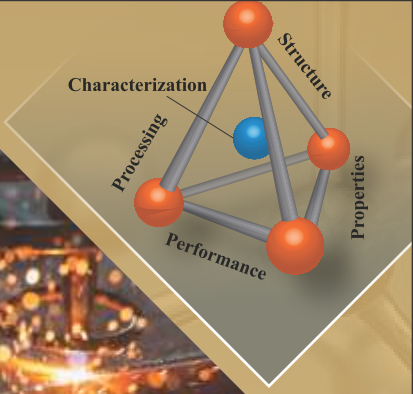
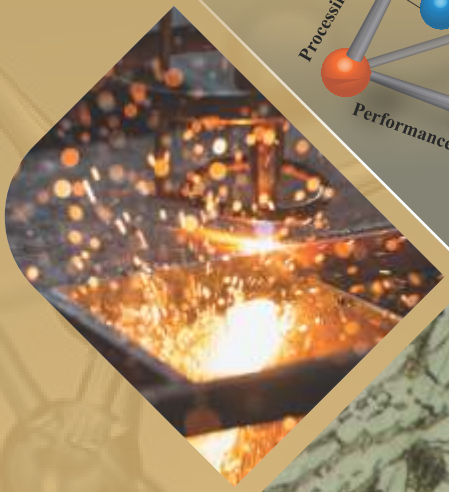
Curriculum for

Metallurgy & Materials Engineering

Bachelor of Engineering Program

2024





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 11th 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 (R) 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 PEC Governing Body / Prof. Emeritus / Advisor MUET, Jamshoro	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, Metallurgy & Materials, Mining, Petroleum & Gas Engg. and 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

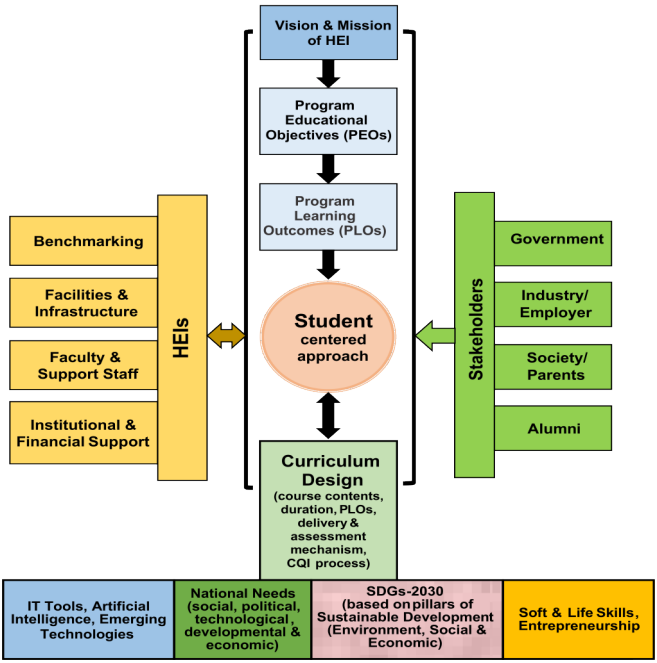
2. ECRDC Agenda

- 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

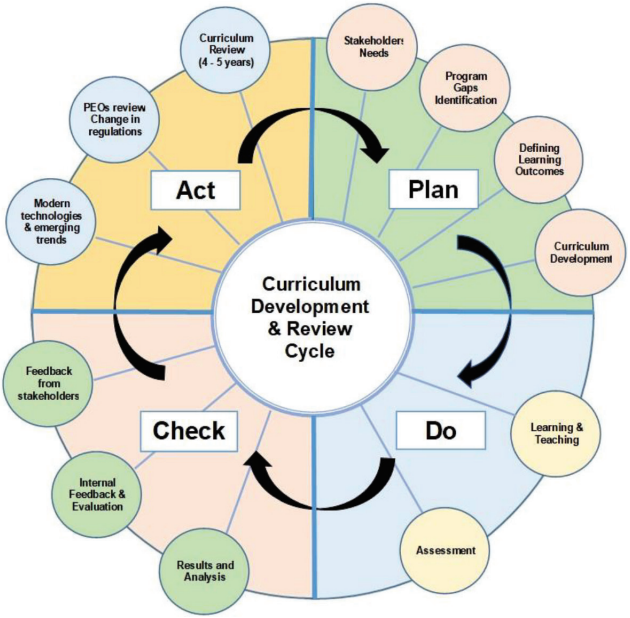
Outcome Based Education (OBE) is an approach of teaching and learning that focuses on what students should be able to attain at the end of the educational program. OBE is a student's centered system which concerns what the students will know and be able to do as learning outcomes. The curriculum development 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 Metallurgy & Materials, Mining & Petroleum and Gas Engineering Disciplines

The PEC Engineering Curriculum Review and Development Committee (ECRDC) of Metallurgy & Materials, Mining & Petroleum and Gas Engineering Disciplines took up the task to review and update the curriculum for the BE Metallurgical and Materials Engineering degree program. The subject Committee had conducted several meetings besides multiple sessions of Sub-Groups and the concluding meeting of ECRDC (Metallurgy & Materials, Mining & Petroleum and Gas Engineering Disciplines) was conducted on 17-18 May, 2024 at PEC Head Office Islamabad. The Committee consisted of following members:

1.	Engr. Prof. Dr. Amanat Ali Bhatti Convener, Metallurgy & Materials, Mining & Petroleum and Gas Engg. & Allied Disciplines	Convener
2.	Engr. Abdullah Shahwani Member PEC Governing Body/ DG Mines & Minerals Department, Balochistan	Member
3.	Engr. Muhammad Raza Chohan Member PEC Governing Body/ Advisor (Academics & Accreditation)/ Nominee of HEC	Member
4.	Engr. Dr. Ibrahim Qazi Professor, Institute of Space Technology, Islamabad	Co-opted Member
5.	Engr. Dr. Abdul Haque Tunio Director, Mehran University of Engineering & Technology, Jamshoro	Co-opted Member
6.	Engr. Dr. Syed Wilayat Hussain Professor, Institute of Space Technology, Islamabad	Co-opted Member
7.	Engr. Dr. Gul Hameed Awan Professor, University of Engineering & Technology, Lahore	Co-opted Member

8.	Engr. Dr. Muhammad Imran Khan Assistant Professor, Ghulam Ishaq Khan Institute of Engineering Sciences and Technology, Swabi	Co-opted Member
9.	Engr. Dr. Fahad Irfan Siddiqui Associate Professor, Mehran University of Engineering & Technology, Jamshoro	Co-opted Member
10.	Engr. Dr. Ishaq Ahmad Associate Professor, University of Engineering & Technology, Peshawar	Co-opted Member
11.	Engr. Dr. Muhammad Khurram Zahoor Professor, University of Engineering & Technology, Lahore	Co-opted Member
12.	Engr. Dr. Muhammad Asif Rafiq Professor, University of Engineering & Technology, Lahore	Co-opted Member
13.	Engr. Dr. Tahir Ahmad Professor, University of the Punjab Lahore	Co-opted Member
14.	Engr. Muhammad Kashif Asst. Manager Engineering Quality (Quality Assurance), Atlas Honda Limited, Lahore	Co-opted Member
15.	Engr. Niaz Ahmed Sr. Additional Registrar/ HoD-EAD	Secretary ECRDCs
16.	Engr Osaf Mahmood Malik Section Head (Curriculum & Development)	Additional Registrar-EAD
17.	Engr. Syed Haider Abbas Bokhari	Assistant Registrar-EAD
18.	Engr. Muhammad Junaid Khan	Assistant Registrar-EAD

19.	Mr. Muhammad Irfan	Office Superintendent -EAD

Sub-Group Metallurgy & Materials Engineering

1.	Engr. Dr. M. Asif Rafiq Professor, UEL Lahore	Convener/ Team Lead Sub-Group
2.	Engr. Dr. Ibrahim Qazi Professor, IST, Islamabad	Member
3.	Engr. Dr. Syed Wilayat Hussain Professor, IST, Islamabad	Member
4.	Engr. Dr. Gul Hameed Awan Professor, UET Lahore	Member
5.	Engr. Dr. Tahir Ahmad Professor, University of the Punjab Lahore	Member
6.	Engr. Dr. M. Imran Khan Dean Student Affairs / Associate Professor, GIK Institute of Engineering Sciences and Technology, Swabi	Member
7.	Engr. Dr. Sajid Hussain Siyal Chairman (HoD), Department of Metallurgy and Materials Engineering, Associate Professor DUET, Karachi	Member
8.	Engr. M. Kashif Asst. Manager Engineering Quality (Quality Assurance), Atlas Honda Limited, Lahore	Member
9.	Engr. Arslan Bin Ubaid Assistant Manager Production and Safety, Model Steel Mill-Lahore	Member
10.	Engr. Dr. M. Zubair Assistant Professor (TTS), Department of Metallurgical and Materials Engineering, University of Engineering and Technology, Lahore	Member/ Secretary Sub-Group

The ECRDC Metallurgy & Materials, Mining & Petroleum and Gas Engineering Disciplines appreciated the extraordinary efforts and contribution of Engr. Dr. Amanat Ali Bhatti (Convener), Engr. Dr. Asif Rafiq (Lead Sub-Group), Engr. Dr. M. Zubair (Member Sub-Group) & Engr. Osaf Mahmood Malik (Section Head Curriculum & Development) for compilation of course contents and proof reading of this curriculum booklet.

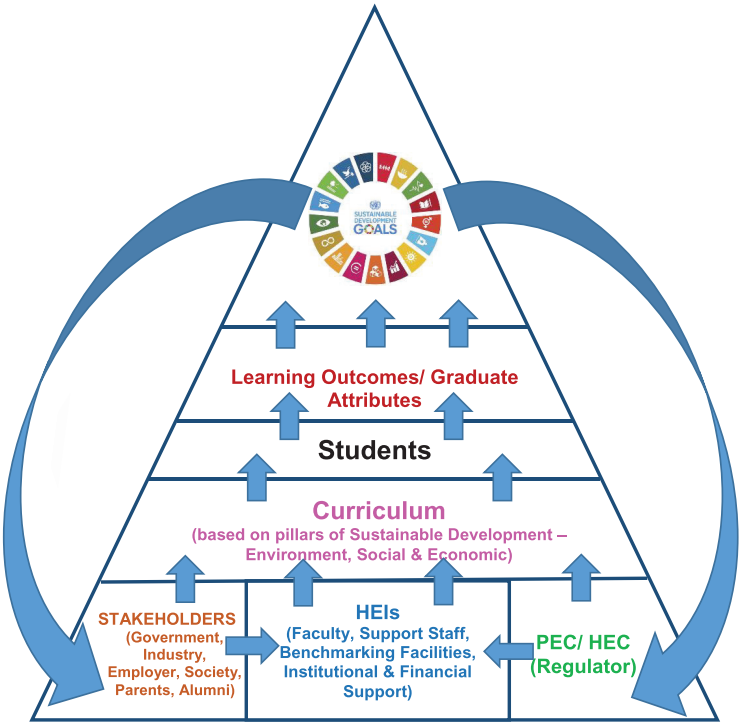
6. Agenda of ECRDC for Metallurgy & Materials, Mining & Petroleum and Gas Engineering Disciplines

- 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/ HEC policies.
- 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. Prof. Dr. Amanat Ali Bhatti 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 of professors and experts from academia, industry and R&D institutions has provided a useful input and suggestions covering new developments to be incorporated in the curriculum. He also highlighted the importance of the field of emerging field for achieving sustainable development while addressing socio-economic issues and challenges envisaged in SDGs-2030 (as provided below) and well mapped with courses;

- Goal-1: No Poverty
- Goal-2: Zero Hunger
- Goal-3: Good Health and Well-being
- Goal-4: Quality Education
- Goal-5: Gender Equality
- Goal-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 attitude that the 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 (WK1-WK4).

- **PLO-2 Problem Analysis:** Identify, formulate, conduct research literature, and analyze complex Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences (WK1-WK4).

- **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 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 the HEI'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.

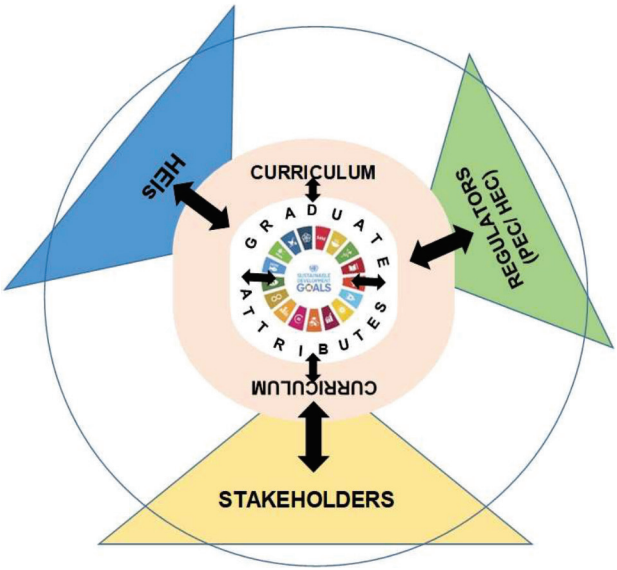


Figure 2: Consideration of UN SDGs in curriculum design

For undergraduate engineering program 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.

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

Sr. #	Description	UN SDGs																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
01	HEI vision and mission with focus on specific engineering program																	
02	Bachelor of Engineering Curriculum (Engg. & Non-Engg. Courses)																	
03	Final Year Design Project (FYDP)																	
04	Other pre-requisite activities (Internship, Community service, Survey camp, etc.)																	
05	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** **Engineering design and operations**	SDG-1, 2, 3, 6, 9, 10, 11, 12, 13, 14 (relevance as per curriculum)
PLO-4 **Investigation:** Breadth and depth of investigation andexperimentation	**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** **Engineeringlesign 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 in and 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 ofactivities 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 differingtypes of activity	**EC-9** Manage engineering activities	(WK-2 & WK-5) **WK-2** **Mathematics & computing** & **WK-5** **Engineering** **design and operations**	SDG-9, 12
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-3, 4, 8, 9, 12, 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: Min. 38 Credit Hours
    - o Engineering Domain: Min. 72 Credit Hours
    - o FYDP/ Capstone Project: 06 Credit Hours
    - o Multidisciplinary Engineering Courses: Min. 06 Credit Hours
    - o HEIs have flexibility of 08-14 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 Petroleum Gas 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 (Languages or study of religion)	2
		Social Science	*** Social Science	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	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	Multidisciplinary Engg Courses		Specific to Program Objectives and outcome	6
			Occupational Health and Safety (Mandatory 01 credit hours)	
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 in line 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 Metallurgical and Materials 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 Metallurgy and Materials Engineering Curriculum

Knowledge Profile (WK-1 to WK-9)	Knowledge Area	Subject Area	Name of Course	Th	Lab	Cr Hrs.	Total Credits
General Education/ Non-Engineering Domain							
WK-7,	**Humanities**	English	Functional English **	3	0	3	**6**
			Expository Writing **	3	0	3	
		Culture	Islamic Studies / Ethics **	2	0	2	**6**
			Ideology and Constitution of Pakistan **	2	0	2	
			Arts and Humanities Elective*	2	0	2	
		Social Sciences	Civics and Community Engagement **	2	0	2	**4**
			Social Sciences Elective***	2	0	2	
	Computer Sciences	Basic Computing	Applications of ICT **	2	1	3	**3**
WK-9,	**Management Sciences**	Professional Practice	Entrepreneurship **	2	0	2	**4**
			Project Management	2	0	2	
WK-2/, WK-1	**Natural Sciences**	Mathematics	Calculus & Analytical Geometry	3	0	3	**12**
			Linear Algebra & Differential Equations	3	0	3	
			Statistical Methods	3	0	3	
			Numerical Analysis	2	1	3	
		Natural Sciences	Applied Physics	2	1	3	**6**
			Materials Chemistry	2	1	3	
Total (General Education/ Non-Engineering Domain)				**37**	**4**	**41**	**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.

