham,C.,andMunoz,D.2010.HumanitarianEngineering.MorganandClaypoolPublishers. Riley,D.2008.Engineering and Social Justice. Morgan and Claypool Publishers.
8. Bugliarello,G.1991.TheSocial Functions of Engineering: A Current Assessment, A Chapter in" Engineering as A Social Enterprise. Sociology

SOCIOLOGY

Credits: 02
Pre-Requisite: Nil

COURSE LEARNING OUTCOMES

- 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 CONTENT

- 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

SUGGESTED TEACHING METHODS

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 INSTRUCTIONAL/READING MATERIALS

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

SOCIAL PSYCHOLOGY

Credits: 02
Pre-Requisite: Nil

COURSE LEARNING OUTCOMES

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 CONTENT

- 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.

SUGGESTED TEACHING METHODS

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 INSTRUCTIONAL/READING MATERIALS

1. Edward Alsworth Ross, "Social Psychology", Macmillan, latest edition.
2. Emory Stephen Bogardus, "Essentials of Social Psychology", Univ. of Southern, California Press, latest edition.
3. Hewstone, M., & Stroebe, W. (Eds.), "Introduction to Social Psychology", 3rd ed., Oxford: Blackwell Publishers, latest edition.
4. Lesko, W.A. "Readings in social psychology General, classic, and contemporary selections, latest edition,

CRITICAL THINKING

Credits: 02
Pre-Requisite: Nil

COURSE LEARNING OUTCOMES

At the end of the course, the students will be able to:

1. Define critical thinking and identify its benefits in the workplace.
2. List the characteristics of a critical thinker and distinguish them from other types of thinking.
3. Explain the importance of asking questions, actively listening, and challenging assumptions.
4. Describe common creative thinking techniques like brainstorming, mind mapping, and De Bono's thinking hats. List and explain root cause analysis techniques like the 5 Whys and Ishikawa Diagram.
5. Describe strategies for effectively presenting recommendations to decision-makers and stakeholders.

COURSE CONTENT/COURSE OUTLINE

Course Overview

- Introduction
- Introduction to Critical Thinking
- Benefits of critical thinking in the workplace
- Critical thinking as a management skill
- What are the characteristics of a critical thinker?
- Other Types of Thinking
- 5 Different thinking styles
- Module Reflection
- A Critical Thinker's Mindset
- Can you develop a critical thinker's mindset?
- The Critical Thinking Process
- Step 1 - Identifying the problem
- Step 2 - Gather and evaluate your information
- Step 3 - Generate alternative solutions
- Step 4 - Select and implement a solution
- Step 5 - Evaluate your solution
- Developing Critical Thinking Skills
- Asking questions

- Active listening
- Challenging assumptions
- Creative Thinking Techniques
- Brainstorming
- Imagining the opposite
- Mind mapping
- De Bono's thinking hats
- Root Cause Analysis Techniques
- Identifying the cause of a problem
- Ishikawa Diagram (Fishbone Diagram)
- 5 Whys technique
- SWOT analysis
- Using Your REACH Profile to Support Critical Thinking
- Adapting your profile
- Presenting Your Recommendations
- Seeking approval from decision makers and Stakeholders

ASSESSMENT

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Critical Thinking for Students Roy van den Brink-Budgen (4th Edition)
2. Thinking, Fast and Slow Daniel Kahneman (2011)

HUMAN RESOURCE MANAGEMENT

Credits: 02
Pre-Requisite: Nil

COURSE LEARNING OUTCOMES

At the conclusion of the course, the students will be able to:

1. Understand key challenges and trends in Human Resource Management (HRM).Compare and contrast global and local HRM practices.
2. Explain basic principles of HRM from Islamic and indigenous perspectives.
3. Apply job analysis techniques, including HR planning, job description, and specification.
4. Differentiate between compensation and benefit packages and their management.
5. Explain staffing strategies, covering recruitment techniques, sources, and selection tests.

COURSE CONTENT/COURSE OUTLINE

- Emerging Human resource management challenges.
- Trends in HRM
- Global vs local HRM practices
- HRM from Islamic and indigenous perspective
- Basic Islamic philosophy of managing human resource
- Conducting Job analysis.
- HR Planning
- Job Description
- Job Specification
- Staffing
- Recruiting and selecting employees
- Recruitment techniques
- Sources of recruitment
- Selection tests and Interviewing techniques
- Employee development
- Performance appraisals
- Performance management
- Training and development
- Training the employees
- Types of training
- Technique of training

- Project Description and discussion
- Compensations
- Managing compensation
- Types of compensation
- Rewarding performance
- Pay for Performance
- Designing and administering benefits
- Types of benefits
- Employee relations

ASSESSMENT

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. By Luis R. Gomez Mejia, David B. Balkin, Robert L. Cardy Managing Human Resources. (Fourth ed.)

ORGANIZATIONAL BEHAVIOUR

Credits: 02
Pre-Requisite: Nil

COURSE LEARNING OUTCOMES

At the conclusion of the course, the students will be able to:

1. Explain the role of individual characteristics, abilities, and learning in organizational behavior.
2. Understand organizational behavior principles from Islamic and indigenous perspectives. Analyze human psychology through the lens of Quran and Sunnah.
3. Identify and classify different attitudes and behaviors in the workplace.
4. Recognize the importance of perception and its role in individual decision-making.
5. Apply motivation concepts, both content and process theories, and use them to design effective reward systems.

COURSE CONTENT/COURSE OUTLINE

- Foundations of Individual Behaviour:
- Biographical Characteristics, Ability, Learning
- Organizational behaviour from Islamic and indigenous perspective
- Understanding human psychology through the lenses of Quran and Sunnah
- Attitudes and Job Satisfaction
- Types of attitudes
- Types of behaviours
- Perception and Individual Decision Making
- Why perception is important
- Types of decision making
- Biases and errors in decision making
- Motivation concept
- Content theories of Motivational
- Process theories of motivation
- Motivation: from concept to application
- Applying motivation concepts for designing reward system

ASSESSMENT

Quizzes, Assignments, Mid Exam, Final Exam

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Robbins, P. S., & Judge, T. A. (2009). Organizational Behaviour. 13th ed.

ENGINEERING LAW

Credits: 02
Pre-Requisite: Nil

COURSE LEARNING OUTCOMES

At the conclusion of the course, the students will be able to:

1. Define key terms: legal studies, law, sources of law.
2. Comprehend the fundamental principles of contract law as they relate to engineers.
3. Recognize the duty of care for engineers and grasp the concept of negligence in engineering. Gain insight into aspects of employment law relevant to engineers.
4. Understand intellectual property concepts, including designs, patents, copyright, and their application in engineering.
5. Learn how to enforce rights to intellectual property in the context of engineering.

COURSE CONTENT/COURSE OUTLINE

- Introduction to legal studies,
- Concepts and sources of law,
- Basic principles of the law contract as it relates to engineers,
- The duty of care for engineers and the concept of negligence,
- Aspects of employment law;
- Intellectual property,
- Designs, patents,
- Copyright in engineering,
- Enforcing rights to intellectual property.

ASSESSMENT

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. R E laidlaw, C R Young, A R Dick, Engineering Law, University Press, 1958.
2. C F Allen, Business law for engineers, University of Michigan library, 1919.

ENGINEERING ECONOMICS

Credits: 02
Pre-Requisite: Nil

COURSE LEARNING OUTCOMES

At the conclusion of the course, the students will be able to:

- Apply economic principles to analyze engineering projects.
- Utilize cost analysis methods to evaluate project feasibility and make decisions.
- Manage risks and uncertainties in engineering economic assessments.
- Consider economic factors such as inflation and taxation in decision making.
- Integrate ethical and sustainable considerations into economic analyses.

COURSE CONTENT/COURSE OUTLINE

1. Introduction

- Engineering Costs
- Estimation Models & Cash Flow Diagram
- Life cycle cost

2. Time value of Money

- Time value of money, equivalence, use of spread sheet, simple and compound interest
- Uniform series & Arithmetic & geometric gradient
- Nominal & effective, continuous compounding Economic criteria,
- Present Worth, future worth and annuity

3. Rate of Return

- Minimum acceptable rate of return(MARR),
- Internal rate of return, External rate of return
- Choosing the best alternative
- Incremental Analysis

4. Benefits and Cost ratio and Payback period

- Benefit and cost ratio (B/C Ratio), discounted benefit and cost ratio
- Simple payback period, discounted payback period
- Sensitivity & breakeven analysis
- Principle of comparative advantage

5. Depreciation

- Depreciation
- Depreciation using Unit of Production

- Depreciation using straight line method
- Depreciation using Depletion

6. Taxes

- Income Taxes, After tax RoR
- Replacement analysis
- Design life, salvage value
- Up gradation Vs replacement

7. Risk and Uncertainty

- Estimation of future events
- Monte Carlo Simulation
- Bayes theorem

8. Concepts of Imports and Exports

- Basic concepts of import and export
- Dumping and anti-dumping and related laws

9. Teaching Methodology

- Lecturing
- Written Assignments
- Presentation

ASSESSMENT

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. William G. Sullivan and Elin M. Wicks, Estimation of future events
2. N. M. Fraser and E. M. Jewkes, Engineering Economics: Financial Decision Making for Engineers
3. D. G. Newnan, J. Whittaker, T. G. Eschenbach and J. P. Lavelle, Engineering Economic Analysis
4. J. Tarquin, L. T. Blank, Engineering Economy, McGraw Hill

CIVICS AND COMMUNITY ENGAGEMENT

UGE Policy V1.1: General Education Course

Credits: 02
Pre-Requisite: Nil

DESCRIPTION

This course is designed to provide students with fundamental knowledge about civics, citizenship, and community engagement. In this course, the students will learn about the essentials of civil society, government, civic responsibilities, inclusivity, and effective ways to participate in shaping the society which will help them apply theoretical knowledge to the real-world situations to make a positive impact on their communities.

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Demonstrate fundamental understanding of civics, government, citizenship and civil society.
2. Understand the concept of community and recognize the significance of community engagement for individuals and groups.
3. Recognize the importance of diversity and inclusivity for societal harmony and peaceful co-existence.

COURSE OUTLINE

1. **Introduction to Civics and Citizenship**
   - Definition of civics, citizenship, and civic engagement
   - Historical evolution of civic participation
   - Types of citizenship: active, participatory, digital etc.
   - The relationships between democracy and citizenship
2. **Civics and Citizenship**
   - Concepts of civics, citizenship, and civic engagement.
   - Foundations of modern society and citizenship.
   - Types of citizenship: active, participatory, digital, etc.
3. **State, Government and Civil Society**
   - Structure and functions of government in Pakistan.
   - The relationship between democracy and civil society.
   - Right to vote and importance of political participation and representation.

4. **Rights and Responsibilities**
   - Overview of fundamental rights and liberties of citizens under Constitution of Pakistan 1973.
   - Civic responsibilities and duties.
   - Ethical considerations in civic engagement (accountability, non-violence, peaceful dialogue, civility, etc.)
5. **Community Engagement**
   - Concept, nature and characteristics of community.
   - Community development and social cohesion.
   - Approaches to effective community engagement.
   - Case studies of successful community driven initiatives.
6. **Advocacy and Activism**
   - Public discourse and public opinion.
   - Role of advocacy in addressing social issues.
   - Social action movements.
7. **Digital Citizenship and Technology**
   - The use of digital platforms for civic engagement.
   - Cyber ethics and responsible use of social media.
   - Digital divides and disparities (access, usage, socioeconomic, geographic, etc.) and their impacts on citizenship.
8. **Diversity, Inclusion and Social Justice:**
   - Understanding diversity in society (ethnic, cultural, economic, political etc.).
   - Youth, women and minorities' engagement in social development.
   - Addressing social inequalities and injustices in Pakistan.
   - Promoting inclusive citizenship and equal rights for societal harmony and peaceful co-existence.

SUGGESTED PRACTICAL ACTIVITIES (OPTIONAL)

As part of the overall learning requirements, the course may have one or a combination of the following practical activities:

1. **Community Storytelling:** Students can collect and share stories from community members. This could be done through oral histories, interviews, or multimedia presentations that capture the lived experiences and perspectives of diverse individuals.
2. **Community Event Planning:** Students can organize a community event or workshop that addresses a specific issue or fosters community interaction. This could be a health fair, environmental cleanup, cultural festival, or educational workshop.
3. **Service-Learning:** Students can collaborate with a local nonprofit organization or community group. They can actively contribute by volunteering their time and skills to address a particular community

need, such as tutoring, mentoring, or supporting vulnerable populations.

4. **Cultural Exchange Activities:** Students can organize a cultural exchange event that celebrates the diversity within the community. This could include food tastings, performances, and presentations that promote cross-cultural understanding.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. "Civics Today: Citizenship, Economics, & You" by McGraw-Hill Education.
2. "Citizenship in Diverse Societies" by Will Kymlicka and Wayne Norman.
3. "Engaging Youth in Civic Life" by James Youniss and Peter Levine.
4. "Digital Citizenship in Action: Empowering Students to Engage in Online Communities" by Kristen Mattson.
5. "Globalization and Citizenship: In the Pursuit of a Cosmopolitan Education" by Graham Pike and David Selby.
6. "Community Engagement: Principles, Strategies, and Practices" by Becky J. Feldpausch and Susan M. Omilian.
7. "Creating Social Change: A Blueprint for a Better World" by Matthew Clarke and Marie-Monique Steckel

PROJECT MANAGEMENT

Credits: 02
Pre-Requisite: Nil

DESCRIPTION

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.

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. To develop competencies in project costing, budgeting, and financial appraisal;
2. To gain exposure to project Planning Control and Management, using standard tools and schedule variance analysis;
3. To appreciate the elements of risk and quality in hi-tech projects;
4. To learn Project Management by "practice", through the medium of "End of Semester Group Project"
5. 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

SUGGESTED TEACHING & ASSESSMENT METHODS

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

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Project Management: A system Approach to Planning, Scheduling and Controlling 11th Edition, Harold Kerzner
2. Bennett, F. Lawrence. 1996. The management of engineering. New York: Wiley
3. Cleland, David. Field guide to project management. New York: Wiley.
4. Eisner, H. Essentials of project management and systems engineering management. New York: Wiley
5. Frame, J. D. Managing projects in organizations. San Francisco: Jossey-Bass
6. Goldratt, Eliyahu. Critical chain. North River Press
7. Haynes, M.E. Project management: From idea to implementation. Los Altos, CA: Crisp Publications.
8. Lewis, James, Project planning, scheduling & control. New York: McGraw-Hill
9. Lewis, James, P. 1998. Mastering project management. New York: McGraw-Hill
10. Lientz, Bennet & Rea, Kathryn. 1995. Project management for the 21st century. San Diego: Academic Press.
11. Miller, Roger & Lessard, Donald. 2000. The strategic management of large engineering projects. Cambridge, MA: MIT Press.

12. Nicholas, J.M. Managing business & engineering projects. Englewood Cliffs, NJ: Prentice Hall
13. Shtub, Avraham, Bard, Jonathan, & Globerson, Shlomo. 1994. Project management: Engineering, technology, and implementation. Englewood Cliffs, Prentice-Hall
14. Project Management by Adrienne Watt
15. J.R. Meredith and S.J. Mantel. Project Management: A Managerial Approach. John Wiley and Sons. New York. 2019. (Reference).

ENTREPRENEURSHIP

UGE Policy V1.1: General Education Course

Credits: 02
Pre-Requisites: Nil

DESCRIPTION

This course is designed to promote entrepreneurial spirit and outlook among students, encouraging them to think critically, identify opportunities, and transform their ideas into successful ventures. It aims at imparting them with the requisite knowledge; skills and abilities, enabling them to seize the identified opportunities for initiating ventures and successfully navigating the challenges that come with starting business and managing it. The course covers topics relevant to entrepreneurship including setting up and initiation of business (including requirements for registration and incorporation with regulators such as SECP and others), market research, opportunity identification, business planning, financial literacy for managing finances and securing funding, marketing and sales, team building and innovation. Overall, the course is geared towards personal growth and professional development for pursing innovative ideas, availing opportunities and initiating start-ups.

COURSE LEARNING OUTCOMES

By the end of this course, students shall have:

1. Knowledge of fundamental entrepreneurial concepts, skills and process;
2. Understanding on different personal, social and financial aspects associated with entrepreneurial activities;
3. Basic understanding of regulatory requirements to set up an enterprise in Pakistan, with special emphasis on export;
4. Ability to apply knowledge, skills and abilities acquired in the course to develop a feasible business plan for implementation.

COURSE OUTLINE

1. **Introduction to Entrepreneurship:**
   - Definition and concept of entrepreneurship;
   - Why to become an entrepreneur?
   - Entrepreneurial process;
   - Role of entrepreneurship in economic development.

2. **Entrepreneurial Skills:**
   - Characteristics and qualities of successful entrepreneurs (including stories of successes and failures);
   - Areas of essential entrepreneurial skills and ability areas such as creative and critical thinking, innovation and risk taking.
3. **Opportunity Recognition and Idea Generation:**
   - Opportunity identification, evaluation and exploitation;
   - Idea generation techniques for entrepreneurial ventures.
4. **Marketing and Sales:**
   - Target market identification and segmentation;
   - Four P's of Marketing;
   - Developing a marketing strategy;
   - Branding.
5. **Financial Literacy:**
   - Basic concepts of income, savings and investments;
   - Basic concepts of assets, liabilities and equity;
   - Basic concepts of revenue and expenses;
   - Overview of cash-flows;
   - Overview of banking products including Islamic modes of financing;
   - Sources of funding for startups (angel financing, debt financing, equity financing etc.)
6. **Team Building for Startups:**
   - Characteristics and features of effective teams;
   - Team building and effective leadership for startups
7. **Regulatory Requirements to Establish Enterprises in Pakistan:**
   - Types of enterprises (e.g., sole proprietorship; partnership; private limited companies etc.);
   - Intellectual property rights and protection;
   - Regulatory requirements to register an enterprise in Pakistan, with special emphasis on export firms;
   - Taxation and financial reporting obligation.

PRACTICAL REQUIREMENTS

As part of the overall learning requirements, students shall be tasked with presenting a comprehensive business plan at the end of the course for a hypothetical or real business idea. This practical exercise will allow them to apply the knowledge, skills and abilities acquired in the course to develop a feasible business plan and where possible explore the possibility of implementing the plan with support and assistance from established business-persons and entrepreneurs.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. "Entrepreneurship: Successfully Launching New Ventures" by Bruce R. Barringer and R. Duane Ireland.
2. "Entrepreneurship: Theory, Process, and Practice" by Donald F. Kuratko.
3. "New Venture Creation: Entrepreneurship for the 21st Century" by Jeffry A. Timmons, Stephen Spinelli Jr., and Rob Adams.
4. "Entrepreneurship: A Real-World Approach" by Rhonda Abrams.
5. "The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses" by Eric Ries.
6. "Effectual Entrepreneurship" by Stuart Read, Saras Sarasvathy, Nick Dew, Robert Wiltbank, and Anne-Valérie Ohlsson.

APPLICATIONS OF ICT

UGE Policy V1.1: General Education Course

Credits: 2+1=3
Pre-Requisite: Nil

DESCRIPTION

This course is designed to provide students with an exploration of the practical applications of Information and Communication Technologies (ICT) and software tools in various domains. Students will gain hands-on experience with a range of software applications, learning how to leverage ICT to solve daily life problems, enhance productivity and innovate in different fields. Through individual and interactive exercises and discussions, students will develop proficiency in utilizing software for communication, creativity, and more.

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Explain the fundamental concepts, components, and scope of Information and Communication Technologies (ICT).
2. Identify uses of various ICT platforms and tools for different purposes.
3. Apply ICT platforms and tools for different purposes to address basic needs in different domains of daily, academic, and professional life.
4. Understand the ethical and legal considerations in use of ICT platforms and tools.

COURSE OUTLINE

1. **Introduction to Information and Communication Technologies:**
   - Components of Information and Communication Technologies (basics of hardware, software, ICT platforms, networks, local and cloud data storage etc.).
   - Scope of Information and Communication Technologies (use of ICT in education, business, governance, healthcare, digital media and entertainment, etc.).
   - Emerging technologies and future trends.
2. **Basic ICT Productivity Tools:**
   - Effective use of popular search engines (e.g., Google, Bing, etc.) to explore World Wide Web.
   - Formal communication tools and etiquettes (Gmail, Microsoft Outlook, etc.).
   - Microsoft Office Suites (Word, Excel, PowerPoint).

- Google Workspace (Google Docs, Sheets, Slides).
- Dropbox (Cloud storage and file sharing), Google Drive (Cloud storage with Google Docs integration) and Microsoft OneDrive (Cloud storage with Microsoft Office integration).
- Evernote (Note-taking and organization applications) and OneNote (Microsoft's digital notebook for capturing and organizing ideas).
- Video conferencing (Google Meet, Microsoft Teams, Zoom, etc.).
- Social media applications (LinkedIn, Facebook, Instagram, etc.).

3. **ICT in Education:**
   - Working with learning management systems (Moodle, Canvas, Google Classrooms, etc.).
   - Sources of online education courses (Coursera, edX, Udemy, Khan Academy, etc.).
   - Interactive multimedia and virtual classrooms.
4. **ICT in Health and Well-being:**
   - Health and fitness tracking devices and applications (Google Fit, Samsung Health, Apple Health, Xiaomi Mi Band, Runkeeper, etc.).
   - Telemedicine and online health consultations (OLADOC, Sehat Kahani, Marham, etc.).
5. **ICT in Personal Finance and Shopping:**
   - Online banking and financial management tools (JazzCash, Easypaisa, Zong PayMax, 1LINK and MNET, Keenu Wallet, etc.).
   - E-commerce platforms (Daraz.pk, Telemart, Shophive, etc.)
6. **Digital Citizenship and Online Etiquette:**
   - Digital identity and online reputation.
   - Netiquette and respectful online communication.
   - Cyberbullying and online harassment.
7. **Ethical Considerations in Use of ICT Platforms and Tools:**
   - Intellectual property and copyright issues.
   - Ensuring originality in content creation by avoiding plagiarism and unauthorized use of information sources.
   - Content accuracy and integrity (ensuring that the content shared through ICT platforms is free from misinformation, fake news, and manipulation).

PRACTICAL REQUIREMENTS

As part of overall learning requirements, the course will include:

1. Guided tutorials and exercises to ensure that students are proficient in commonly used software applications such as word processing software

(e.g., Microsoft Word), presentation software (e.g., Microsoft PowerPoint), spreadsheet software (e.g., Microsoft Excel) among such other tools students may be assigned practical tasks that require them to create documents, presentations and spreadsheets etc.

2. Assigning of tasks that involve creating, managing, and organizing files and folders on both local and cloud storage systems.. students will practice file naming conventions, creating directories, and using cloud storage solutions (e.g., Google Drive, OneDrive).
3. The use of online learning management systems (LMS) where students can access course materials, submit assignments, participate in discussion forums, and take quizzes or tests. This will provide students with the practical experience with online platforms commonly used in education and the workplace.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. "Discovering Computers" by Vernmaat, Shaffer, and Freund.
2. "GO! With Microsoft Office" Series by Gaskin, Vargas, and McLellan.
3. "Exploring Microsoft Office" Series by Grauer and Poatsy
4. "Computing Essentials" by Morley and Parker
5. "Technology in Action" by Evans, Martin and Poatsy

QUANTITATIVE REASONING (I)

UGE Policy V 1.1: General Education Course

Credits: 03
Pre-Requisite: Nil

DESCRIPTION

Quantitative Reasoning (I) is an introductory-level undergraduate course that focuses on the fundamentals related to the quantitative concepts and analysis. The course is designed to familiarize students with the basic concepts of mathematics and statistics and to develop students' abilities to analyze and interpret quantitative information. Through a combination of theoretical concepts and practical exercises, this course will also enable students cultivate their quantitative literacy and problem-solving skills while effectively expanding their academic horizon and breadth of knowledge of their specific major / field of study.

COURSE LEARNING OUTCOMES

By the end of this course, students shall have:

1. Fundamental numerical literacy to enable students work with numbers, understand their meaning and present data accurately;
2. Understanding of fundamental mathematical and statistical concepts;
3. Basic ability to interpret data presented in various formats including but not limited to tables, graphs, charts, and equations etc.

COURSE OUTLINE

1. **Numerical Literacy:**
   - Number system and basic arithmetic operations;
   - Units and their conversions, dimensions, area, perimeter and volume;
   - Rates, ratios, proportions and percentages;
   - Types and sources of data;
   - Measurement scales;
   - Tabular and graphical presentation of data;
   - Quantitative reasoning exercises using number knowledge.
2. **Fundamental Mathematical Concepts:**
   - Basics of geometry (lines, angles, circles, polygons etc.);
   - Sets and their operations;
   - Relations, functions, and their graphs;
   - Exponents, factoring and simplifying algebraic expressions;

- Algebraic and graphical solutions of linear and quadratic equations and inequalities;
- Quantitative reasoning exercises using fundamental mathematical concepts.

3. **Fundamental Statistical Concepts:**
   - Population and sample;
   - Measures of central tendency, dispersion and data interpretation;
   - Rules of counting (multiplicative, permutation and combination);
   - Basic probability theory;
   - Introduction to random variables and their probability distributions;
   - Quantitative reasoning exercises using fundamental statistical concepts.

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Quantitative Reasoning: Tools for Today's Informed Citizen" by Bernard L. Madison, Lynn and Arthur Steen.
2. "Quantitative Reasoning for the Information Age" by Bernard L. Madison and David M. Bressoud.
3. "Fundamentals of Mathematics" by Wade Ellis.
4. "Quantitative Reasoning: Thinking in Numbers" by Eric Zaslow.
5. "Thinking Clearly with Data: A Guide to Quantitative R easoning and Analysis" by Ethan Bueno de Mesquita and Anthony Fowler.
6. "Using and Understanding Mathematics: A Quantitative Reasoning Approach" by Bennett, J. O., Briggs, W. L., & Badalamenti, A.
7. "Discrete Mathematics and its Applications" by Kenneth H. Rosen.
8. "Statistics for Technology: A Course in Applied Statistics" by Chatfield, C.
9. "Statistics: Unlocking the Power of Data" by Robin H. Lock, Patti Frazer Lock, Kari Lock Morgan, and Eric F. Lock.

QUANTITATIVE REASONING (II)

UGE Policy V1.1: General Education Course

Credits: 03
Pre-Requisite: Quantitative Reasoning (I)

DESCRIPTION

Quantitative Reasoning (II) is a sequential undergraduate course that focuses on logical reasoning supported with mathematical and statistical concepts and modeling / analysis techniques to equip students with analytical skills and critical thinking abilities necessary to navigate the complexities of the modern world. The course is designed to familiarize students with the quantitative concepts and techniques required to interpret and analyze numerical data and to inculcate an ability in students the logical reasoning to construct and evaluate arguments, identify fallacies, and think systematically. Keeping the pre-requisite course of Quantitative Reasoning (I) as its base, this course will enable students further their quantitative, logical and critical reasoning abilities to complement their specific major / field of study.

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Understanding of logic and logical reasoning;
2. Understanding of basic quantitative modeling and analyses;
3. Logical reasoning skills and an ability to apply them to solve quantitative problems and evaluate arguments;
4. Ability to critically evaluate quantitative information to make evidence based decisions through appropriate computational tools.

COURSE OUTLINE

1. **Logic, Logical and Critical Reasoning:**
    - Introduction and importance of logic;
    - Inductive, deductive and abductive approaches of reasoning;
    - Propositions, arguments (valid; invalid), logical connectives, truth tables and propositional equivalences;
    - Logical fallacies;
    - Venn Diagrams;
    - Predicates and quantifiers;
    - Quantitative reasoning exercises using logical reasoning concepts and techniques.

2. Mathematical Modeling and Analyses

- Introduction to deterministic models;
- Use of linear function for modeling in real-world situations;
- Modeling with the system of linear equations and their solutions;
- Elementary introduction to derivatives in mathematical modeling;
- Linear and exponential growth and decay models;
- Quantitative reasoning exercises using mathematical modeling.

3. Statistical Modeling and Analyses

- Introduction to probabilistic models;
- Bivariate analysis, scatter plots;
- Simple linear regression model and correlation analysis;
- Basics of estimation and confidence interval;
- Testing of hypothesis (z-test; t-test);
- Statistical inference in decision making;
- Quantitative reasoning exercises using statistical modeling.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. "Using and Understanding Mathematics: A Quantitative Reasoning Approach" by Bennett, J. O., Briggs, W. L., & Badalamenti, A.
2. "Discrete Mathematics and its Applications" by Kenneth H. Rosen.
3. "Discrete Mathematics with Applications" by Susanna S. Epp.
4. "Applied Mathematics for Business, Economics and Social Sciences" by Frank S Budnick.
5. "Elementary Statistics: A Step by Step Approach" by Allan Bluman.
6. "Introductory Statistics" by Prem S. Mann.
7. "Applied Statistical Modeling" by Salvatore Babones.
8. "Barrons SAT" by Sharvon Weiner Green, M.A and Ira K.Wolf.

CALCULUS AND ANALYTICAL GEOMETRY

Credit Hours: 3+0=3
Pre-Requisites: Nil

COURSE LEARNING OUTCOMES

- 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 (THEORY)

- **Analytical Geometry:**
  a. Review of vectors, scalars and vector products.
  b. Three dimensional coordinate system and equation of straight line and plane
- **Functions Limit and Continuity**
  a. Review of functions and graphs,
  b. Limits & Continuity,
  c. Techniques of Finding Limits,
  d. Discontinuity.
  e. Limits of Sine and Cosine and Exponential Functions
- **Differentiation:**
  a. Introduction to Derivatives
  b. Examples of Derivatives
  c. Derivative as Rate of Change
  d. Derivative's Rules
  e. Implicit Differentiation
  f. Higher order derivative
  g. Leibnitz Theorem
- **Applications of Derivatives:**
  a. Applications of Derivatives
  b. Monotonic functions
  c. Optimization problems
  d. Relative and Absolute extrema
  e. First and second derivative tests
  f. Point of inflection
  g. Concavity

h. Curvature
i. Indeterminate Forms and L' Hospital rule
j. Differentials

- **Integration:**
  a. Integrals and Properties of Integrals
  b. Techniques of Integration
  c. Integration by Parts
  d. Definite Integrals
  e. Integration of Trigonometric
  f. Exponential and Inverse Functions
  g. Integration by Partial Fractions
  h. Reduction Rules
- **Applications of Integration:**
  a. Applications of Integration
  b. Area under the curve
  c. Area between curves
  d. Solids of Revolution
  e. Volume of Solids of revolution by disk
  f. washer, Cylindrical shell & Cross Section Methods
  g. Center of Pressure and Depth of Center of Pressure
  h. Center of mass
  i. Arc length
- **Improper Integrals:**
  a. Improper Integral
  b. Integrals and Singularities
  c. Convergence of improper integrals
- **Infinite Sequence and Series:**
  a. Sequence and Infinite Series
  b. Convergence and Divergence of sequences and series
  c. Positive Term Series
  d. Integral Test
  e. Basic Comparison Test
  f. Limit Comparison Test
  g. Ratio and Root tests
  h. Alternating series
  i. Absolute and Conditional Convergence
- **Power and Taylor Series:**
  a. Power series
  b. Maclaurin and Taylor Series and its Applications

SUGGESTED TEACHING & ASSESSMENT METHODS

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

RECOMMENDED TEXT AND REFERENCE BOOKS

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

LINEAR ALGEBRA AND DIFFERENTIAL EQUATIONS

Credit Hours: 3+0=3
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed understanding of Linear Algebra and Differential equations. The course will provide detailed guidance on Linear Algebra and Differential equations employed in the field of Chemical engineering. The main focus on solving the real problems of Chemical engineering using Linear Algebra and Differential equations .

COURSE LEARNING OUTCOMES

The knowledge units in this area collectively encompass the following:

- To comprehend basic concepts of Linear Algebra and optimi zation
- To apply techniques of Linear Algebra and optimization for solution of engineering problem.
- 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 (THEORY)

1. **System of Linear Equations and Applications**
   - **a.** Overview of linear system of equations, Cases of unique solution, No solution and infinite solutions,
   - **b.** Echelon form, Gauss elimination method, Inversion of matrix in the context of solution of system of equations, LU factorization, Row space and column space
   - **c.** 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
2. **Vector Spaces and Transformations**
   - **a.** Vector Spaces: Real vector spaces, Subspaces, Basis and dimension, Rank, Nullity
   - b. Gram-Schmidt process for finding orthonormal basis
   - c. Linear Transformation, Kernel of Transformation, Range of Transformation, Matrix of Transformation,

d. Applications: Cryptography, Coding and decoding, Breaking of codes, Robotic Applications of linear transformations

3. Eigenvalues and Eigen Vectors

a. Eigenvalues, Eigenvectors, Similar matrices, Diagonalization,
b. Quadratic forms, Positive definite Matrices, Singular Value Decomposition, Inner product Spaces
c. Applications of linear Algebra: Constructing curves and surfaces, Computer graphics, Genetics

4. Application of Linear Algebra in Dynamical Systems

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

5. Basic Concepts and Modelling

a. 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
b. 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.

6. Analytical Methods of Solution for First-order ODEs

a. 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
b. Exact equations, Integrating factors, Linear equations and related examples, Bernoulli's equations, Orthogonal trajectories and solution of the related ODE models by these methods

7. Mathematical Models Based on Second-order ODEs

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

8. Analytical Methods of Solution for Second-order ODEs

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

9. Laplace Transform

a. Laplace Transform, Derivation of Basic formulae, Inverse Laplace Transform, First shift theorem
b. 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
c. Application of Laplace transform to a system of ODEs and related applications

10. Partial Differential Equations

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

SUGGESTED TEACHING & ASSESSMENT METHODS

1. Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

2. Suggested Assessment Methods Theorey

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

3. Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Introductory Linear Algebra: By Bernard Kolman and David R. Hill, Latest Edition.
2. Elementary Linear Algebra: By Howard Anton and Chris Rorrers, Latest Edition.
3. Advanced Engineering Mathematics by Erwin Kreyzig, John Wiley & Sons Inc. Latest Edition.
4. Differential Equation with Boundary Value problems by D. G. Zill, M. R Cullen Latest Edition, Brooks/Cole Publishers.
5. A First Course on Differential Equations with Modelling Applications by D. G. Zill, Latest Edition, Brooks/Cole Publishers.
6. An Introduction to Mathematical Modelling by Bender, E.A., Latest Edition, Wiley, New York.

ORGANIC & INORGANIC CHEMISTRY

Credit Hours: 2+1=3
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed understanding of Physical and Analytical Chemistry. The course will provide detailed guidance on Analytical and physical chemistry techniques and knowledge employed in the field of Chemical engineering.

COURSE LEARNING OUTCOMES

1. Explain the fundamentals of organic and inorganic chemistry.
2. Explain the chemical reactions involved in organic and inorganic synthesis. Apply the organic or inorganic synthesis reactions in industrial applications

COURSE OUTLINE

- Overview of periodic table
- Molecular orbital theory
- Chemistry of transition metals
- Coordination compound and radioactive elements
- Crystalline state of metals and lattice structure
- Chemistry of solutions, Industrial inorganic Chemistry
- Qualitative and group theory of inorganic Chemistry
- Functional groups o Inter conversion of functional groups
- Reactions mechanism
- Unit Process
- polymerization/polymers o Classification of polymers
- Application of petrochemicals
- Mechanism of sulfonation, nitration; hydrogenation, amination, halogenation, oxidation

COURSE OUTLINE (PRACTICALS)

1. To purify the provided compound using re-crystallization method
2. To purify the provided organic compound (naphthalene) by sublimation
3. To determine the amount of Iron (II) in provided sample using redox titration
4. To separate the provided ternary mixture using physical or chemical methods
5. One step organic synthesis: Synthesis of acetanilide
6. To determine the purity of provided organic compound (naphthalene) using mixed boiling point method

7. To isolate the secondary metabolite (Limonene) from citrus peels using steam distillation method
8. To isolate the given organic compound using solvent extraction method
9. To identify the given salt using salt analysis (Lead acetate)
10. To identify the given salt using salt analysis (Barium Chloride)
11. To identify the given salt using salt analysis (copper sulphate)

SUGGESTED TEACHING & ASSESSMENT METHODS

1. **Suggested Teaching Methods**
   - Lecturing
   - Laboratory Demonstration
   - Written Assignments
   - Guest Speaker
   - Project
2. **Suggested Assessment Methods Theorey**
   - One hour test(s)/Mid-term
   - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
   - Final Exam
3. **Suggested Assessment Methods Practicals**
   - Laboratory Participation
   - Laboratory Report/Manual
   - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Groggins, P. H. (1958). Unit processes in organic synthesis.
2. Kirk, R. E., & Othmer, D. F. (1953). Encyclopedia of Chemical Technology. Vol. 2.
3. Austin, G. T. (1984). Shreve's chemical process industries.
4. Kent, J. A. (Ed.). (2012). Riegel's handbook of industrial chemistry. Springer Science & Business.
5. Miessler, G. L., & Tarr, D. A. (2004). Inorganic chemistry. Upper Saddle River, N.J: Pearson Education.
6. Wade, L. G. (2006). Organic chemistry. Upper Saddle River, N.J: Pearson Prentice Hall.

APPLIED PHYSICS

Credit Hours: 2+1
Pre-Requisites: Nil

DESCRIPTION

An Applied Physics course covers fundamental topics such as vectors, mechanics, electrostatics, and magnetism, providing a strong foundation in classical physics. It then delves into specialized areas like semiconductor physics, exploring the behavior of materials crucial to modern electronics. Additionally, students study waves, oscillations, optics, and lasers, exploring into the principles behind light and its applications. The course may conclude with an overview of modern physics, offering insights into cutting-edge research and technologies.

COURSE OUTLINE

1. **Vectors:**
   - Review of vectors, Ordinary Differentiation of Vector, Gradient of Scaler field, Divergence and Curl of Vector Field, Line and Surface Integrals with applications.
2. **Mechanics:**
   - Newton Laws and their Applications(Simple Accelerometer, Banked Curve and Rotor), Frictional Forces and determination of Co-efficient of Friction, Work-Energy Theorem, applications of law of Conservation of Energy, Angular Momentum, Centre of Mass of two-particles, Many-particles and Solid Object, Rotational Inertia of Solid Bodies.
3. **Electrostatics And Magnetism:**
   - Electric field due to Discrete and Continuous Charge Distribution, Electrostatic Potential of discrete and Continuous charges, Applications of Gauss's Law, Lorentz Force and Hall effect, Ampere's Law, Magnetic Field due to Circular Current Loop and Solenoid, Magnetic dipole, Atomic and Nuclear Magnetism, Magnetization, Magnetic Materials.
4. **Semiconductor Physics:**
   - Energy levels in a Semiconductor, Hole concept, Intrinsic and Extrinsic regions, Law of Mass Action. P-N junction, Transistors.
5. **Waves And Oscillations:**
   - Simple Harmonic Oscillator, Damped Harmonic Oscillation, Forced Oscillation and Resonance, Types of Wave and Superposition Principle, Wave Speed on a stretched string. Wave equation, Energy & Power of a Wave.

6. **Optics And Lasers:**
   - Huygens Principle, Two-slit interference, Single-Slit Diffraction, Resolving power of Optical Instruments. Principles for Laser action, Types of Laser, Applications of Laser.
7. **Modern Physics:**
   - Planck's explanations of Black Body Radiation Photoelectric Effect, Compton Effect, De-Broglie Hypothesis, Electron Microscope, Atomic structure, X-rays and Moseley's Law, Atomic Nucleus and Properties of Nucleus, Radioactive Decay and Radioactive Dating, Radiation Detection Instruments, Nuclear Reactions. Radiation Detection Instruments, Nuclear Reactions.

PRACTICAL REQUIREMENTS

Note: "Labs/ Practical: The course practical/labs should be defined and synchronized with the course outline"

SUGGESTED TEACHING & ASSESSMENT METHODS

1. **Suggested Teaching Methods**
   - 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
2. **Suggested Assessment Methods**
   - Assessment
   - Mid Term,
   - Report writing/ Presentation,
   - Assignments,
   - Project Report,
   - Quizzes, Final Term

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Physics, By: Halliday, Resnick & Krane, Edition: 10th Edition.
2. University Physics, BY: Hugh D. Young and R.A. Freedman, EDITION: 12 Physics for Scientist & Engineers, BY: Serway, Jewett, (latest edition)

14.2 Engineering Domain

PROGRAMMING AND DATA SCIENCES

Credit Hours: 2+1=3
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed understanding of programming and data sciences using Python programming. The course will provide detailed guidance on python tools employed in the field of Chemical engineering. The main focus on solving the real problems of Chemical engineering using python programming.

COURSE LEARNING OUTCOMES

Discuss the introduction to computer programming with data sciences and their tools usage (C2, PLO5)

COURSE OUTLINE

1. Introduction to Computers and Python: Overview of Hardware and Software, Operating systems, Python and other Programming Languages, Internet and World Wide Web, Software Technologies, How Big is Big Data?
2. Introduction to Python Programming: Variables and Assignment Statements, Arithmetic operators, Function print and an intro to strings, getting input from user
3. Programming Logic: Flow charts, program structure, logic building, algorithms
4. Conditional Statements: Boolean operators and, or and not. The if statement and Comparison Operators, Algorithms, Pseudocode, Control Statements, If statement, If else. else statements
5. Repetition Structures: Sequence-Controlled Repetition, Sentinel-Controlled Repetition, Nested Control Statements, break and continue statements
6. Functions: Defining functions, functions with multiple parameters, Random Number generation, case study: A game if chance, python standard library, math module functions, Default parameters values, Keyword Arguments, scope rules, import: A deeper look, function Call stack, Case study: Processing sample dataset in python
7. Sequences: Lists and Tuples: Lists, Tuples, Unpacking Sequences, Sequences Slicing, del statement, Passing lists to functions, Sorting lists, searching sequences, simulating stacks with lists, Two Dimensional lists
8. Dictionaries and sets: Creating a Dictionary, iterating through a dictionary, Basic Dictionary operations, Dictionary Methods keys and values,

Dictionary Comparisons, Comparing sets, Mathematical set operations. Mutable set operators and Methods, Set Comprehensions

9. Array oriented programming with NumPy: Creating arrays from existing data, array Attributes, Filling arrays with specific values, creating arrays from Ranges, List vs array performance, NumPy calculation Methods, Indexing and slicing, views, Reshaping and transposing
10. Manipulating Strings: Formatting strings, concatenating and repeating strings, stripping whitespace from strings, other string manipulation functions
11. Files and Exceptions: Files, Text file processing, updating text files, serialization with JASON, Focus on security, pickle serialization and deserialization, Handling expressions

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Paul Deitel, Harvey Deitel , "Intro to Python for Computer Science and Data Science: Learning to Program with AI, Big Data and The Cloud" 1st Edition, Pearson Education, Inc. 2021
2. Wes McKinney, "Python for Data Analysis", O'Reilly Media, Inc, 2018

NUMERICAL METHODS WITH SOFTWARE APPLICATIONS

Credit Hours: 2+1=3
Pre-Requisites: Nil

DESCRIPTION

This course will give students a brief understanding of linear algebra and its applications to solves various first and second order systems. The course will provide detailed guidance on the significance of simulation using different software tools.

COURSE LEARNING OUTCOMES

1. Discuss linear algebra methods involving first order systems. (C2, PLO1)
2. Apply the linear algebra for numerical solutions using integrals and differential equations (C3, PLO2)

COURSE OUTLINE

1. Linear Algebra

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

2. Linear Algebra Application

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

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

CHEMICAL ENGINEERING THERMODYNAMICS-1

Credit Hours: 2+1=3
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed understanding of Thermodynamic processes and different property relations to solve engineering systems. The students will be able to identify different systems and application of thermodynamic principles to understand the refrigeration and air conditioning systems.

COURSE LEARNING OUTCOMES

1. Explain basic concepts, laws of thermodynamics, and volumetric properties of pure fluids
2. Apply thermodynamics principles and models on systems level

COURSE OUTLINE

1. Thermodynamic systems and processes

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

2. Property relations relevant to engineering thermodynamics

- P-v-t relation, evaluating thermodynamic properties, generalized compressibility chart ideal gas model, internal energy, enthalpy and specific heat of ideal gases,
- Evaluating changes in specific enthalpy and internal energy for ideal gases, polytropic process of an ideal gas.
- Introducing the control volume, conservation of mass and energy in a control volume, steady-state and transient forms of mass and energy rate balances.
- Second law of thermodynamics, isentropic efficiencies of turbines, nozzles, applications of thermodynamics to flow processes, nozzles, turbines, compressors, heat engines, refrigeration, the carnot cycle.

3. Entropy and entropy balance for closed and open systems

- Entropy changes, evaluating entropy data. The clausius inequality

- Entropy balance for closed systems, entropy rate balance for control volumes, isentropic processes, isentropic efficiencies of turbines, nozzles, etc.
- Applications to flow processes, nozzles, turbines, compressors, heat engines,
- Refrigeration & air conditioning
- Refrigeration & air conditioning, and liquefaction of gases.
- Evaluation and application methods of leak detection

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

ENGINEERING DRAWING AND GRAPHICS

Credit Hours: 0+1=1
Pre-Requisites: Nil

DESCRIPTION

This course will help the students to get a schematic overview of various drafting techniques using different drawing instruments and equipment. The course will emphasis on the development schematics figures using the key dimensions. It will also furnish the drawing skills of students for the design of equipment using free hand sketch as well as the computer based designing.

COURSE LEARNING OUTCOMES

1. Ability to apprehend complete shape and inner details of any object from their drawings.
2. Competency in original design.
3. A clear conception and appreciation of form, Proportion and purpose
4. Description of various drawing tools and sheet planning. Ability to convert isometric views into orthographic projection on sheets.

COURSE OUTLINE

1. **Introduction to engineering drawing and graphics**
   - Use of drawing instruments and equipment,
   - Basic drafting techniques and standards;
   - Geometrical curves including plane curves; cycloid;
   - Hypocycloid and involute.
2. **Projection fundamentals**
   - Projection theory,
   - Orthographic projections, projection of points and lines,
   - Dimensioning and tolerance, engineering geometry,
   - Sectioning, orthographic reading and writing, engineering curves,
   - Development of surfaces, fastening method and connectors,
3. **Drawing and Graphics Applications**
   - Concept of working drawing of component parts of machines and engines.
   - Introduction to computer aided drawing software.
   - Computer-aided drawing.
   - Production engineering drawing,
   - Intersections at various positions of geometrical bodies such as prisms, pyramids, cylinders and cones: development of surfaces of prisms, pyramids, cylinders and cones.

- Freehand sketching of machine and engine parts,

4. **Locking Arrangements**
   - Foundation bolts;
   - Stuffing box;
   - Shaft couplings;
   - Foot step bearing;
   - Pulleys; engine connecting rod.
   - Description, dimensions and specifications;
   - Limit dimensioning and geometric tolerance;
   - Limits; fits and tolerances;
   - Conventional symbols.
   - Sectioning of machine and engine components;
   - Isometric views with particular reference to piping and ducting.

SUGGESTED TEACHING & ASSESSMENT METHODS

- Suggested Teaching Methods
- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam

- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

MASS TRANSFER

Credit Hours: 3+1=4
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed understanding of fundamentals of mass transfer and its applications on molecular and macroscopic levels. The students will be familiarized with different mass transfer principles and laws. The students will study the mass transfer operation including distillation, absorption and adsorption in details including their working and different design methods.

COURSE LEARNING OUTCOMES

1. Estimate the diffusion co-efficient for different modes of mass transfer.
2. Describe the basic concepts of mass transfer for multistage separation processes.
3. Calculate the mass transport coefficients for membrane based separation processes.
4. Calculate the mass transport coefficients for liquid-solid and gas-solid, liquid-liquid mass transfer processes.
5. Apply the principles of simultaneous heat and mass transfer on drying, humidification, and de-humidification processes.

COURSE OUTLINE

1. **Fundaments of mass transfer and application**
   - Introduction to mass transfer: processes and operation
   - Theory of mass transfer, concept of mass transfer coefficient, overall mass transfer coefficient, analogies between momentum and mass transfer coefficients,
   - Diffusion in fluids molecular and eddy diffusion in a gas and liquid,
   - Steady state diffusion under stagnant and laminar flow condition, diffusion measurement and calculations, ordinary diffusion in multicomponent gaseous mixtures, diffusion in solids, interface mass transfer,
   - Classification of mass transfer operations; the choice of mass transfer methods
   - Principles and laws
2. **Fick's law of diffusion; steady state diffusion in fluids at rest or in laminar motion.**
   - Concept of mass transfer coefficients, their calculation in laminar and

turbulent flows; interphase mass transfer; equilibrium and diffusion across the interface and the concept of stages. Phase equilibrium in mass transfer.

3. Distillation

- Introduction to distillation
- Application and fundaments of distillation
- Lewis-Sorel; McCabe -Thiele methods.
- Importance of the reflux ratio; calculation of minimum reflux ratio; number of plates at total reflux; underwood and Fenske methods; selection of economic reflux ratio.
- Effect of multiple feeds and side streams.
- Plate efficiency and Murphree's formula. Concept of a theoretical plate and HETP.
- Concept of NTU and HTU
- Method of transfer units and HTU. Enthalpy-concentration method. Multi-component distillation: degrees of freedom in separation specifications. Key components in multi-component mixtures and recovery fraction. Continuous flash distillation with heat balancing;
- Equilibrium and enthalpy expressions; numerical examples of multi-component separation problems; side streams and partial condensers.
- Column design: tray design; hydraulics and performance.
- Batch distillation: operation at constant product composition or constant reflux ratio. Calculation of column diameter and height.
- Heterogeneous azeotropes; Illustrative examples of azeotropic distillation. Reactive distillation.

4. Absorption

- Extension of design techniques toabsorption.

5. Adsorption

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

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments

- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

CHEMICAL PROCESS INDUSTRIES

Credit Hours: 3+0= 3
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed understanding of the various processes covering acid based industries, sugar and fermentation industries, fertilizer industry, pulp and paper industry, cement, polymer etc. This will enable students to apply their engineering knowledge to improve the existing processes.

COURSE LEARNING OUTCOMES

Explain the process equipment symbols, process flow diagram, feedstock and product requirements, and process conditions for important chemical industries

COURSE OUTLINE

An introduction to the fundamentals of data analysis, investigation, design, and communication in chemical engineering. Introduction to chemical product and process design. Needs analysis and problem identification. Literature search and brainstorming. Design requirements, constraints, and criteria. Process synthesis, block diagrams, process flow diagrams (PFD), and piping and instrumentation diagrams (P&ID).

Following industries must cover the above-mentioned points.

a. Acid Industries: Manufacture, history, properties and uses of acetic acid, formic acid, benzoic acid, phthalic acid, and oxalic acid.
b. Sugar and Fermentation Industries: Introduction, culture development, inoculums preparation, nutrients for microorganism, toxic effects on culture. Manufacture, properties and uses of Industrial alcohol, absolute alcohol, butyl alcohol, glycerol, ethylene glycol and propylene glycol.
c. Fertilizer Industry: Ammonia and Urea
d. Pulp and Paper Industry:
e. Cement Industry:
f. Industrial sodium Compounds: Manufacture, properties and uses of industrial sodium compounds like sodium thiosulfate, sodium bromide, sodium sulfate and sodium sulfite etc.
g. Polymers and Petrochemical Industry:

h. Halogens and chlorinated Compounds: Introduction, manufacture, properties and uses of fluorine, bromine, iodine, chlorine, methyl chloride, dichloromethane, chloroform, and carbon tetrachloride

i. Electro-thermal Industries: Introduction, classification, and advantages of electric furnace. Manufacture of silicon carbide, calcium carbide, graphite, and carbon electrodes.

j. Industrial Solvents: Synthesis and properties of dimethylformamide (DMF), dimethyl sulfoxide (DMSO), tetrahydrofuran, dimethyl ether, and diethyl ether.

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
  - Suggested Assessment Methods Practical
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

FLUID MECHANICS-1

Credit Hours: 2+1= 3
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed understanding about various characteristics of fluids and the factors affecting them. The emphasis will be on the study of Newtonian and non-Newtonian fluids and designing of different flow measuring devices.

COURSE LEARNING OUTCOMES

1. Understand the physical properties of a fluid and mechanics of laminar, turbulent, and transition flows
2. Apply the laws of conservation of mass, energy, and linear momentum on steady state fluid flow problems in simple geometries

COURSE OUTLINE

1. **Fluid Mechanics Fundamentals**
   - Significance and application of fluid mechanics in chemical plants
   - Concept, properties and types of fluids, stress analysis of static fluids, newton's law of viscosity, newtonian and non-newtonian fluids.
   - Pressure forces on surfaces, pressure distribution, estimation and measurement
   - Manometry and Head calculations, pressure measuring devices, buoyancy, pressure in accelerated rigid body motions.
2. **Fluid Statics and Dynamics**
   - Fluid statics: Navier-stokes equation,
   - Nature of flow: laminar & turbulent flow, compressible & non-compressible
   - Bernoulli's equation and its applications; continuity equation
   - Momentum of a flowing fluid; newton's 2nd law of motion & momentum balance, calculations for laminar & turbulent pipe flow, nozzle flow & other example.
   - Stress in fluids; viscosity, shear stress components, newtonian and non-newtonian flow
   - Dimensional analysis and similitude, viscous flow in internal flows,
3. **Concept of boundary layer and its importance in fluid dynamics**
   - Flow of incompressible newtonian fluids in pipes & channels shear

stress in a pipe, friction factor & pressure drop, losses in fittings and bend pipes, enlargements and contractions, friction in non-circular channels, velocity distribution for turbulent flow in a pipe.

- Piping network analysis.

4. Flow Measurement Devices

- Orifice meter, venturi meter, rota-meter, nozzle. Notch and wier, electromagnetic flow meter, concept of centrifugal pumps; flow measuring devices such as bernoulli devices,

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

HEAT TRANSFER

Credit Hours: 3+1=4
Pre-Requisites: Nil

DESCRIPTION

This course will give an overview of different modes of heat transfer and the associated relations for their applications. The students will be able to get an insight of different heat transfer equipment and the possible best flow configurations to effectively transfer the maximum heat to the cold object.

COURSE LEARNING OUTCOMES

1. Explain the modes of heat transfer and their governing mechanisms.
2. Describe the mechanism of heat transfer in boiling and condensation and estimation of respective heat transfer coefficients.
3. Apply different methods/strategies to the design of heat transfer equipment.