Knowledge Profile (WK-1 to WK-9)	Knowledge Area	Subject Area	Name of Course	Th	Lab	Cr. Hrs.	Total Credits
Engineering Domain							
WK-2/, WK-4/, WK-5/, WK-6	**Advanced Computer and Information Sciences**	ICT/AI/ Data Science/ Programming	Machine learning in Materials Engineering	2	1	3	**6**
			Computational Materials Science	1	2	3	
WK-2/, WK-3	**Engineering Foundation**		Introduction to Engineering Materials	3	0	3	**23**
			Engineering Drawing	0	2	2	
			Workshop Practice	0	1	1	
			Mechanics of Materials	3	0	3	
			Materials Thermodynamics	3	0	3	
			Mechanical Behavior of Materials	3	0	3	
			Inspection and Testing of Materials	3	1	4	
			Physical Metallurgy	3	1	4	
WK-1/, WK-2/, WK-4	**Major Based Core (Breadth)**		Manufacturing Processes	3	0	3	**23**
			Iron and Steel Making	3	0	3	
			Polymer and Composite Materials	3	1	4	
			Ceramic Materials	3	1	4	
			Characterization Techniques	3	0	3	
			Non-ferrous Metallurgyy	2	0	2	
			Heat Treatment and Phase Transformations	3	1	4	

WK-5/, WK-6	**Major Based Core (Depth)**		Advanced Materials	3	0	3	**23**
			Powder Metallurgy	2	0	2	
			Corrosion and Protection	3	1	4	
			Joining of Materials	2	1	3	
			Foundry Engineering	2	1	3	
			Electronic, Magnetic, and Optical Materials	2	0	2	
			Biomaterials	2	0	2	
			Surface Engineering	2	0	2	
			Nanomaterials	2	0	2	
WK-1/, WK-2/, WK-3/, WK-4	**Multi-Disciplinary Engineering**		Instrumentation and Control	2	0	2	**6**
			Basic Electrical Engineering	2	1	3	
			Occupational Health and Safety	1	0	1	
WK-6/, WK-7/, WK-8	**Final Year Design Project (FYDP)/ Capstone**	Industrial/ Innovative/ Creative Project	FYDP (Part-I)	0	3	3	**6**
			FYDP (Part-II)	0	3	3	
Total (Engineering Domain)				**66**	**21**	**87**	**87**
WK-6/ WK-7	**Industrial Training**	6-8 weeks industrial training mandatory (Non- Credit)				**Mandatory & Qualifying**	
	Flexible Engineering/ Non-Engineering Courses		Technical Elective - I ***	2	0	2	**8**
			Technical Elective - II ***	2	0	2	
			Technical Elective - III ***	2	0	2	
			Technical Elective - IV ***	2	0	2	
Total (Flexible Domain)				**8**	**0**	**8**	**8**
Total (Credit Hours)						**136**	

Note:

1. Credits of Holy Quran Translation (QT), Sirat-ul-Nabi (Peace Be Upon Him) and any elective of multidisciplinary / Interdisciplinary courses will be allowed as over and above 136 Cr. Hrs. after necessary approval of relevant forum of HEI.
2. The above-mentioned Framework, Curriculum and Scheme of Studies are for guideline purposes to HEIs in Pakistan.

12. Scheme of Studies for Bachelor of Metallurgy and Materials Engineering Curriculum

1st Year				
First Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Basic Electrical Engineering	2	1	3
2.	Functional English	3	0	3
3.	Introduction to Engineering Materials	3	0	3
4.	Calculus & Analytical Geometry	3	0	3
5.	Islamic Studies/Ethics	2	0	2
6.	Applications of ICT	2	1	3
	Total	**15**	**2**	**17**

Second Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Expository Writing	3	0	3
2.	Ideology and Constitution of Pakistan	2	0	2
3.	Linear Algebra & Differential Equations	3	0	3
4.	Mechanics of Materials	3	0	3
5.	Materials Chemistry	2	1	3
6.	Engineering Drawing	0	2	2
7.	Workshop Practice	0	1	1
	Total	**13**	**4**	**17**

2nd Year				
Third Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Arts and Humanities Elective*	2	0	2
2.	Social Sciences Elective**	2	0	2
3.	Numerical Analysis	2	1	3
4.	Applied Physics	2	1	3
5.	Materials Thermodynamics	3	0	3
6.	Mechanical Behavior of Materials	3	0	3
7.	Civics and Community Engagement	2	0	2
	Total	**16**	**2**	**18**

Fourth Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Statistical Methods	3	0	3
2.	Entrepreneurship	2	0	2
3.	Physical Metallurgy	3	1	4
4.	Inspection and Testing of Materials	3	1	4
5.	Polymer and Composite Materials	3	1	4
	Total	**14**	**3**	**17**

3rd Year				
Fifth Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Ceramic Materials	3	1	4
2.	Heat Treatment and Phase Transformations	3	1	4
3.	Iron and Steel Making	3	0	3
4.	Characterization Techniques	3	0	3
5.	Occupational Health and Safety	1	0	1
6.	Machine learning in Materials Engineering	2	1	3
	Total	**15**	**3**	**18**

Sixth Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Non-ferrous Metallurgy	2	0	2
2.	Joining of Materials	2	1	3
3.	Powder Metallurgy	2	0	2
4.	Corrosion and Protection	3	1	4
5.	Computational Materials Science	1	2	3
6.	Manufacturing Processes	3	0	3
	Total	**13**	**4**	**17**

4th Year				
Seventh Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Instrumentation and Control	2	0	2
2.	Foundry Engineering	2	1	3
3.	Technical Elective - I***	2	0	2
4.	Project Management	2	0	2
5.	Electronic, Magnetic and Optical Materials	2	0	2
6.	Advanced Materials	3	0	3
7.	FYDP (Part-1)	0	3	3
	Total	**13**	**4**	**17**

Eighth Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Technical Elective - II***	2	0	2
2.	Technical Elective - III***	2	0	2
3.	Technical Elective - IV***	2	0	2
4.	Surface Engineering	2	0	2
5.	Nanomaterials	2	0	2
6.	Biomaterials	2	0	2
7.	FYDP (Part-1)	0	3	3
	Total	**12**	**3**	**15**

*** List of Arts and Humanities Electives (2+0)**	**** List of Social Sciences 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 Psychology • Critical Thinking • Human Resource Management • Organizational Behavior • Engineering Law • Engineering Economics • Applied Psychology • Engineering Management • Financial Management • Marketing Management • Leadership and Personal Grooming • Any other relevant course decided by the HEI as per requirement.

*** List of Technical Electives (2+0)
• Advanced Steels • Vacuum Technology • Fracture Mechanics and Failure Analysis • Additive Manufacturing • Functional Materials • High temperature Materials • Extractive Metallurgy • Mineral Processing • Thin Films and Coatings Techniques • Nuclear Materials • Construction Materials • Design and Selection of Materials • Metalworking Processes • Any other relevant course/ language decided by the HEI as per requirement.

13. Program Specific Laboratories

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

- Applications of ICT
- Materials Chemistry
- Workshop Practice
- Engineering Drawing
- Basic Electrical Engineering
- Numerical Analysis
- Applied Physics
- Physical Metallurgy
- Inspection and Testing of Materials
- Polymer and Composite Materials
- Ceramic Materials
- Heat Treatment and Phase Transformations
- Machine learning in Materials Engineering
- Joining of Materials
- Corrosion and Protection
- Computational Materials Science
- Foundry Engineering

Note:

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

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

14. Course 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.

The course learning outcomes (CLOs) are guidelines only, Higher Education Institutions (HEIs) have the flexibility to modify them based on the difficulty level of the course and the mapping with the specific Program Learning Outcomes (PLOs).

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: 3+0
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.).

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: 3+0
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 APPLICATIONS 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.

"Writing Today" by Richard Johnson-Sheehan and Charles Paine

ISLAMIC STUDIES

UGE Policy V1.1: General Education Course

Credits: 2+0
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.

IDEOLOGY AND CONSTITUTION OF PAKISTAN

UGE Policy V1.1: General Education Course

Credits: 2+0
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.

*** List of Arts and Humanities 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.

COMMUNICATION AND PRESENTATION SKILLS

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

"Communication and Presentation Skills" is designed to enhance students' abilities to communicate effectively in professional and academic settings. The course covers various aspects of communication including writing, reading, listening, and speaking skills. Students learn techniques for improving vocabulary, writing essays and letters, critical reading, active listening, verbal and non-verbal communication, and presentation strategies. Emphasis is placed on developing effective communication skills essential for job interviews and successful interactions in the workplace.

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.
5. Select and use audio-visual aids to enhance presentations.
6. Demonstrate effective communication skills in diverse contexts.

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 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: 2+0
Pre-Requisite: Nil

DESCRIPTION

"Beginners Spanish" introduces students to the fundamentals of the Spanish language, focusing on basic communication skills and grammatical structures. The course covers essential vocabulary and expressions for greeting, introducing oneself and others, describing people and places, discussing daily activities, and expressing opinions. Additionally, students learn grammatical concepts such as verb conjugation, noun gender and number, and basic sentence structure to develop a foundation for further language proficiency.

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 INSTRUCTIONAL/ READING MATERIALS

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

ELEMENTARY ARABIC

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

"Elementary Arabic" provides students with a foundational understanding of the Arabic language, focusing on basic vocabulary, grammar, and conversational skills. The course covers essential greetings, introductions, and everyday life vocabulary, along with fundamental grammar concepts such as verb conjugation, noun and adjective formation, and sentence structure. Students will develop proficiency in speaking, listening, reading, and writing Arabic at an introductory level.

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 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: 2+0
Pre-Requisite: Nil

DESCRIPTION

"Elementary French" offers students an introduction to the French language, covering essential vocabulary and grammatical structures for basic communication. Students will learn to engage in social interactions, discuss daily activities, express preferences, and describe personal experiences. The course emphasizes practical language skills necessary for everyday situations, such as greetings, shopping, and discussing food and leisure activities.

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 INSTRUCTIONAL/ READING MATERIALS

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

ELEMENTARY CHINESE

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

"Elementary Chinese" introduces students to the fundamentals of Mandarin Chinese, focusing on developing basic speaking, listening, reading, and writing skills. Students will learn Hànyǔ Pīnyīn for accurate pronunciation and recognize around 260 Chinese characters. The course covers essential grammar structures, vocabulary, and sentence patterns to enable students to communicate in simple everyday situations.

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 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: 2+0
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. Articulate the practical applications of studying history, recognizing its significance in informing decision-making, shaping identities, and contributing to a deeper comprehension of contemporary issues.
5. Explain the epistemological nature of history, including its methods of knowledge production and the challenges it faces.
6. 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

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: 2+0
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. Assess the scope and limits of knowledge within the realm of epistemology, considering their impact on the acquisition and application of knowledge in engineering contexts.
4. Examine different perspectives on knowledge within epistemology, relating these perspectives to engineering practices and the development of technological solutions.
5. Analyze the concept of induction, exploring its role in reasoning and its applications in the engineering field.
6. Compare and contrast the philosophical perspectives of rationalism and empiricism, considering their implications for the understanding of engineering phenomena.
7. Explore philosophical perspectives on meaning, considering how these perspectives influence the interpretation and significance of concepts within engineering contexts.

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

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: 2+0
Pre-Requisite: Nil

DESCRIPTION

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

COURSE LEARNING OUTCOME

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

1. Understand the ethical principles and theories underpinning engineering practice, including moral autonomy and professional obligations.
2. Critically analyze codes of ethics and apply ethical frameworks to evaluate engineering decisions in various contexts.
3. Assess safety, risk, and environmental considerations in engineering design, incorporating principles of sustainable development and risk-benefit analysis.
4. Navigate complex ethical dilemmas related to confidentiality, conflict of interest, and whistle-blowing, considering the rights and responsibilities of employees and employers.
5. Demonstrate ethical leadership and engage in responsible engineering practices that prioritize public welfare, environmental stewardship, and social justice.

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.

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

CIVICS AND COMMUNITY ENGAGEMENT

UGE Policy V1.1: General Education Course

Credits: 2+0
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.

List of Social Sciences Electives (2+0)
• Sociology for Engineers • Sociology • Social Psychology • Critical Thinking • Human Resource Management • Organizational Behavior • Engineering Law • Engineering Economics • Applied Psychology • Engineering Management • Financial Management • Marketing Management • Leadership and Personal Grooming

SOCIOLOGY FOR ENGINEERS

Credits: 2+0
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 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. APhilosophyofTechnology: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: 2+0
Pre-Requisite: Nil

COURSE LEARNING OUTCOMES

1. To introduce the necessary subject knowledge and understanding required for the successful study of Sociology and related Social Science disciplines at undergraduate.
2. To develop skills of application, analysis and evaluation in the context of the study of Social Science.
3. To develop a knowledge and understanding of sociology both at a global and national level.
4. To introduce the planning and organization skills necessary to develop as independent, autonomous learners.
5. 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 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: 2+0
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

1. Principles of sociology and psychology with emphasis on the individual and his/her reciprocal interaction with groups,
2. 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,
3. 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,
4. corruption and its control, thinking processes and decision making.

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: 2+0
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. Identify the steps involved in the critical thinking process.
4. Explain the importance of asking questions, actively listening, and challenging assumptions.
5. Describe common creative thinking techniques like brainstorming, mind mapping, and De Bono's thinking hats.
6. List and explain root cause analysis techniques like the 5 Whys and Ishikawa Diagram.
7. Identify and adapt your REACH profile to support critical thinking.
8. Describe strategies for effectively presenting recommendations to decision-makers and stakeholders.

COURSE CONTENT

- 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

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: 2+0
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).
2. Compare and contrast global and local HRM practices.
3. Explain basic principles of HRM from Islamic and indigenous perspectives.
4. Apply job analysis techniques, including HR planning, job description, and specification.
5. Differentiate between compensation and benefit packages and their management.
6. Explain staffing strategies, covering recruitment techniques, sources, and selection tests.
7. Identify key elements of employee relations.

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

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

ORGANIZATIONAL BEHAVIOR

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

"Organizational Behaviour" delves into understanding human behaviour within organizational settings, exploring topics such as structure, learning, stress management, motivation, leadership, group dynamics, and organizational culture. Through theoretical frameworks and practical applications, students gain insights into individual and group behaviours, organizational dynamics, and strategies for effective management.

COURSE LEARNING OUTCOMES

1. Analyze the structures and controls within organizations, including bureaucratic systems, managerial roles, and contingency theories.
2. Evaluate individual learning processes, stress management techniques, and the impact of individual differences on organizational behaviour.
3. Examine motivational theories and their application in enhancing job satisfaction and organizational performance.
4. Assess group dynamics, including social interactions, group processes, and leadership styles, to foster effective teamwork and collaboration.
5. Understand the significance of organizational culture, its role in shaping organizational identity and behaviour, and strategies for managing and evaluating organizational culture.