COURSE OUTLINE

1. Fundaments of heat transfer

- Introduction to heat transfer

2. Modes of heat transfer

- Conduction; Fourier's law of heat conduction, steady state one dimensional heat conduction without and with heat generation, conduction in multi layers geometries and its application in insulation. Unsteady state heat conduction;
- Introduction to heat conduction in two dimensions.
- Convection; concept of free and forced convection; concept of heat transfer coefficient and newton's law of cooling; forced convection in laminar and turbulent flows in pipes and on flat plates; use of dimensional analysis in convection, concept of overall heat transfer coefficient;
- Convective heat transfer with and without phase change. Correlations for forced and natural convection.
- Concept of thermal boundary layer and its analogy with momentum boundary layer.
- Radiation heat transfer; laws of radiation, radiation surface behavior concept of shape factor for black body and non-black body radiation.

3. Heat transfer equipment

- Types and selection criteria; types of heat exchangers and design; heat transfer with phase change; boiling and condensation; the boiling curve; and evaporators selection.

- Industrial applications, categorization, selection criteria and design of numerous heat transfer equipment: heat exchangers.
- International standards, e.g. TEMA, ASTM, and IPS standards shall be followed.

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

CHEMICAL ENGINEERING PRINCIPLES-1

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will facilitate the students to understand the development of process scheme by linking various unit operations and unit processes. The students will familiarize with various flowsheet to understand the process in depth. It will enable the students to undertake the mass balance calculations for a given capacity and throughput.

COURSE LEARNING OUTCOMES

1. Identify standard symbols for process equipment and interpret process flow diagrams
2. Explain the process flow diagram, feedstock and product requirements, and process conditions for important chemical industries

COURSE OUTLINE

1. **Introduction and application of chemical engineering principles**
   - Units, dimensions and conversions, temperature and pressure scales,
   - Composition of mixtures, principles of stoichiometric combination.
   - Nature of balances: concept of a balance. Input-output relationships.
   - Steady state considerations.
   - Black box approach.
   - Sub-systems and interconnections.
2. **Familiarization with flow sheets.**
   - Block diagrams and tables.
   - Process flow diagrams
   - P&I diagram
3. **Mass balances calculations**
   - Balances for continuous plant.
   - Balances for combustion processes.
   - Tie components.
   - Overall and component balances, limiting and excess reactants.
   - Balances for systems with recycle, purge and by-pass streams.
   - Mass balances for reactive processes.
   - Mass balances for multiple streams of plant,
   - Choice of basis/datum for balances.
   - Differential mass balance for batch processes

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

CHEMICAL ENGINEERING PRINCIPLES- II

Credit Hours: 2+0=2
Pre-Requisites: Chemical Engineering Principles- I

DESCRIPTION

This course will give students a detailed understanding of dimensional analysis and consistency for solving different steadystate and dynamic problems. This will help students to undertake the energy calculations as well as the simultaneous mass and energy balances of various chemical processes.

COURSE LEARNING OUTCOMES

1. Discuss dimensional analysis for equations validation (C2, PLO1)
2. Apply the mass and energy balances using process conditions for various case studies (C3, PLO2)

COURSE OUTLINE

1. **Dimensional analysis and consistency**
   - Dimensional consistency
   - Dimensional analysis and degree of freedom
2. **Energy balance**
   - Components of energy balance and Thermochemistry.
   - Balances with reaction: energy balances for reacting systems.
   - Energy balances for combustion processes.
   - Standard states. Temperature and pressure dependence
   - Computer applications/ Programming in stoichiometric calculations.
3. **Simultaneous mass and energy balances**
   - Temperature and pressure dependence.
   - Balances for condensing systems.
   - Dynamic balances.
   - Environmental balances: Sub-systems and interconnections.
   - Case studies on balances for a selection of important industrial processes.
   - Efficiency and conversion.

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

INSTRUMENTATION & PROCESS CONTROL

Credit Hours: 3+1=4
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed understanding of different instruments used for the measurements of various characteristics. The course will also focus on the process dynamics and their control for the smooth run of chemical processes.

COURSE LEARNING OUTCOMES

1. Explain the fundamental concepts, selection criteria and significance of instrumentation in the process systems
2. Assess the dynamic behavior, stability and frequency response for various controllers and process control system by developing transfer functions
3. Develop and apply various control configurations to chemical process units

COURSE OUTLINE

1. Instrumentation

- Principles, sensors, modifiers, recorders etc., calibration and error analysis, instrumentation for temperature, flow, level, weight, load, pressure, composition and pH measurement, transducers, advanced measurement devices employing piezoelectric current, ultrasonic, laser, microwave etc. final control elements.

2. Process Dynamics

- Process modeling procedure and validation, response and linearization, Laplace transformation, step, impulse and frequency response, dead time and transfer functions, construction of block diagrams, dynamics of first and second order systems. Non-Linear processes.

3. Introduction to Process Control

- Concept of feedback/feed forward and components of a typical control loop, structure and interpreting control diagrams, symbols and terminology, control objectives integration with safety, environment, production rate and quality.

4. Feedback control

- Overall transfer function testability, controllers (P, PI, PID etc.) algorithm, final control elements, dynamic behavior of feedback controlled processes, representation of control systems, multiple control loops, cascade, ratio, over-riding etc., introduction to stability of chemical processes, tuning methods, response, stability including

Routh's criteria, Bode plots, Nyquit method, initial and final value theorem.

5. **Feed forward control**
   - Introduction, modeling, algorithm, tuning, and performance.
6. **Discretization**
   - Computer control, Introduction to distributed Control Systems, performance, applications and case studies, computer aided design of control systems using programming, controller self-learning.

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Smith, C. A, Corripio, A. B, Principles and Practice of Automatic Process Control, John Wiley, 3rd Edition 2006.
2. Marlin, T.E., Process Control, 2nd Ed., McGraw-Hill Book Co., 2000.
3. Ogunnaike, B. A., et al., Process Dynamics, Modeling, and Control, Oxford University Press, 1997.
4. Coughanowr, D. R. and S. E. LeBlanc,, Process system Analysis & Control, 3rd Edition, 2009, McGraw-Hill.
5. Process Control Instrumentation Technology, Curtis D. Johnson, Pearson Education 2003.
6. Chemical Process Control, G. Stephanupolos, Prentice Hall 2002
7. Essentials of Process Control, W.L. Luyben McGraw-Hill 1997.

FLUID MECHANICS-II

Credit Hours: 2+0=2
Pre-Requisites: Fluid mechanics-I

DESCRIPTION

This course will enable the students to familiarize with the flow handing and transport devices. The students will learn in details the non-newtonian fluids, the parameters affecting their flowability and the working of fluid motive machineries.

COURSE LEARNING OUTCOMES

1. Describe the function of devices for compressible and incompressible fluid's transportation and select suitable equipment for particular application.
2. Describe and model flow through packed and fluidized beds
3. Demonstrate the application of fluid flow principles in agitation and mixing of fluids, suspension of solids, and dispersion of gases.

COURSE OUTLINE

1. **Flow Handling and Transportation**
   - Centrifugal pump characteristics; NPSH and its application in chemical engineering; concept of specific speed; similarity laws in centrifugal pumps; pumps in series and parallel;
   - Positive displacement pumps, their classification, characteristics and selection; matching system characteristics with pump characteristics.
2. **Flow of Compressible Newtonian Fluids**
   - Flow through porous media: Fluidization and types of fluidized beds and their use in chemical engineering, Particle and Regime classification, minimum fluidization and particulate fluidization, entrainment and elutriation, concept of hydrodynamic characteristics of fluidized beds, bubbling fluidization, turbulent fluidization, slurry bed fluidization. Industrial application of fluidization.
3. **Introduction to non -Newtonian fluids**
   - Flow through packed beds
   - types of packing, hydrodynamics of packed column
4. **Fluid Motion**
   - Fluid Motion in the Presence of Solid Particles, Relative motion between a fluid and a single particle, Effect of presence of other particles and wall on the particle velocity Turbo-machinery and its classifications. Compressors, their classification, characteristics and selection.

Turbines, their classification and selection. Compressible flow and its application in chemical engineering, concept of choked flow.

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

TRANSPORT PHENOMENA

Credit Hours: 3+0=3
Pre-Requisites: Heat transfer + Mass transfer

DESCRIPTION

This course will enable the students to understand the fundamentals of transport processes covering momentum transport, energy transport and mass transport. The students will learn to derive respective equations and their applications to solve the physical and chemical processes problems.

COURSE LEARNING OUTCOMES

1. Identify and describe mechanisms of transport processes present in isothermal, non-isothermal, laminar, and turbulent flow systems
2. Establish and simplify appropriate conservation statements (i.e., the general equations of change and macroscopic balances) for steady and unsteady momentum, heat, and mass transfer processes
3. Make appropriate connections between the equations of change and physical phenomena in systems involving momentum, heat and/or mass transfer

COURSE OUTLINE

1. **Transport processes fundamentals**
   - mechanisms of momentum, energy and mass transport, concept of continuum and fluid statics.
2. **Momentum transport**
   - derivation of equations of continuity and motion (Navier- Stoke's equation), application in laminar and turbulent flow problems (Newtonian & non-Newtonian fluids), equation of change for isothermal systems.
3. **Energy transport**
   - derivation of energy equation. application to heat transfer problems involving conduction, forced and free convection, application in laminar and turbulent flow problems, equation of change for non-isothermal systems and temperature distribution/profiles development, energy transport by radiation
4. **Mass transport**
   - derivation of species conservation equations for binary and multi-component mixtures, application to mass transfer problems with and

without chemical reaction, application in laminar and turbulent flow problems, development of concentration profiles.

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Bennett C. O., Myers J. E. "Momentum, Heat & Mass Transfer" 3rd Ed. 1983. McGraw-Hill Book Company.
2. Bird R. Byron, S Warren E., Lightfoot Edwin N. "Transport Phenomena", Revised 2nd Edition, 2007, John Wiley & Sons Inc.
3. B Robert S., Hershey Harry C. "Transport Phenomena–A Unified Approach", 1988, McGraw-Hill International Editions.
4. Incropera Frank P., De Witt David P. "Fundamentals of Heat and Mass Transfer" 3rd Ed. 1990. John Wiley and Sons.
5. James Welty, Charles E. Wicks, Gregory L. Rorrer, Robert E. Wilson, Fundamentals of Momentum, Heat and Mass Transfer, 5th Edition, 2008, Wiley.
6. Bird RB, Stewart WE, Lightfoot EN, Klingenberg DJ. Introductory transport phenomena. Wiley Global Education; 2015 Feb 13

PARTICULATE TECHNOLOGY

Credit Hours: 3+1=4
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed understanding of characteristics of materials and their use in defining the particulate matters. The course emphasis is on particulate storage systems, mixers and separator of their particles with/from other particles and fluids.

COURSE LEARNING OUTCOMES

1. Perform elementary calculations for analyzing typical industrial processes involving particulate solids
2. Describe common equipment involving particulate solids

COURSE OUTLINE

1. **Characterization**
   - Particle and particulate systems (Sieve analysis, Particle size analysis); Processing (Granulation, Sedimentation); Powder, ultra-fine and nanoparticles technology
2. **Particle Formation and processing**
   - Granulation, Agglomeration, fluidization and size reduction; Description & Energy calculations for coarse to ultrafine size reducing equipment.
3. **Engineering the Properties of Particulate Systems**
   - Colloids, Coal-Water Slurries, Slurry Rheology, Motion of particles in fluid; drag force on a spherical particle, motion of bubbles and drops, accelerated motion of particles in centrifugal field. Sedimentation of fine particles and coarse particles.
4. **Storage and Transport**
   - Hopper Design, Conveyors and its types Pneumatic Conveying, Standpipes, Slurry Flow; Flow through porous media, Carman-Kozney equation. Safety considerations in solid transport.
5. **Separation**
   - Filtration, Settling, Cyclones, Electrostatic Precipitation.
6. **Solid -Liquid mixing**
   - Types of mixing and mixing mechanism. Equipment for solid-liquid mixing.

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

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

INTEGRATED MANAGEMENT SYSTEM (IMS)

Credit Hours: 3+0 = 3
Pre-Requisites: Chemical Process Industries

DESCRIPTION

This course will enable the students to familiarize with the quality control and quality management. The students will learn six sigma concept and good manufacturing practices in the process design.

COURSE LEARNING OUTCOMES

1. Discuss basic concepts, processing steps with other conceptual knowledge to incorporate the integrated management system (C2, PLO1)
2. Perform economic for enhancing the quality and equipment effectiveness using good manufacturing practices (C6, PLO7)

COURSE OUTLINE

- Basic concepts and definition: Traditional Quality Control, Total Quality management, Deming's principles, Customer focus, Employee involvement, Continuous process improvement, PDCA cycle
- Seven step process: Kaizen, Quality measurements, Quality costs, QFD, QMS-ISO9000 standards-requirements and documentation, Taguchi methods, quality loss function, Parameter design and Tolerance design concepts
- Six sigma concepts: define and measure phase, flow charting, basic tools, probability and hazard plotting, Six sigma measurements, basic control charts and process performance matrices, Measurement systems analysis.
- Design of experiments: basics, single factor, two factor experiments. ANOVA, Taguchi approach to design of experiments, orthogonal arrays, Signal to noise ratio, RSM-concepts and methods.
- Analysis approach: Fundamental aspects of reliability, Reliability mathematics, Reliability testing and evaluation methods. FMEA, Failure data analysis
- Total Productive Maintenance: maintainability and Availability Concepts, Reliability management.
- Quality Certifications: ISO9001-2000, ISO14001, ISO22000/HACCP, HALAL Certification, ISO17025, ISO45001 / OHSAS18001, SMETA

(Sedex member ethical trade audit). Concept, clauses and implementation in industries.

- Overall Equipment Effectiveness (OEE): Concept, formulation, relation with productivity and efficiency and benefits.
- Cost of Poor Quality: Concept, calculation and usage in industry.
- Root cause analysis (RCA): Concept, techniques to conduct RCA and usage in industry.
- Corrective Action Preventive Action (CAPA): Concept, techniques of CAPA. Relation with RCA and its benefits.
- Good Manufacturing Practices (GMP), Good Laboratory Practices (GLP) and Good Warehouse Practices (GWP): Concept, techniques, implementation and benefits.

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Dale H; Besterfield, Total quality Mangement, Pearson Education Inc, Latest Edition
2. Caplen, Practical Approach to Quality Control, Random House, Latest Edition
3. O'Connor, Practical Reliability Engineering, John Wiley and Sons, Latest Edition
4. Ryan, Statistical Methods for Quality Improvement, John Wiley and Sons, Latest Edition
5. Ross, Taguchi Techniques for Quality Engineering, McGraw Hill Publishers, Latest Edition

6. Douglas C. Montgomery. Design and Analysis of Experiments, John Wiley and Sons, Latest Edition
7. Balaguruswami E., Reliability Engineering, Tata Mc Graw Hill Publishing Co. Pvt Ltd, Latest Editio.

FUELS & ENERGY

Credit Hours: 2+1=3
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed understanding of fuels, their selection for a specific application, the refinement methods to improve the properties used in their exploitation. The students will get an insight of the different conversion routes of fuel to energy and the overview of energy policy. The emphasis will be on renewable sources of energy for clear energy production.

COURSE LEARNING OUTCOMES

1. Explain the Types, sources, states and resources of Energy.
2. Outline pros and cons of the different energy sources
3. Assess the availability and environmental impacts of different energy resources in Pakistan
4. Discuss and illustrate the concept of different fuel processing techniques

COURSE OUTLINE

1. **Introduction to fuels:**
   - Introduction and overview of locally available fuels
   - Industrial fuels: Classification and storage of solids, liquids and gaseous fuels
   - Characterization of fuel oil, coal and gas, storage, handling and preparation of fuels
2. **Fuel selection**
   - Criteria and characterization for the selection of fuels for industrial purposes
3. **Fuel Up gradation**
   - Carbonization, liquefaction and gasification of coal; Synthetic fuels; Petroleum refining, natural gas processing & syngas production, Fisher-tropsch process and clean coal technology
4. **Principles of combustion**
   - Combustion of solid, liquid and gaseous fuels, mechanism and kinetics of combustion. Combustion calculation
5. **Combustion technologies**
   - Oil & Gas Burners, Fluidized Bed Combustion Boilers. Furnaces and Waste Heat Recovery: Classification, general fuel economy measures in furnaces, excess air, heat distribution, temperature control, draft control.

6. **Overview of Energy Policies:**
   - Energy conversion: Energy conversion technologies in industrial energy systems: overview of technologies and engineering thermodynamics for process utility boilers, steam turbine, gas turbine, combined heat and power (CHP).
   - Emissions control: Greenhouse gas emissions and its consequences, energy efficiency measures in industry, Optimization of industrial Energy systems, Reduction potential for greenhouse gas emissions in industry, Carbon capture and sequestering.
7. **Alternative resources of Energy:**
   - Introduction to ARE sources.
   - Biomass Sources, Biomass conversion processes and technologies, Gasification and liquefaction, Kinetics of gasification.
   - Solar energy, hydel power, wind and tidal energy, geothermal energy. Energy conservation, methodologies of selected systems.

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
    Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

CHEMICAL ENGINEERING THERMODYNAMICS-II

Credit Hours: 2+0=2

Pre-Requisites: Chemical Engineering Thermodynamics-I

DESCRIPTION

This course will give students a detailed review of mass, energy and entropy balances along with the fundamental property relations. The student will learn to solve binary and multi-component mixtures using gas laws and activity models.

COURSE LEARNING OUTCOMES

1. Analyze the power cycles, refrigeration, liquefaction, vapor liquid and chemical reaction equilibria
2. Determine the properties of chemical species in solutions and in gas mixtures

COURSE OUTLINE

1. Review

- Mass, energy and entropy balance, laws of thermodynamics, thermodynamic cycles and equation of state, General Vapour Liquid Equilibrium (VLE) behavior: Equilibrium criterion and Raoults's law. Bubble point, Dew point and Flash calculations.

2. Fundamental property equations

- Partial derivatives, identities and Maxwell relations, residual properties, calculation of thermodynamic properties for pure species, fugacity, chemical potential, and activity coefficients, the gibbs-duhem relation.

3. Mixture properties

- Partial molar quantities; Excess properties; mixing rules, thermodynamic properties calculations of mixtures.

4. Activity models

- Introduction, calculations in Phase Equilibria: Liquid-Liquid, development of ternary diagrams, Liquid-Solid, thermodynamic Analysis of Chemical Processes.

5. Chemical reaction equilibrium

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

6. Introduction to Statistical Thermodynamics

- Boltzman model, fermi-dirac model, Bose Einstein model, Maxwell Boltzman model

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing

- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual

  Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Smith J. M., Van Ness H. C., Abbott M. M. "Chemical Engineering Thermodynamics" 6th Ed. 2001. McGraw-Hill International Edition.
2. Daubert Thomas E. "Chemical Engineering Thermodynamics", 1st Ed. 1985, McGraw-Hill Book Company.
3. Sandler Stanley I. "Chemical and Engineering Thermodynamics" 5th Ed., 2017 John Wiley and Sons, Inc.
4. Eastop, Mc Conkey "Applied Thermodynamics" National Book Foundation
5. Moran M. J., Shapiro H. N., "Fundamentals of Engineering Thermodynamics" 6th Ed, John Wiley & Sons
6. Cengel, Y. A., Boles, M. A., "Thermodynamics: An Engineering Approach", 2008, McGraw-Hill.

ENVIRONMENTAL ENGINEERING

Credit Hours: 2+1= 3
Pre-Requisites: Nil

DESCRIPTION

This course will enable the students to familiarize with different environmental pollutions including air water and land pollution. The course will emphasize the adverse effects of all kinds of environmental pollution and the remediation actions to control or minimize these issues for safe and clean environment.

COURSE LEARNING OUTCOMES

1. To acquire the knowledge about the different kids of pollution and design methods of their control
2. To learn about the ecosystems, impacts of technology and pollution on ecosystems, sustainable development, green chemistry and engineering

COURSE OUTLINE

1. **Basic Concepts:**
   Introduction to environment and ecology, pollution concept, types of pollution. Environmental national and international policy and standards;
2. **Environmental Monitoring (gas, liquid, solids):**
   Sampling and monitoring mechanism, Design and types of samples, Pre-sampling requirements/ information, sampling and design purposes.
3. **Pollution Control and Treatment Techniques:**
   Air pollution control technologies, water pollution control technologies, water treatment technologies, sub-soil / soil pollution control technologies, noise pollution control technologies, cleaner production and zero emissions, Biotechnology for environment, industrial pollution control; covering design, sizing and operation.
4. **Climate Change**:
   Global warming and climate change, Different Weathers, Earth's climate system, types and influencing Factors, Green house effect, Energy use and carbon emissions, Effect and Importance of climate on environment , Impacts of climate changes on human life and environment, History and data analysis of climate changes, Controls of climate changes, UNO action plan of climate changes.
5. **Assessment Techniques:**
   Principles and purposes of IEE and EIA and its significance for the society, Main stages in EIA process. Public consultation and

participation in EIA process. EIA methods and techniques for impact prediction and evaluation. Environmental standards.

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Cheremisinoff Handbook of Air Pollution Prevention and Control, 2002

Proposed Streams / Electives for Chemical Engineering

A - Chemical Engineering	B - Design Engineering	C - Oil & Gas Engineering
A-1: Polymer Engineering	**B-1:** Computational Fluid Dynamics (CFD)	**C-1:** Petroleum Refinery Engineering
A-2: Novel Separation Processes	**B-2:** Experimental Design and Data Analytics	**C-2:** Gas Processing & Transmission
A-3: Mineral Processing Technology	**B-3:** Advanced Machine learning technology	**C-3:** Petrochemical Engineering
A-4: Nanotechnology Engineering	**B-4:** Operation Management and Risk Assessment	**C-4:** Fuel and energy Management
A-5: Chemical process design and Simulation	-	**C-5:** Advanced Fuel Technology
A-6: Industrial Safety and Hazardous Waste Management	-	**C-6:** Drilling Engineering
-	-	**C-7:** Natural Gas Processing & Pipeline Management
-	-	**C-8:** Field Operations and Production
-	-	**C-9:** Reservoir Engineering Management
-	-	**C-10:** Principles of Enhanced Oil Recovery
D - Biochemical Engineering	**E - Green Engineering**	**F - Nuclear Engineering**
D-1: Biochemical Engineering	**E-1:** Green Technologies & sustainable Development	**F-1:** Introduction to Nuclear Engineering
D-2: Biochemical Operation and Kinetics	**E-2:** Industrial Ecology	**F-2:** Nuclear Physics & Reactor Theory
D-3: Biomaterials Engineering	**E-3:** Environment Impact Assessment	**F-3:** Nuclear Materials & Fuels
D-4: Bio separations	**E-4:** Sustainability in Process & Energy Systems	**F-4:** Radiation detection and measurement
D-5: Bioreactor Design		**F-5:** Nuclear Waste Assessment & Management
D-6: Biofuels and Biorefineries	-	-
D-7: Biochemical Treatment of Wastes	-	-

G - Process Engineering	H - Energetic Materials	I - Energy & Power
G-1: Chemical Process Design, Analysis and Optimization	**H-1:** Thermodynamics of energetic Materials	**I-1:** Industrial Energy Systems
G-2: Chemical Wet Processing of Textiles	**H-2:** Material Characterization techniques	**I-2:** Energy Auditing and Management
G-3: Food Processing Engineering	**H-3:** Polymer & composites	**I-3:** Fuel Cell, and Sustainable Energy Technologies
G-4: Advanced Process Control	**H-4:** Alloy Processing and Characterization	**I-4:** Internal Combustion Engines
G-5: Computer-Aided Process Synthesis	**H-5:** Corrosion Engineering	**I-5:** Clean Coal Technology and Co-Generation
G-6: Process Intensification	**H-6:** Computer Aided Design and Manufacturing	**I-6:** Combustion Engineering
G-7: Advanced Process Safety	-	-

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

(ELECTIVE COURSES)

A- CHEMICAL ENGINEERING

A-1 POLYMER ENGINEERING

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of polymer materials and their manufacturing process. The students will get familiarize with various characteristics of polymeric materials.

COURSE LEARNING OUTCOMES

1. Explain the fundamentals of Polymer engineering, its synthesis and properties (C2, PLO1)
2. Describe the processing and rheology of polymers, their blends and composites for existing and advanced technologies (C2, PLO1)

COURSE OUTLINE

- **Introduction to Polymer Science:** Classification of Polymers, Polymer Structure, Molecular Weight, Chemical Structure and Thermal Transitions
- **Polymer Synthesis:** Step-Growth Polymerization, Chain-Growth Polymerization, Polymerization Techniques, Polymer Reactivity, Polymer Conformation and Chain Dimensions
- **Solid-State Properties:** Amorphous and Crystalline state, thermal transitions and properties, mechanical properties, Viscoelasticity and Rubber Elasticity, Thermoplastics, Elastomers, and Thermosets
- **Additives, Blends, Block Copolymers and Composites:** Additives, Polymer Blends and Interpenetrating Networks, Block Copolymers, Composites, Polymer Degradation and The Environment
- **Polymer Processing and Rheology:** Basic Processing Operations, Introduction to Polymer Rheology, Analysis of Simple Flows, Modeling of Polymer-Processing Operations
- **Polymers for Advanced Technologies:** Membrane Science and Technology, Biomedical Engineering and Drug Delivery, Applications in Electronics and Energy, Photonic Polymers, Sensor Applications

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

A-2 NOVEL SEPARATION PROCESSES

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of novel separation processes in the Chemical industries for general and specific separation objectives. The student will also learn the cascading and hybrid separation process for dealing the multi components complex mixtures.

COURSE LEARNING OUTCOMES

1. Explain the fundamentals of novel separation processes (C2, PLO1)
2. Design suitable novel separation technique for a given application in industry and research. (C5, PLO3)

COURSE OUTLINE

- **General Principles:** Phase Equilibria, Mass Transfer Principles, Phase Segregation Multistage Separations based upon Equilibrium and Rate Processes.
- **Ion Exchange Process:** Theory, design and analysis of ion exchange processes along with their industrial applications.
- **Membrane Process:** Mass transfer processes through membranes: separation of chemical species using Pressure driven, osmotic driven and other membrane processes, Design of membrane contactors. Liquid membrane Processes.
- **Chromatographic separation:** Chromatographic separation technology and its application to chemical and biochemical separations.
- **Microwave-assisted Extraction:** Introduction to microwave theory,
- **Microwave-assisted Extraction for Bioactive Compounds:** Essential oils and Aroma, Fats and oils, Antioxidants and Food colors.
- **Microwave-Assisted Extraction of Phenolic Compounds:** Scale-up to industrial scale, quality and safety consideration during scale-up

- **Ultrasonic Separation:** Principles behind this technology and how it can be implemented into existing separation processes

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. R W Rousseau "Handbook of Separation Process Technology", John Wiley & Sons.
2. M A Mchugh & V J Krukonis "Supercritical Fluid Extraction", Butterworth Heinmann.
3. W C Wankat "Large Scale Adsorption & Chromatography" CRC Press Inc.
4. N N Li "Advanced Membrane Technology and Applications" Wiley
5. Seader, J. D., and Ernest J. Henley. Separation Process Principles. New York, NY: Wiley, 1998.
6. King, C. J. Separation Processes. 2nd Edition, New York, NY: McGraw-Hill, 1980
7. Manson Benedict, Nuclear Chemical Engineering, 2nd Edition, McGraw-Hill, 1981
8. Treybal, R. E. Mass Transfer Operations. 3rd Edition, New York, NY: McGraw-Hill

A-3 MINERAL PROCESSING TECHNOLOGY

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of mineralogy, their processing and concentration processes. The course will focus on the curve ananlysis methods and application of biotechnology in mineral processing.