COURSE OUTLINE

Introduction to Organizational Behaviour

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

Structure and Control in Organizaion

- Introduction of Bureaucracy
- Managerial Work
- Contingency theory
- Organizational Design

Individual and Work Learning

- Learning Theories
- Learning and Work

Stress

- Types of Stress and Work

- Occupational Stress Management

Individual Differences

- Personality and its factors
- Personality dimensions and social learning Intelligence

Motivation and Job Satisfaction

- Needs at Work
- Theories of Motivation and job satisfaction
- Correlates of Job satisfaction

Group and Work

- Social Interaction
- Dramaturgy and impression Mangement
- Social Skill

Group and Inter group Behaviour

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

Leadership

- Leadership as an attribute
- Leadership Style

Patterns of Work

- Work-the classical approach
- Marx, Weber, & The critique of labor
- Foucault & Disciplinary Power
- Conflict and Consent in Work
- The labor Process debate
- Work place control and resistance
- Industrial conflict and industrial relations

Organizational Culture

- Organizational culture and strategic management
- Exploring organizational culture
- Evaluating concept of culture

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

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

ENGINEERING LAW

Credits: 2+0
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. 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.

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

Credit: 2+0
Pre-Requisites: Nil

DESCRIPTION

This course explores the critical intersection of engineering and economics, emphasizing the pivotal role engineers play in business and strategic decision-making for large-scale projects. Participants delve into fundamental economic principles and learn to navigate complex economic landscapes inherent in engineering endeavors.

COURSE LEARNING OUTCOMES

Upon completion, participants gain expertise in making strategic economic decisions, evaluating project cash flows, and navigating economic uncertainties in engineering projects. The course equips individuals to analyze costs, assess financial viability, and contribute effectively to engineering economic decision-making processes.

COURSE OUTLINE

Engineering Economics

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

Interest Rate and Economic Equivalence

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

Understanding Money and Its Management

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

Present-Worth Analysis

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

Annual Equivalent-Worth Analysis

- Annual Equivalent-Worth Criterion
- Capital Costs versus Operating Costs

- Applying Annual-Worth Analysis
- Life-Cycle Cost Analysis
- Design Economics

Rate-of-Return Analysis

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

Cost Concepts Relevant to Decision Making

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

Depreciation and Corporate Taxes

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

Developing Project Cash Flows

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

Project Risk and Uncertainty

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

Special Topics in Engineering Economics

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

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

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

APPLIED PSYCHOLOGY

Credit Hours: 2+0
Pre-Requisites: Nil

DESCRIPTION

This course provides an essential foundation in psychological principles tailored to the needs of engineering students. The course explores the scientific and historical contexts of psychology, the biological bases of behavior, and the intricate processes of sensation, perception, learning, memory, cognition, and language. It also covers intelligence, creativity, motivation, emotion, personality, and social psychology, with a focus on practical applications in engineering contexts. Through this course, students will gain insights into human behavior that enhance their professional and interpersonal skills in the field of mechatronics engineering.

COURSE LEARNING OUTCOMES

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

1. Understand Fundamental Psychological Concepts
2. Analyze the Biological Basis of Behavior
3. Examine Sensation and Perception Processes
4. Explore Learning and Memory Mechanisms

Evaluate Cognitive Processes and Language

COURSE OUTLINE

Understanding Psychology

- Psychology: Scientific perspective
- Historical perspective
- Schools of psychology
- Methods of psychology
- Ethical issues
- Fields of psychology and their application

Biological Basis of Behavior

- Neuron and its function
- Central nervous system
- Peripheral nervous system
- Endocrine system

Sensation and Perception

- Senses: Vision, audition, smell, taste and kinesthetic
- Introduction to perception
- Gestalt principles
- Binocular and monocular cues
- Illusions and extra sensory perception

Learning

- Definition of learning
- Types of learning: Classical and operant conditioning

- Punishment and its effects
- Latent and observational learning

Memory

- Definition and types of memory
- Processes and techniques of improving memory
- Forgetting: Nature and causes

Cognition and Language

- Concept of cognition
- Problem solving
- Judgment and decision making
- Language development
- Language and cognition
- Language and culture

Intelligence and Creativity

- Concept of intelligence
- Theories of intelligence
- Assessment of intelligence
- Mental retardation
- Concept of creativity and its stages

Motivation and Emotion

- Introduction to motivation
- Factors affecting motivation
- Introduction to emotions
- Types of emotions
- Physiology and emotion
- Theories of emotion

Personality

- Defining personality
- Theories of personality
- Personality assessment

Social Thinking and Social Influence

- Social facilitation
- Attribution theory
- Crowd behavior
- Conformity, Obedience
- Helping behavior

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Atkinson R. C., & Smith, E. E. (2000).Introduction to psychology (13th ed.). NY: Harcourt
2. Brace College Publishers.
3. Coon, D., &Mutterer, J. (2008).Introduction to psychology: Gateways to mind and behavior
4. (12th ed.). USA: Wadsworth Cengage Learning.
5. Fernald, L. D., & Fernald, P.S (2005).Introduction to psychology. USA; WMC Brown Publishers

ENGINEERING MANAGEMENT

Credit Hours: 2+0
Pre-Requisites: Nil

DESCRIPTION

This course delves into the multifaceted aspects of technology commercialization, offering a comprehensive exploration of industrial networks, product and process development, and the critical skills required for successful business ventures. Participants will gain practical knowledge and experience in navigating the journey from concept to market, with a focus on problem-solving, teamwork, and outreach activities.

COURSE LEARNING OUTCOMES

Upon completion, participants will possess the skills and knowledge necessary for successfully commercializing new technological inventions. They will be adept at navigating the various stages, from proof of concept to market distribution, and equipped to develop robust business plans aligned with market demands and technological advancements.

COURSE OUTLINE

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

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

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

FINANCIAL MANAGEMENT

Credit Hours: 2+0
Pre-Requisites: Nil

DESCRIPTION

This course introduces essential financial principles and practices tailored for engineering students. The course covers risk and return fundamentals, short-term financing decisions, cash conversion cycle, management of marketable securities, inventory and receivables management, leverage and capital structure, payout policy, and long-term debt management. Students will learn to apply financial management concepts to enhance decision-making processes, optimize resource allocation, and support strategic engineering projects.

COURSE LEARNING OUTCOMES

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

1. Understand Risk and Return Principles
2. Manage Short-term Financing Decisions
3. Optimize Inventory and Receivables Management
4. Evaluate Leverage and Capital Structure
5. Understand Long-term Debt Management and Payout Policies

COURSE OUTLINE

Risk and return (Required rate)

- Risk and Return Fundamentals: Definition, and Meanings; Basic Model; Risk Preference, Risk Preferences Behaviors; Risk of a Single Asset: (1) Risk Assessment including Scenario Analysis and Probability Distribution and (2) Risk Measurement including Standard Deviation and Coefficient of Variation; Risk of a Portfolio: Portfolio Return and Standard Deviation, Correlation, Diversification; The Capital Asset Pricing Model (CAPM): (1) Types of risk and (2) The CAPM Model covering Beta Coefficient, The Equation, The Graph, The security Market Line (SML) and Shifts in the security Market Line

Short-term Financing Decisions (Current Assets and Current Liabilities)

- Current Asset Investment Policies
- Working Capital Management
- Working Capital Terminologies: Gross VS Net; Trade-off between Profitability and Risk

Cash Operating / Conversion Cycle

- Calculating Cash Conversion Cycle; Funding Requirement of the Cash Conversion Cycle; Cash Management Alternative Strategies; Cash Budget

Management of Marketable Securities

- Inventory Management
- Inventory Levels and Costs; Common Techniques for managing Inventory

Receivables Management

- Credit Selection and Standards; Credit Terms and Policy; Credit Monitoring

Management of Receipts and Disbursements

- Float; Speeding-up Receipts and Slowing-down Payments; Cash Concentration; Zero-balance Accounts

Generic Current Assets' Management

- Financing Current Assets; Alternative Current Asset Financing Policies; Advantages and disadvantages of Short Term Financing

Management of Current Liabilities

- Sources of Short Term Financing; Spontaneous Liabilities; Accounts Payable Management; Accruals; Unsecured Sources of Short Term Financing; Bank Loans; Commercial Papers; Secured Sources of Short Term Financing; Accounts Receivables as Collaterals; Inventory as Collateral

Leverage and Capital Structure

- Leverage; Meanings and Use of Leverage; Breakeven Analysis; Operating Leverage; Financing Leverage; Capital Structure; Types/Dimensions of Capital; External Assessment of Capital Structure; Theory of Capital Structure; Target/Optimal Capital Structure, and its Determination; EBIT – EPS Approaches to Capital Structure; Variations in Capital Structures; Comparing Alternative Capital Structures; Capital Structure and Risk; Value Estimation; Maximizing Value VS Maximizing EPS

Payout Policy

- Mechanics of Payout Policy; Factors affecting Dividend Policy; Classification of Dividend Policies (General and w.r.t. Pakistan)

Long-term Debt Management

- Long-term Debt Considerations; Corporate Bonds; Preferred Stock; Leases; Mergers of Definition of Mergers; Convertible Securities; Options of Major Types of Options

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Brigham F Eugene, Houston F Joel (Latest edition), Fundamentals of Financial Management, South Western Publishers, Ohio
2. Lawrence J. Gitman, Latest Edition, 'Principles of Managerial Finance'
3. Horne Van, Jr. Wackowicz (Latest Edition), Fundamentals of Financial Management,
4. Apprentice Hall International Inc, New Jersey

MARKETING MANAGEMENT

Credit Hours: 2+0
Pre-Requisites: Nil

DESCRIPTION

This course explores the essential marketing principles and strategies relevant to engineering professionals. This course provides an understanding of how marketing management has evolved and its impact on customer value. Topics include market segmentation, customer value creation, consumer behavior analysis, brand positioning, product and pricing strategies, value networks, marketing communications, and sales promotions. The course aims to equip students with the skills to apply marketing concepts to engineering products and services, fostering strong customer relationships and effective market positioning.

COURSE LEARNING OUTCOMES

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

1. Understand the Scope and Evolution of Marketing
2. Identify and Target Market Segments
3. Analyze Consumer Markets and Buying Behavior
4. Craft and Communicate Brand Positioning
5. Develop Product and Pricing Strategies
6. Design and Manage Marketing Channels and Communications

COURSE OUTLINE

- Defining Marketing For The 21st Century. Importance and scope of Marketing.
- Discussion on Course Outline:
- Some fundamental Marketing Concepts, How Marketing Management changed. How does the Marketing affect customer Value? Discussion on Project Outline
- Identifying Market Segments and Targets. Different levels of market segmentation & requirements of effective segmentation? How companies divide a market into segments?
- Creating and delivering Customer Value, satisfaction and loyalty. What is the lifetime value of customers and how can marketers maximize it? How can companies cultivate strong customer relationship? How can companies both attract and retain customers?
- Analyzing Consumer Markets & Globalization How do consumer characteristics influence buying behavior & major psychological processes influence consumer Reponses to the marketing program?
- Crafting the Brand Positioning How can a firm choose and communicate an effective positioning in the market & how brands are differentiated.
- Creating Brand Equity Neuro Marketing How brands create brand Equity

- Setting Product Strategy Product characteristics & classification How companies differentiate products?
- How should a company set prices initially for products or services? When should company initiate a price change? How should a company respond to a competitor's price change?
- Designing and Managing Value Networks and Channels. The students need to recognize the importance of designing marketing channel system
- Managing Retailing, Wholesaling Why companies choose different marketing channels and how these marketing channels perform?
- Designing & Managing Integrated Marketing Communications Role of Marketing Communication. What are the guidelines for effective marketing communication mix?
- Managing Mass Communications: What steps are required in developing an advertising program? How should sales promotion decisions be made? What are the guidelines for effective brand-building events and experiences?
- Sales Promotions, Events Public Relations. Service Marketing Presentation

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Marketing Management 16th Edition (A South Asian Perspective) by Philip Kotler & Kevin Lane Keller.
2. Basic Marketing (1st Edition) by Salman Zaheer
3. Blue Ocean Strategy by Renée Mauborgne and W. Chan Kim

LEADERSHIP AND PERSONAL GROOMING

Credit Hours: 2+0
Pre-Requisites: Nil

DESCRIPTION

This course is designed to develop essential leadership skills and personal development strategies tailored for future engineering professionals. The course covers fundamental leadership concepts, servant leadership, community development frameworks, social capital, community building practices, and professional ethical standards. Students will learn to assess community assets, build effective organizations, market their initiatives, mobilize resources, and measure progress in community and economic development projects.

COURSE LEARNING OUTCOMES

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

1. Understand Leadership Fundamentals
2. Analyze Community Development Foundations
3. Apply Social Capital and Community Building Principles
4. Conduct Community Development Assessments
5. Develop and Market Community Organizations

COURSE OUTLINE

Fundamentals of Leadership and Servant Leadership

- What is leadership; Leadership Traits; Servant Leadership

Foundations of Community Development

- The frame work for community and economic development; Seven theories for seven community developers; Bases of community development; Process of community development; Challenges of the process

Social Capital, Community Building and Community Development Practice

- Social capital; Community social capacity and how does it influence development • Intentional action to increase social capacity; Factors that influence the success of community-building efforts; Principles and process of practicing community development; How does community development practice relate to economic development? Professional standards of ethical practices in community development

Community development assessment,

- Community Asset mapping and surveys, Assessing local economy.
- Community Mapping; Surveys Forms; The importance of asset mapping.

Building Powerful Community Organizations

- Bringing a group together; Scanning the functions of Community Organizations present in the market; The idea generation; Developing Vision, Mission and Goals; Structuring the Organization; Defining SOPs

Marketing your Organization

- Marketing a Community Organization; Effective role and guidelines for conducting meetings

Mobilizing Resources: Raising Money

- Community development finance; Finding sources of money; Securing grants for community development projects; Preparing grant proposals

Measuring Progress

- Community development indicators, Best practices & Benchmarking

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. The heart of leadership: A leader people want to follow by Mark Miller, Berret-Kohler Publisher 2013.
2. Leadership and Art of Struggle by Steven Snyder & B. Geage Berret Kohler Publisher 2013.
3. Strategic Leadership: How to think and plan by John Adair, Kogan Page Ltd 2010

ENTREPRENEURSHIP

UGE Policy V1.1: General Education Course

Credits: 2+0
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.

PROJECT MANAGEMENT

Credits: 2+0
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 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).

APPLICATIONS OF ICT

UGE Policy V1.1: General Education Course

Credits: 2+1
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 Power-Point), 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

CALCULUS AND ANALYTICAL GEOMETRY

Credit: 3+0
Pre-Requisites: Nil

DESCRIPTION

"Calculus and Analytical Geometry" provides students with a comprehensive understanding of mathematical concepts essential for engineering applications. Topics covered include vectors, functions, limits, continuity, derivatives, integrals, sequences, series, and Taylor series. Emphasis is placed on analytical techniques, problem-solving skills, and their practical applications in engineering.

COURSE LEARNING OUTCOMES

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

COURSE OUTLINE

- **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 INSTRUCTIONAL/ READING MATERIALS

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

LINEAR ALGEBRA & DIFFERENTIAL EQUATIONS

Credit Hours: 3+0
Pre-Requisites: Nil

COURSE LEARNING OUTCOMES

The knowledge units in this area collectively encompass the following:

1. To comprehend basic concepts of Linear Algebra and optimization
2. To apply techniques of Linear Algebra and optimization for solution of engineering problem.

COURSE OUTLINE

Linear Algebra:

a. Basic Concepts. Matrix Addition. Scalar Multiplication Matrix Multiplication
b. Linear Systems of Equations. Gauss Elimination.
c. Solution of Linear Systems: Existence, Uniqueness, General Form
d. Inverse of a Matrix. Gauss-Jordan Elimination.
e. Vector Spaces, Sub Spaces and Linear Transformations
f. Linear dependence, linear independence, spanning set, basis
g. Eigenvalues and Eigenvectors

Differential Equations:

a. Separable Variables.
b. Homogeneous Equations.
c. Exact Equations and Integrating Factors.
d. Linear Equations.
e. Equations of Bernoulli, Ricatti and Clairaut.
f. Applications of Linear and Non-Linear First Order ODEs.
g. Linear Differential Equations of Higher Order: Preliminary Theory, Initial and Boundary Value Problems, Linear Dependence and Linear Independence.
h. Homogeneous Linear Equations with constant coefficients.
i. Non-Homogeneous Linear Equations with constant coefficients: Undetermined Coefficients, Variation of Parameters.
j. Non-Homogeneous Linear Equations with Variable Coefficients: Cauchy-Euler Equation.
k. Laplace Transform: Laplace Transform and Inverse Transform
l. Unit step function, Dirac delta function
m. Solution of 1st and higher order initial value problem using Laplace Transform

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Dennis G. Zill and Michael Cullen, Differential Equations, 3rd edition.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 9th edition.
3. Glyn James, Modern Engineering Mathematics, Latest edition.

STATISTICAL METHODS

Credit: 3+0
Pre-Requisites: Nil

COURSE OUTLINE

Introduction & role of statistics in engineering.

1. Population & samples, Variables, Methods of displaying data sets, Stem & leaf display, Histogram, Histogram shapes, Boxplot, Bar chart, Pareto diagram, Dot diagram, Frequency distributions & their graphs, Outlier.
2. Mean, Median, Quartile, Percentile, Range, Deviation from mean, Sample variance, Sample standard deviation, Coefficient of variation.
3. Probability, Concepts & definitions, Basic theorems of probability, Law of total probability, Bayes theorem, Discrete and continuous random variables and their probability distributions, Density and distribution functions; Expectation.
4. Mean & variance of discrete & continuous random variables, Binomial distribution, Poisson distribution, Normal distribution, t-distribution, Chi-square distribution, F-distribution.
5. Sampling techniques and sampling distribution; Point estimation and interval estimation of parameters, Least square linear & polynomial regression, Linearization of nonlinear models, Correlation, Design of experiments, Analysis of variance.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Applied Statistics for Engineers & Scientists by Devore/Farnum. 3rd ed. Thomas.
2. Probability and Statistics for Engineers and Scientists by Ronald E. Walpole. 8th ed. Pearson Educational International, (2007).
3. Probability and Statistics for Engineering and Sciences. 8th ed. CENGAGE Learning.
4. Advanced Engineering Mathematics by Erwin Kreyszig. 11th ed. John and Wiley and Sons.
5. Applied Statistics and Probability for Engineers by Montgomery and Runger. 3rd ed. John and Wiley and Sons.
6. Probability and Random Variables and Stochastic Processes by Papoulis Athanasios, 3rd ed. McGraw-Hill Inc.

NUMERICAL ANALYSIS

Credit: 2+1
Pre-Requisites: Nil

COURSE LEARNING OUTCOMES

The knowledge units in this area collectively encompass the following:

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

COURSE OUTLINE

- **Error Analysis and Interpolation**
  a. Error analysis, Types of error, Sources of error, Norms of vectors and matrices, Computer arithmetic, Condition number of a matrix, Significant digits and loss of significant digits, Floating point arithmetic, Binary and decimal representation, Single and double precision
  b. Interpolation: Newton forward and backward difference formula for interpolation, Central difference interpolation formulae, Lagrange's interpolation, Error in interpolation, Linear least square approximation, Interpolation versus least square approximation, Relevant engineering case studies
- **Numerical Differentiation and Integration**
  c. Derivation of numerical differentiation of first order and second order derivatives using two points, three points, and five points formulas along with its application in engineering, Relevant case studies
  d. Numerical integration: Trapezoidal rule, Simpson's rules, Composite Trapezoidal Simpson Rules and Romberg integration, Applications of numerical in engineering, Relevant case studies
- **Methods of solution a system of Linear Equations**
  a. Solution of system of linear algebraic equations, Gauss elimination method
  b. LU factorization, Tridiagonal solver
  c. Applications of these methods in engineering disciplines, Relevant case studies
- **Iterative Methods for Linear and Nonlinear Equations**
  a. Numerical Solution of nonlinear equations: Bisection method, Newton's method, Secant method, Convergence analysis of these methods

b. Newton's method for system of nonlinear equations
c. Solution of system of linear equations by Jacobi, Gauss Seidel and SOR methods, Applications of these methods in engineering disciplines, Relevant case studies

- **Numerical Methods for IVPs and BVPs**
  a. Euler's method and its variations, Taylor's higher order methods, Error analysis, Consistency, stability and convergence
  b. Runge-Kutta methods of order 2, 3, and 4, Stiff ODEs, Consistency, stability and convergence
  c. Linear multistep methods, Numerical solution of system of ODEs
  d. Numerical solution of BVPs by Finite Difference Method
  e. Applications in engineering: Some relevant case studies
- **Numerical Methods for Computing Eigenvalues**
  a. Eigenvalues and Eigenvectors of matrix: power method,
  b. Inverse power method, Shifted inverse power method.
  c. Applications of eigenvalues in engineering disciplines.
- **Numerical Optimization**
  a. Unconstrained Optimization,
  b. Golden search ratio, Lagrange Multipliers,
  c. Method of steepest descent
  d. Applications of optimization in engineering disciplines

COURSE OUTLINE (PRACTICALS)

Note: "Labs/ Practical: The course practical/labs may be conducted in the computer lab"

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Richard L. Burden and J. Douglas Faires, Numerical Analysis, Publisher: Cengage Learning, Latest edition.
2. R.W. Hamming, Numerical Methods for Scientists and Engineers, Publisher: Dover Publications, Latest edition.
3. Steven C. Chapra and R. P. Canale, Numerical Methods for Engineers, Publisher: McGraw-Hill Education, Latest edition.

APPLIED PHYSICS

Credit: 2+1
Pre-Requisites: Nil

DESCRIPTION

"Applied Physics" introduces fundamental principles of physics and their practical applications. Topics include vectors, mechanics, electrostatics, magnetism, semiconductor physics, waves and oscillations, optics and lasers, and modern physics concepts. The course integrates theory with hands-on laboratory sessions to reinforce understanding and application of physical principles in engineering systems.

COURSE LEARNING OUTCOMES

1. Understand and apply vector analysis techniques to describe physical quantities and their transformations in engineering problems.
2. Apply Newton's laws of motion to analyze mechanical systems, including the calculation of forces, work, energy, and momentum.
3. Analyze electrostatic and magnetic fields, and their effects on charged particles and magnetic materials, with applications in sensors and actuators.
4. Describe semiconductor physics principles, including P-N junctions and transistors, and their role in electronic devices and circuits.
5. Analyze wave phenomena and optics principles, including interference, diffraction, and laser operation, with applications in communication and sensing technologies.
6. Explain key concepts in modern physics, such as quantum mechanics, atomic structure, and nuclear physics, and their applications in various engineering fields.

COURSE OUTLINE

Vectors:

- Review of vectors, Ordinary Differentiation of Vector, Gradient of Scaler field, Divergence and Curl of Vector Field, Line and Surface Integrals with applications.

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.

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.

Semiconductor Physics:

- Energy levels in a Semiconductor, Hole concept, Intrinsic and Extrinsic regions, Law of Mass Action. P-N junction, Transistors.

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.

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.

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.

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

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Halliday, Resnick, Krane, Physics, 10th Edition.
2. Hugh D. Young, R. A. Freedman, University Physics, 12th Edition.
3. Serway, Jewett, Physics for Scientists & Engineers, Latest Edition.

MATERIALS CHEMISTRY

Credits: 2+1
Pre-requisites: Nil

DESCRIPTION

This course provides students with an essential foundation in chemistry that is tailored to their field of metallurgical and materials engineering. The course primarily focuses on relevant principles and applications. The students will gain an understanding of the applications of materials chemistry in a wide range of fields, such as metal extraction, corrosion prevention, polymer synthesis, energy conversion and storage, biomedical devices, electronics and optoelectronics.

COURSE LEARNING OUTCOMES

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

1. describe fundamental principles of physical, analytical, solution and organic chemistry.
2. analyze the role of physical, analytical, and solution chemistry in materials engineering.
3. evaluate the role of organic chemistry in materials engineering.

COURSE CONTENT

- Introduction to chemistry, its scope and importance in Metallurgical and Materials Engineering.
- Classification of elements, periodic table and electronic configuration, transition metals, noble metals, active metals, rare earths, semimetals, and semiconductors. Chemical bonding in materials.
- Chemical reactions; stoichiometry, mass and heat balance, oxidation, and reduction reactions in ferrous and non-ferrous materials extraction. Solution chemistry. Physical chemistry: equilibrium, kinetics and reaction rate laws, effect of physical variables (pressure, temperature etc.) on equilibrium and kinetics, phase rule. Introduction to oxidation and reduction reactions in ferrous and non-ferrous extraction.
- Organic chemistry: Introduction, nature and sources of compounds, hydrocarbon compounds, polymeric materials, introduction to biochemistry, biomaterials.
- Analytical chemistry: Introduction, qualitative and quantitative analysis of ferrous and non-ferrous metals, analysis of various ores, coals, liquid solution, introduction to analytical instrumentation.
- Applications of materials chemistry in energy conversion and storage, electronics and optoelectronics, and biomedical devices.

PRACTICAL REQUIREMENTS

The course practical/ labs should be defined and synchronized with the course outline.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Materials Chemistry by B. D. Fahlman. 4th ed., Springer (2023).
2. Materials Chemistry: For Scientists and Engineers by M. A. Benvenuto. De Gruyter (2022).
3. Chemistry for Engineer: an applied approach by M. J. Shultz. Houghton Mifflin (2007).
4. Chemical Metallurgy by J.J. Moore. 2nd ed., Elsevier (Butterworth-Heinemann) (1990).
5. Applied Chemistry: A Textbook for Engineers and Technologists by O. Roussak, H. D. Gesser. 2nd ed., Springer (2013).
6. Chemistry for Engineers by T .F. Yen. Imperial College Press (2008).

14.2 Engineering Domain

MACHINE LEARNING IN MATERIALS ENGINEERING

Credits: 2+1

Pre-Requisite: Applications of ICT

DESCRIPTION

In recent years, machine learning has revolutionized the way materials are designed, discovered, characterized, and optimized. In this course, students will learn how machine learning techniques can be applied to materials engineering such as predicting material properties, analyzing materials data, and designing materials.

COURSE LEARNING OUTCOMES

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

1. Use regression and classification algorithms to predict structure-property relationship for different materials.
2. Compare and analyze the performance of different machine learning models.
3. Apply different machine learning methods to solve a given materials engineering problem.

COURSE CONTENT

Introduction to machine learning in metallurgical and materials engineering: Materials discovery, property prediction, structure-property relationships, materials design, and materials informatics

Basic Math: Review of Linear Algebra, Statistics, and Probability

Programming and Data Science Tool: Introduction to Python (scikit-learn, pytorch, Jupyter notebook), Materials Databases (Materials Project, Citrination)

Linear Regression: Univariate, Multivariate, Polynomial Regressions

Clustering data/classification: K-means/db-scan, classification trees/forests

Computer vision: applying concepts from clustering data, training models and Evaluating results with validation methods(e.g. Cross-validation)

Deep Neural Network: Basic architecture of neural networks, different types of neural networks, Retraining hyper parameter modification

Excursion: Big data in Materials science, Inverse design of materials, DFT Ml-Potentials, Integrations of machine learning, simulations, and experiments

PRACTICAL REQUIREMENTS

The course practical/ labs should be defined and synchronized with the course outline.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Deep learning by I. Goodfellow, Y. Bengio, A. Courville. MIT Press (2016).
2. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow by A. Geron. 2nd ed., O'Reilly Media (2019).
3. Machine Learning in Materials Science by K. T. Butler, F. Oviedo, P. Canepa. American Chemical Society (2022).
4. Artificial Intelligence for Materials Science by Y. Cheng, T. Wang, G. Zhang, 1st ed., Springer (2021).

COMPUTATIONAL MATERIALS SCIENCE

Credits: 1+2

Pre-Requisite: Applications of ICT

DESCRIPTION

This course introduces the basic concepts, techniques, and applications of computational methods in materials engineering. The students will learn about different modelling and simulation tools to predict the behavior of materials at different length scales.

COURSE LEARNING OUTCOMES

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

1. explain the process of finite element analysis and interpret the role of modelling and simulation softwares in materials engineering.
2. apply modelling and simulating techniques to predict mechanical behavior of materials under various loading scenarios.
3. generate plots and graphs to effectively communicate the experimental findings.

COURSE CONTENT

Introduction to computational material science and engineering.

Introduction to modelling and simulation software (Abaqus / Solidworks); 3D part and assembly modelling, finite element analysis; stress analysis using finite element modeling.

1D Structural Analysis (Truss Elements – Overhead Hoist); 3D Mechanical (Elastic/Plastic) Analysis; deformation of basic structure (Cantilever Beam); 3D Mechanical (Elastic) Analysis; deformation of mechanical parts (Connecting Lug); 2D Heat Transfer + Mechanical Analysis (Plane Stress/Strain) (2D Trapezoidal Plate); Tensile Test – Axisymmetric, 2D or 3D – Elastic, Elasto-plastic with/without damage (Tensile Test of a Ductile Material); Contact analysis including rigid and deformable bodies (3 Points Bend Test;, Modelling of elastic properties; plastic deformation and mechanical behavior of engineering materials. Data analysis and plotting.

PRACTICAL REQUIREMENTS

The course practical/ labs should be defined and synchronized with the course outline.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Introduction to Computational Materials Science: Fundamentals to Applications by R. LeSar. 1st ed. Cambridge University Press (2013)

2. Introduction to Materials Modelling by Z. H. Barber. Maney Publishing, (2005)
3. Computational Materials Science by D. Raabe. Wiley VCH Verlag GmbH, (1998)
4. An Introduction to Computer Simulation by M. M. Wolfson, G.J. Pert. Oxford, (1999)

INTRODUCTION TO ENGINEERING MATERIALS

Credits: 3+0
Pre-Requisite: Nil

DESCRIPTION

The course introduces the basics of Materials Engineering to the students. The course focuses on types of materials, their scope and role in industrial development. Students will learn about atomic bonding, crystal structures and their relation to properties of materials. The relationship between structure, processing, properties, and applications of various materials will be emphasized.