COURSE LEARNING OUTCOMES

1. Explain the minerals processing operations for ore preparation, blending and size reduction (C2, PLO1)
2. Apply elementary calculations for particle size and curve analysis and its performance (C3, PLO2)

COURSE OUTLINE

- **Core Concept:** Introduction to Mineralogy; Objectives of mineral processing. Mine-mill interface. Properties of minerals and ores. Sampling and evaluation, Ore handling
- **Processing:** Particle-size Analysis, Comminution: fracture, liberation, size criteria, energy- size relationships. Crushing and grinding. Screening and classifying.
- **Concentration processes:** gravity concentration, density and other physical processes. Interfacial phenomena. Froth Flotation. Liquid-solid separation: flocculation, thickening, filtration, Magnetic and High-tension Separation, Heavy Medium Separation
- **Curves analysis:** Wash ability curves, Partition curves, Material balances, Performance prediction.
- **Bioprocessing:** Applications of biotechnology in mineral processing

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theorey**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

A-4 NANOTECHNOLOGY ENGINEERING

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of nanomaterials and their characteristics. The main objective is to get the detailed overview on the nanotechnology for the manufacturing of nanomaterials for various industrial applications.

COURSE LEARNING OUTCOMES

1. Explain the fundamental principles of nanotechnology and their application (C1, PLO1)
2. Apply engineering concepts for nano scale synthesis and analysis. (C3, PLO2)

COURSE OUTLINE

- **Basics:** Definition of nanomaterials and their importance
- **Role and Impacts:** Effect of the nano-size on physico-chemical properties of nanomaterials and comparison with bulk/coarse-grained materials (electrical, magnetic and optical properties, surface and structural properties, chemical reactivity)
- **Preparation:** Fabrication of nanomaterials (nanoparticles, thin films, complex nanostructures) with physical techniques (lithography, pulsed laser deposition, electron beam epitaxy, chemical vapour deposition)
- **Synthesis:** Chemical synthesis (coprecipitation, sol-gel, thermal decomposition of organo- metallic compounds, hydrothermal, sonochemical and microwave synthesis) of nanomaterials (nanoparticles, thin films). Functionalization and coating of nanomaterials' surfaces.
- **Analysis:** Characterization of nanomaterials (issues related to the nano size)
- **Assembling:** Assembly of nanoparticles (self-assembly, directed assembly) into complex structures (composites, films, bulk materials)
- **Application of nanomaterials and Nano safety:** applications in different fields
- **Nanotechnology in clean and renewable energies:** nanotechnologies in solar cells and thin film photovoltaics, nanotechnologies in rechargeable batteries: Li- ion batteries, Li- Polymer batteries

- Energetic materials, nanotechnologies in thermoelectricity, fuel cells and supercapacitors, nanotechnology in hydrogen production and storage, energy sustainability, green nanofabrication, safety, and economics

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam
- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. C. P. Poole Jr., F. J. Owens, "Introduction to Nanotechnology", John Willey & Sons,Inc., 2003.
2. J. N. Israelachvili, "Intermolecular and Surface Forces ", Academic Press Inc. LTD,1985
3. R. Pugh, L. Bergstrom, "Surface and Colloid Chemistry in Advanced Ceramic Processing", Marcel Dekker Inc., 1994

A-5 CHEMICAL PROCESS DESIGN AND SIMULATION

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of different routes for design and the factors affecting the design. The students will gain simulation expertise to develop and design the process before their final execution.

COURSE LEARNING OUTCOMES

1. Explain the fundamental concepts of process model development and simulation, and applications of various simulation tools (C2, PLO5)
2. Develop steady state process model for simple chemical processes with their economic evaluation (C3, PLO5)

COURSE OUTLINE

- **Hierarchy of process design;** Process synthesis and design strategy. Pinch design method. Heat and power integration. Reactor network design. Separation system selection and design. Design of heat exchanger networks.
- **Computer-Aided Process Design and Simulation:** Process Design, Development of process flow diagrams, starting a simulation with Aspen Plus and Aspen HYSYS
- **Design and Simulation of single-unit operations:** Heat Exchangers, Pressure changing Equipment, Reactors, Separation Equipment, Solid Handling.
- **Simple concept design of a new process:** Analysis of Materials and Chemical Reactions, Ethyl Acetate Process, Styrene Process, Selection of Technology, de-bottlenecking.
- **Economic evaluation of processes:** Estimation of Capital and Operating Costs, Raw Materials, Utilities, Labor and Manufacturing Costs, General Expenses

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker

- Project

- **Suggested Assessment Methods Theory**
  - One hour test(s)/Mid-term
  - Quiz tests, Assignments, Project Reports/Term Paper/Presentations
  - Final Exam

- **Suggested Assessment Methods Practicals**
  - Laboratory Participation
  - Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Juma Haydary, Chemical Process Design and Simulation: Aspen Plus and Aspen HYSYS Applications, Wiley, 2019
2. Chau, Pao C. "Process Control: A First Course with MATLAB", Cambridge University Press, 2002.
3. Davis, Timothy A. and Sigmon, Kermit, "MATLAB Primer, 7th Ed." Chapman & Hall/CRC, 2004.
4. Smith, R, "Chemical Process Design and Integration" 2005, John Wiley & Sons.

A-6 INDUSTRIAL SAFETY AND HAZARDOUS WASTE MANAGEMENT

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of waste classification and their disposal methods using safe working practices. The student will be able to devise the waste management process using safe practices and least environmental issues.

COURSE LEARNING OUTCOMES

1. Classify the hazardous wastes with respect to their hazardous properties and select appropriate waste management scheme (C1, PLO1)
2. Apply the pollution prevention techniques with regard to hazardous waste along with emergency preparedness and relevant trainings (C3, PLO2)

COURSE OUTLINE

- **Introduction to hazardous wastes:** Hazardous wastes & non-hazardous wastes, the relationship between contamination and hazardous wastes, toxic 12 chemicals.
- **Categories of Waste:** Municipal Solid Waste, Hazardous Waste, Industrial Waste, Medical Waste, Universal Waste, Construction and Demolition Waste, Radioactive Waste, Mining Waste, Agricultural Waste
- **Management of contamination and hazardous wastes:** contamination audit, Contamination impacts on occupational health & safety, hazardous waste regulations and the need for harmonization, Workplace Hazardous Materials Information System (WHMIS), Material Safety Data Sheet (MSDS), Globally Harmonized System (GHS), Managing a waste disposal site
- **Characterization of Municipal Solid Waste:** collection and sampling protocols of MSW, variability affecting waste sampling, common components and properties of municipal solid waste.
- **Hazardous Waste:** Transportation, Treatment, Storage, Disposal Facility Requirements and Incineration.
- **Pollution prevention planning:** Life Cycle Management of all equipment, Reduce, Reuse, Recycle, Recover and Rethink – the 5 R's, Proper storage and disposal of hazardous materials, The importance of ongoing training within organizations

- Contingency planning for major incidents Emergency plan sections and review cycles, The influence of ISO 14001, 18001 and 9001 on hazardous waste management, Types of environmental audits, Preventable major accidents
- Emergency response to hazardous substance release Fundamentals of an emergency response plan, Components in an emergency response plan, Skilled support personnel, Specialist employees, Procedures for handling emergency response
- **Training levels/programs:** First responder awareness level, First responder operations level, Hazardous materials technician, Hazardous materials specialist, On scene incident commander, Refresher training, Medical surveillance and consultation, Personal Protective Equipment (PPE)
- **Management's role in prevention of contamination and hazardous wastes:** HAZID (Hazard Identification), HAZOP (Hazard & Operability), Environmental ethics, Climate change update and its significance.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. John Pichtel, Waste Management Practices: Municipal, Hazardous, and Industrial, CRC Press
2. C. Ray Asfahl, David W. Rieske, Industrial Safety and Health Management, Prentice Hall, 2010
3. Handbook of Industrial and Hazardous Wastes Treatment, Lawrence K. Wang, Yung-Tse Hung, Howard H. Lo, Constantine Yapijaki

B-DESIGN ENGINEERING

B-1 COMPUTATIONAL FLUID DYNAMICS

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of computational fluid dynamics including grid formation, adding equations and solving for engineering problems. The students will solve different case studies to see the heat distribution, velocity distribution etc. in the enclosed system.

COURSE LEARNING OUTCOMES

1. Explain the basic structure and mathematical/numerical modeling strategies (C2, PLO1)
2. Apply CFD codes in the design of fluid system and components for different case studies (C3, PLO5)

COURSE OUTLINE

- **CFD Fundamentals:** CFD and its significance, problem solving using CFD
- **Conservation laws of fluid motion and boundary conditions:** Scope and limitations of experimental, analytical and numerical methods in transport processes, The Continuity Equation and governing equations for Momentum, Heat and Mass transport in a continuum; The General Transport Equation.
- **Turbulence and its modelling:** Characteristics of simple turbulent flows, The effect of turbulent fluctuations on properties of the mean flow, Reynolds-averaged Navier–Stokes equations, Large eddy simulation, Direct numerical simulation
- The finite volume method for convection and diffusion problems: Finite volume method for one-, two- and three-dimensional steady state diffusion, The power-law scheme, TVD schemes, The hybrid differencing scheme
- **Discretization:** basic concepts and methods, Discretized forms and solution methodologies for steady and unsteady-state one-dimensional heat conduction, Extension of discretization concepts to two- and three-dimensional domains, Modeling of Convection and Diffusion terms using various discretization schemes; Calculation of flow field using SIMPLE algorithm.

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

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

B-2 EXPERIMENTAL DESIGN AND DATA ANALYTICS

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of engineering design and data analytics to study the chemical processes. The course will focus on improving the existing processes by screening design and regression methods.

COURSE LEARNING OUTCOMES

1. Demonstrate the statistical and probability study for experimentation (C3, PLO2)
2. Analyze standard data sets, interpret the results and conclude in a clear and comprehensive manner (C4, PLO3)

COURSE OUTLINE

- **Strategies for Experimentation with Multiple Factors:** Introduction, Classical versus Statistical Approaches to Experimentation, Diagnosing the Experimental Environment, Example of a Complete Experimental Program
- **Statistics and Probability:** Introduction, Graphical and Numerical Summaries of a Single Response-Variable, Graphical and Numerical Summaries of the Relation Between Variables, Using Theory to Help Interpret Experimental Data
- **Basic and Advanced Two-Level Factorial Experiments:** Two-Level Factorial Design Geometry, Main Effect Estimation, Interactions, Randomization, Number of Replicates Needed for Desired Precision
- **General Factorial Experiments and ANOVA:** Mathematical Model for Multiple Level Factorials, Testing the Significance of Main effects and Interaction effects, Analysis of Blocked and Split-Plot Factorial Experiments with Multilevel Factors, Comparison of Means after the ANOVA
- **Screening Designs:** Cause-and-Effect Diagrams, Fractionating Factorial Designs, Fractional Factorial Designs, Plackett–Burman Screening Designs, Screening Designs with Multiple Level Factors
- **Regression Analysis:** Method of Least Squares, Linear Regression, Multiple Regression, Quantifying Model Closeness, Checking Model Assumptions, Data Transformation for Linearity Response Surface Designs and Response Surface Model Fitting: Response Surface Concepts and Methods, Empirical Quadratic Model, Design Considerations, Central Composite Designs, Statistical Check of Model Adequacy – Lack of Fit, Analytical Interpretation

of Response Surfaces, Numerical Methods for Interpreting Response Surfaces

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theorey

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. John Lawson and John Erjavec, Basic Experimental Strategies and Data Analysis for Science and Engineering, CRC Press, 2017
2. Denis Constales, Gregory S. Yablonsky, Dagmar R. D'hooge, Joris W. Thybaut, Guy B. Marin, Advanced Data Analysis and Modelling in Chemical Engineering, Elsevier Science, 2016

B-3 ADVANCED MACHINE LEARNING TECHNOLOGY

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of introduction to machine learning. Student will get familiarize with supervised, unsupervised, reinforcement learning and applications.

COURSE LEARNING OUTCOMES

1. Introduce key concepts in machine learning for supervised and unsupervised learning (C1, PLO1)
2. Demonstrate a toolbox of techniques which can be immediately applied to real/future world problems (C3, PLO2).

COURSE OUTLINE

- **Introduction to machine learning;** concept learning: General-to-specific ordering of hypotheses, Version spaces Algorithm, Candidate elimination algorithm;
- **Supervised Learning:** decision trees, Naïve Bayes, Artificial Neural Networks, Support Vector Machines, Overfitting, noisy data, and pruning, Measuring Classifier Accuracy; Linear and Logistic regression;
- **Unsupervised Learning:** Hierarchical Agglomerative Clustering. K-means partitional clustering; Self-Organizing Maps (SOM) k-Nearest-neighbor algorithm; Semi supervised learning with EM using labeled and unlabeled data;
- **Reinforcement Learning:** Hidden Markov models, Monte Carlo some inference Exploration vs. Exploitation tradeoffs, Markov Decision Processes, Ensemble Learning using committees of multiple hypotheses, Bagging, and Boosting
- **Applications:** The Computational Support of Scientific Discovery, Pre and Post Processing in Machine Learning and Data Mining, Machine Learning in User Modeling, Economics, Finance and Marketing, Medical Applications, Power Systems, Human Language Technology and Intelligent Information Systems.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing

- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Georgios Paliouras, Vangelis Karkaletsis, Constantine D. Spyropoulos, Machine Learningand its Applications, Springer, 2001
2. Ella Hassanien, Abdel-Badeeh M. Salem, Rabie Ramadan, Tai-hoon Kim, Advanced Machine Learning Technologies and Applications: Proceedings of AMLTA 2021, Volume 1339 of Advances in Intelligent Systems and Computing
3. Shahar Mendelson, Alexander J. Smola, Advanced Lectures on Machine Learning: Machine Learning Summer School, 2002

B-4 OPERATION MANAGEMENT AND RISK ASSESSMENT

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of evaluating the management science, the classification, decisions and implementation of project management along with different risk assessment tools.

COURSE LEARNING OUTCOMES

1. Apply operation and project management in strategizing the decisions and implementation (C2, PLO11)
2. Apply risk assessment methods to assess the current risk and their forecasting in deciding the control measures (C3, PLO6)

COURSE OUTLINE

- **Introduction:** Introduction to Evaluation of Management Science: Entrepreneurship, SMEs. Nature & scope of Operation Management.
- **Classification and strategies:** Introduction to production management functions and classification of production systems. Production Operation Strategies, Goals tactics and mission.
- **Decisions and implementation:** The decision process, characterization of operation decision, General approach to decision making, Decision Environmental, Decision Models, Resource Allocation- Linear Programming: Model Formulation Types/ Classification of Models; Analysis of linear programming model, Graphics approach, Simplex method, Application of linear programming.
- **Forecasting:** Forecasting Environments & their modeling. Design of Work System: Facilities layout basic types, line balancing, Waiting Lines Goal, measuring system performance Quening Models Infinite Source, Finite Source. Reliability & Liability.
- **Product Life Cycle. Process selection & capacity planning;** Breakeven Analysis, Linear & Non-Linear. Cost volume analysis.
- **Capacity Management:** the meaning of capacity; Capacity factor, Capacity planning; Inventory Management/types & EOQ model, quantity Discount models.
- **Project Management:** PERT CPM Analysis, Queuing Analysis/waiting lines.
- **Risk assessment:** Major hazard accidents; Basic concepts of risk; Hazard identification risk assessment and determining control, HIRADC procedures and techniques; What-if; HAZOP; FMEA; PHA
- **Analysis:** Consequence analysis concerning release of chemical hazards including discharge models, dispersion, and effect models.

- **Fire and Explosion:** Fire and explosion models, effect models. Estimation of incident frequencies (estimation of incident frequencies from historical data, frequency modeling techniques, FTA and ETA).
- **Risk assessment:** Human factors in risk analysis; Risk of chemical reactions, e. g. chemical reactivity and run away, active and passive safety in the design of equipment and systems.
- **Control measures:** Actions required for the handling of hazards to eliminate risks
- **Planning:** Emergency planning and responses; Storage and transportation of hazardous materials. Introduction to International safety standards (e.g., OSHA etc.) A specific case study.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theorey

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/ManualLaboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Bufa E. S., 'Elements of Production/ Operations Management', New York: John Wiley &Sons, 1980
2. Chase Richard B. Aquilano, Nicholas, J. (1973), 'Production of operations management: alifecycle approach'. Homewood, III: R. D. Irwin.
3. Raymond R. Mayer, 'Production and Operations Management', McGraw-Hill, 1975
4. John V. C. Lawrence R. P. Reavil A. C. Payne (2004), Management of Engineers, Scientists& Technologists', 2nd Edition, Wiley & Son.
5. Fullwood R. R., "Pobabilitistic Safety Assessment in Chemical and Nuclear Industries".

C-OIL & GAS ENGINEERING
C-1 PETROLEUM REFINERY ENGINEERING

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of refinery of petroleum feedstock, their processing and modern techniques for achieving refined fractions.

COURSE LEARNING OUTCOMES

1. Describe the refinery products, test methods and petroleum properties (C1, PLO1)
2. Design suitable refining, separation, blending and auxiliary operations (C4, PLO3)

COURSE OUTLINE

- **Introduction;** Crude Petroleum Oil, Indigenous and World resources, Composition of Crude Oil, Physical Properties of Crude Oil, Origin of Hydrocarbons, Exploration Techniques, Resource Estimation, Oil Field Development, Well Logging, Oil Production Processes.

- **Feed stock Properties and Processing:** Petroleum Products and Test Methods, Crude Oil Analysis, Lubricating Oils and Grease, Characterization of feed stocks and product, Processing Operations in a Petroleum Refinery, Crude Oil Receiving, Crude processing, Desalting of Crude Oil, Distillation and Stripping, Atmospheric Distillation, Stabilization, Amine Absorption.

- **Design Approach:** Material and Energy Balances, Measurement of Quantity of Crude Oil and Products, Overall Material Balance , Energy Balance in a Plant , in Heat Exchanger , in a Furnace and Distillation Column, Design calculations for Distillation and Stripping, Processes of Distillation and Stripping , Batch Distillation , Boiling Point and Equilibrium Diagrams, Reactor Calculations , Reactors in Refineries, Design Steps for Crude Pipes , Economic Pipe Diameter , Product Transfer Lines, Gas Transfer Lines, Pumps and Compressors problem

- **Modern Techniques:** Modern petroleum processing, Refining operation, Atmospheric distillation, Vacuum distillation, Alkylation, Reforming

Isomerization, Hydroprocessing, Visbreaking and Coking, Gas Processing and Polymerization, Refinery supporting processes, Solvent Extraction.

- **Auxiliary Operation;** Supporting processes of Refinery, Auxiliaries operation of refinery. Use of linear programming techniques to solve refinery blending and production problem. Plant management and economics

- **Environment and Safety:** Waste in Refinery, Gas waste management, liquid waste management and solid waste management, Safety analysis of refinery, HAZAN analysis, DOW index, MOND index

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. W.L.Nelson,PetroleumRefineryEngineering,1991,McGraw-Hill.
2. MohamedA.Fahim,TaherA.AlSahhaf,AmalElkilani,FundamentalsofPetroleumRefining,Elsevier, 2010
3. G.D.Hobson,ModernPetroleumtechnology,AppliedSc.Publisher,1991
4. J.H.GaryandG.EHandwerk,PetroleumRefineryTechnology&Economics,2001,Dekker
5. Uttam Ray Chaudhuri "Fundamentals of Petroleum and Petrochemical Engineering"

C-2 GAS PROCESSING & TRANSMISSION

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of gas processing techniques and their transmission.

COURSE LEARNING OUTCOMES

1. Apply fundamental knowledge of thermodynamics to estimate natural gas properties (C3, PLO1)
2. Analyse the natural gas purification processes and their distribution networks (C4, PLO2)

COURSE OUTLINE

- **Basic Concepts:** Introduction to natural gas industry, gas production, testing of well fluid; Test separator, Multiphase flow meters, establishing GOR.
- **Separation process:** Gas-liquid separation design and configurations
- **Gas Sweetening Process:** Chemical and Physical solvent processes. Membrane/molecular sieve processes, Cryogenic separation, solvent regeneration. Dehydration of Natural Gas, LPG recovery and condensate stabilization, LNG and CNG. Gas processing facilities, process flow schemes and product specifications.
- **Processing facilities:** Gas processing facilities, process flow schemes and product specifications.
- **Gas Emissions:** Disposal of gas field emissions, effluent, produced water (EOR, Re-injection, flaring) Design, metallurgy and corrosion protection of gas pipelines and equipment. Sludge handling.
- **Gas compression and Equipment's:** Gas compression; compressors types, selection between centrifugal and reciprocating compressor, design considerations. Energy conservation in gas processing facilities. Pigging of gas lines
- **Flare System: Flare system design;** PSVs, blow down, flare/vent stack sizing.

- **Case Studies:** Simulation process of Sweetening process

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theorey

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Ken Arnold, Maurice Stewart, Design of Gas Handling Systems and Facilities, Volume 2, Gulf Publishing Company, 1989
2. Stephen A. Newman, Acid and Sour Gas Treating Processes, Gulf Publishing Company, 1985.
3. Donald L. Katz , Handbook of Natural Gas Engineering, McGraw-Hill, 1990.
4. M. Saeed, Handbook of Natural Gas Transmission and Processing, Gulf Publishing Company, 2006.
5. E. J. Hoffman, Membrane Separation Technology, Gulf Publishing Company, 2003.
6. Tarek Ahmed, "Reservoir Engineering Handbook", Gulf Professional Publishing, 4E , 2010.
7. Charles R. Smith, G. W. Tracy, and R. Lance Farrar, "Applied Reservoir Engineering", Vol 1 and Vol 2 – OGCI Publications, 1992
8. Boyan Guo and Ali Ghalambor, "Natural Gas Engineering Handbook", Gulf Publishing Company, 2nd Edition, 2005 (latest Edition).

C-3 PETRO CHEMICAL ENGINEERING

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of petroleum based chemicals and their application in chemical process industries.

COURSE LEARNING OUTCOMES

1. Describe the natural gas and petroleum derivative feedstocks, properties and their applications areas (C1, PLO1)
2. Explain the process synthesis of different natural gas and petroleum derivatives (C2, PLO3)

COURSE OUTLINE

- **Introduction of Natural Gas:** Composition and properties, natural gas liquids, gas condensate, gas hydrates, other types of gases
- **Petroleum derivatives:** Composition and properties, Opportunity Crude Oil, High Acid Crude Oil, Foamy Oil, Tight Oil, Other Petroleum-derived Feedstocks, Heavy Oil, Extra Heavy Oil, and Tar Sand Bitumen, Naphtha
- **Other Feedstocks:** Coal, Oil Shale, and Biomass, Waste
- **Gas Streams Feedstock Preparation:** Gas Streams from Natural Gas, Natural Gas Liquids and Liquefied Petroleum Gas, Gas Streams from Crude Oil, Acid Gas Removal, Recovery of Condensable Hydrocarbon Derivatives, Water Removal, Nitrogen Removal, The Claus Process
- **Petroleum Streams Feedstock Preparation:** Refinery Configuration, Cracking Processes, Thermal Cracking Processes, Catalytic Cracking Processes, Dehydrogenation Processes, Dehydrocyclization Processes, Streams from Coal Gas and Coal Liquids, Oil Shale Gas and Shale Oil and Biogas and Bio-liquids.
- **Feedstock Preparation by Gasification:** Gasification Chemistry, Gasification Processes, Gas, Liquid, Solid Production
- **Hydrocarbon Sources and Raw materials;** their characterization, availability and pricing. Processes for the production of ethylene, acetylene, and other monomers, Petroleum in Monomers, Polymers, Plastics, Pharmaceuticals

- **Chemicals from:** Paraffin Hydrocarbons, Olefin Hydrocarbons, Aromatic Hydrocarbons, Non-hydrocarbons, Fischer–Tropsch Process
- **Processes:** Processes for the production of ethylene, acetylene, and other monomers, Polymerization of monomers into useful plastics, Synthesis gas production, separation and purification, ammonia synthesis. TX production, separation and purification.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theorey

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. James G. Speight, Handbook of Petrochemical Processes, CRC Press, 2019
2. Austin George T. Shreve's Chemical Processes Industries McGraw-Hill, 6th Ed. 1997.
3. Meyers, Handbook of Petrochemical Production Processes, 2005, McGraw-Hill.
4. C. Waddems, Chemicals from Petroleum, John Murray, 1963
5. S. Strelzoff, Technology and Manufacture of Ammonia, 1982, Inter Science Publishers.
6. Kirk Othmer, Encyclopedia of Chemical Technology, 1999, Intoosc Publishers.

C-4 FUEL AND ENERGY MANAGEMENT

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of advanced management methods for fuel and energy applications.

COURSE LEARNING OUTCOMES

1. Explain the types, sources, and resources of energy (C, PLO4)
2. Discuss different conversion technologies and their environmental impacts (C2, PLO1)

COURSE OUTLINE

- **Classification of fuels:** Introduction and overview of locally available fuels, industrial fuels: Classification and storage of solids, liquids and gaseous fuels, Renewable fuels,
- **Fuel Properties and characterization:** Various properties, Characterization of fuel oil, coal and gas, storage, handling and preparation of fuels. Fuel selection criteria for industrial applications
- **Fuel Upgradation:** Carbonization, liquefaction and gasification of coal; Synthetic fuels; Petroleum refining, natural gas processing & syngas production, Fisher-tropsch process and clean coal technology
- **Principles of combustion:** Combustion of solid, liquid and gaseous fuels, mechanism and kinetics of combustion. Combustion calculation
- **Combustion technologies:** Fluidized Bed Combustion Boilers. Furnaces and Waste Heat Recovery: Classification, general fuel economy measures in furnaces, excess air, heat distribution, temperature control, draft control, waste heat recovery.
- **Energy conversion:** Energy conversion technologies in industrial energy systems: overview of technologies and engineering thermodynamics for process utility boilers, heat pumps, steam turbine combined heat and power (CHP) and gas turbine CHP. Energy conversion performance of such systems for given energy conversion process parameters and given process head load.
- **Emissions control:** Greenhouse gas emissions consequences of energy efficiency measures in industry. Greenhouse gas emissions from industrial energy systems. Optimization of industrial Energy systems considering future costs associated with greenhouse gas emissions. Potential for

greenhouse gas emissions reduction in industry. Overview of energy policy Instruments and their impact on industrial energy system decision-making.

- **Alternative resources of Energy:** Introduction to ARE sources, Biomass Sources, Pretreatment of biomass for thermo-chemical conversion, methods of production of fuels from biomass, Gasification and liquefaction of forest products, Biomass volatilization, Kinetics of gasification, Ethanol and Methanol production from biomass, Solar energy, hydel power, wind and tidal energy, geothermal energy. Energy conservation, methodologies of selected systems.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Turns, S. R. "An Introduction to Combustion" 2nd Edition, McGraw-Hill. 2000.
2. Griffiths, J. F. & Barnard, J. A. "Flame and Combustion", 3rd Edition, Blackie Academic & Professional. 1995.
3. Harker J. H., Backhurst J. R. "Fuel and Energy", 1981, Academic Press"
4. Marion L. Smith, Karl W. stinson, "Fuels and Combustion", McGraw-Hill, 1952

C-5 ADVANCED FUEL TECHNOLOGY

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of advanced fuel technologies for their effective exploitation.

COURSE LEARNING OUTCOMES

1. Explain the process synthesis of advanced derived sustainable fuels (C2, PLO3)
2. Develop safe energy storage and transportation facility for derived fuels (C4, PLO3)

COURSE OUTLINE

- **Advanced Fuel Technologies:** Sustainability, recycling, carbon free fuels, next generation fuels.
- **Methanol & Ethanol:** Historical development of Methanol & Production of methanol Reactions and applications of methanol & Future opportunities and challenges Storage and handling aspects, Pure methanol & Methanol containing system Toxicity, Occupational health, and environmental concerns.
- **Production of methanol:** Thermodynamics and kinetics of methanol synthesis & Syngas preparation process Steam reforming of natural gas to methanol & Conversion of methanol to gasoline. Conversion of methanol to olefins, Methanol fuel & Methanol as a fuel, Methanol vehicle exhaust emissions & Future methanol engine and vehicles Methanol in heavy duty engines & Outlook for fuel methanol
- **Hydrogen:** An energy dependent world & The basics of hydrogen History and development, why hydrogen as a fuel & Pros and cons into the future Production Hydrogen from fossil electrolysis, Hydrogen from coal Hydrogen from methane & Hydrogen from Biomass pyrolysis /steam reforming Modeling of hydrogen separation & Storage and handling aspects Membrane for enhanced hydrogen production from Water Gas shift reaction, Hydrogen-metal systems & Mass storage of hydrogen
- **Hydrogen storage for future energy systems:** Fuel cell system model Transportation of gaseous hydrogen by pipelines & Hydrogen fuel Transportation of liquid hydrogen by truck or ship & Analysis and

simulations Fuel cells, Progress in PEM fuel cell development & Hydrogen fueled transportation Fuel cell vehicles,

- **Hydrazine:** Introduction & Physical properties of hydrazine Hydrazine chemistry, Production of hydrazine & Hydrazine handling aspects Decomposition and combustion of hydrazine & Hydrazine applications

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Chris Hayhurst Hydrogen Power: New Ways of Turning Fuel Cells Into Energy, Rosen Publishing Group, 2003.
2. Wu-Hun Cheng, H.H. Kung, Methanol production and use, Marcel Dekker, 1994
3. Schmidt "Hydrazine & its derivatives: Preparation, Properties, Applications", Wiley, 2001
4. G. Padro, F. Lau "Advances in Hydrogen energy", Springer, 2013
5. Pukrushpau, Awa G., HueiPeng "Control of Fuel Cell Power Systems: Principles, Modeling, Analysis and Feedback Design", Springer, 2004

C-6 DRILLING ENGINEERING

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of drilling methods for oil and gas exploration.

COURSE LEARNING OUTCOMES

1. Explaining the fundamentals of drilling for oil and gas exploration (C2, PLO1)
2. Explain different methods and their effects on the drilling behavior and related products (C3, PLO2)

COURSE OUTLINE

- **Introduction to drilling methods:** Rotary drilling operations. Rig components and their functions. Bit type selection and evaluation.
- **Drilling fluids:** Functions, types, and compositions. Mud properties and calculations. Mud pump ratings and horsepower requirements.
- **Cementing:** Cementing for strengthening, types and composition, testing, standardization of cements and additives, cement placement techniques,.
- **Drilling hydraulics:** Hydrostatic Pressure in Liquid, Gas and Complex Fluid Columns, Buoyancy, Rheological Models, Particle Slip Velocity
- **Formation pore pressure and fracture resistance:** Formation Pore Pressure, Methods for Estimation
- **Casing Design:** Manufacture of Casing, Standardization of Casing, API Casing Performance Properties
- Drilling hazards and their remedies: Pressure relationship in the formation and bore hole. The hydrostatic fluid head including mud and cement slurries.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term

- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. T Bourgoyne jr., K. K. Millehim, Applied Drilling Engineering, Society of Petroleum Engineers, 1991. ISBN: 1555630014.
2. J. L. Lummus, Drilling Fluids Optimization: A Practical Field Approach, Pennwell Corp ISBN: 0878143068.
3. Norton J. Lapeyrouse, Formulas and Calculation for Drilling, Production and Workover, ASIN: B001MT21K0.
4. Hussain Rabia, Oil Well Drilling Engineering, Principles & Practice, ISBN: 0860107140.
5. Hussain Rabia, Fundamentals of Casing Design, ISBN: 0860108635

C-7 NATURAL GAS PROCESSING AND PIPELINE MANAGEMENT

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of processing methods for natural gas and the pipeline management scheme.

COURSE LEARNING OUTCOMES

1. Apply fundamental knowledge of thermodynamics to estimate natural gas properties (C3, PLO1)
2. Analyze the corrosion behavior of natural gas, storage and distribution components (C4, PLO2)

COURSE OUTLINE

- **Introduction to natural gas industry:** natural gas properties, flow and compression calculations, gas transmission, sweetening and dehydration of crude gases, distribution of gas in the city, gas stations, pipe line welding techniques, testing and welding defects and gas flow measurements.
- **Corrosion Principles:** Corrosion mechanism, causes of corrosion cells, polarization and factors of polarization, high temperature corrosion, stress corrosion cracking; sulfide stress corrosion cracking, chloride stress corrosion cracking, caustic stress corrosion cracking, environmentally inducted cracking. Hydrogen damages and corrosion losses.
- **Corrosion Control:** Corrosion detection methods; corrosion coupons, corrosion resistance probes, caliper measurements, ETT, sonic testing, casing potential profile tool. Corrosion control methods; material selection environment modification, inhibitor treatment. Evaluation of inhibitor treatment program, cathodic protection, properties of galvanic anodes, design of impressed current, G/B, criteria of cathodic protection, interference and anodic protection.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term

- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Handbook of Natural Gas Engineering by Donald & Katz, ISBN: 007033384X.
2. Petroleum Transportation Handbook by Harold Sill, ASIN: B0000CM32Q
3. Gas Conditioning and Processing by John M. Campbell, ASIN: B000UMK60W.
4. Petroleum Reservoir Engineering, Physical Properties by James W. Amyx, ISBN:0070016003.
5. Corrosion Engineering, by Mars G. Fontana, Norbert D. Greene, ISBN: 0070214611.
6. Control of Pipeline Corrosion by A. W. Peabody, ISBN: 1575900920.
7. Pipeline Corrosion and Cathodic Protection, by Marshall Parker, Edward G. Peattie, ISBN:0872011496.

C-8 FIELD OPERATIONS AND PRODUCTION

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of field operation and production.

COURSE LEARNING OUTCOMES

1. Explaining the fundamentals of drilling for oil and gas exploration (C2, PLO1)
2. Explain operational behavior of drilling in oil and gas field operations (C3, PLO2)

COURSE OUTLINE

- **Introduction;** Production Operations and Geologic Considerations; Reservoir Considerations in Well Completions; Fluid and Rock Properties, Formation Pressure Regimes, Reservoir Fluid Flow, Use of Well Test Analysis in Determining Reservoir Fluid and Rock Properties. Reservoir Drive Mechanisms.
- **Field Operations;** Wire line Operations, Production Logging, Coiled Tubing-scale clean outs, Problem Wells e.g., Formation Damage – Minimization and Stimulation. Primary Cementing, Well Completion Design, Tubing Strings, Packers, Subsurface Control Equipment, Perforating Oil and Gas Wells, Completion and Work over Fluids, Work over Systems; Through-Tubing Production Logging, Work over and Completion Rigs; Squeeze Cementing - Remedial Cementing, Sand Control, Formation Damage, Surfactants for Well Treatments, Acidizing; Hydraulic Fracturing, Scale Deposition, Removal, and Prevention, Corrosion Control

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations

- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Petroleum Production Engineering: A computer Assisted Approach by Boyun Gue,William C. Lyons and Ali Ghalambor ISBN: 0750682701.
2. Production Operations, by Thomas O. Allen and Alan P. Roberts, ASIN: B007OAP64O.
3. Natural Gas Production Engineering by Chi U. Ikoku, ISBN: 0894646397.
4. Introduction to Petroleum Production; Volume I & II by D. R. Skinner, ISBN: 0872017672.
5. Well Performance by Michael Golan and Curtis Whitson, ISBN: 9027722838.
6. Surface Operation in Petroleum Production, by G. V. Chillingarian, J. O. Robertson, ISBN:0444424733.

C-9 RESERVOIR ENGINEERING MANAGEMENT

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of reservoir engineering management methods.

COURSE LEARNING OUTCOMES

1. Explaining the fundamentals of reservoirs for oil and gas exploration (C2, PLO1)
2. Explain reservoir management, surveillance for its performance forecast (C3, PLO2)

COURSE OUTLINE

- **Introduction to Reservoir Management:** Primary production, reservoir life cycle offsetting decline, business planning, meeting the short and long term goals.
- **Reservoir Management Process:** Maintaining well count to meet the production commitments. Offsetting decline. Business development planning and implementation. Production strategies evaluation. Learning from failures and management mistakes.
- **Reservoir Surveillance:** Common data types. Pressure data collection, validation and isobaric mapping. PVT samples collection for PVT analysis. Using acquired data. Monthly well testing for production allocation and field production potential estimates.
- **Reservoir Performance Analysis and Forecast:** Natural production mechanisms. Reserve estimates (Volumetric, simulation, decline curve analysis and material balance)
- **Reservoir Management Economics:** Economic criteria, scenarios, economic evaluation, risk and uncertainties. Economic optimization example.
- **Case Studies:** Reservoir Management planning for newly discovered fields, secondary and EOR operated fields.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing

- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. LP Dake, Fundamentals of Reservoir Engineering, Elsevier Science, 1978, ISBN044441830X
2. BC Craft and MF Hawkin, Applied Petroleum Reservoir Engineering, Prentice Hall, 1991,ISBN 0130398845
3. Charles R. Smith, G. W. Tracy, R. Lance Farrar, Applied Reservoir Engineering, Vol. I &II, OGCI Publications, 1992, ISBN 0930972155
4. Sylvai Joseph Pirson, Elements of Oil Reservoir Engineering by, McGraw-Hill, 1950,ISBN 0882755005
5. M Walsh & LW Lake, A Generalized Approach to Primary Hydrocarbon Recovery of Petroleum Exploration & Production, Elsevier Science, 2003, ISBN 0444506837
6. Chi U Ikoku, Natural Gas Production Engineering, Krieger Pub Co.,ISBN 0894646397

C10-PRINCIPLES OF ENHANCED OIL RECOVERY

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of principles of enhanced oil recovery systems.

COURSE LEARNING OUTCOMES

1. Explaining the fundamentals of enhanced oil recovery operation (C2, PLO1)
2. Illustrate different approaches for EOR, their selection, injection mechanisms and impact on the enhanced production (C2, PLO1)

COURSE OUTLINE

- **Basic concepts of EOR:** Linear, two- and three-dimensional displacements, The role of reservoir geology in the design and operations. Microscopic efficiency of linear immiscible displacement, Areal and vertical displacement efficiency in 2-D and 3-D systems.
- **Water Flooding:** Selection criteria, displacement theories and performance calculations. Selection and efficiency of various flood patterns, Practical considerations for waterflood design.
- **Immiscible Displacement by Gas Injection:** Surface installations; compression and treatment methods. Special applications of gas injection.
- **Thermal Recovery Methods:** Steam and Hot Water Displacement, In-situ combustion.
- **Miscible Flooding:** Thermodynamic Miscibility, Ternary Diagram, First and Multiple Contact Miscibilities, Carbon Dioxide, Nitrogen and Water Alternating Gas Flooding.
- **Chemical injection:** Polymers, Misceller Polymer, Alkaline and Surfactants.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term

- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Tarek Ahmed, "Reservoir Engineering Handbook", Third Edition, Elsevier, 2006.
2. Don W. Green and G. Paul Willhite, "Enhanced Oil Recovery", 22nd Edition, Volume 6, Society of Petroleum Engineers Richardson Texas, 1998.
3. Larry W. Lake, "Enhanced Oil Recovery", Society of Petroleum Engineers Richardson Texas, Prentice Hall, 2010.
4. Marcel Latil, "Enhanced oil Recovery", Editions TECHNIP, 1980, ISBN: 0872017753
5. Rafael Sandrea, Ralph Nielsen, "Dynamics of Petroleum Reservoirs under Gas Injection", Gulf Publishing Company, 1974, ISBN: 0872012190

D - BIOCHEMICAL ENGINEERING

D1-BIOCHEMICAL ENGINEERING

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of biochemical engineering.

COURSE LEARNING OUTCOMES

3. Analyze elementary mechanisms for microbiology, molecular biology and genetic engineering (C4, PLO2)
4. Analyze reaction rate data to develop a suitable rate equation and determine its kinetic parameters in Biochemical reactions (C4, PLO2)

COURSE OUTLINE

- Review of elementary aspects of microbiology,
- Biochemistry, molecular biology, and genetic engineering.
- Introduction of biological systems to produce commercial goods and services, e.g., foods, pharmaceuticals, chemicals, fuels, diagnostics, waste treatment, and biomaterials.
- Introduction to design of bioprocess systems, including biosafety and sustainability.
- Development of reaction kinetics associated with biological systems.
- Quantification of metabolism. Development of material balances for key constituents in bioreactors operated in different modes, e.g., batch, fed-batch, continuous stirred-tank reactor (CSTR), perfusion, recycle. Introduction to mass and heat transfer considerations for bioreactors. Dynamic simulation of cultures defined by ordinary differential equations. Introduction of downstream processes associated with biological systems and recovery of biological products.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

D2 - BIO-CHEMICAL OPERATIONS & KINETICS

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of biochemical operation and kinetics.

COURSE LEARNING OUTCOMES

1. Explain the fundamentals of biochemical operations and relevant stoichiometry (C2, PLO1)
2. Design the reactors based on cell kinetics and fermentation technology (C5, PLO3)

COURSE OUTLINE

- **Basic concepts and principles:** Introduction, Elements of Physical Transfer Processes, Chemical and Biochemical Kinetics, Material balances, Energy balances, Mixing and Scale up.
- **Cell Kinetics:** Cell Nutrients, Microbial Growth and Kinetics, Enzymatic Reactions and Kinetics, Bioreactors (Batch, Fed Batch, Continuous Flow), Cell Immobilization and Immobilized Cell Bioreactors.
- **Fermentation technology:** Mass Transfer (Oxygen Transfer), Unit Operations (Downstream Processing), Homogenous Reactions, Metabolic Engineering with Focus On Industrial Applications, Laboratory Exercises with Laboratory Scale Bioreactor, Solid State Fermentation, Bioreactor and Fermenter Scale-Up/Scale Down, Mixing, Aeration, Instrumentation, And Genetic Engineering.
- **Unit Operations and Apparatus for Biosystems:** Membrane Processes, Cell-Liquid Separation and Cell Disruption, Sterilization, Adsorption and Chromatography.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Shigeo Katoh, Jun-ichi Horiuchi, Fumitake, Biochemical Engineering: A Textbook for Engineers, Chemists and Biologists, Wiley-VCH
2. Michael L. Shuler and Fikret Kargi, Bioprocess Engineering, Basic Concepts," 2nd Edition, Prentice Hall, 2001. ISBN-10: 0130819085 ISBN-13: 978-0130819086.

D3- BIOMATERIALS ENGINEERING

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of biomaterials engineering.

COURSE LEARNING OUTCOMES

1. Discuss different types of bio-materials and their properties (C2, PLO1)
2. Select suitable bio-material for a given application considering both its efficacy and sustainability (C4, PLO3)

COURSE OUTLINE

- **Introduction:** Definitions, Types of Bonds in Materials, Types of Materials, Impact of Biomaterials
- **Basic Properties of Materials:** Mechanical Properties, Electrochemical Properties, Surface Properties, Structure and Properties of Biologic Tissues and Biocompatibility
- **Biological Systems:** Genetic Regulation and Control Systems, The Plasma Membrane, Cell Signaling Pathways, Biological Testing Techniques.
- **Characterization of Biomaterials:** Infrared Spectroscopy, X-Ray Photoelectron Spectroscopy, Secondary Ion Mass Spectroscopy, Atomic Force Microscopy, Scanning Electron Microscopy
- **Metals: Structure and Properties:** Titanium and its Alloys, Stainless Steel, Cobalt Chromium Alloys, Nitinol, Tantalum, Magnesium.
- **Polymers:** Molecular Structure of Polymers, Types of Polymerization, Physical States of Polymers, Common Polymeric Biomaterials, Hydrogels, Nanopolymers
- **Ceramics:** Classification, Bioceramics, Nanoceramics
- **Natural Biomaterials:** Collage, Elastin, Silk, Chitosan, Cellulose, Alginate, Hyaluronan, Chondroitin Sulfate, Coral
- **Surface Modification:** Abrasive Blasting, Plasma Glow Discharge Treatments, Thermal Spraying, Physical Vapor Deposition of Materials Science and Engineering Topics.
- **Applications of Biomaterials**: Drug Delivery Systems, Metallic, Ceramic, and Polymer Materials used for Surgical and Dental Implants; Biomaterials

Processing and Selection, Implant Design, Physical and Mechanical Testing; Corrosion and wear in the body.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Gopinath Mani, Joo L. Ong, Mark R. Appleford, C. Mauli Agrawal, Introduction to Biomaterials: Basic Theory with Engineering Applications, Cambridge University Press, 2013
2. Encyclopedia of Biomaterials and Biomedical Engineering, E. Wnek Gary, Gary L. Bowlin, 2004

D4- BIOSEPARATIONS

Credit Hours: 2+0=2

Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of bioseparations systems.

COURSE LEARNING OUTCOMES

1. Describe basic concepts of bio-separation processes and its physiochemical properties (C2, PLO1)
2. Select and design appropriate separation process for bio-chemical engineering application (C5, PLO3)

COURSE OUTLINE

- **Overview of Bioseparations Engineering:** Bio-separation and applications, Nature of Bioseparation, Economic Importance of Bioseparation, Physical Forms Separated in Bioseparation
- **Properties of Biological Material:** Introduction, Size, Molecular Weight, Diffusivity, Sedimentation Coefficient, Osmotic Pressure, Electrostatic Charge, Solubility, Partition Coefficient, Light Absorption, Fluorescence
- **Analytical Methods:** (A) Assay Attributes, (B) Analysis of Biological Activity, (C) Analysis of Purity
- **Cell Disruption:** Cell Lysis and Flocculation, Molecular Diffusion in Liquid Medium, Diffusion of Solutes in Dense and Porous Solids, Equilibrium and Rate Processes
- **Bioseparations Using:** (A) Filtration, (B) Sedimentation, (C) Extraction, (D) Adsorption and Chromatography, (E) Precipitation, (F) Crystallization, (G) Evaporation, (H) Drying
- **Membrane Based Bioseparation:** Introduction, Classification of Membrane Processes, Membrane Equipment, Ultrafiltration, Microfiltration, Dialysis, Liquid Membrane Processes, Membrane Chromatography
- **Bioseparation Design and Economics**

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Ghosh, R., Principles of Bioseparations Engineering. World Scientific Publishing, 2006.
2. Ladisch, M. R., Bioseparations Engineering: Principles, Practice, and Economics. John Wiley & Sons, 2001
3. Forciniti, D., Industrial Bioseparations: Principles and Practice. Blackwell Publishing, 2008.
4. Harrison, R. G.; Todd, P. W.; Rudge, S. R.; Petrides, D. P., Bioseparations Science and Engineering. 2nd Edition; Oxford University Press, 2015.

D5 - BIOREACTOR DESIGN

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of bioreactor design.

COURSE LEARNING OUTCOMES

1. Evaluate the appropriate bio-reactor based on stoichiometry and reaction kinetics (C5, PLO3)
2. Perform scale up and scale down study, CFD study for particular biochemical application (C3, PLO5)

COURSE OUTLINE

- **Introduction and Basics:** General Features of Bioreactor Design, Stoichiometry and kinetics of bioreactions, Analysis of bioreactor dynamics. Membrane and hollow-fiber bioreactors
- **Design and Operation of Microbioreactor Systems for Screening and Process Development:** Thermodynamics of microbial systems, Robotics for Microbioreactors, Gas–Liquid Mass Transfer, Fed-Batch and Continuous Operation of Microbioreactors, Fluidized bed reactors for aerobic processes
- **Scalable Manufacture for Cell Therapy Needs: R**equirements for Cell Therapy, Microcarriers and Stirred-Tank Bioreactors, Autologous and Allogeneic Products
- **Design, Applications, and Development of Single-Use Bioreactors:** Cell Culture Application, Wave-Mixed Bioreactors, Stirred Single-Use Bioreactors, Orbital-Shaken Single-Use Bioreactors, Mass Transfer Requirements for Cell Culture, Perfusion Processes in Single-Use Equipment, Plant, Phototrophic Algae and Hairy Root Cell Cultivation in Single-Use Bioreactors
- **Computational Fluid Dynamics for Bioreactor Design:** Multiphase Flows, CFD Simulations, Case Studies
- **Scale-Up and Scale-Down Methodologies for Bioreactors: S**cale-Up of Bioreactors, Scale-Down Experiments and Physiological Responses

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments

- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Klaas van't Riet, Johannes Tramper, Basic Bioreactor Design, CRC Press, 1991
2. Mandenius, C.-F., Bioreactors: Design, Operation, and Novel Applications.Wiley-VCH, 2016.
3. Villadsen, J.; Nielsen, J.; Lidén, G., Bioreaction Engineering Principles. 3rd Edition; Springer, 2011.
4. Bao, J.; Ye, Q.; Zhong, J.-J., Bioreactor Engineering Research and Industrial Applications
5. II. Springer, 2016.
6. Yoon, S.-H., Membrane Bioreactor Processes: Principles and Applications. CRC Press, 2015.

D6 - BIOFUELS AND BIOREFINERIES

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of biofuels and biorefineries.

COURSE LEARNING OUTCOMES

1. Explain basic concepts and processes related to biofuels and biorefineries (C2, PLO1)
2. Describe the refinery process flow and its design along with life cycle assessment (C2, PLO1)

COURSE OUTLINE

- Renewable biomass resources: Manufacture of biofuels and recovery of products
- Biochemical Engineering and Bioprocess Management for Fuel Ethanol: Historical Development of Bioethanol as a Fuel, Fermentor Design and Novel Fermentor Technologies, Simultaneous Saccharification and Fermentation and Direct Microbial Conversion, The Economics of Bioethanol, Sustainable Development and Bioethanol Production
- Chemistry, Biochemistry, and Microbiology of Lignocellulosic Biomass: Structure and properties of lignocellulosic biomass, Cellulases: Biochemistry, Molecular Biology, and Biotechnology, Chemical compositions and reactions of lignocellulosic biomass, Pretreatment and processing of lignocellulosic biomass
- Biorefinery layout and process design: Systematic Screening of Multiple Processing Paths in Biorefineries: The ABC (Assessing Biomass to Chemicals) Project and Its Potential to Build Process Synthesis Capabilities
- Life cycle assessment of a biorefinery: Technoeconomic Assessment and Risk Analysis of Biorefinery Processes, Optimal Synthesis of Sustainable Biorefineries

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker

- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Mousdale, D. M., Biofuels: Biotechnology, Chemistry, and Sustainable Development. CRC Press, 2008.
2. Chen, H., Lignocellulose Biorefinery Engineering: Principles and Applications. Woodhead Publishing, 2015.
3. Fang, Z., Pretreatment Techniques for Biofuels and Biorefineries. Springer, 2013.

D7 - BIOCHEMICAL TREATMENT OF WASTES

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of biochemical treatment of wastes.

COURSE LEARNING OUTCOMES

1. Describe various types of biochemical operations and their sensitivity to changes in environment (C2 PLO7)
2. Explain different types of bio-pollutants, its effects on nature and society, and relevant control techniques (C2, PLO7)

COURSE OUTLINE

- Classification of Biochemical Operations: Fundamentals of Biochemical Operations. Stoichiometry and Kinetics of Biochemical Operations.
- Fundamentals of biochemical operations: Major Types of Microorganisms and Their Roles, Microbial Ecosystems in Biochemical Operations
- Objective of waste treatment: Characteristics of liquid and solid wastes
- Primary, secondary, and tertiary wastewater treatment processes: Physical and chemical treatment processes for handling liquid and solid wastes
- Biological waste treatment: Anaerobic, aerobic, and aerated waste treatment processes, Biological and physicochemical removal of heavy metals from wastewater, Activated sludge process, Treatment and disposal of biowastes
- Techniques for Evaluating Kinetic and Stoichiometry Parameters: Aerobic Growth of Heterotrophs in a Single CSTR Receiving Soluble Substrate. Multiple Microbial Activities in Single CSTR. Multiple Microbial Activities in Complex Systems. Anaerobic Systems for Acidogenesis and Methanogenesis, Applications: Suspended Growth Reactors.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
  - Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Grady Jr., C. P. L.; Daigger, G. T.; Love, N. G.; Filipe, C. D. M., Biological Wastewater Treatment. 3rd Edition; CRC Press, 2011.
2. Orhon, D.; Babuna, F. G.; Karahan, O., Industrial Wastewater Treatment by Activated Sludge. IWA Publishing, 2009.
3. Tang, W. Z., Physicochemical Treatment of Industrial Wastes. CRC Press, 2004.

E - GREEN TECHNOLOGY

E1 - GREEN TECHNOLOGIES & SUSTAINABLE DEVELOPMENT

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of green technologies and sustainable development..

COURSE LEARNING OUTCOMES

1. Explain basic concepts of green technology and their applications (C2, PLO7)
2. Evaluate life cycle assessment, zero waste and circular economy for a particular green operation (C6, PLO7)

COURSE OUTLINE

- Introduction to green technologies: Concept of green technology, advantages and disadvantages, benefits, and challenges.
- Green energy: Introduction, conventional energy, Types of green energy, Applications, Renewable energy efficiency, green chemistry, and engineering.
- LCA and role of technology: Principles of Sustainable Systems, Technology Development and Lifecycle Assessment, Metrics for Technology Evaluation
- Green Technology and applications: Green Chemistry and Materials, Materials preparation, and characterization, green agriculture and food, green Nanotechnology, Green manufacturing, and supply chain management.
- Zero waste engineering: Introduction, Modeling of Zero, Waste Engineering Processes with Inherent Sustainability, The Formulation of a Comprehensive Mass and Energy Balance Equation, Energy sources and Utilization of Waste, Solar Aquatic Process to Purify Desalinated/ Wastewater, A Zero-Waste Design for Direct Usage of Solar Energy, Ideal energy
- Resource Management: Resource Management Technologies, Sustainable Water and Wastewater Systems, High -Performance Building Systems, Applied Renewable Energy Technologies, Energy Management and Power Systems, Sustainable Transportation Technologies, Behavioral Aspects and Feedback Systems

- Renewable Energy resources and their importance: World energy use – Reserves of energy resources –Environmental aspects of energy utilization, Solar , Thermal and Wind Energy
- Bio-fuels Sources: Potential, Properties and characterization, Bio-gas generation through Aerobic and Anaerobic digestion, Thermo-chemical methods biofuel utilization, Combustion, and Gasification.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual

Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Matthew N. O. Sadiku "Emerging Green Technologies", 2020 Taylor & Francis Group
2. M. M. Khan, M. R. Islam ,"Zero Waste Engineering: A New Era of Sustainable Technology Development", 2nd Edition, 2016

E2 - INDUSTRIAL ECOLOGY

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of industrial ecology..