COURSE LEARNING OUTCOMES

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

1. Explain types and structures of materials at different scales and properties (mechanical, thermal, electrical, optical, electrical, magnetic etc.).
2. Describe various materials processing (manufacturing, joining, heat treatment, protection etc.) techniques.
3. Describe the structure-processing-properties relationship in engineering materials.

COURSE CONTENT

An overview of Metallurgical and Materials Engineering, Classification of materials: metals, ceramics, polymers, and composites. Structure-properties relationship, crystal structures and crystalline defects, mechanical properties of materials. An overview of characterization techniques in materials science. Introduction to metal processing techniques: casting, metal working, welding, powder metallurgy, and heat treatment processes. Corrosion and prevention. An introduction to various alloys and phase diagrams. An overview of polymeric and ceramics materials processing techniques. Introduction to electric and magnetic materials. Introduction to nanomaterials, biomaterials, functional materials, smart materials.

PRACTICAL REQUIREMENTS

Nil.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Materials Science and Engineering: An Introduction by W. D. Callister, D. G. Rethwisch. 10th ed. Wiley (2018).
2. The Science and Engineering of Materials by D. R. Askeland, W. J. Wright. enhanced 7th ed. Cengage Learning (2020).
3. Foundations of Materials Science and Engineering by W. F. Smith, J. Hashemi. 7th ed. Mc Graw Hill (2022)
4. Engineering Materials 1 by D. R. H. Jones, M. F. Ashby. 5th ed. Butterworth-Heinemann (2019)
5. Engineering Materials 2 by M. F. Ashby, D. R. H. Jones. 4th ed. Butterworth-Heinemann (2013)

ENGINEERING DRAWING

Credits: 0+2
Pre-Requisite: Nil

DESCRIPTION

This lab course introduces various ways to describe engineering components and assemblies with the help of various forms of drawing and projections. Students will also learn use of softwares for drawing as well as development of 2D and 3D models.

COURSE LEARNING OUTCOMES

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

1. Demonstrate design details, forms and proportions of different mechanical parts/structures and assemblies.
2. Prepare engineering drawings using different softwares.
3. Develop 2D and 3D model of objects using different softwares.

COURSE CONTENT

Introduction, types of lines, lettering, dimensioning, use of pencil and drawing instruments, planning of drawing sheet.

Projections, types of projections, orthographic projections, plane of projections, four quadrants, Isometric and pictorial projections of solids/machine parts.

Making of freehand sketches from solid objects and from orthographic projections, Sections of joints, screw thread systems, nuts and bolts, keys and cotter, coupling and simple bearings, pipe connections and engine details, preparation of assembly drawings.

Use of necessary softwares for engineering drawing such as AutoCad, SolidWorks, etc.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. First Year Engineering Drawing, A.C. Parkinson.
2. Engineering Drawing, T.E. French, McGraw-Hill (2006)
3. Engineering Drawing Practice and Theory and Practice, H.L. Thompson, International textbook company (2007)
4. Elementary Mechanical Drawing, C.W. Weick, McGraw-Hill (2006)
5. Engineering Graphics, F.E. Giesecke, Prentice Hall (2003)

WORKSHOP PRACTICE

Credits: 0+1
Pre-Requisite: Nil

DESCRIPTION

Workshop Practice is a foundational course designed for undergraduate students pursuing BSc in Metallurgical and Materials Engineering. This course provides hands-on experience and practical skills development in various workshops. The course will provide students with a solid foundation in machining, fitting and fabrication, carpentry, and electrical wiring through extensive practical exercises.

COURSE LEARNING OUTCOMES

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

1. Identify operations of different shops such as machine shop, carpentry shop, and electrical shop etc.
2. Perform all operations related to sheet metal shop, machine shop, carpentry shop, and electrical wiring.
3. Design engineering systems or components with given dimensions.

COURSE CONTENT

Workshop health and safety precautions.

Machining: Detailed study of centre lathe and accessories. Plain and Taper turning. Basic lath operations including turning, facing, simple screw cutting/ treading, knurling, Grooving (Drilling and Boring), cutting tools and their grinding. Brief Introduction of shaper, milling Sharing and Surface Grinding Machine. Assigning of Practical Jobs.

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

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

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

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Comprehensive Workshop Technology (Manufacturing Process), S. K. Garg, 1st ed., Laxmi Publication's (2005).
2. Workshop Technology part-1, W.A.J Chapman.
3. Wiring Simplified, H.P. Richter, W.C. Schwan, F.P. Hartwell, 41st ed., Park Publishing, Inc. (2005)
4. Wiring Manual by Pak Cables Limited.

MECHANICS OF MATERIALS

Credits: 3+0
Pre-Requisite: Nil

DESCRIPTION

This course provides a fundamental understanding of the behavior of solid materials under various types of loading conditions. The students will develop an understanding of the fundamental concepts of mechanics of materials and their applications. The course discusses the principles related to elasticity, plasticity, and the failure of materials, including fracture, fatigue, and creep.

COURSE LEARNING OUTCOMES

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

1. Apply the laws of mechanics of materials to determine stresses and strain in structures.
2. Estimate the elastic and plastic properties of materials from the given data
3. Compute shear force and bending moment diagrams for the given situation.

COURSE CONTENT

Short review of methods of statics, Stresses in the member of a structures, Analysis and design, Concept of Stress, Axial Loading: Normal Stress, Centric & Eccentric Loading, Shearing Stress, Bearing Stress in Connections, Stress Analysis & Design Example, Stress in Two Force Members, Stress on an Oblique Plane, Stress Under General Loadings, Factor of Safety, Normal Strain, Stress-Strain Test, Tensile testing machine (operation modes & outputs), Stress-Strain Diagram: Ductile vs. Brittle Materials, Hooke's Law: Modulus of Elasticity, Elastic vs. Plastic Behavior, Fatigue, Static Indeterminacy, Thermal Stresses, Poisson's Ratio, Generalized Hooke's Law, Dilatation: Bulk Modulus, Stress Concentration: Hole & Fillet, Torsional Loads on Circular Shafts, Net Torque Due to Internal Stresses, Axial Shear Components, Shaft Deformations, Torsional Failure Modes, Angle of Twist in Elastic Range, Pure Bending, Symmetric Member in Pure Bending, Bending Deformations, Stress and Strain Due to Bending, Deformations in a Transverse Cross-Section, Bending of Members Made of Several Materials, Reinforced Concrete Beams, Shear and Bending Moment Diagrams, Relations Among Load, Shear, and Bending Moment, Design of Prismatic Beams for Bending, Singularity Functions used to determine Shear and Bending Moment, Mohr's Circle.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Mechanics of Materials by F. Beer, E. Johnston, J. DeWolf, D. Mazurek. 8th ed. McGraw Hill Inc., (2020).
2. Mechanics of Materials by B. J. Goodno, J. M. Gere. 9th ed., Cengage Learning, (2017).

3. Engineering Mechanics (Statics and Dynamics) by R. C. Hibbeler. 14th ed., Pearson Prentice Hall (2009).
4. Engineering Mechanics: Statics by J. N. Bolton, J. L. Meriam, L. G. Kraige. 9th ed. Wiley (2018).
5. Mechanics of Engineering Materials by P. P. Benham, R. J. Crawford, C.J. Armstrong. 2nd ed., Pearson-Prentice Hall (1996).

MATERIALS THERMODYNAMICS

Credits: 3+0
Pre-Requisite: Introduction to Engineering Materials

DESCRIPTION

In this course, the students will learn the fundamental Laws of thermodynamics and how they influence the behavior of materials at the micro and macro scale. The students will learn the concept of work, heat, enthalpy and entropy. The concept of free energy and equilibrium will be introduced. Solving thermodynamic problems using various laws and rules will be discussed. Application of theories to single-component solutions, multi-component solutions will be highlighted. The role of thermodynamic concepts in electrochemistry will be presented.

COURSE LEARNING OUTCOMES

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

1. Describe the basic terms and laws related to thermodynamics.
2. Calculate enthalpy/entropy of reaction, heat capacity and Gibbs free energy.
3. Analyze the feasibility of various reactions and phase transformations using Ellingham and Binary Phase diagrams.

COURSE CONTENT

Introduction to Materials Thermodynamics, concept of system and surroundings, extensive and intensive properties.

First Law of Thermodynamics, concept of Enthalpy, calculation of heat of reactions, concept of heat capacity and its variation with temperature, Kirchoff's equation and its applications in the calculation of heat of reaction at high temperatures.

Concept of Entropy, Second Law of thermodynamics, Reversible and spontaneous processes, Third law of thermodynamics, calculation of entropy of elements and reactions at various temperatures.

Free-energy, and the concept of driving-force behind a chemical or physical reaction,

Equilibrium constant, Le-Chatlier's Principle, Factors affecting the equilibrium position, Relationship of equilibrium constant with free energy, Calculations of equilibrium partial pressures. Ellingham diagrams and their application to commercially important reactions

Behavior of solutions, concept of activity, ideal and non-ideal solutions, Raoult's and Henry's Law, Free energy of mixing, Gibbs Phase Rule, Clausius Clapeyron Equation, Concept of diffusion, Phase diagrams.

Introduction to electrochemistry, Chemical and electrical driving force, EMF, determination of thermodynamic properties from electrochemical data.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Basics of Materials Thermodynamics by S. W. Husain, I. Qamar. Scientific Information and Priniting Services (2024).
2. Introduction to the Thermodynamics of Materials by D. R. Gaskell, D. E. Laughlin. 6th ed. Taylor and Francis (CRC Press) (2017).Materials
3. Thermodynamics by Y. A. Chang, W. A. Oates. 1st ed. Wiley (2009).
4. Textbook of Materials and Metallurgical Thermodynamics by A. Ghosh. PHI Learning Pvt Ltd (2009)
5. Metallurgical Thermodynamics Kinetics And Numericals by S. K. Dutta, A. B. Lele. S. Chand Publishing (2020).
6. An introduction to Chemical Metallurgy by R. H. Parker. 2nd ed. Pergamon (1978).
7. Chemical Metallurgy by J. J. Moore, 2nd ed., Elsevier (Butterworth-Heinemann) (1990).
8. Phase Transformation in Metals and Alloys by D. A. Porter, K. E. Easterling, M. Y. Sherif. 4th ed. CRC Press (2021).

MECHANICAL BEHAVIOR OF MATERIALS

Credits: 3+0
Pre-Requisite: Introduction to Engineering Materials

DESCRIPTION

This course builds on the knowledge students already have about the mechanical behavior of engineering materials. Here, the emphasis will be on the elastic and plastic behaviors of different materials as well as on their fracture mechanics. The students will study in detail the mechanisms of elastic and plastic deformation. Additionally, students will learn how different materials may perform in a given situation. As a result, they will be able to select the best material for a particular application.

COURSE LEARNING OUTCOMES

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

1. Explain types and theories of different types of mechanical behaviors: reversible (elastic) and irreversible (plastic) deformations.
2. Describe theory of dislocations and its types and mechanisms of fracture in materials.
3. Differentiate fatigue & creep behaviors and demonstrate mechanical behavior of thin films/coatings.
4. Investigate mechanical design problems and metallurgical failures using knowledge of deformation and fracture of materials and formulate solutions.

COURSE CONTENT

A review of the structure of materials and crystalline imperfections. Elasticity (review of stress and strain concepts, Hooke's law, Elastic strain energy); Plasticity (Analysis of Stress-strain behavior, Yielding criteria of Metals and Hardness); Notches (Stress concentration factor, Neuber's rule, Tensile testing of notched specimens).

Fracture Mechanics (Fracture modes; Linear elastic fracture mechanics: stress intensity factor and fracture toughness); Theoretical cohesive strength and Griffith criteria; Plain strain toughness testing; crack tip opening displacement (CTOD).

Plastic deformation and role of Dislocations; types of dislocations; Slip systems; Critical resolved shear stress; Taylor factor; Dislocation interaction; Thermally activated processes; Intersection of dislocations. Ductile-brittle transition. Strengthening Mechanisms. Severe plastic deformation. Fracture behavior of metallic materials (ductile, brittle fractures); different types of embrittlements; Stress-corrosion cracking. Fatigue and creep deformation and fracture (Structural changes; theories and mechanism of crack initiation and propagation; Materials' selection).

Mechanical behavior of thin films and coatings; Mechanical behavior of Polymers, Ceramics, glasses and composites; Weibull Modulus

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Mechanical Behavior of Material, N. E. Dowling, S. L. Kampe, M. V. Kral, 5th ed. Pearson (2019)
2. Mechanical Behaviour of Engineering Materials: Metals, Ceramics, Polymers by J. Roesler, H. Harders, M. Baeker. 1st ed. Springer (2007)
3. Mechanical Metallurgy by G. E. Dieter. SI Metric ed. McGraw Hill Inc. (2002)
4. Deformation and Fracture Mechanics of Engineering Materials by R. W. Hertzberg, R. P. Vinci, J. L. Hertzberg. 6th ed. Wiley (2021).
5. Introduction to Dislocations by D. Hull, D. J. Bacon. 5th ed. Butterworth-Heinemann (2011).

INSPECTION AND TESTING OF MATERIALS

Credits: 3+1
Pre-Requisite: Introduction to Engineering Materials

DESCRIPTION

In this course, the students will learn to perform and interpret the results of destructive & non-destructive testing of materials as per renowned international standards. The special emphasis will be on hardness, tensile, compression, torsion, bending, impact, creep, and fatigue testing. Additionally, different non-destructive testing techniques will also be discussed in detail. The students will learn how to ensure the quality of the material to meet the specific industrial requirement.

COURSE LEARNING OUTCOMES

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

1. Describe the working principles of various material inspection techniques for their application to engineering materials.
2. Analyze the data generated from various testing techniques to determine mechanical properties of engineering materials.
3. Compare different NDT techniques used for determining flaws and other useful properties of engineering materials to ensure product quality standards.

COURSE CONTENT

Introduction to inspection and testing of Materials.

Hardness Testing (Arbitrary or indentation hardness, Rebound of dynamic hardness, Scratch hardness, Abrasion test, File test. Macrohardness Testing (Brinell, Rockwell), Microhardness Testing (Knoop, Vicker, Ultrasonic).

Tensile testing (Engineering Stress Strain Curve and its explanation. Resilience, Toughness, True-stress-strain concepts, ductile & brittle fracture, Power law or Holloman's relationship, Effect of strain rate & temperature, Compression test.

Bend test, Torsion test (Rotational-Linear Parallels, Polar Moment of inertia, torsion properties, Torque Twist Diagram, Torsional stresses for large plastic strains, Mohr's Circle, Hot Torsion Test.

Fatigue test (SN curve), Creep test (creep curve), Impact Test (Izod, Charpy), Temperature Transition Curve (Ductile to Brittle Tranisiton Temperature

Non-destructive testing (Visual Testing, Leak Testing, Radiographic method, Magnetic particle method, Magnetic flux leakage, Eddy Current Testing, Dye penetrant method, ultrasonic method, Phase array testing, Thermal/infrared testing, Vibration Analysis, Boroscopy.

Reliability and maintainability, inspection of different types of materials and products for evaluation. Introduction to standards. Familiarization of standards for testing of materials, ASTM, BS, JIS GOST and ISO. Pakistan Standards.

PRACTICAL REQUIREMENTS (If Any)

The course practical/ labs should be defined and synchronized with the course outline.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Inspection of Metals: Understanding the Basics by F. C. Campbell, ASM International (2015)
2. Volume 8: Mechanical Testing and Evaluation, ASM Handbook edited by H. Kuhn and D. Medlin. ASM International, (2000) Mechanical Metallurgy by George E. Dieter. McGraw-Hill Book Company (UK) Ltd., (2002)
3. Introduction to Non-Destructive Testing, a training guide by Paul E. Mix. 2nd ed. Wiley, (2005)
4. The Science and Engineering of Materials by D. R. Askeland, W. J. Wright. enhanced 7th ed. Cengage Learning (2020).
5. https://www.nde-ed.org/NDETechniques/index.xhtml .

PHYSICAL METALLURGY

Credits: 3+1
Pre-Requisite: Introduction to Engineering Materials

DESCRIPTION

The course primarily focusses on the knowledge that links the structure of materials with their properties. The role of processing in developing various types of structures will be discussed. This understanding will also help in alloy designing for various applications and interpreting the behavior of materials under different conditions.

COURSE LEARNING OUTCOMES

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

1. Explain the atomic & crystalline structures and the role played by them in the properties of metallic materials.
2. Interpret different types of crystalline defects in metallic materials and the role played by microscope in the analysis of microstructure.
3. Examine different types of equilibrium phase diagrams for understanding phase transformations and microstructural changes in alloys.
4. Design a hypothetical phase diagram involving different phase transitions & reactions and predict microstructures at different temperatures.

COURSE CONTENT

Introduction to Physical Metallurgy; structure properties relationship; Types of bonding, Atomic and crystalline structure; crystal symmetry; crystallographic defects; Allotropy and polymorphism; Miller indexing system; stacking of planes; Atomic, linear and planar densities; concept of Interstitial Voids.

Solidification (Homogeneous and heterogeneous); Nucleation and growth; Grain-boundaries and grain structure; Role of Metallurgical microscope in the analysis of microstructure; theory of etching and concept of grain boundary energy. Diffusion in solids

Phase-rule; Solid solutions; limits of solid solubility; types of Compounds; different types of binary phase diagrams: Isomorphous system, Eutectic and eutectoid reactions, coherent/in-coherent precipitates, Peritectic and peritectoid reactions; Ordered and disordered solutions; Iron-Iron carbide system, microstructure and properties of plain carbon steels and cast-irons; microstructure of common copper-base and aluminum-base alloys.

PRACTICAL REQUIREMENTS (If Any)

The course practical/ labs should be defined and synchronized with the course outline.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Physical Metallurgy: Principles and Design by G. N. Haidemenopoulos. 1st ed. CRC Press (2018)
2. Physical Metallurgy: Metals, Alloys, Phase Transformations by V. M. Schastlivtsev, V. I. Zel'dovich. De Gruyter GmbH (2022)
3. Materials Science and Engineering: An Introduction by D. G. Rethwisch, W. D. Callister Jr. 10th ed. Wiley (2018)
4. Physical Metallurgy Principles by R. Abbaschian, L. Abbaschian, R. E. Reed-Hill. 4th ed. Cengage Learning (2010)
5. Physical Metallurgy edited by D. Laughlin, K. Hono. 5th ed. Elsevier (2014)

MANUFACTURING PROCESSES

Credits: 3+0
Pre-Requisite: Introduction to Engineering Materials

DESCRIPTION

The course aims to build theoretical knowledge in students about various manufacturing processes commercially carried out by industries. This knowledge will help in understanding how the properties of the materials affect the selection of specific manufacturing operation to produce the quality product to meet the service conditions.

COURSE LEARNING OUTCOMES

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

1. explain different manufacturing processes used for shaping or designing materials.
2. analyze the advantages and limitations of different manufacturing processes.
3. select the most suitable process for a given material or application.

COURSE CONTENT

Basic concepts of manufacturing and types of manufacturing processes. Materials and process selection: forging and its types, rolling, extrusion, forming methods, shearing, blanking, bending, stretch forming, shear forming, flow turning, deep drawing and incremental forming, upsetting, drawing of rods and wires. Machining operations for special geometries and high-speed machining, cutting tools and coolant selection. Electro-discharge machining (EDM), CNC machining, Rapid prototyping, micro/nano-fabrication and lithography, injection and blow moulding. Iso-static pressing.

Additive Manufacturing: process fundamentals, applications, and different processes/techniques for 3D printing.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Manufacturing Processes for Engineering Materials by S. Kalpakjian, S. R. Schmid. 6th ed. Pearson (2021)
2. DeGarmo's Materials and Processes in Manufacturing by J. T. Black, R. A. Kohser, 13th ed. Wiley (2019).
3. Fundamentals of Modern Manufacturing: Materials, Processes, and Systems by M. P. Groover, 7th ed. Wiley(2019).
4. Additive Manufacturing Technologies by I. Gibson, D. Rosen, B. Stucker, M. Khorasani. 3rd ed. Springer (2021)
5. Introduction to Manufacturing Processes and Materials by R. C. Creese, 1st ed. Taylor and Francis (1999)

IRON AND STEEL MAKING

Credits: 3+0
Pre-Requisite: Nil

DESCRIPTION

The course is intended to impart to the students a basic understanding of the contemporary iron and steel making routes, raw materials for iron and steel making and their characterization. The environmental impacts of iron and steelmaking will also be discussed. Additionally, the students will also study the latest developments in this field such as green steel production.

COURSE LEARNING OUTCOMES

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

1. describe the general features of iron and steel-making processes.
2. apply the fundamental principles of thermodynamics to manage the processes that control the quality and composition of iron and steel.
3. analyze the developments in processes aimed at improving the efficiency of iron and steel-making.
4. evaluate the harmful impact of iron and steel-making industries on the environment and suggest suitable measures to reduce that.

COURSE CONTENT

A brief review of solution thermodynamics. Mineral processing of iron ores, agglomeration processes for iron ores, blast furnace process and reactions, blast furnace gas cleaning system and blast furnace stoves. Recent developments in BF process. Alternate iron making processes. Introduction to steelmaking fundamentals, oxidation reactions in steelmaking processes. Primary steelmaking processes: basic oxygen furnace (BOF) and electric arc furnace (EAF), design and process description, latest trends in BOF and EAF Processes. Induction furnace, design, and process description. Secondary steelmaking processes: argon purging, ladle de-oxidation, degassing, and emerging ladle metallurgy processes. Continuous casting of steel. Charge calculations for iron and steel making processes.

Environmental impacts of steel industry. Green steel making processes. Concepts of standards and specification of ferrous alloy systems.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Basic Concepts of Iron and Steel Making by S. K. Dutta and Y. B. Chokshi, (eBook), Springer Nature, (2020).
2. Modern Blast Furnace Ironmaking an introduction, M. Geerdes, R. Chaigneau, O. Lingiardi, R. Molenaar, R.V, Opbergen, Y. Sha, J. Warren, 4th ed., IOS press (2023)

3. An Introduction to Modern Iron Making by R.H. Tupkary and V.R. Tupkary. 4th ed. Khana Publications India, (2013).
4. An Introduction to Modern Steel Making by R. H. Tupkary and V. R. Tupkary. 7th ed. Khana Publications India, (2008).

POLYMER AND COMPOSITE MATERIALS

Credits: 3+1
Pre-Requisite: Introduction to Engineering Materials

DESCRIPTION

This course provides an overview of the structure, properties, and applications of polymeric and composite materials. The discussion will consider the needs of society and industry. The students will learn about various properties (such as thermal, rheological, and mechanical), processing and characterization of such materials.

COURSE LEARNING OUTCOMES

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

1. describe general features including physical, chemical, and mechanical properties of polymers and composite materials.
2. compare different manufacturing processes used for polymers and composite materials considering their advantages, limitations, and suitability for a given situation.
3. analyze different characterization techniques used to evaluate polymers and composite materials.
4. assess latest research trends in polymers and composite materials.

COURSE CONTENT

Introduction to polymeric and composite materials. Classification of polymeric and composite materials.

Molecular structure of polymers. Principles, kinetics and mechanisms of polymerization. Systems and techniques of polymerization. Different Additives for polymers. Glass transitioning temperature. Polymers' crystallinity. Liquid crystal polymers. Visco-elastic behavior of polymeric materials. Polymer Processing, Polymer testing & Characterization, Smart Polymers, Degradation of polymeric materials.

Role of Interface in composites. Fibers, whiskers and particulates in composites: Synthesis and properties of glass fibers, carbon fibers, aramid fibers, metallic and ceramic fibers and particulates. Matrixes and interface developments, Manufacturing of PMC's (Polymeric Matrix Composites), MMCs (Metal Matrix Composites) and CMCs (Ceramic Matrix Composites).

Mechanics of composites, Factors effecting mechanical properties of polymers and composites, rule of mixture, calculations related to rule of mixtures, multi-ply laminates, Halpin-Tsai equations.

Recycling of polymers and composites, Latest research trends in polymers and composites, Material Selection for different applications. Nanocomposites

PRACTICAL REQUIREMENTS (If Any)

The course practical/ labs should be defined and synchronized with the course outline.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Polymer Science and Technology by J. R. Fried. 3rd ed. Prentice Hall, (2014)
2. Foundations of Materials Science and Engineering by W. F. Smith, J. Hashemi. 7th ed. Mc Graw Hill (2022)
3. Fundamentals of Materials Science and Engineering by W. D. Callister, D. G. Rethwisch: An Integrated Approach. 5th ed. Wiley (2018)
4. Introduction to Composite Materials Design by E. J. Barero. 3rd ed. CRC Press (2018)
5. Principles of Composite Material Mechanics by R. F. Gibson. 4th ed. CRC Press (2016)
6. Smart Polymers and their Applications edited by M. R. Aguilar, J. S. Roman. Woodhead Publishing Limited (2014)
7. Composite Materials: Science and Applications by D. D. L. Chung. 2nd ed. Springer (2010)

CERAMIC MATERIALS

Credits: 3+1
Pre-Requisite: Introduction to Engineering Materials

DESCRIPTION

This course provides an overview of the structure, properties, manufacturing, and design of traditional and advanced ceramics. Different characterization techniques commonly used to evaluate the performance and properties of ceramics will also be discussed. Additionally, new approaches to enhance fracture toughness of ceramics will be presented.

COURSE LEARNING OUTCOMES

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

1. relate different properties (electrical, magnetic, mechanical, and chemical) of ceramics with their crystal structures.
2. select the most suitable material processing technique for a given application.
3. analyze different types of sintering and characterization techniques used for ceramics.
4. analyze the emerging trends in using ceramics for electronics, structural, and biomedical applications.

COURSE CONTENT

Introduction to various classes of ceramics, Traditional versus advance ceramics, History, applications.

Bonding Characteristics of Ceramics.

Production and processing of ceramics, Basic principles and techniques of consolidation and shaping of ceramics: powder pressing – uni-, bi-axial and cold & hot isostatic pressing, injection molding, slip casting, tape-casting.

Sintering and sintering theory of ceramics. Defects in Ceramics, Types of defects and Quasichemical Defect Reactions, Kroger Vink notation and use in defect equations, Electronic Defects and Band Structure. Glasses, glass-system, vitrification process in glasses, Structures of Glasses, Zachariasen's Rules. Refractory ceramics.

Characterization and property measurement of ceramics. Aerogels. Alumina ceramics. Zirconia ceramics. SiC ceramics. Si_3N_4 ceramics. Nuclear ceramics. Manufacturing processes.

Bio-medical applications of ceramic materials. Ceramics for energy and environment technologies – an introduction including fuel cell, Thermoelectrics etc. Ferroelectric, Piezoelectric and Pyro-electric ceramics for insulating, semi-conducting and super-conducting applications. Li-Ion Batteries. Smart and nano-ceramics.

PRACTICAL REQUIREMENTS (If Any)

The course practical/ labs should be defined and synchronized with the course outline.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Fundamentals of Ceramics by M. W. Barsoum. 2nd ed. CRC Press, (2020)
2. Modern Ceramic Engineering: Properties, Processing, and Use in Design by D. W. Richerson, W. E. Lee. 4th ed. CRC Press (2018)
3. Ceramic and Glass Materials: Structure, Properties and Processing edited by J. F. Shackelford, R. H. Doremus. 1st ed. Springer, (2008)
4. Advanced Ceramics for Versatile Interdisciplinary Applications edited by S. Singh, P. K. Das, D.P. Mondal, 1st ed. Elsevier (2022)

CHARACTERIZATION TECHNIQUES

Credits: 3+0
Pre-Requisite: Nil

DESCRIPTION

The course deals with studying the structure of materials at both micro and macro level using various types of microscopes and diffraction methods. Various techniques used for the determination of chemical nature and composition of various materials will be taught. Methods to evaluate various physical and chemical properties of materials will be presented.

COURSE LEARNING OUTCOMES

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

1. compare the operating principles, capabilities, limitations, and applications of various characterization techniques used in materials engineering.
2. interpret the data generated from various characterization tools such as XRD, electron microscopes, spectroscopy, and thermal analysis.
3. select an optimum characterization technique for a given material under different circumstances.

COURSE CONTENT

Introduction to characterization techniques and their application in Materials science and Engineering

Production and absorption of X-rays; use of filters; X-ray diffraction and Bragg's law; structure factor calculations; diffraction methods; Debye-Scherer camera; Laue back-reflection; and rotating-crystal method. XRD spectrum and its Indexing; Precise lattice parameter determination; Particle size and micro/macro strains calculations. Chemical analysis by X-ray fluorescence.

Stereographic projections; orientation of crystal with respect to a reference; rotation of crystal around an axis; planes of a zone. Crystal structure determination; single crystals orientation; pole figures; Applications of X-ray diffraction.

Scanning electron microscope (SEM); construction and working principle; interaction of electrons with matter; modes of operation; image formation of plane and fractured surfaces. Energy Dispersive X-rays and wavelength dispersive X-rays systems;

Electron diffraction and basics of transmission electron microscopy (TEM); Image formation; resolving power and magnification; depth of focus; elementary treatment of image contrasts; important lens defects and their correction. Bright

field and dark field images. Introduction to Scanning Tunneling microscope and its various types e.g Atomic force microscopy; Piezo-force microscopy; Magnetic force microscopy etc. Introduction to Raman spectroscopy and its use in materials science. Spectroscopic techniques, spark emission spectroscopy, absorption spectroscopy etc. Thermal analysis of materials.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Materials Characterization: Modern Methods and Applications edited By N. (Mohan) Ranganathan, 1st ed. Jenny Stanford Publishing (2015)
2. Characterization of Materials, 3 Volume Set by E. N. Kaufmann. 2nd ed. Wiley, (2012)
3. X-Ray Diffraction by B. D. Cullity. 3rd ed. Prentice Hall, (2001)

NON-FERROUS METALLURGY

Credits: 2+0
Pre-Requisite: Introduction to Engineering Materials

DESCRIPTION

The course focusses on extraction and production of non-ferrous metals from different ores and scrap. The environmental impacts of non-ferrous metals production will be presented. The course also discusses the general classification, properties, physical metallurgy, and applications of important non-ferrous metals and alloys.

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

1. explain different methods for extracting nonferrous metals from oxide, sulfide, and halide sources.
2. analyze phase diagrams of different nonferrous alloys to comprehend their microstructural features and mechanical behavior.
3. examine the suitability of different nonferrous alloys for a specific engineering application.
4. analyze the environmental impacts of nonferrous metals production and develop strategies for their sustainable production.