COURSE LEARNING OUTCOMES

1. Describe industrial ecology, their goals and inventory management (C2, PLO7)
2. Perform life cycle assessment and indicate role of key stakeholders for industrial operations (C3, PLO7)

COURSE OUTLINE

- Introduction to Industrial ecology, Origin of IE, environment and industrial systems, material resources, societal factors and environmental equity. Link to sustainable development
- Ecologically sustainable systems. Environment and the industrial systems, material resources, societal factors, and environmental equity. Link to sustainable development. Goals and concepts Systems analysis, industrial metabolism, biological analogies, material and energy flow and their transformations, closing the materials cycle (open vs, closed- loop systems).
- Industrial ecosystems and key issues in eco-industrial development. Components of an industrial ecosystem, industrial symbiosis, role of government, community, developers, management, evaluating the success of ecoindustrial development.
- Life Cycle Analysis. Life cycles of products, processes, and facilities; life cycle assessment (components, methodology, applications, difficulties), design for environment, efficient use of material (remanufacturing, recycling, reuse, etc. Perspective on industrial ecology from India and other developing countries such as China and Thailand, with cases studies.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term

- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Bourg D. and Erkman S., (edited) Perspectives on Industrial Ecology, 46(2) (hardback).
2. Case Study of the Textile Industry in Tirupur (available at http://www.roionline.org/bookchapters.php?bid=1, accessed on 17 June 2011).
3. Edward Cohen-Rosenthal E. and Musnikow J. (edited) (2003) Eco-industrial Strategies, Sheffield, UK: Greenleaf Publishing.
4. Erkman S. and Ramaswamy R. (2003) Applied Industrial Ecology – A New Platform for Planning Sustainable Societies, AICRA Publishers, Bangalore, India.
5. Industrial Symbiosis and Residual Recovery in the Nanjangud Industrial Area, report by ROI (2010) Bangalore and Yale University.
6. Manahan S.E. (1999) Industrial Ecology Environmental Chemistry and Hazardous Waste.
7. Thomas E.G., and Brad R.A., Industrial Ecology and Sustainable Engineering, 3nd edition.

E3 - ENVIRONMENTAL IMPACT ASSESSMENT

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of environmental impact assessment.

COURSE LEARNING OUTCOMES

1. Perform environmental impact assessment and life cycle assessment of a chemical process (C3, PLO7)

COURSE OUTLINE

- **Introduction**: Introduction to environmental impact assessment, environment Background, Sustainable development, principles and procedures, origin and development
- **History of Environmental Impact Assessment**: Definition of Environmental Impact Assessment, Benefits and Directive of Environmental Impact Assessment
- **Impact prediction methodologies and mitigation measures** a. Air b. Surface and ground water c. Biologic d. Noise e. Cultural and socio-economic, Participation, presentation andreview
- **The Environmental Impact Assessment Process:** Types of Assessments 1) Environmental Assessments 2) Environmental Impact Statement, Basic Steps in the Process 1) Alternative 2) Screening 3) Scoping 4) Impact analysis 5) Mitigation 6) Followup 7) Public involvement
- Monitoring and Auditing: The importance of monitoring and auditing in the EIA process,
- Case study
- Special topics a. Social Impact Assessment b. Strategic Environmental Appraisal

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Introduction To Environmental Impact Assessment By John Glasson, Riki Therivel, Andrew Chadwick
2. Environmental Impact Assessment: Practical Solutions to Recurrent Problems, By David P. Lawrence

E3 - SUSTAINABILITY IN PROCESS & ENERGY SYSTEMS

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of sustainability in process and energy systems.

COURSE LEARNING OUTCOMES

1. Perform life cycle assessment of a process and energy systems (C3, PLO7)

COURSE OUTLINE

- **Fundamental Approach:** Principles of Sustainable Systems
- **LCA and role of technology**: Technology Development and Lifecycle Assessment, Metrics for Technology Evaluation
- **Green Technology and applications**: Green Chemistry and Materials, Materials preparationand characterization
- **Resource Management**: Resource Management Technologies, Sustainable Water and Wastewater Systems, High -Performance Building Systems, Applied Renewable EnergyTechnologies, Energy Management and Power Systems, Sustainable Transportation Technologies, Behavioral Aspects and Feedback Systems

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Laudon and Laudon, "Essentials of Management Information Systems", 8/E, Prentice Hall Latest Edition

F – NUCLEAR ENGINEERING

F1 – INTRODUCTION TO NUCLEAR ENGINEERING

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of introduction to nuclear engineering.

COURSE LEARNING OUTCOMES

1. Explain the basic fundamentals of Nuclear engineering and interaction with radiations (C2, PLO1)
2. Describe the safe procedures for nuclear reactor and power systems (C2, PLO2)

COURSE OUTLINE

- **Basic concepts:** Fundamental Particles, Atomic and Nuclear Structure, Mass and Energy, Particle Wavelengths, Excited States and Radiation, Nuclear Stability and Radioactive Decay, Radioactivity Calculations, Nuclear Reactions and Binding Energy, Nuclear Models.
- **Interaction of Radiation with Matter:** Neutron Interactions, cross-sections, neutron attenuation, neutron flux, energy loss in scattering collision, nuclear fission and chain reaction,ϑ ray interactions with matter, charged particles.
- Nuclear Reactors and Nuclear Power: principles of nuclear reactors, neutron moderation, the fission chain reaction, nuclear reactor fuels & their characteristics, components of nuclear reactors & their characteristics, power reactors and nuclear steam supply systems, nuclear cycles, isotope separation, homogeneous and heterogeneous cores, reflectors, reactor kinetics, fission product poisons, some typical power reactors
- Radiation Protection & Shielding: Radiation units, biological effects of radiation, Quantitative effects of radiation on the human species, exposure from, -ray sources, gamma- ray shielding, buildup factors, multilayered shields, nuclear reactor shielding.
- Nuclear Power Plant Safety: Principles of nuclear power plant safety, dispersion of effluents from nuclear facilities, radiation doses from nuclear plants, reactor accidents, accident risk analysis, environmental radiation doses.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Lamarsh, J. R, Introduction to Nuclear Engineering, 3rd Edition, Prentice Hall, 2001.
2. J. Kenneth Shultis, Nuclear Energy: An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, 8th Edition Butterworth-Heinemann, 2019.
3. J. Kenneth Shultis, Fundamentals of Nuclear Science and Engineering, 3rd Edition, CRC Press, 2016.
4. Bahman Zohuri, Nuclear Micro Reactors, 1st Edition, Springer, 2021.

F2 - NUCLEAR PHYSICS & REACTOR THEORY

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of nuclear physics and reactor theory.

COURSE LEARNING OUTCOMES

1. Explain the basic concepts of nuclear physics and newtron interaction (C2, PLO1)
2. Select or design appropriate nuclear reactor for safe power production (C5, PLO3)

COURSE OUTLINE

- **Nuclear Reaction Fundamentals:** Nuclear Reactions, Curve of Binding Energy, Fusion andfission Reactions, Fission products, Radioactivity.
- **Neutron Physics and Interaction:** Neutron sources, Neutron reactions, Neutron Cross Sections, Neutron Energy Range, Neutron Scattering, Neutron sources and reactions, resonances, Neutron Life Cycle, Measuring basic neutron physics data.
- **The Power Reactor Core:** Core Composition, Fast Reactor Lattices, Thermal Reactor Lattices, The Four Factor Formula, Pressurized Water Reactor Example.
- **Small Modular Reactors:** Introduction, Small Modular Reactors as Renewable Energy Sources, Small Modular Reactors Application, Small Modular Reactor-Driven Hydrogen Energy for Renewable Energy Source, Modular Construction Using Small Reactor Units, HeatPipe Reactor, Safety, Security, and Cost Concerns, Economies of Scale and Catch.
- **Reactor Kinetics:** Neutron Balance Equations, Kinetics with delayed neutrons, Kinetics without delayed neutrons, Step Reactivity Changes, Kinetics of specific problem. Establishingthe diffusion equation.
- **Neutron Poisons & Control Rods:** Fixed Burnable Poisons, Soluble Poisons, Non-BurnablePoisons, Fission Product Poisons, Xenon, Samarium and other fission product poisons, controlrods.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments

- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Elmer E. Lewis, Fundamentals of Nuclear Reactor Physics, Elsevier, 2018.
2. Paul Reuss, Neutron physics, 1st Edition, EDP Sciences, 2008
3. J. Kenneth Shultis, Nuclear Energy: An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, 8th Edition Butterworth-Heinemann, 2019.
4. Fundamentals Handbook Nuclear Physics Nuclear Physics And Reactor Theory, Vol 1 & 2,
5. U.S. Department of Energy, 1993
6. J. Kenneth Shultis, Fundamentals of Nuclear Science and Engineering, 3rd Edition, CRC Press, 2016.
7. Bahman Zohuri, Nuclear Micro Reactors, 1st Edition, Springer, 2021.
8. Daniel T. Ingersoll, Small Modular Reactors: Nuclear Power Fad or Future?, 1st Edition, Woodhead Publishing, 2015.

F3 - NUCLEAR MATERIALS & FUELS

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of nuclear materials types and their application as fuels.

COURSE LEARNING OUTCOMES

1. Discuss different types of materials and their properties for nuclear applications (C2, PLO1)
2. Select suitable material for a safer nuclear application considering radiation effects (C4, PLO3)

COURSE OUTLINE

- **Overview:** Types of Nuclear Energy, Neutron sources and Classification, Interactions of Neutrons with Matter, Neutron Cross Section, Types of Reactors, Materials Selection Criteria.
- **Nature of Materials:** Crystal Structure, Crystal Defects, Polymorphism, Phenomenological Theories of Diffusion, Miller Indices for Denoting Crystallographic Planes and Directions, Crystal Structure of Carbon: Diamond and Graphite, Crystal Structure in Ceramics, Criticality conditions, , Diffusion, Phenomenological Theories of Diffusion, Atomic Theories of Diffusion, Atomic Diffusion Mechanisms, Diffusion as a Thermally Activated Process, Diffusion in Multicomponent Systems, Diffusion in Different Microstructural Paths.
- **Properties of Materials:** Mechanical Properties, Hardness Properties, Fracture, Impact Properties, Fracture Toughness, Creep Properties, Fatigue Properties and Fatigue Curve, Creep–Fatigue Interaction, Thermophysical Properties, Corrosion.
- **Radiation Effects on Materials:** Fundamentals of Radiation Damage, Displacement Threshold, Radiation Damage Models, Microstructural Changes, Mechanical Properties, Radiation Effects on Physical and Corrosion Properties.
- **Nuclear Fuel Materials:** Nuclear Fuel Cycle, Reprocessing of Nuclear Fuel, Metallic Fuels and Ceramic Fuels and types, Special Nuclear Materials, Thorium.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. K. Linga Murty, An Introduction to Nuclear Materials: Fundamentals and Applications, 1st Edition, Wiley, 2013.
2. C. K. Gupta, An Introduction to Nuclear Materials: Fundamentals and Applications, vol:1, CRC Press, 2018.
3. Gary S. Was, Fundamentals of Radiation Materials Science, 2nd Edition, Springer, 2017.
4. J. Kenneth Shultis, Fundamentals of Nuclear Science and Engineering, 3rd Edition, CRC Press, 2016.

F4 - RADIATION DETECTION AND MEASUREMENT

Credit Hours: 2+0=2

Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of radiation detection and measurement methods.

COURSE LEARNING OUTCOMES

1. Explain the radiation sources, interaction and their detection techniques (C2, PLO1)
2. Perform data analysis to evaluate the radiation exposure and impact (C6, PLO7)

COURSE OUTLINE

- **Radiation Sources:** Fast Electron Sources, Heavy Charged Particle Sources, Sources of Electromagnetic Radiation, Neutron Sources.
- **Radiation Interactions:** Interaction of Heavy Charged Particles, Interaction of Fast Electrons, Interaction of Gamma Rays, Interaction of Neutrons, Radiation Exposure and Dose.
- **Data Analysis Methods:** Characterization of Data, Statistical Models, Applications of Statistical Models, Error Propagation, Optimization of Counting Experiments, Limits of Detectability, Distribution of Time Intervals.
- **General Properties of Radiation Detectors:** Simplified Detector Model, Modes of DetectorOperation, Pulse Height Spectra, Counting Curves and Plateaus, Detection Efficiency & deadtime.
- **Miscellaneous Detector Types:** Cherenkov Detectors, Gas-Filled Detectors, High-Pressure Xenon Spectrometers, Liquid Ionization and Proportional Counters, Cryogenic Detectors, Photographic Emulsions, Thermoluminescent Dosimeters and Image Plates, Track-Etch Detectors, Bubble Detectors, Neutron Detection by Activation, Detection Methods Based on Integrated Circuit Components.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker

- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Glenn F. Knoll, Radiation Detection and Measurement, 4th Edition, Wiley, 2010.
2. David Jenkins, Radiation Detection for Nuclear Physics: Methods and Industrial Applications, Iop Publishing Ltd, 2020.
3. J. Kenneth Shultis, Fundamentals of Nuclear Science and Engineering, 3rd Edition, CRC Press, 2016.
4. Nicholas Tsoulfanidis, Measurement & Detection of Radiation, 4th Edition, CRC Press, 2015.
5. Douglas McGregor, Radiation Detection and Measurement: Concepts, Methods and Devices, Taylor & Francis, 2016.
6. J. Kenneth Shultis, Nuclear Energy: An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, 8th Edition Butterworth-Heinemann, 2019.
7. Syed Naeem Ahmed, Physics and Engineering of Radiation Detection, AP Academic Press, 2007.

F5 - NUCLEAR WASTE ASSESSMENT & MANAGEMENT

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of nuclear waste assessment methods and management strategies.

COURSE LEARNING OUTCOMES

1. Explain different types of nuclear pollutant, its effects on nature and society, and relevant control and management techniques (C2, PLO7)

COURSE OUTLINE

- **Radiation characteristics and protection:** Types of radiation, Interaction of radiation with matter, Modes of exposure, Effects of radiation, Dose–response characteristics, Radiological protection.
- **Decommissioning:** Decommissioning of nuclear facilities, Decontamination Techniques, dismantling techniques, Decommissioning strategy, Decommissioning operations, nuclear decommissioning authority, Decommissioning of nuclear submarines, Regulatory aspects in decommissioning, Safety and financial aspects of decommissioning. Case histories
- **Radioactive waste classification and inventory:** Radioactive substances and radioactive waste, Classification of radioactive waste, Partitioning and transmutation, Waste inventory, General principles of waste management
- **Management, Treatment and Conditioning of radioactive waste:** General principles of waste management, Regulatory issues of waste management, Operations Preceding Treatmentand Conditioning, Treatment of Waste, Conditioning of Waste, Characterization of Conditioned Waste, Spent fuel Management, high-level waste Management, Transuranic waste. Low-level waste, Mixed waste
- **Storage, transportation and Disposal of radioactive waste:** Storage, Safety Aspects of Radioactive Material Transport, Transportation of radioactive materials, Waste packages, Transportation of waste, Disposal concepts & systems, Disposal management and practices, Performance assessment of disposal system, Disposal of Spent fuel & high-level waste.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing

- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Rahman, "Decommissioning and Radioactive Waste Management", 1st Edition, CRC press, 2008.
2. James Saling, Radioactive Waste Management, 2nd Edition, CRC press, 2001.
3. William R Roy, Radioactive Waste Management In The 21st Century, World Scientific, 2021.
4. J. Kenneth, Fundamentals of Nuclear Science and Engineering, 3rd Edition, CRC Press, 2016.
5. Yim, Nuclear Waste Management: Science, Technology, and Policy, Springer Nature, 2022.
6. J. Kenneth Shultis, Nuclear Energy: An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, 8th Edition Butterworth-Heinemann, 2019.
7. Colin Bayliss, Nuclear Decommissioning, Waste Management, and Environmental Site Remediation, Elsevier, 2003.

G - PROCESS ENGINEERING

G1 - CHEMICAL PROCESS ANALYSIS AND OPTIMIZATION

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of chemical process analysis and optimization techniques.

COURSE LEARNING OUTCOMES

1. Evaluate the optimization techniques for a particular process engineering application (C6, PLO2)

COURSE OUTLINE

- **Importance and hierarchy of optimization:** Significance of optimization in chemical engineering, Classification and model development, Solution and interpretation of optimization models, Economic and time value of objective functions
- **Linear programming application to chemical processes in multi-variant situations**: Unconstrained functions with one-dimensional search, Nonlinear mixed integer optimization, Application of optimization in heat transfer and energy conservation,
- **Optimal design and operation of conventional mass transfer operations**: Optimal design of fluid flow in pipes with and without pumping and compressing devices, Optimization of medium scale plants along with integrated planning and control in process industries

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Biegler, L. T., Nonlinear Programming: Concepts, Algorithms, and Applications to Chemical
2. Processes. SIAM, 2010.
3. Buzzi-Ferraris, G, Manenti, F., Nonlinear Systems and Optimization for the Chemical
4. Engineer: Solving Numerical Problems. John Wiley & Sons, 2013.
5. Corsano, G., Montagna, J. M.; Iribarren, O. A.; Aguirre, P. A., Mathematical Modeling
6. Approaches for Optimization of Chemical Processes. Nova Science Publishers, 2009.
7. Edgar, T. F, Himmelblau, D. M.; Lasdon, L. S., Optimization of Chemical Processes, 2nd edition McGraw Hill, 2001

G2 - CHEMICAL WET PROCESSING OF TEXTILES

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of chemical wet processing of textiles products.

COURSE LEARNING OUTCOMES

1. Explain the basic chemistry of textile processing and its applications (C2. PLO1)
2. Describe pre-treatments, printing and curing operations for the textile applications (C2, PLO2)

COURSE OUTLINE

- **Chemistry of textile processing**; Introduction to Dyeing and printing processes, fundamental aspects of drying theories, classification of dyes by structure and method of application, and machines for desizing, scouring, bleaching and mercerization.
- **Pretreatments**; Application of reactive vat and another classes of dyestuff on various machines. Dying of cotton, viscous rayon and blend fibers. Printing, exposing print paste,pigment, and reactive types. thickening.
- **Rotary printing machine on curing process**: Objective and service performance of chemical finishing of soft and hard finishing agents. Printing flexibility using CAD/CAMsystem; Treatment of effluent from Textile Industry; Recovery of chemicals and their sustainable aspects.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual

- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

G3 - FOOD PROCESSING ENGINEERING

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of food processing steps and engineering involved.

COURSE LEARNING OUTCOMES

1. Explain the basic fundamental of food sciences, quality and hygienic safety (C2, PLO1)
2. Describe different methods and techniques for food processing and preservation (C2, PLO2)

COURSE OUTLINE

- **Introduction to food science:** Evolution of food processing and preservation, factors effecting food supply and processing, Impact of invention and scientific discovery,
- **Methods and techniques** used to transform raw ingredients into food for consumption byhumans. Principles of operation and design of industrial equipment used in processing, storage, and packaging of foods, food supplements.
- **Food quality and food safety** as related to food processing equipment. Classification anddescription of food processing equipment, colors, flavors preservatives.
- **Engineering principles of food processing and preservation**. Laboratory experiments designed for hands-on experience using state-of-the-art equipment to understand theengineering principles associated with food processing and preservation taught in lectures.
- **Physical properties of food materials:** Mechanical properties, water activity, reaction kinetics, elements of process control, size reduction
- **Food security:** Introduction, history of food security, Food risk, the precautionary principle, food risk management and communication, quantitative risk assessment.
- **Biological Contaminants:** Bacteria, viruses, parasites
- **Chemical contaminants:** Fungicides, pesticides, herbicides, veterinary medicines, naturaltoxins.
- **Food allergy:** Introduction, genetics of allergy, milk, peanut and soy allergy, nuts allergy

- **Food legislation:** legal processes, food legislation around the world.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Ian C. Shaw," Food Safety: The Science of Keeping Food Safe", 2nd edition, 2018
2. Zeki Berk "Food Process Engineering and Technology", 2009 Elsevier Inc.
3. Geoffrey Campbell-Platt, "Food Science and Technology", John Wiley & Sons, 26-Aug- 2011
4. Norman N. Potter, "Food Science" Springer Netherlands, 26-Nov-2012

G4 - ADVANCED PROCESS CONTROL

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Advance process control

COURSE LEARNING OUTCOMES

1. Analyze the dynamic behavior, stability, and frequency response for various controllers and process controls systems using transfer functions (C4, PLO3)
2. Apply various control configurations to chemical process units (C3, PLO2)

COURSE OUTLINE

- **Introduction to Process Control**: Why process control, Control Objectives and Benefits,process dynamics, Modelling tools for process dynamics, Inversion by partial fractions
- **Review of basic concepts:** (a) Incentives for process control, (b) Control block diagrams,
- Designing and tuning PID controllers
- **Linear open loop systems:** Response of first order systems, Higher order systems
- **Linear Closed Loop systems:** The Control systems, Controllers and Final control elements, Closed loop transfer functions.
- **Modelling and Analysis for Process Control**: Continuous-time internal model control (IMC) and IMC-based PID controllers, Algorithms for digital control, Dynamic Behavior of Typical Process Systems
- **Enhancements to Single-Loop PID Feedback Control**: Cascade Control, Feedforward Control, Adapting Single-Loop Control Systems for Non-linear Processes, Inferential Control, Level and Inventory Control, Single-variable Model Predictive Control
- **Process response:** Advanced Control strategies, Analysis of cascade control, feed forwardcontrol, Feedback Loop, ratio control, dead-time compensation, control valves, theoreticalanalysis of complex processes.
- **Model predictive control,** Stochastic control, Singular value analysis

- **Frequency Response**: Introduction, Techniques for control system design by frequency response, Integration of process design and process control
- **Computers in process control:** Features and tasks of microprocessors-based controllers,Distributed control

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Steven E. LeBlanc Donald R. Coughanowr," Process Systems Analysis and Control"3rdEdition; McGraw Hill, 2009.
2. Johnson, C. D., Process Control Instrumentation Technology. 8th Edition; Prentice Hall,2006.
3. Luyben, W. L.; Luyben, M. L., Essentials of Process Control. McGraw Hill, 1997.
4. Marlin, T. E., Process Control: Designing Processes and Control Systems for DynamicPerformance. 2nd Edition; McGraw Hill, 2000.
5. Ogunnaike, B. A.; Ray, W. H., Process Dynamics, Modeling, and Control. OxfordUniversity Press, 1994.
6. Smith, C. A.; Corripio, A., Principles and Practice of Automatic Process Control. 3rdEdition; John Wiley & Sons, 2006.
7. Stephanopoulos, G., Chemical Process Control: An Introduction to Theory and Practice.Prentice Hall, 1984.

G5 - COMPUTER-AIDED PROCESS SYNTHESIS

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Computer-Aided Process Synthesis

COURSE LEARNING OUTCOMES

1. Develop alternate solutions for a chemical process design problem using computing tools (C4, PLO5)
2. Evaluate a given chemical process to identify opportunities for mass and heat integration (C5, PLO5)

COURSE OUTLINE

- **Significance of Process Analysis and Simulation in Chemical Engineering:** Chemical Process Simulators, Applications of Process Simulation, Convergence Analysis, Sensitivity Analysis, Design Specifications
- **Preliminary Analysis and Evaluation of Processes:** Overview of Flowsheet Synthesis, Mass, and Energy Balances, Equipment Sizing and Costing, Economic Evaluation, Designand Scheduling of Batch Processes.
- **The design process:** (a) Steps in product and process design, (b) Safety and environmentalconsiderations, (c) Role of computers in process synthesis
- **Heuristics for process creation and integration**: Algorithmic approaches to process synthesis
- **Synthesis of separation trains for:** (a) Ideal fluid mixtures, (b) non-ideal fluid mixtures, Gas mixtures, (d) Solid–fluid mixtures
- **Chemical Reactors**: Reactor design and reactor network synthesis, Synthesis of reactor– separator–recycle networks
- **Heat Exchange Equipment and process Heat Integration**: Thermal pinch analysis and heat exchanger network synthesis
- **Optimization Approaches to Process Synthesis and Design:** Optimization Techniques for Reactor Network Synthesis, Structural Optimization of Process Flowsheets, Optimal Design and Scheduling for Multiproduct Batch Plants.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Biegler, L. T.; Grossmann, I. E.; Westerberg, A. W., Systematic Methods of ChemicalProcess Design. Prentice Hall, 1997.
2. Chaves, I. D. G.; López, J. R. G.; Zapata, J. L. G.; Robayo, A. L.; Niño, G. R., ProcessAnalysis and Simulation in Chemical Engineering. Springer, 2016.
3. Seider, W. D.; Seader, J. D.; Lewin, D. R.; Widagdo, S., Product and Process DesignPrinciples: Synthesis, Analysis, and Evaluation. 3rd Edition; John Wiley & Sons, 2009.
4. Sundmacher, K.; Kienle, A.; Seidel-Morgenstern, A., Integrated Chemical Processes:Synthesis, Operation, Analysis, and Control. Wiley-VCH, 2005.
5. Turton, R.; Bailie, R. C.; Whiting, W. B.; Shaeiwitz, J. A.; Bhattacharyya, D., Analysis,Synthesis, and Design of Chemical Processes. 4th Edition; Pearson Education, 2012.

G6 - PROCESS INTENSIFICATION

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Process Intensification.

COURSE LEARNING OUTCOMES

1. Evaluate a given chemical process to identify opportunities for process integration and optimization (C5, PLO3)

COURSE OUTLINE

- Introduction to process intensification and its benefits
- Techniques for process intensification in Chemical Engineering
- **Process intensification in heat exchangers**: (a) Multi-stream heat exchanger, (b)Compact heat exchanger
- **Process intensification in reactors**: (a) Spinning disc reactor, (b) Rotary packed-bed reactor, (c) Oscillatory baffled reactor, (d) Micro-reactor
- **Process intensification in distillation columns**: (a) Divided-wall column, (b) Petlyukcolumn, (c) Heat-integrated distillation column, (d) Cyclic distillation

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Kiss, A. A., Advanced Distillation Technologies: Design, Control, and Applications. JohnWiley & Sons, 2013.

2. Reay, D.; Ramshaw, C.; Harvey, A., Process Intensification: Engineering for Efficiency,Sustainability, and Flexibility. 2nd Edition; Butterworth-Heinemann, 2013.
3. Segovia-Hernández, J. G.; Bonilla-Patriciolet, A., Process Intensification in Chemical Engineering: Design, Optimization, and Control. Springer, 2016.
4. Stankiewicz, A.; Moulijn, J. A., Re-engineering the Chemical Processing Plant: ProcessIntensification. CRC Press, 2003.
5. Stankiewicz, A.; van Gerven, T.; Stefanidis, G., The Fundamentals of ProcessIntensification. John Wiley & Sons, 2015.

G7 - ADVANCED PROCESS SAFETY

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Advanced Process Safety.