COURSE CONTENT

Introduction to Non Ferrous metals. Nonferrous ore deposits in Pakistan, General extraction processes for nonferrous metallic ores. Principles of metals extraction, Extraction of metals from oxide sources, Extraction of metals from sulfide ores, Extraction of metals from halides. Environmental impacts of non-ferrous metals extraction. Recycling of non-ferrous metals.

General classification, physical, chemical, and mechanical properties, phase relationships, and applications of various non-ferrous alloys such as Aluminum alloys, Copper alloys, Titanium alloys, Magnesium alloys, Ni alloys, etc.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Extraction of Nonferrous Metals by H.S. Ray, R. Sridhar and K.P. Abraham. Affiliated East West Press Pvt Ltd., New Delhi, (2007).
2. Extraction of nuclear and non-ferrous metals, S.K. Dutta, D.R. Lodhari, ebook, Springer, (2018)
3. Principles of Extractive Metallurgy by T. Rosenqvist. 2nd ed. (reprinted), McGraw Hill, New York, (2004)
4. Light Alloys: Metallurgy of the Light Metals by I. Polmear, D. StJohn, J.-F. Nie, M. Qian, 5th ed. Butterworth-Heinemann (2017)
5. Physical Metallurgy Principles by R. Abbaschian, L. Abbaschian, R. E. Reed-Hill. 4th ed. Cengage Learning (2010)

HEAT TREATMENT AND PHASE TRANSFORMATIONS

Credits: 3+1
Pre-Requisite: Physical Metallurgy

DESCRIPTION

The course presents the principles of thermodynamics and kinetics of phase transformation. These principles are used to understand various types of transformations during different heat treatments. Additionally, the effect of different heat treatment processes on the mechanical properties of the alloys will be presented. The role of composition, time, and temperature of transformation on the evolution of different microstructures will be taught.

COURSE LEARNING OUTCOMES

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

1. Apply thermodynamic principles to predict the stability of phases and construct phase diagrams.
2. Analyze mechanisms involving diffusion-less and diffusion involving solid-state transformations.
3. Correlate the effects of various heat treatments and phase transformations on the microstructure and mechanical properties of metals and alloys.
4. Design a heat treatment process for common metals/alloys to develop desired microstructure and properties.

COURSE CONTENT

Thermodynamics of Phase Transformation: Gibbs free energy and phase equilibrium. Free-energy changes in single component system, Clausius Clapeyron equation. Gibbs free energy changes in binary alloys, Free energy of mixing, Ideal and real solutions, Ordered-disordered phases. G vs XB curves and phase diagrams, Gibbs phase rule. Driving Force for diffusion, free energy and diffusion, Fick's first and second laws of diffusion. Interfaces: Structure and types of interfaces, free energy of grain boundary, Nucleation and Growth: Nucleation of precipitates from a supersaturated matrix, driving force for nucleation. Diffusion and diffusion less transformations: Kinetics and mechanisms of Austenitic, Pearlitic, Bainitic and martensitic transformations. Time temperature transformation and continuous cooling diagrams.

Heat Treatment processes: Annealing, normalizing, and quenching processes. Hardenability measurement techniques. Surface hardening methods. Precipitation hardening (ageing). Heat treatment of die and tool steels, heat treatment of cast-irons, heat treatment of common non-ferrous alloys.

PRACTICAL REQUIREMENTS (If Any)

The course practical/ labs should be defined and synchronized with the course outline.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Heat Treatment: Principles and Techniques by T.V. Rajan, C.P Sharma, Ashok Sharma. 2nd ed. Prantice Hall, India, (2011)
2. Phase Transformation in Metals and Alloys by D. A. Porter, K. E. Easterling and M. Y. Sherif. 3rd ed., CRC press (2009)
3. Physical Metallurgy: Metals, Alloys, Phase Transformations by V. M. Schastlivtsev, V. I. Zel'dovich. De Gruyter GmbH (2022)
4. Phase Equilibria, Phase Diagrams and Phase Transformation: Their Thermodynamic Basis by M. Hillert. 2nd ed. Cambridge University Pres (2007).
5. Steel Heat Treatment, Metallurgy and Technologies edited by G. E. Totten. 1st ed. CRC Press (2006)

ADVANCED MATERIALS

Credits: 3+0
Pre-Requisite: Physical Metallurgy

DESCRIPTION

This course discusses the principles, properties, and applications of materials beyond the basics covered in introductory courses. This course discusses advanced materials that are shaping the future of various industries including electronics, aerospace, healthcare, and energy.

COURSE LEARNING OUTCOMES

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

1. explain the peculiar properties and applications of different advanced materials.
2. assess and compare the mechanical, thermal, and electrical properties of advanced materials.
3. analyze the challenges associated with developing and implementing advanced materials for engineering applications in the real-world.

COURSE CONTENT

Introduction: Functionally graded materials, Smart materials, Optical materials, Semiconductors, Superconductors, advanced steels and bulk metallic glasses (BMG) etc.

High Temperature Materials, superalloys, refractory metals and alloys, Intermetallics, ceramics, carbon-carbon composites.

Advanced Alloying: mechanically alloyed metals, ODS alloys.

Energy Materials: Basics of energy materials, Types of energy materials, Fuel cell, solar cells, materials for hydrogen generation and storage.

Biomaterials and Nanomaterials.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Advanced Materials-An Introduction to Modern Materials Science by A. Behera. 1st ed., Springer (2021)
2. Nanomaterials: Synthesis, Characterization, and Applications edited by A. K. Haghi, A. K. Zachariah, N. Kalariakkal. CRC press (2013)
3. Modern Materials and Manufacturing Techniques edited by R. Kant. 1st ed. CRC Press (2024)

4. Modern Materials and Manufacturing Processes by R. G. Bruce, W. K. Dalton, J. E. Nelley, R. R. Kibbe. 3rd ed. Prentice Hall (2004).
5. An Introduction to Biomaterials edited by J. O. Hollinger. 2nd ed. CRC Press (2012)
6. Introduction to Nanotechnology by C. P. Poole Jr., F. J. Owens. Wiley (2003)
7. Chemistry and Physics of Modern Materials: Processing, Production and Applications edited by J. N. Aneli, A. Jimenez, S. Kubica. Apple Academic Press & CRC Press (2013)

POWDER METALLURGY

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

This course provides a deep understanding of the principles, processes, materials, and applications involved in the production and utilization of powdered materials. Powder metallurgy (PM) is a manufacturing process that enables the production of complex-shaped components with required properties. This makes PM an important technology in various industries including aerospace, automotive, electronics, biomedical, and other industrial applications.

COURSE LEARNING OUTCOMES

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

1. understand the applications, advantages, limitations and design considerations of PM products.
2. explain various metallic powder production techniques.
3. compare different testing methods used to determine quality of metallic powders.
4. evaluate and design different approaches for the sustainability of the process.

COURSE CONTENT

Introduction to powder metallurgy, Applications of powder metallurgy. Advantages and design limitations of powder metallurgy

Powder particles sampling, dispersion & de-agglomeration; Sieve and microscopic analysis; sedimentation; laser light; particle size distributions; data presentation

Characterization of powders: microstructure; particle shape; pycnometer; surface area test; internal structure and chemistry

Production of powders: mechanical methods; electrolytic methods; Atomization techniques; chemical methods

Powders modification and handling; mixing and blending; different lubricants and binders; Powders molding, shaping and compaction (cold and hot compacting methods physical characteristics of powder compacts, compaction defects).

Sintering theory and practices, solid state and liquid phase sintering, modern sintering techniques, sintering atmospheres, thermodynamics of sintering.

Inspection and quality control for P/M parts, the economics of P/M production, new development in powder metallurgy processes

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Powder Metallurgy: Science, Technology, and Materials by A. Upadhyaya, G. S. Upadhyaya. 1st ed. Universities Press, (2011)
2. Powder metallurgy: science, technology and applications by P. C. Angelo, B. Ravisankar, R. Subramanian. 2nd ed. PHI Pvt. Ltd. (2022)
3. Fundamentals of Powder Metallurgy by L. F. Pease, W. G. West. Metal Powder Industries Federation, (2002)

CORROSION AND PROTECTION

Credits: 3+1
Pre-Requisite: Materials Thermodynamics

DESCRIPTION

This course entails description of corrosion mechanisms, types, and prevention strategies. Starting with the fundamentals of corrosion science, the course progresses to include electrochemical reactions, environmental effects, and degradation processes. Additionally, various corrosion prevention and protection techniques will be explored.

COURSE LEARNING OUTCOMES

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

1. apply electrochemical principles to determine corrosion rates in different situations.
2. analyze various corrosion processes and their underlying mechanisms.
3. determine the effectiveness of different types of corrosion prevention methods, including inhibitors, coatings, and cathodic protection.
4. select the most suitable method to protect the material from corrosion.

COURSE CONTENT

Introduction to Corrosion – Electrochemical Nature; Electrochemical cell and Principles; corrosion rate expressions (based on weight loss & penetration); EMF & Galvanic Series; Nernst Equation & its application; Reference electrodes.

Pourbaix Diagrams (Al, Fe, Zn E-pH diagrams); thermodynamic approach to pourbaix diagrams; equilibrium conditions; limitations of pourbaix diagrams.

Corrosion Kinetics; Polarization; different types of corrosion and their control.

Passivity; Cathodic protection (CP) & design of CP system; Anodic Protection.

Electrochemical parameters & their use in corrosion studies.

Corrosion Prevention Methods (Corrosion control) by: Inhibition, Coatings, Corrosion testing through weight loss and electrochemical methods. Selection of materials

Introduction to API methods of Corrosion evaluation.

PRACTICAL REQUIREMENTS (If Any)

The course practical/ labs should be defined and synchronized with the course outline.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Corrosion Science and Engineering by P. Pedeferri, Springer link (2018)
2. Corrosion Engineering by M. G. Fontana. 3rd ed. Tata McGraw-Hill, (2005)
3. API-571 Document.
4. Handbook of Corrosion Engineering by P. R. Roberge. 2nd ed. McGraw-Hill (2012)
5. Corrosion and Corrosion Control: An Introduction to Corrosion Science and Engineering by R. W. Revie, H. H.Uhlig. Wiley (2008)
6. Corrosion Technology, Vol.1,2, by I. H. Khan. Institute of Chemical Engineering, University of Punjab, Lahore, Pakistan
7. Corrosion and Protection edited by E. Bardal.1st ed. Springer (2004)
8. Handbook of Corrosion Engineering: Modern Theory, Fundamentals and Practical Applications by C. M. Hussain, C. Verma, J. Aslam, R. Aslam, S. Zehra. Elsevier (2023).
9. Principles and Prevention of Corrosion by D. A. Jones. Prentice Hall (1996)

JOINING OF MATERIALS

Credits: 2+1
Pre-Requisite: Introduction to Engineering Materials

DESCRIPTION

This is a specialized course that discusses various methods and techniques used to effectively join different materials. This multidisciplinary course emphasizes the understanding of fundamental principles, practical applications, and advanced trends in joining processes. Starting with traditional joining methods such as welding, brazing, and soldering, students will also learn modern joining processes.

COURSE LEARNING OUTCOMES

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

1. classify and distinguish various industrial fusion and non-fusion welding processes.
2. apply fabrication knowledge to formulate joints via brazing, soldering, and adhesive bonding.
3. analyze the basic metallurgical changes during welding processes
4. evaluate fabricated joints for soundness and defects free structures according to governing specifications

COURSE CONTENTa

- Introduction to Joining Processes and Classification.
- Fusion Welding: Arc Welding Processes; Resistance Welding processes; Special Welding processes
- Solid State Welding: Brazing, Soldering, Adhesive Bonding, Friction stir welding, etc.
- Metallurgy of Welding: Weld-ability of Ferrous and Non-ferrous Alloy Systems, Stresses in Welds, Testing and Non-Destructive Evaluation of Welds.
- Formulation of WPS, WPQ and WPR, Fabrication and Repair procedures for Weld Assemblies, Welding of Dissimilar Materials with special emphasis on Metal-Ceramic and Ceramic-Ceramic Joining, recent Trends in Joining Technologies.
- Polymers as joining materials, glasses as joining materials
- Joining of Polymers, Joining of Ceramics
- Polymers and glasses as joining materials

PRACTICAL REQUIREMENTS (If Any)

The course practical/ labs should be defined and synchronized with the course outline.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Welding: Principles and Applications, L. Jeffus. 9th ed. Cengage Learning (2020)
2. Principles of Welding: Processes, Physics, Chemistry and Metallurgy by R. W. Messler, Jr. 1st ed. Wiley-VCH (2015)
3. Joining of Materials and Structures: From Pragmatic Process to Enabling Technology, Robert W. Messler. 1st ed. Butterworth-Heinemann, (2004)
4. Metallurgy of Welding by J. F. Lancaster. 6th ed. Woodhead Publishing (1999)
5. Advanced Joining Processes: Welding, Plastic Deformation, and Adhesion edited by L. D. Silva, M. El-Zein, P. Martins. Elsevier (2021) Friction Stir Welding and Processing: Fundamentals to Advancements edited by S. Rathee, M. Srivastava, J. P. Davim. Wiley (2024)

FOUNDRY ENGINEERING

Credits: 2+1
Pre-Requisite: Non-Ferrous Metallurgy

DESCRIPTION

This course provides a thorough understanding of the principles, techniques, and applications of various foundry processes. The students will also learn course various foundry processes starting from raw material preparation to finished product inspection.

COURSE LEARNING OUTCOMES

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

1. describe types of foundries, discuss various types of patterns, their materials, and pattern allowances.
2. differentiate between various casting processes & their end products.
3. select the right mold material and gating system to produce sound castings.
4. identify various casting defects and report remedies to minimize or remove these defects.

COURSE CONTENT

Introduction to Foundry Engineering and Practice; Scope and importance; Foundry industry in Pakistan; Types and different sections of a foundry; foundry tools, machines and types of furnaces; Furnace Charges and Calculations.

Pattern; pattern design, materials and pattern making techniques. Selection, properties and testing of suitable molding and core materials. Molding Processes: Green sand and dry sand molding; Shell molding; Core sand molding; CO_2 molding; water glass molding; resin sand molding; alpha set and no bake process; molding sand properties and testing. Pit and floor molding; Loam molding; Molding machines and equipment; Mold coatings; 3D printing in sand molding. Molding Cores: Ingredients and Properties of core sand; Binders; core design, coatings; baking and finishing; core testing.