COURSE LEARNING OUTCOMES

1. Explain the basic concept of process safety, source exposure and prevention (C2. PLO6)
2. Analyze health and safety hazards for a given process (C4, PLO6)

COURSE OUTLINE

- **Introduction:** Process safety, implementing control logic, control blocks for process control, PID controller, Accident and Loss Statistics, The Nature of the Accident Process, Inherent Safety, Seven Significant Disasters.
- **Toxicology:** How Toxicants Enter and eliminated from Biological Organisms, Effects of Toxicants on Biological Organisms, Toxicological Studies, Dose versus Response, Relative Toxicity and Threshold Limit Values, Models for Dose and Response Curves.
- **Source Models:** Source Models, Flow of Liquid through a Hole in a Tank, Flow of Liquidsthrough Pipes, Flow of Gases or Vapors through Holes, Flow of Gases or Vapors through Pipes, Flashing Liquids, Parameters Affecting Dispersion.
- **Fires and Explosions:** The Fire Triangle, Flammability Characteristics of Liquids and Vapors, Flammability Diagram, Autoignition, Auto-Oxidation, Adiabatic Compression, Ignition Sources, Sprays and Mists, Explosions.
- **Fires and Explosions prevention:** Inerting, Static Electricity, Controlling Static Electricity, Explosion-Proof Equipment and Instruments, Ventilation, Sprinkler Systems, Miscellaneous Concepts for Preventing Fires and Explosions.
- **Reliefs:** Relief Concepts, Location of Reliefs, Relief Types and Characteristics, Relief Systems, Spring-Operated and Disc reliefs, Venting, Reliefs for Thermal Expansion of Process Fluids.
- **Chemical hazards**: (a) Flammability, (b) Explosivity, (c) Toxicology, (d) Corrosiveness Hazards in process industry

- Risk analysis and management process
- Hazards Identification and Risk Assessment: Methodologies for hazard identification: (a) What-if analysis, (b) HAZOP analysis, (c) Event tree analysis, (d) Fault tree analysis,
- (e) Bow-tie analysis, (f) Layer of protection analysis, Process Hazards Checklists and surveys, Safety Reviews, Common Mode Failures (Event Trees & Fault Trees), QRA and LOPA.
- Consequence modeling: (a) Source models, (b) Toxic release and dispersion models, (c) Fire and explosion
- Types of Controllers: Cascade control, split range, override control, valve position control
- Design for fire and explosion prevention: Incident investigation and reporting, Emergency preparedness and response, Safety instrument systems and safety integrity level
- Case studies from accidents in process industry

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Daniel A. Crowl," Chemical Process Safety Fundamentals with Applications", 2001
2. Cecil L. Smith, "Advanced Process Control: Beyond Single Loop Control"
3. Arendt, J. S.; Lorenzo, D. K., Evaluating Process Safety in the Chemical Industry: A User's Guide to Quantitative Risk Analysis. AIChE, 2000.
4. Atherton, J.; Gil, F., Incidents that Define Process Safety. AIChE, 2008.
5. Kletz, T. A., Learning from Accidents. 3rd Edition; Routledge, 2001.
6. Martel, B., Chemical Risk Analysis: A Practical Handbook. CRC Press, 2000.

7. Rausand, M., Risk Assessment: Theory, Methods, and Applications. John Wiley & Sons, 2011.

H- ENERGETIC MATERIAL

H-1 - THERMODYNAMICS OF ENERGETIC MATERIALS

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Thermodynamics of Energetic Materials.

COURSE LEARNING OUTCOMES

1. Discuss different types of energetic-materials and their properties (C2, PLO1)
2. Select suitable energetic-material for a given application considering both its efficacy and sustainability (C4, PLO3)

COURSE OUTLINE

- **Introduction to energetic materials:** Overview, New development, polymer bonded explosives, initial characterization of new energetic materials, Combustion, detonation, and deflagration.
- **Classification of energetic materials:** Primary and secondary explosives, propellant charges, Rocket propellants, detonation velocity and detonation pressure.
- **Thermodynamics of energetic materials:** Theoretical basis, computational methods, semi-empirical calculations
- **Design of Novel energetic materials:** Classification, polynitrogen compounds, high- nitrogen compounds,
- **Synthesis of energetic materials:** Molecular Building Blocks, Nitration reactions and processing, energetic materials of the future
- **Physical and Thermodynamic properties of energetic materials**: Crystal density, quantum mechanical approach, nitroaromatic energetic compounds, heat of formation, enthalpy and entropy of fusion, heat of sublimation, impact sensitivity, electric spark and shock sensitivity, friction and heat sensitivity, relation between different sensitivities

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Thomas M. Klapötke "Chemistry of High-Energy Materials" 4th edition, 2017
2. Mohammad Hossein Keshavarz, Thomas M. Klapötke "The Properties of EnergeticMaterials: Sensitivity, Physical and thermodynamic properties", 2021
3. D. R. Gaskell "Introduction to Thermodynamics of Materials"

H2 - MATERIAL CHARACTERIZATION TECHNIQUES

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Material Characterization techniques.

COURSE LEARNING OUTCOMES

1. Explain different materials characterization techniques and their applications (C2, PLO1)

COURSE OUTLINE

- **Transmission Electron Microscopy**: Introduction, Types of electron microscopes, electron specimen interactions and their applications, special applications of electron microscopy. Principles of electron optics and Design of important components of electron optical instruments, Beam-Matter interaction, Scanning Electron Microscopy (SEM),Environmental Scanning Electron Microscopy (ESEM), Transmission Electron Microscopy (TEM): Electron Diffraction, Convergent Beam Electron Diffraction (CBED)
- **Elements of Transmission electron microscope**: electron Guns, the illuminated system of TEM, the imaging system of TEM, scanning transmission electron microscopy (STEM),Image recording and electron detection
- **Analytical methods using Xray** microanalysis (EDX) and Electron Energy Loss Spectroscopy (EELS). Specific X-ray analysis techniques, Single crystal diffraction, Surface Mass Spectroscopy- SIMS: Mass detection, ToF Mass Spectroscopy.
- **Molecular Absorption** and Atomic Absorption Spectroscopy, Induction Coupled Plasma(ICP) Absorption and Emission Spectroscopy.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. B. D. Cullity and S. R. Stock "Elements of X-ray Diffraction"
2. Ludwig Reimer "Transmission Electron Microscopy: Physics of Image Formation andMicroanalysis",1984
3. Walter S. Struve "Fundamentals of Molecular Spectroscopy", Wiley and Sons, 1989
4. Yale E Strausser "Characterization in Silicon Processing"
5. Abraham Ulman "Characterization of Organic Thin Films"
6. David L Andrews "Applied Laser Spectroscopy'
7. M H Loretto "Electron Beam Analysis of Materials"
8. C. R. Brundle, C.A. Evans, S. Wilson, eds, Butterworth Heinemannn "Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films'
9. Banwell and McCash 'Molecular Spectroscopy'
10. Elton N. Kauffman "Characterization of Materials", 2 Volumes

H3 - POLYMERS AND COMPOSITES

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Polymers and Composites.

COURSE LEARNING OUTCOMES

1. Explain the fundamentals of the polymeric composites, their properties, synthesis and their characterization techniques (C2, PLO1)

COURSE OUTLINE

- **Introduction to polymer-composites:** Basic about polymers, melts and screening, rubber formation, the elastomer matrix, polymers of larger connectivity, reinforcing fillers, Hydrodynamic reinforcement of elastomers, Polymer–filler & Filler–filler interactions.
- **Natural polymer blends and composites**: Starch–Cellulose Blend, Starch–Sodium Caseinate Blend, Novel Plastics and Foams from Starch and Polyurethanes, Chitosan-Properties and Application, Blends and Composites.
- **Advances in Polymer Composites**: Macro- and Micro composites, Classification of Composites, Polymer Matrix Composites, Factors Affecting Properties of PMCs, Fabrication of Composites, Applications
- **Relations between material structures and properties for polymers and composites**.: Mechanical and thermal properties of thermoplastics, thermosets and composites based onglass, carbon, and aramide fibres.
- **Polymer types and application**: Polymerization and kinetics, molecular weight, structureand morphology, crystallization regimes, glass transition and melting point, mechanical properties, processing, composite classification, applications, matrices and reinforcements.
- **Shock and Impact Response of Glass Fiber-Reinforced Polymer Composites**: testing of composites, production of fibers, production of MMCs, CMCs, PMCs, effect of structure on physical and mechanical properties.
- **Carbon Fiber-Reinforced Polymer Composites**: Production, properties and application of carbon-carbon composites, mechanics of composites, Characterization of Injection- Molded Parts with Carbon Black-Filled Polymers

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. T.A.Vilgis "Reinforcement of polymer nano-composites, Theory, Experiments and Applications", CAMBRIDGE UNIVERSITY PRESS ,2009
2. L.C. Hollaway "Advanced Polymer Composites and Polymers in the Civil Infrastructure",Elsevier, 2001
3. Ru-Min Wang, Shui-Rong Zheng and Ya-Ping Zheng "Polymer matrix composites and technology", Woodhead Publishing Limited,

H4 - ALLOY PROCESSING AND CHARACTERIZATION

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Alloy processing & characterization.

COURSE LEARNING OUTCOMES

1. Describe the alloy synthesis, their properties, characterization and manufacturing techniques (C2, PLO2)

COURSE OUTLINE

- **Alloy Manufacturing:** Mechanical properties of metals and alloys, strain, conventional and true stresses, elastic stress-strain relationships, elements of plastic deformation, compression, hardness and bending, impact loading, creep, and stress rupture, fatigue, andfracture.
- **Casting**, pattern making and materials, types of patterns, core making and materials, testing and control of molding sands, molding processes and materials, casting techniques,gating system design, melting furnaces,
- **Fundamentals of mechanical working**: Forging, rolling, extrusion, drawing, deep drawing, high energy rate-forming.
- **Solidification of pure metal and alloys**, casting defects and inspection, crushing and grinding, concentration processes, Blast furnace, steel and cast iron, charge calculations and Ellingham diagram, steel making processes, non-ferrous metals Al, Ni, Ti, Cu, Mg
- **Liquid Metal processing:** Structural rearrangements in metallic melts, effect of heat- timetreatment of melts on the structure and properties of aluminum alloys, Ultrasonic treatmentof aluminium melts

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Amit Bhaduri "Mechanical Properties and Working of Metals and Alloy"
2. I.G. Brodova, P.S. Popel, G.I. Eskin, "Liquid Metal Processing: Applications toAluminium Alloy Production",2002
3. Mark Anthony Benvenuto, De Gruyter "Metals and Alloys: Industrial Applications", 06-Jun-2016 – Technology & Engineering

H5 – CORROSION ENGINEERING

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Corrosion Engineering.

COURSE LEARNING OUTCOMES

1. Explain the basic concepts of corrosion and electrochemical kinetics (C2. PLO1)
2. Select appropriate mitigation techniques for particular application (C6, PLO6)

COURSE OUTLINE

- **Corrosion engineering**: Introduction to corrosion science and engineering, Significance of corrosion and purpose, forms of corrosion, causes of corrosion, corrosion rate determination, corrosion environments and damage, corrosion classification, roles ofcorrosion engineer,
- **Electrochemical kinetics of Corrosion**: Theory and thermodynamics of corrosion, Nernstequation, Pourbaix diagrams, emf and galvanic series. Faraday law and corrosion rate determination. Electrode kinetics, polarization, and types, Ohmic drop at electrolyte/metalinterface, mixed potential theory, passivity.
- **Galvanic and concentration cell corrosion**: Fundamentals of galvanic series, determiningrates of galvanic corrosion.
- **Pitting and Cervice corrosion:** Mechanism of pitting and cervice corrosion evaluation and examination.
- **Atmospheric Corrosion**: Atmospheric Corrosion of metals, corrosion products
- **Oxidation**: Introduction, initial stages, mechanism and thermodynamics
- **Corrosion failures**: Corrosion testing: salt spray/fog test, electrochemical corrosion testing, corrosion data analysis, Tafel extrapolation.
- **Corrosion protection measures**: cathodic/anodic protection, coatings, metallic coating, organic and in-organic coating and inhibitors, synergistic mixtures, design considerations,corrosion of ceramics and degradation of polymers.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing

- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Denny A. Jones "Principles and Prevention of corrosion'
2. Philip A. Schweitzer P.E. "Atmospheric Degradation and Corrosion Control", CRC Press,Year: 1999
3. Herbert H. Uhlig "Corrosion and Corrosion control'

H-6 - COMPUTER AIDED DESIGN AND MANUFACTURING

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Computer aided design and manufacturing.

COURSE LEARNING OUTCOMES

1. Describe the application of computing tools in manufacturing processes and its management (C2, PLO5)

COURSE OUTLINE

- **Introduction and history**: Design Concepts in CAD/CAM environment, benefits of software application, geometric modelling, feature based design, CAD hardware and software, 2D and 3D graphics and transformations, assembly modelling and analysis, concurrent engineering, axiomatic design.
- **CAD/CAM Tools**: DFM, DFA, group technology, CE tools, process planning, manual, variant, generative and hybrid approaches, tolerance charts, manufacturing planning and control, cellular and JIT manufacturing.
- **Computer aided manufacturing and Controllers:** Numerical control, NC programming, CNC, DNC, robotics, computer-integrated manufacturing, Creo based lab sessions relatedto design, assembly and manufacturing.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Zhuming Bi, Xiaoqin Wang "Computer Aided Design and Manufacturing"
2. Groover "CAD/CAM: Computer-Aided Design and Manufacturing"

I - ENERGY & POWER

I-1 - Industrial Energy Systems

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Industrial Energy Systems.

COURSE LEARNING OUTCOMES

1. Discuss different energy conversion technologies, their upgradation and environmental impact (C2, PLO1)
2. Perform economic and life cycle analysis for different energy conversion technologies (C6, PLO7)

COURSE OUTLINE

- **Overview:** An overview of energy conversion technologies in industrial energy systems, the Impact of Plant Economics on the Design of Industrial Energy Systems, Managing Energy Resources from within the Corporate Information Technology System
- **Process Integration:** Basics of process integration methodologies with emphasis on Pinch analysis (Pinch temperature, minimum process heating and cooling requirements, composite curves and grand composite curves, targeting for minimum number of heat exchanger units). Design of heat exchanger networks for maximum heat recovery.
- **Fundamental Characteristics of Energy Conversion Equipment:** Fossil-fuel Fired Boilers,Steam Pressure Reducing Valves, Steam Desuperheaters, Steam Surface Condensers, CoolingTowers
- **Process Principles for Energy Efficiency:** Process integration principles for high-efficiency energy conversion technologies (heat pumps and combined heat and power units) and energy-intensive chemical separation operations (distillation, evaporation). Energy efficiency and economic performance evaluation of process integration measures.
- **Retrofit applications**: Process integration methodologies for retrofit applications in existing industrial energy systems. Impact of reduced steam demand on electricity production for an industrial process equipped with a steam turbine, CHP unit.
- **Economics Evaluation**: Economics of energy conversion in industrial energy systems: characteristics of heat pumps and combined heat and power

(CHP) units (performance, investment costs). Influence of operating conditions on performance.

- **Process Optimization**: linear programming applications, Optimization of size and various design parameters based on process integration principles. Methodology for identifying the cost-optimal mix of technologies for satisfying a process heat demand, accounting for heat load variation over the course of the year.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

I-2– ENERGY AUDITING & MANAGEMENT

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Energy auditing & Management.

COURSE LEARNING OUTCOMES

1. Perform energy audit and management related calculations for optimized system performance (C6, PLO4)

COURSE OUTLINE

- **Introduction:** Energy Audit, Energy audit-necessity, Types of energy audit
- **Theoretical considerations of energy audits:** Investigations on energy audits, comparisonbetween financial audits and energy audits, quality aspects on energy audits
- **Energy Management:** Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, matching energy use to requirement
- **Research on energy balances:** Typification of energy balances, energy balance of anorganization, multiple energy audits processing, universal data model for energy audits.
- **Optimization:** Maximizing system efficiencies, Optimizing the input energy requirements,Fuel and energy substitution
- **Instruments:** Energy audit technique and instruments

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Michael Krutwig, Adrian Dumitru Tanțău, 'Energy Audits: Theoretical Examination andModeling of Energy Audits", 2021
2. Handbook of Energy Audits, 9th Edition, by Albert Thumann, Terry Niehus, & Wilian J.Younger, published in December, 2012.

I-3 FUEL CELL, AND SUSTAINABLE ENERGY TECHNOLOGIES

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Fuel cell and sustainable Energy technologies.

COURSE LEARNING OUTCOMES

1. Describe the hydrogen production techniques, hydrogen carriers and its storage (C2, PLO1)
2. Analyze solar related emerging technologies for economical electric power production (C4, PLO2)

COURSE OUTLINE

- **Hydrogen Production:** Production of Hydrogen, Steam reforming, Partial oxidation, autothermal, and dry reforming, Water electrolysis: reverse fuel cell operation, Biological hydrogen production, Bio-hydrogen production pathways, Issues related to scale of production.
- **Hydrogen conversion:** Uses as energy carrier, uses as energy storage material, combustionuses, hydrogen fuel cell uses for transportation, direct uses.
- **Hydrogen Storage:** Compressed gas storage, liquid hydrogen storage, hybrid storage, chemical thermodynamics, Strategic considerations, safety, storage efficiency, Alkali metal hydrides, Nanostructured materials, cost of stored hydrogen
- **Solar radiation**. Semiconductors. Electric power from solar cells, principles of operation, characteristics. Power losses and efficiency. Sizing and construction of solar-cell systems.Production and storage of hydrogen. Water electrolysis.
- **Emerging Technologies**: Energy from biomass and sustainable developments.
- **Electrical energy from fuel cells**. Introduction to fuel cells, Principal technologies, Fuel cell systems, proton exchange membrane fuel cells, Alkaline fuel cells, direct, liquid fuel cells, phosphoric caid fuel cells, Solid oxide fuel cells.
- **Economical and energy analyses** for the introduction of energy systems based onrenewable energy resources and hydrogen

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. AL Dicks and DAJ Rand "Fuel Cell Systems Explained"
2. Bent Sorensen "Hydrogen and Fuel cells. Emerging Technologies and Applications",2012.

I-4 INTERNAL COMBUSTION ENGINES

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Fuel cell and sustainable Energy technologies.

COURSE LEARNING OUTCOMES

1. Explain the fundamentals of internal combustion engine and its performance against different fuels (C2, PLO1)
2. Evaluate the industrial combustion engine for its environmental impact (C6, PLO7)

COURSE OUTLINE

- **Internal combustion engines:** Engine cycles, engine performance parameters, configurations, thermal engine cycles.
- **Basic Engine Types and their Operation:** Four-stroke spark ignition engine, Speed andload control in S.I engine, The Four-stroke compression Ignition Engine, Speed and LoadControl in C.I engine, the two-stroke cycle, Supercharging, Wankel rotary engine, four stoke fuel air Otto cycle
- **Testing**: Measurement of engine torque and power, Dynamometer principle, Different types of dynamometers: Measurement of brake and indicated horsepower, Mechanical pressure indicators, Use of indicator diagram, Use of On-board Diagnostics.
- **Equilibrium Charts**: Idealized cycles and processes, The diesel cycle, The dual cycle, Regenerative cycles, Brayton cycle.
- **Fuels**: The natural fuels, non-petroleum fuels, Characteristics of S.I and C.I engine fuels,LPG as I.C. engine fuel, Octane and Cetane number, Knock and engine Variable:Autoignition in S.I and C.I engines, Knock and S.I engine, Knock and the C.I engine.
- **Exhaust Gas Analysis and Air Pollution**: Air Pollution and the engine, Air pollution andthe fuel, Control of exhaust-Gas constituents.
- **Fuel Metering of SI Engine**: The Engine requirements, The Elementary carburetor, Elements of complete carburetor, Calculation of Air: Fuel ratio, Gasoline injection system,Stratified charging.
- **Fuel Metering of CI Engine**: C.I injection systems, C.I engine nozzles, Homogeneous Charge Compression Ignition (HCCI)
- **Engine Characteristics**: Heat transfer and the engine valve, Timing diagram, Engine- Lubrication systems: Engine performance and

lubrication, Lubricants of different kinds.

- **Fuel-air and combustion thermodynamics:** Thermodynamic properties of ideal gas mixtures, general chemical equilibrium and equilibrium constants.

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Colin R. Ferguson, Allan T. Kirkpatrick, "Internal Combustion Engines: AppliedThermosciences", 2016
2. V Ganesan, Internal Combustion Engines, 4th Ed. McGraw Hill Education, 2017.
3. W. Pulkrabek, Engineering Fundamentals of the Internal Combustion Engine, 2nd Ed.Pearson, 2003.

I-5 CLEAN COAL TECHNOLOGY AND CO-GENERATION

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Clean Coal Technology and Co-Generation.

COURSE LEARNING OUTCOMES

1. Explain the fundamentals of coal technology, its significance and relevant engineering calculations (C2. PLO2)
2. Select suitable technique for conversion of coal to power and its impact on environment and society (C6, PLO7)

COURSE OUTLINE

- **Introduction of coal as fuel:** Origin of Coal, Chemical and physical characteristic of coal,Coal analysis, types of coal, ranks of coal, grades of coal, classification systems
- **Review of boilers and steam cycles:** (a) Principles of boiler operation, (b) Classificationand specification, (c) Steam cycle, (d) Re-heater and re-heat cycle, (e) Combined cycle, (f)Heat recovery
- **Fuel and combustion calculations:** (a) Characteristics of typical fuels, (b) Stoichiometriccalculations, (c) Enthalpy calculation of air and combustion products, (d) Heat balance, (e)Generation of SOx and NOx
- **Design** of technologies for conversion of solid fuels
- **Pulverizing coal fired technology**: (a) Design of pulverized coal-fired furnace, (b) Pulverized coal burner, (c) Tangential firing, (d) Natural circulation design, (e) Forced andsupercritical boilers
- **Atmospheric and pressurized fluidized-bed technology**: (a) Features of fluidized-bed boilers, (b) Basics of fluidized beds, (c) Design of bubbling fluidized-bed boilers, (d) Design of circulating fluidized-bed boilers
- **Integrated gasification combined cycle (IGCC) technology**: (a) Potential and current status, (b) Design issues
- **Indirectly fired cycle:** (a) Potential and current status, (b) Thermodynamic analysis
- **Emissions**: (a) Emission of gaseous and solid pollutants, (b) Air pollution standards, (c) Emission control technologies
- **Steam plant economics** and tariff calculation
- **Revamping of old technologies with advanced technologies**: (a) Revamping of existingboiler, (b) Co-firing of opportunity fuel with fossil fuel, (c) Waste to energy
- **Case studies**: (a) Computer simulation of different cycle models, (b)

Steam generator, (c) Detailed design of steam generating unit with examples, (d) Steam turbine

- **Effect of Coal usage on human health and environment**: Coal mining, coal **preparation**,transportation, combustion by-products, emissions from coal combustion, NOx, Sox,particulate matter, greenhouse gases (CO_2)

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Bartnik, R.; Buryn, Z., Conversion of Coal-Fired Power Plants to Cogeneration and Combined-Cycle: Thermal and Economic Effectiveness. Springer, 2011.
2. Miller, B. G., Clean Coal Engineering Technology. Butterworth-Heinemann, 2011.
3. Kehlhofer, R.; Hannemann, F.; Stirnimann, F.; Rukes, B., Combined-Cycle Gas and SteamPower Plants. 3rd Edition; PennWell Corporation, 2009.
4. Miller, B. G., Coal Energy Systems. Elsevier, 2005.

I-6 COMBUSTION ENGINEERING

Credit Hours: 2+0=2

Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Combustion Engineering.

COURSE LEARNING OUTCOMES

1. Explain the fundamentals of combustion engineering and related engineering calculations (C2, PLO2)
2. Select suitable cleaner and sustainable technique for coal combustion (C6. PLO7)

COURSE OUTLINE

- **Introduction to Combustion engineering**: The nature of combustion, combustion emissions, Principle and mechanism of combustion, Global Climate change sustainability, world energy production
- **Combustible Fuels:** Gaseous and vaporized fuels, characterization of gaseous fuels, liquid, characterization of liquid fuels, liquid fuel types, solid fuels, biomass, peat, coal, refused derived fuel, characterization of solid fuels. Types of flames**,** Energy balance and furnaces and boilers type and efficiency,
- **Thermodynamics of combustion**: Review of first law, properties of mixtures, combustion stoichiometry, chemical energy, chemical equilibrium, Factors affecting combustion efficiency
- **Chemical kinetics of combustion**: elementary, chain and global reactions. Laminar flame propagation and determination of burning velocity
- **Burners Fundamentals:** Heat transfer from burners, open flame burners, radiant burners, effects on heat transfer fuel effect, oxidizer effects, stagging effects, burner orientation, heat recuperation, in-flame treatment. Design of gas burner, Combustion of an oil droplet, Spray combustion and methods for atomization of liquid fuels.
- **Description of Reactors:** Reactor modeling in the petroleum refining industry, Fixed-Bed Reactors, Slurry-Bed Reactors, Deviation from an Ideal Flow Pattern, Reactor Modeling
- **Catalytic Reforming Processes**: Introduction, Types of Catalytic Reforming Processes, Process Variables, Fundamentals of Catalytic Reforming, modeling, and simulation of fluidized-bed catalytic cracking converters, basic principles of catalytic reforming processes, catalytic reforming technologies.
- **Thermal cracking:** Efficiency enhancement during Pyrolysis or thermal cracking, the process of burning of fuel in the absence of oxygen in an inert gas environment. Effect of pressures and temperatures on rate of cracking.

- **Fluidized bed combustion:** Fluidization fundamentals, combustion in bubbling bed, atmospheric fluidized bed combustion systems, circulating fluidized beds, pressurized fluidized bed combustion, problems.
- **Effect of Coal usage on human health and environment**: Coal mining, coal preparation, transportation, combustion by-products, emissions from coal combustion, NOx, Sox, particulate matter, greenhouse gases (CO_2), Emissions control using pre- and post-combustion

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Ragland, K. W.; Bryden, K. M., Combustion Engineering. 3rd Edition; CRC Press, 2022
2. Gardiner Jr., W. C., Gas-Phase Combustion Chemistry. Springer, 2000.
3. Jarosinski, J.; Veyssiere, B., Combustion Phenomena: Selected Mechanisms of Flame Formation, Propagation, and Extinction. CRC Press, 2009.
4. Mullinger, P.; Jenkins, B., Industrial and Process Furnaces: Principles, Design, and Operation. 2nd Edition; Elsevier, 2014.
5. Tillman, D. A., The Combustion of Solid Fuels and Wastes. Academic Press, 1991.
6. Soni O. Oyekan, Catalytic Naphtha Reforming Process, 2019
7. Jorge Ancheyta, Modeling and Simulation of catalytic reactors for petroleum refining, 2011
8. Baukal Jr., C. E., Industrial Burners Handbook. CRC Press, 2004.
9. Yunus.A.Cengel- A textbook of Thermodynamics
10. Gary.L.Borman, Combustion Engineering-McGraw Hill international Edition,1998
11. Roger.A.Strehlow-Combustion fundamentals- McGraw Hill international Edition,198.

SEPARATION PROCESSES

Credit Hours: 3+1=4
Pre-Requisites: Mass transfer

DESCRIPTION

This course will give students a detailed understanding of fundamentals of separation processes. Student will get familiarize with commonly used separation techniques, the selection of the best option among many based on the exploitable property of the mixture and the achievable targets.

COURSE LEARNING OUTCOMES

1. Explain the fundamental principles of various separation processes and classify them for appropriate separation technique for intended problem.
2. Analyze the basic concepts of Pervaporation, Electrostatic Separation and Reverse Osmosis and their applications for specific operation.
3. Design multistage separation systems (i.e. Height of packing, Transfer Units, Number of Stages and specifications of the equipment) for absorption, liquid-liquid extraction, leaching, and membrane separations

COURSE OUTLINE

1. Fundamentals

- Introduction to separation processes

2. Liquid-Liquid extraction

- Introduction, Extraction Processes, Equilibrium data, Calculation of the number of theoretical stages for various cases of countercurrent and co-current operations.

3. Humidification and Cooling Towers

- Humidification terms, wet-bulb and adiabatic saturation temperature, Humidity data for the air-water system, temperature- humidity chart, enthalpy-humidity chart, determination of humidity, humidification and dehumidification. Basic principles, types, features and operation of various cooling towers. Cooling tower design; Alternative sinks for waste heat. Design of equipment based on worst case scenarios. Water and air-based systems. Environmental effects.

4. Drying

- General principles, Rate of drying, Diffusion and Capillary theory of drying, Classification and selection of dryers (Tray, tunnel, rotary, drum, spray, pneumatic, fluidized beds, turbo-shelf, disc and centrifuge

dryers), solvent drying, superheated steam drying, freeze drying, flash drying, partial-recycle dryers, the drying of gases.

5. **Leaching**

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

6. **Crystallization**

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

7. **Ion exchange**

- Principles, applications and equipment.

8. **Membrane Separation Processes**

- Principles, applications and equipment

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. McCabe Warren L., Smith Julian C., Harriott Peter "Unit Operations of Chemical Engineering" 7th Ed. 2005. McGraw-Hill Inc.
2. Coulson J.M., Richardson J. F. "Chemical Engineering" Vol-II, 5th Ed. 2002. The English Book Society and Pergamon Press.
3. Incropera Frank P., De Witt David P. "Fundamentals of Heat and Mass Transfer" 3rd Ed. 1990. John Wiley and Sons.
4. Treybal Robert E. "Mass Transfer Operations", 1981, McGraw-Hill Book Company.
5. Schweitzer, "Handbook of Separation Techniques for Chemical Engineers", 1979, McGraw-Hill Book Co.

6. Coulson J. M., Richardson J. F. "Chemical Engineering" Vol-I, 1999. The English Book Society and Pergamon Press
7. Alan S. Foust, Leonard A. Wenzel "Principles of Unit Operations" 2nd Ed. 1980. John Wiley & Sons.
8. Diran Basmadjian. "Mass Transfer and Separation Process (Principles and Applications) CRC Press Taylor and Francis Group. 2007.
9. Christie J. Geankoplis, "Transport Processes and Unit Operations", 4th Ed., 2003, Prentice Hall Professional Technical Refere.

CHEMICAL REACTION ENGINEERING

Credit Hours: 3+1=4
Pre-Requisites: Nil

DESCRIPTION

This course will enable the students to understand the fundamentals of chemical reaction engineering and the kinetics and design of homogenous and heterogenous systems.

COURSE LEARNING OUTCOMES

1. Apply principles of chemical reaction kinetics to develop and analyze reaction mechanisms
2. Demonstrate relevant skills and techniques for the processing and interpretation of reaction rate data
3. Design an appropriate reactor type and/or combination to achieve desired conversion

COURSE OUTLINE

1. Fundamentals

- Introduction to chemical reaction engineering

2. Kinetics of homogeneous reactions

- Rate of reaction, variables affecting the rate of reaction, order of reaction, rate constant; searching for a mechanism of reaction, activation energy and temperature dependency, Interpretation of batch reactor data for single and multiple reactions. Integral method and differential method of analysis for constant volume and variable volume batch reactors. Search for a rate equation.

3. Design of homogeneous reactors

- Batch, Mixed flow, Plug flow reactors, Comparison of single reactor, multiple reactor systems in parallel/series. Temperature and pressure effects, Adiabatic and non-adiabatic operations.

4. Design of heterogeneous reactors

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

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations

- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

PROCESS MODELING, SIMULATION AND OPTIMIZATION

Credit Hours: 3+1= 4
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of process modeling, simulation and optimization techniques using Aspen Hysys. Different case studies will enable the students to get an overview of the possible outcomes of any activity before implementing it.

COURSE LEARNING OUTCOMES

1. Describe fundamental concepts of process model development and simulation, and applications and limitations of various process simulation software
2. Develop steady-state process simulation models for simple chemical processes in Aspen Plus(R) and interpret the simulation results

COURSE OUTLINE

- Fundamental concepts: Overview of chemical processes design basics, design principles, Hierarchy of process design, Process synthesis and design strategy
- Development of models: Mathematical models; conservation laws, steady state models; dynamic models, distributed and lumped models, Pinch design method, Heat and power integration
- Optimization Models and their significance: Adaptive models, Empirical models based on non-linear regressive adaptive refinement of models, State variables models and matrix differential equations, and Quantitative models.
- Optimization by Simulation tools: Analysis of systems behavior for process optimization, flexibility and safety. Stability and multiple states, Optimization methods; Analytical/numerical techniques for single variable and multi variable (constrained and unconstrained) functions; linear programming.

- Applications: Overview of different simulation tools and their limitations, Basic equipment, Development of various industrial processes and their analysis, data entry and properties selection by using ASPEN HYSYS, Energy and economics evaluation.
- Case studies: Reactor network design, Separation system selection and design, Design of heat exchanger networks Design and development of processes by using ASPEN HYSYS.

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

CHEMICAL PLANT DESIGN

Credit Hours: 3+0=3
Pre-Requisites: Heat transfer+ Mass transfer+ Engineering materials+ Instrumentation and control

DESCRIPTION

This course will give students a detailed overview of different steps involved in the chemical plant design. The course will focus on the hazard's identification and risk assessment in the design of chemical plant. The design ethic is an important component of chemical plant design that will be covered in this course.

COURSE LEARNING OUTCOMES

1. Create alternate processes for a chemical process based on general design considerations
2. Design of different process equipment by applying core chemical engineering knowledge
3. Apply optimization methods for design of process equipment
4. Select and apply of appropriate computing tools for process and equipment design

COURSE OUTLINE

- Fundamentals: General design considerations. Design codes, standards & materials selection.
- Economic evaluation and optimization: Basic Concepts of Cost Indexing & Optimization, Optimization of Unconstrained Functions, Linear Programming Applications, Non-Linear Programming with Constraints.
- Process Design: Process design and development, process flow sheeting, flow diagrams, PFD and PID, Equipment and instrument symbols.
- Hazards Identification and Risk Assessment: Process Hazards Checklists and surveys, Safety Reviews, Common Mode Failures (Event Trees & Fault Trees), QRA and LOPA.
- Applications: stationary equipment like, Vessel design, Low, medium and high pressure storage and transportation vessels; Cryogenic vessels, Design of mass transfer equipment; material transport; material handling,

Heat transfer equipment including furnaces and refrigeration units, heat exchangers, Piping and pipeline design. rotating equipment including Pumps, Motors, compressors, turbines.

- Design Ethics: Local and Global Impact Analysis

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Peters Max S., Timmerhaus Klaus D. "Plant Design and Economics for Chemical Engineers" 4th Ed. 1991. McGraw-Hill Inc.
2. Ludwig Ernest E. "Applied Process Design for Chemical and Petrochemical Plants" Vol 1, 2 & 3, 3rd Ed. 2002, Gulf Publishing Company.
3. Walas Stanley M. "Chemical Process Equipment Selection and Design "Butterworth Heinemann" 1999.
4. Coulson J. M, and Richardson, "Chemical Engineering", Vol VI, "Butterworth Heinemann" 1999.
5. Wells G. L. Rose L. M. "The art of Chemical Process Design" 1986. Elsevier.
6. Smith Robin "Chemical Process Design" 1995. McGraw-Hill Inc.
7. Backhurst & Harker, "Chemical Process Design, John Wiley
8. Evans, "Handbook of Chemical Equipment Design"
9. E. L. Cussler and G. D. Moggridge, "Chemical Product Design", 2001, Cambridge University Press.
10. Special Issue of Chemical Engineering Research and Design, Part A 80 (A1), 2002 on "Process and Product Development"

11. James Wel, Molecular Structure and Property: Product Engineering, Ind. Engg. Chem. Res. 41(8) 1917-1919 (2002)
12. Robbin Smith, "Chemical Process: Design and Integration," 2005, Wiley.

CHEMICAL PROCESS SAFETY

Credit Hours: 1+0= 1

Pre-Requisites: Chemical Process Industries

DESCRIPTION

This course will give students a detailed overview of different risks and hazards e.g. toxicology, fire and explosions etc. The course will include chemical safety procedure and other protection methods for the chemical process safety.

COURSE LEARNING OUTCOMES

1. Discuss the occupational health and safety hazards, their types and sources at workplace
2. Examine and assess the risk of all routine and non-routine activities at workplace and apply control measures to reduce the risk
3. Discuss the safety management system and legal framework for occupational health and safety

COURSE OUTLINE

- Introduction: Accident and Loss Statistics, The Nature of the Accident Process, Inherent Safety, Seven Significant Disasters.
- Toxicology: How Toxicants Enter and eliminated from Biological Organisms, Effects of Toxicants on Biological Organisms, Toxicological Studies, Dose versus Response, Relative Toxicity and Threshold Limit Values, Models for Dose and Response Curves.
- Source Models: Introduction to Source Models, Flow of Liquid through a Hole in a Tank, Flow of Liquids through Pipes, Flow of Gases or Vapors through Holes, Flow of Gases or Vapors through Pipes, Flashing Liquids, Parameters Affecting Dispersion.
- Fires and Explosions: The Fire Triangle, Flammability Characteristics of Liquids and Vapors, Flammability Diagram, Autoignition, Auto-Oxidation, Adiabatic Compression, Ignition Sources, Sprays and Mists, Explosions.
- Fires and Explosions prevention: Inerting, Static Electricity, Controlling Static Electricity, Explosion-Proof Equipment and Instruments, Ventilation, Sprinkler Systems, Miscellaneous Concepts for Preventing Fires and Explosions.
- Reliefs: Relief Concepts, Location of Reliefs, Relief Types and Characteristics, Relief Systems, Spring-Operated and Disc reliefs, Venting, Reliefs for Thermal Expansion of Process Fluids.

- Case Histories

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Daniel A. Crowl. "Chemical Process Safety Fundamentals with Applications", 4th edition, 2019, Pearson.
2. Biswas. "Fundamentals of Process Safety Engineering", 2021, CRC Press.
3. Mihir Kumar Purkait. "Hazards and Safety in Process Industries", 2021, CRC Press.
4. Raju. "Chemical Process Industry Safety", 2014, McGraw Hill Education.

WORKSHOP PRACTICE

Credit Hours: 0+1=1
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Workshop Practice.

COURSE OUTLINE

Familiarization with workshop tools and types of workshop practices

- Principles and practice of machine tools of the engineering metal shop, measurements, filing and fitting; drilling; welding; bench work, grinding, Soldering and brazing, Welding, Heat treatment, Molding, casting and sheet metal operations, conventional turning and milling operations are included.
- Simple machine shop processes, such as turning, shaping, Milling and sheet metal
- Use of carpenter's tools, Exercise in preparing simple joints, Bench fitting practice, Exercise in marking and fittings, Use of measuring instruments.
- Smith's forge, Exercise in bending, Upsetting and swaging.

Carpentry workshop

- Introduction and use of carpentry tools, exercise in preparing simple joints, bench fitting practice.
- Exercise in marking and fittings; use of measuring instruments.

Smithy, molding, and casting workshop

- Smith's forge, bending, upsetting, and swaging.
- Moulding and casting. Simple machine shop processes, such as turning, shaping, milling, and sheet metal work.

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

ENGINEERING MATERIALS

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed understanding of materials commonly employed in chemical engineering and construction (steel, aggregates, cement, concrete, masonry, asphalt and asphalt mixtures, wood, Ceramics, and composites) including their methods of manufacture, evaluation of their physical and mechanical properties, and life-cycle impact. The course will provide detailed guidance on material preparation (e.g. material manufacture and concrete and asphalt mix design) and material testing that are commonly employed in the construction and civil engineering disciplines. Emphasis will be placed on selection criteria, design, applications and proper use of these materials.

COURSE LEARNING OUTCOMES

1. To understand and evaluate the types of materials, thermal and mechanical properties with special focus on chemical engineering materials.
2. To achieve the understanding of the phase diagrams of engineering materials, selection of the materials and techniques to prevent the material malfunctioning.

COURSE OUTLINE

1. **Fundamentals of engineering materials**
   - Introduction to engineering materials and their properties
   - Introduction to ceramics materials, polymers, metals, alloys, composites and their properties, processing and applications,
   - Introduction to advanced materials and nanotechnology.
   - Crystal structures, imperfection and defects in solids, diffusion and mass transfer, solutions and phase diagrams, metals and alloys, effects of stress on structure, mechanical properties,
   - Stress, strain, modulus, elastic, and plastic behavior of materials.
   - Physical, mechanical, thermal properties and characterization.

2. **Properties, classification, and application of materials of fabrication**
   - Iron, steel, stainless-steel, nickel, haste alloy, copper alloys, aluminum and its alloys, lead, titanium and tantalum, PVC, Teflon, poly-olefins,

PTFE glass, stone ware, acid resistant bricks and tiles. Biomaterials, composites, ablatives & thermal insulation and other materials.

- Electrical and optical properties of materials, biodegradable materials and recyclable materials.

3. **Corrosion**
   - Nature, types and rate of corrosion,
   - Corrosion protection, surface treatment, heat treatment.
   - Material testing (destructive and nondestructive testing); international standards for material testing. Problem evaluation.

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

OCCUPATIONAL HEALTH AND SAFETY

Credit Hours: 1+0=1
Pre-Requisites: Nil

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.

COURSE LEARNING OUTCOMES

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

1. Identify hazards in the home, laboratory and workplace that pose a danger or threat to their safety or health, or that of others.
2. Control unsafe or unhealthy hazards and propose methods to eliminate the hazard.
3. 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.
4. Demonstrate a comprehension of the changes created by WHMIS and OSHA legislation in everyday life.

COURSE OUTLINE

1. 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

2. 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

3. 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

4. Finding hazard information

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

5. 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

6. 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

7. Preparing for Emergency Response Procedures

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

8. 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

9. Incident investigation

- Importance of investigation
- recording and reporting
- Techniques of investigation
- Monitoring
- Review

- Auditing Health and Safety

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practicals

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

PROBABILITY & STATISTICS

Credit Hours: 3+0=3
Pre-Requisites: Nil

DESCRIPTION

Statistical techniques in Engineering Probability are used for understanding data, making predictions and decision-making. They include techniques like hypothesis testing and regression methods.

COURSE LEARNING OUTCOMES

The knowledge units in this area collectively encompass the following:

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

COURSE OUTLINE

- **Basic Statistics,**
  a. Statistics, Branches of Statistics, Importance of statistics, population, sample, observation, variables, measurement of variable, Data, primary data, secondary data
- **Data Presentation,**
  a. Frequency distribution (grouped, ungrouped), stem and leaf display, histogram, frequency polygon, cumulative frequency polygon, Simple & Multiple Bar diagrams
- **Measure of central tendency,**
  a. Arithmetic Mean (A.M), Geometric Mean (G.M), Harmonic Mean (H.M), Quantiles (Median, Quartiles, Deciles, Percentiles), Mode, Applications of Averages
- **Measure of Dispersion,**
  a. Background, Range, Quartile deviation, Mean deviation, Variance, Standard deviation, Coefficient of variation, Moments, Moments ratios, Skewness, Kurtosis
  b. Applications in different Engineering Disciplines
- **Simple Regression, Correlation and Curve fitting**
  a. Introduction to regression theory, Simple linear regression line, Line fitting by least square methods, Coefficient of

determination,

b. Simple correlation, coefficient of correlation, fitting of a first and second degree curve, fitting of exponential and logarithmic Curves, related problems.
c. Principle of least squares.

- **Probability and random variables,**
  a. Probability review, Laws of probability, Conditional probability, Bayesian theorem, independent, dependent events.
  b. Random variables, Discrete and Continuous random variables, Probability mass and density functions, Distribution functions, Mathematical expectation,
  c. Variance of random variable, Bivariate distribution, Joint probability distribution, Moment generating function
- **Probability Distributions,**
  a. Discrete distributions:
  b. Bernoulli distribution, Binomial, Geometric, Negative binomial, Hyper-geometric, Poisson distribution, Properties and application of these distributions.
  c. Continuous Distributions: Uniform Distribution, Exponential distribution, Normal distribution, Applications
- **Sampling and Sampling Distributions**
  a. Introduction, Population, Parameter & Statistic, Objects of sampling, Sampling distribution of Mean, Standard errors, Sampling & Non-Sampling Errors,
  b. Random Sampling, Sampling with & without replacement, Sequential Sampling, Central limit theorem.
  c. Applications in relevant engineering discipline
- **Statistical Inference and Testing of Hypothesis,**
  a. Introduction to inferential statistics, Estimation, hypothesis testing of population mean, proportion,
  b. Variance, Applications in Engineering

SUGGESTED TEACHING & ASSESSMENT METHODS

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

RECOMMENDED TEXT AND REFERENCE BOOKS

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

PHYSICAL & ANALYTICAL CHEMISTRY

Credit Hours: 2+1=3
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed understanding of Physical and Analytical Chemistry. The course will provide detailed guidance on Analytical and physical chemistry techniques and knowledge employed in the field of Chemical engineering.

COURSE LEARNING OUTCOMES

1. EXPLAIN the fundamentals of physical and analytical chemistry.
2. DEMONSTRATE understanding of instrumental techniques

COURSE OUTLINE

- Kinetic theory of gases
- Dalton's law
- Henry's law
- Raoult's law.
- Antoine equation.
- Relative volatility.
- Surface Phenomena
  - Adsorption
  - Catalysis
  - Enzyme catalysis.
- Electrochemistry, including fuel cells.
- Colloidal chemistry
- Reaction kinetics and equilibrium.
- Introduction to instrumental techniques involving potentiometery, pH-Metery, liquid solid chromatography, high performance liquid chromatography, ion exchange, gas chromatography, plane chromatography.
- Spectroscopy, Basics of spectroscopy UV and visible spectroscopy.

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration

- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Miessler, G. L., & Tarr, D. A. Inorganic Chemistry. Pearson Education. *Upper Saddle River, NJ*, 345.
2. Khopkar, S. M. Basic concepts of analytical chemistry. New Age International.
3. Skoog, D. A., & West, D. M. Fundamentals of analytical chemistry. Holt, Rinehart and Winston.

MAINTENANCE & UTILITY ENGINEERING

Credit Hours: 2+0=2
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Maintenance & Utility Engineering.

COURSE LEARNING OUTCOMES

1. Explain various aspects of maintenance and its applications in the process industry (C2, PLO1)
2. Analyze the design considerations and the overall safety of plant and personnel keeping in view the hazards, accidents, and government regulations (C4, PLO3)
3. Discuss the utilities, their importance and their selection criteria for assisting and controlling the process (C2, PLO6)

COURSE OUTLINE

Role of maintenance in plant operation

- Types of maintenance: preventive, predictive, and corrective, break down and total productive maintenance.
- Individual versus group replacement; infernal versus Eternal maintenance. Scheduling and planning of maintenance.

Management of maintenance

- Hierarchy and training of maintenance workforce.
- Organizational structure, human resource management,
- Design considerations; layout and construction.
- Production planning methods, capacity planning and control; production control systems, job shop scheduling, quality control, production control charts, scheduling techniques, software for project management, purchasing and procurement,
- Computerized maintenance, inspection techniques, non-destructive testing techniques,
- Maintenance of rotary and stationery equipment, inspection techniques; non-destructive testing techniques.
- Basics of rigging and lifting, lubrication and lubricants, industrial management, process layout analysis and comparison, material handling considerations in layout,

Importance of utilities in process industries

- Basic utilities of process, selection criteria, and economical utilization.

Flare network, instrument & plant air, boiler feed water, steam, cooling water supply

- Types of fire, Firefighting system,

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

APPLIED ELECTRICAL ENGINEERING

Credit Hours: 2+1=1
Pre-Requisites: Nil

DESCRIPTION

This course will give students a detailed overview of Applied Electrical Engineering.

COURSE LEARNING OUTCOMES

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

COURSE OUTLINE

1. **Introduction to electrical engineering**

- Quantities, SI units, electric circuits, charges, current, voltage, resistance, energy and power, series/parallel circuits, KCL, KVL, review of RLC circuit and applications, AC/DC motors, their types and control;
- Transformers, ac circuits, power factor.
- Generators; transformers; single and multi-phase. AC/DC circuits; power factor;

2. **Electronics and circuit analysis**

- Integrated circuits, resisters, micro-processors. Controller and their types
- integrated circuits, microprocessors and applications
- Electronics and PCB Design

SUGGESTED TEACHING & ASSESSMENT METHODS

- Lecturing
- Laboratory Demonstration
- Written Assignments
- Guest Speaker
- Project

Suggested Assessment Methods Theory

- One hour test(s)/Mid-term
- Quiz tests, Assignments, Project Reports/Term Paper/Presentations
- Final Exam

Suggested Assessment Methods Practical

- Laboratory Participation
- Laboratory Report/Manual
- Laboratory Quiz /Viva Voce

RECOMMENDED TEXT AND REFERENCE BOOKS

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

Annexure A

NON-EXHAUSTIVE LIST OF CONSIDERED KEY PHRASES IN UN SDGs

FOR MAPPING WITH BACHELORS OF ENGINEERING PROGRAM

SDG-1 (1.5 ..... reduce their exposure and vulnerability to climate-related extreme events .....)
SDG-2 (2.4 ..... implement resilient agricultural practices ..... adaptation to climate change, extreme weather, drought, flooding and other disasters ....)
SDG-3 (3.6 ..... halve the number of global deaths and injuries from road traffic accidents)
SDG-3 (3.9 ..... air, water and soil pollution and contamination)
SDG-4 (4.3 ..... ensure equal access for all women and men ..., including university .....)
SDG-4 (4.4 ..... increase the number of youth and adults ....., for employment, decent jobs and entrepreneurship)
SDG-4 (4.5 ..... eliminate gender disparities in education .....)
SDG-4 (4.7 ..... all learners acquire the knowledge and skills needed to promote sustainable development.....)
SDG-4 (4.c ..... substantially increase the supply of qualified teachers.....)
SDG-5 (5.1 End all forms of discrimination against all women and girls everywhere)
SDG-5 (5.5 ..... Ensure women's full and effective participation ..... at all levels.....)
SDG-6 (6.1 ... access to safe and affordable drinking water for all)
SDG-6 (6.2 ... adequate and equitable sanitation and hygiene for all and end open defecation ..)
SDG-6 (6.3 ..... improve water quality by reducing pollution.....)
SDG-6 (6.4 ..... increase water-use efficiency across all sectors .....)
SDG-6 (6.5 ..... implement integrated water resources management at all levels.....)

SDG-6 (6.a ..... water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies.....)
SDG-6 (6.b ..... improving water and sanitation management.....)
SDG-7 (7.b ... expand infrastructure.....)
SDG-8 (8.3 ..... decent job creation, entrepreneurship.....)
SDG-8 (8.6 ..... reduce the proportion of youth not in employment, education or training....)
SDG-8 (8.8 ..... promote safe and secure working environments for all workers.....)
SDG-9 (9.4 ..... greater adoption of clean and environmentally sound technologies and industrial processes.....)
SDG-9 (9.5 ..... encouraging innovation and substantially increasing the number of research and development workers.....)
SDG-9 (9.b Support domestic technology development, research and innovation in developing countries.....)
SDG-9 (9.c significantly increase access to information and communications technology.....)
SDG-10 (10.2 ..... empower and promote the social, economic ..... inclusion of all.....)
SDG-11 (11.2 ..... access to safe, affordable, accessible and sustainable transport systems for all.....)
SDG-11 (11.5 ..... reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses ..... by disasters, including water-related disasters.....
SDG-11 (11.6 ..... special attention to air quality and municipal and other waste management.....)
SDG-11 (11.a ..... positive economic, social and environmental links between urban, peri-urban and rural areas.....)
SDG-11 (11.c ..... resilient buildings utilizing local materials)
SDG-12 (12.2 ..... achieve the sustainable management and efficient use of natural resources)
SDG-12 (12.4 ..... achieve the environmentally sound management of chemicals and all wastes throughout their life cycle.....)
SDG-12 (12.5 ..... substantially reduce waste generation through prevention, reduction, recycling and reuse)
SDG-12 (12.7 Promote public procurement practices that are sustainable.....)
SDG-12 (12.8 ..... relevant information and awareness for sustainable development.....)

SDG-12 (12.a ..... more sustainable patterns of consumption and production)
SDG-13 (13.1 Strengthen resilience and adaptive capacity to climate related hazards and natural disasters.....)
SDG-13 (13.2 Integrate climate change measures.....)
SDG-13 (13.3 Improve education, awareness-raising ..... on climate change mitigation, adaptation, impact reduction and early warning.....)
SDG-13 (13.b ... effective climate change-related planning and management.....)
SDG-14 (14.1 ..... reduce marine pollution of all kinds.....)
SDG-14 (14.3 ..... impacts of ocean acidification.....)
SDG-15 (15.3 ..... land affected by desertification, drought and floods.....)
SDG-16 (16.3 ..... rule of law at the national and international levels.....)
SDG-16 (16.5 ..... reduce corruption and bribery in all their forms)
SDG-16 (16.6 ..... effective, accountable and transparent institutions at all levels.....)
SDG-17 (17.1 Strengthen domestic resource mobilization.....)
SDG-17 (17.13 ..... macroeconomic stability.....)
SDG-17 (17.17 ..... effective public, public private and civil society partnerships.....)

Annexure B

MAPPING GUIDE OF SELECTED COURSE WITH SDGs

SOCIOLOGY FOR ENGINEERS

Credits: 02
Pre-Requisite: Nil

DESCRIPTION

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, with emphasis on UN SDGs.

Mapped SDGs:

DG-13 Climate Change	13.2 Integrate climate change measures.....

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. 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.
2. To provide opportunity for students to begin the process of considering social problems/ issues while designing engineering products.
3. To allow engineers to play a pro-active role in critical discussions of social issues specifically.
4. 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

1. 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 & heir interface with Engineering Project/services,

Sociology & Impact of Technology & Engineering Products/Projects on Society.

2. 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.

3. 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.

4. 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

5. 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

6. 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, UN SDGs.

7. 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

8. Climate Change and Ecological Friendliness from Engineering Perspective 173

- 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)

9. **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.

10. **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.

11. **Engineering Intervention for Social Stratification**

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

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

SUGGESTED TEACHING & ASSESSMENT METHODS

Suggested Teaching Methods

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

Suggested Assessment Methods Theory

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Godhade, J. B., and S.T. Hunderkari. 2018. Social Responsibility of Engineers.

International Journal of Academic Research and Development. Vol. 03; Special Issue. March, 2018.174

2. Nichols,S.P.andWeldon,W.F.2017. Professional Responsibility: The Role of Engineering in Society Center for Electro-mechanics, The University of Texas at Austin, USA.

3. 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.

4. 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.

5. Jamison,A.,Christensen,S.H.,andLars,B.2011.A Hybrid Imagination: Science and
Technology in cultural perspective

6. Vermaas,P.,Kroes,P.,Poet,l.,andHoukes,W.2011.APhilosophyof Technology: FromTechnical Artefacts to Socio technical systems.

7. Mitcham,C.,andMunoz,D.2010.HumanitarianEngineering. Morganand Claypool Publishers. Riley,D.2008.Engineering and Social Justice. Morgan and Claypool Publishers.

8. Bugliarello,G.1991.TheSocial Functions of Engineering: A Current Assessment, A Chapter in" Engineering as A Social Enterprise. Sociology

Available at:
http://www.pec.org.pk