Mold designing: Design and essentials of gating system; design of pouring cups sprue; runners types and gates; Gating ratio; riser shape, location and design; pressure-less and pressurized gating systems

Other foundry techniques: Plaster casting; Investment casting; low pressure die casting; high pressure die casting; Permanent mold casting; Centrifugal casting; Slush casting; Ingot as casting; Gravity die casting

Ferrous and non-ferrous casting techniques; selection and control of melting processes; Casting and fettling operation; Metal gas interaction; Solidification of pure metal and alloys; Solidification in a mold; Directional and non-directional solidification, Cast Irons

Casting Defect types; remedies; inspection of castings; Role of casting simulations to control defects and minimize losses. Casting Cleaning methods

PRACTICAL REQUIREMENTS (If Any)

The course practical/ labs should be defined and synchronized with the course outline.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Principles of Metal Casting by M. Sahoo, S. Sahu, 3rd ed. McGraw Hill (2014)
2. Complete Casting Handbook: Metal Casting Processes, Metallurgy, Techniques and Design by J. Campbell, 2nd ed. Butterworth Heinemann (2015)
3. Principles of Foundry Technology by P. L. Jain. 8th ed. McGraw-Hill, (2008)
4. Foundry Technology by P. Beeley, 2nd ed. Butterworth-Heinemann (2001)
5. The Foseco Non-Ferrous Foundryman's Hand Book by J. R. Brown. Butterworth-Heinemann (1999)

ELECTRONIC, MAGNETIC, AND OPTICAL MATERIALS

Credits: 2+0
Pre-Requisite: Introduction to engineering materials

DESCRIPTION

This course provides a detailed understanding of the basic principles governing the behavior of materials with specific physical properties such as electronic, magnetic, and optical properties. It explores the complex relationships existing between the atomic, electronic and crystal structure of materials and their macroscopic properties. The special emphasis will be on the applications of these materials in different industries.

COURSE LEARNING OUTCOMES

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

1. describe the fundamentals of electrical, magnetic, and optical materials.
2. characterize and analyze different properties of electrical, magnetic and optical materials.
3. select different electrical, magnetic, and optical materials for a given application.

COURSE CONTENT

Classification and concept of Electrical and Electronic Materials. Metallic materials and their electrical properties. Semiconductor materials and their electrical properties. Semiconductor devices. Ceramic materials used in electronic applications.

Magnetic materials and their classification. Magnetization curve, hysteresis loop. Types of magnetic behavior. Ferromagnetic domains. Experimental evidence for domains. Domain wall motion. Hindrances to wall motion. Soft Magnetic Materials: Desirable properties for soft magnetic materials. Potential applications of soft magnetic materials. Hard Magnetic Materials: Properties of Hard magnetic materials. Origin of Ferromagnetism in Rare Earth based permanent magnets. Potential applications of permanent magnets.

Characteristics of optical materials, Types of optical materials.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Fundamentals of Materials Science and Engineering by W. D. Callister, D. G. Rethwisch: An Integrated Approach. 5th ed. Wiley (2018)
2. Foundations of Materials Science and Engineering by W. F. Smith, J. Hashemi. 7th ed. Mc Graw Hill (2022)

3. The Science and Engineering of Materials by D. R. Askeland, W. J. Wright. enhanced 7th ed. Cengage Learning (2020).
4. Optical Materials by K. S. Potter, J. H. Simmons. 2nd ed. Elsevier (2021)

BIOMATERIALS

Credits: 2+0

Pre-Requisite: Nil

DESCRIPTION

Biomaterials is an interesting and an emerging field that combines materials science, biology, engineering, and medicine. In this course, students will learn about the development, characterization, and application of materials used in implants, medical devices, tissue engineering, and drug delivery systems.

COURSE LEARNING OUTCOMES

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

1. differentiate between different types of biomaterials and explain the properties that are required for various biomedical applications.
2. analyze the principles and methods of in-vitro and in-vivo testing for biomaterials.
3. evaluate how biocompatible materials will interact with proteins and cells in the human body.
4. select the most suitable biomaterial for a specific biomedical application.

COURSE CONTENT

Introduction to biomaterials and biochemistry; biocompatibility and bioactivity, bio-reabsorable & bio-erodible materials. Hydrogels & smart polymers.

Cell biology, surface properties of materials, intermolecular forces in biology. Response of materials in human body; effect of mechanical forces on cells & tissues; biomematic materials; Importance of water in biomaterials.

In-vivo and In-vitro testing. Biocompatible metals: Ti-based, Stainless Steels, Co-Cr-Mo alloys, nitinol; biomaterials surface & protein; textured & porous materials; Bio active glasses; Bioreabsorbale ceramics; adhesives & sealants.

Applications (Orthopedic, Dental, cardiovascular, soft tissue replacement, hard tissue replacement); Drug delivery system (nano-carriers, polymer-drug conjugates, nucleic acids, etc.),

Biomaterial corrosion; blood & materials interaction; tumors associated with biomaterials

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Biomaterials Science: An Introduction to Materials in Medicine edited by W. R. Wagner, S. E. Sakiyama-Elbert, G. Zhang, M. J. Yaszemski . 4th ed. Academic Press (2020)

2. Biomaterials: principles & applications by J. B. Park, J. D. Bronzino. 1st ed. CRC Press (2002)
3. An Introduction to Biomaterials by J. O. Hollinger. 2nd ed. CRC Press (2012)

SURFACE ENGINEERING

Credits: 2+0

Pre-Requisite: Corrosion and Protection

DESCRIPTION

This course focuses on exploring the surface properties of materials and improving them to enhance material performance. The students will learn various aspects of surface modification, improving appearance, hardness, wear resistance, corrosion resistance, and tribological properties.

COURSE LEARNING OUTCOMES

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

1. apply the concept of surface science and tribology to engineering materials.
2. use different surfaces cleaning methods to remove surface defects.
3. compare and distinguish various surface deposition and surface treatment technologies.
4. Design durable and sustainable surfaces with improved characteristics for engineering applications.

COURSE CONTENT

Tribology of surfaces: surface integrity; surface roughness and waviness; measurement of surface roughness and texture; friction and theories; types of wear and their mechanisms; lubrication and its regimes; applications of lubrications in wear

Mechanical surface treatment: Propelling abrasive media; blasting techniques; selection of abrasive media; different peening techniques. Surface finishing methods: selection and applications; tumbling; vibratory finishing; belt Sanding; wire brushing, buffing and electro-polishing. Chemical cleaning of surfaces: selection and applications; alkaline cleaning; solvent cleaning and vapor degreasing; molten salt bath cleaning; ultrasonic cleaning; acid cleaning; pickling and descaling.

Coatings: Paints and organic coatings; powder coating; hot-dip coating; chemical conversion coatings; blackening; coloring of metals; electroplating, electrophoretic deposition; anodizing; electroless-plating; mechanical plating; Chemical vapor deposition (CVD) and Physical vapor deposition (PVD) techniques; Thermal and cold spraying methods; Sputtering; sol gel method. A brief overview of surface hardening methods. Cladding techniques; roll bonding; explosive welding; applications of cladding in nuclear, marine and other technological fields

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Surface Engineering: Enhancing Life of Tribological Components by D. K. Dwivedi. 1st ed. Springer (2018)
2. Tribology and Surface Engineering for Industrial Applications edited by C. I. Pruncu, A. Aherwar, S. Gorb, 1st ed. CRC Press (2021)
3. Manufacturing Processes for Engineering Materials by S. Kalpakjian, S. R. Schmid. 6th ed. Pearson (2021)

NANOMATERIALS

Credits: 2+0

Pre-Requisite: Physical Metallurgy

DESCRIPTION

In this course, students will study the behavior of materials at the nanoscale. This multi-disciplinary course integrates principles of physics, chemistry, biology, and engineering to achieve special properties. Emerging applications of nanomaterials will also be discussed.

COURSE LEARNING OUTCOMES

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

1. apply the basic theories of surface energy and quantum confinement to understand the stabilization mechanisms of nanoparticles.
2. examine the synthesis, properties, characterization, and utilization of 0-, 1- and 2-D materials.
3. choose the appropriate processing and characterization technique for a given scenario.
4. design solutions for common problems related to nano materials.

COURSE CONTENT

Overview of Nanostructures and Nanomaterials; Bottom up and Bottom Down approaches; Surface Energy concept; Chemical potential of surface; different types of stabilizations.

Nanostructures: Zero Dimensional nanomaterials: Nanoparticles, Quantum Dots, One-Dimensional nano-materials: Nanowires nano-rods, carbon nanotubes, Two-Dimensional nanomaterials: Thin films and monolayers, Carbon-based nanomaterials: Carbon nanotubes, Graphene, Nanostructured carbon. Synthesis of Nano-materials.

Applications of nanostructures: Reinforcement in Ceramics, Drug delivery, Giant magneto- resistance, etc. Cells response to nanostructures. Overview of characterization of nanostructures and nanomaterials.

Surfaces and interfaces in nanostructures. Ceramic interfaces, Superhydrophobic surfaces, Grain boundaries in Nano-crystalline materials, Defects associated with interfaces.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Nanomaterials: The original product of nanotechnology by M. Benelmekki. IOP Science (2019)

2. Nanostructures and Nanomaterials: Synthesis properties and applications by G. Cao, Y. Wang. 2nd ed. World Scientific (2011).
3. Nanoscale Science and Technology edited by R. W. Kelsall, I. W. Hamely, M. Geoghegan. Wiley, (2005)

INSTRUMENTATION AND CONTROL

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

This multi-disciplinary course will cover the principles, techniques, and industrial applications of instrumentation and control systems. The students will learn different measurement systems, industrial automation, and practical applications.

COURSE LEARNING OUTCOMES

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

1. analyse major instruments used for pressure measurement.
2. differentiate between different temperature measurement instruments and select an appropriate one for a particular application.
3. Evaluate different level, flow, weight, and stress measurement techniques.
4. examine the components of process control systems, including control loops, units, and standards.

COURSE CONTENT

Basic Concepts about instrumentation and process control

Pressure Measurement: Pressure units, Manometers, Diaphragms, Bellows, Bourden Tubes, Secondary transducers (strain gauge and LVDT).

Temperature Measurement: Introduction and units. Liquid Expansion Thermometers (Mercury in Glass, Liquid in glass), Bimetallic strip Thermometers, Pressure-Spring thermometers, Resistance Temperature Detectors, thermistors, Thermocouples. Pyrometers.

Level Measurement: Differential Pressure, Displacer, Bubbler, Capacitance, Conductance, Ultrasonic,

Flow Measurement: Head type flow meters (Orifice plate, Venturi tube, pilot tube) Rotameter, Anemometers, Electromagnetic flow meters, Mechanical Meter (turbine type), Ultrasonic type flowmeter.

Weight, force, stress, and strain measurement.

Introduction to process control: Process Control, Definitions of the Elements in a Control Loop, Units and Standards, Instrument Parameters, Control types.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Fundamentals of Industrial Instrumentation and Process Control by W. C. Dunn. 2nd ed. McGraw Hill Professional (2018)

2. Process Control Instrumentation Technology by C. D. Johnson. Pearson/ Prentice Hall, (2006)
3. Instrumentation and Control Systems by W. Bolton. 3rd ed. Newness (2021)

BASIC ELECTRICAL ENGINEERING

Credits: 2+1

Pre-Requisite: Nil

DESCRIPTION

This inter-disciplinary course typically introduces the fundamental principles of electricity and circuits to the undergraduate students of metallurgical and materials engineering. This course also highlights how electrical engineering principles play a crucial role in understanding and manipulating materials for various electrical applications.

COURSE LEARNING OUTCOMES

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

1. understand basic electrical quantities and circuit laws.
2. apply concepts of electromagnetism to analyze AC circuits and electrical machines.
3. analyze the behavior of AC circuits including capacitive and inductive networks.
4. analyze the performance of different electronic devices.

COURSE CONTENT

DC Machines: Types of Excitation, Operation and characteristics of series, Shunt and compound generators and motors, Armature reaction, Stators, Selection of motors, Elementary transmission and distribution, DC and AC systems transmission voltages, Elements of house wiring: its testing, distribution, switching and fusing from the utilization point of view

AC Circuits: Series and parallel circuits and their combinations, Improvement of power factor by condensers, Three phase AC: advantages of single phase, Vector diagrams for the balances three phase system, Earthing of apparatus.

Transformers: Basic principle, Ration of transformation, Iron and Copper losses, Efficiency and regulation. Brief discussion and uses of instrument transformers and auto transformers, Three phase transformers, Star and delta connections, Scott connections, Constructional features, Cooling and protection from fire hazards.

AC Generators: Construction and working principles of alternator frequency, simple emf equation. Polyphase generation.

AC Motors: Concept of rotating field, polyphase induction motors, production of torque, slip, squirrel cage and slipring motors, starting of motors, construction of

synchronous motors, production of torque and starting characteristics, selection of AC motors, measuring instruments, basic principles of construction and operation of moving iron dynamometer and hot wire instruments, power and energy meters, elementary consideration.

Storage Batteries: Lead and Nickel Iron cells, charge and discharge, quantity and energy efficiencies.

PRACTICAL REQUIREMENTS

The course practical/ labs should be defined and synchronized with the course outline.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Electricity: Principles and Applications by R. Fowler. 8th ed. Mc-Graw Hill, (2012).

OCCUPATIONAL HEALTH AND SAFETY

Credit: 1+0
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

By the end of this course, students 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 CONTENT

- **Health and Safety Foundations**
  - Nature and scope of health and safety
  - Reasons/benefits and barriers for good practices of health and safety
  - Legal framework and OHS Management System
- **Fostering a Safety Culture**
  - Four principles of safety- RAMP (Recognize, Assess, Minimize, Prepare)
  - Re-thinking safety-learning from incidents
  - Safety ethics and rules
  - Roles and responsibilities towards safety
  - Building positive attitude towards safety
  - Safety cultures in academic institutions
- **Recognizing and Communicating Hazards:**
  - Hazards and Risk
  - Types of hazards: Physical (mechanical and non-mechanical), Chemical (Toxic and biological agents), electrical, fire, construction, heat and temperature, noise and vibration, falling and lifting etc.

- Learning the language of safety: Signs, symbols and labels
- **Finding Hazard Information**
  - Material safety data sheets
  - Safety data sheets and the GHS (Globally Harmonized Systems)
- **Accidents & Their Effect on Industry**
  - Costs of accidents
  - Time lost
  - Work injuries, parts of the body injured on the job
  - Chemical burn injuries
  - Construction injuries
  - Fire injuries
- **Assessing and Minimizing the Risks from Hazards**
  - Risk Concept and Terminology
  - Risk assessment procedure
  - Risk Metric's
  - Risk Estimation and Acceptability Criteria
  - Principles of risk prevention
  - Selection and implementation of appropriate Risk controls
  - Hierarchy of controls
- **Preparing for Emergency Response Procedures**
  - Fire
  - Chemical Spill
  - First Aid
  - Safety Drills / Trainings:
  - Firefighting
  - Evacuation in case of emergency
- **Stress and Safety at Work environment**
  - Workplace stress and sources
  - Human reaction to workplace stress
  - Measurement of workplace stress
  - Shift work, stress and safety
  - Improving safety by reducing stress
  - Stress in safety managers
  - Stress and workers compensation

- **6. Incident Investigation**
- Importance of investigation
- Recording and reporting
- Techniques of investigation
- Monitoring
- Review
- Auditing Health and Safety

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. "The A-Z of health and safety" by Jeremy Stranks
2. "The Manager's Guide to Health & Safety at Work" by Jeremy Stranks
3. "Occupational safety and health law handbook" by Ogletree, Deakins, Nash, Smoak and Stewarts

ADVANCED STEELS

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

After reviewing microstructure-property relationships in steels, their types, and classifications, students will explore a wide range of advanced steel alloys. These include high strength low alloy steels, stainless steels, duplex, super duplex, and a few others. Additionally, the course covers advanced steel production routes, such as vacuum induction melting, vacuum arc remelting, electroslag remelting, and thermo-mechanical processing. Students will also learn about the applications of advanced steels.

COURSE LEARNING OUTCOMES

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

1. analyze the microstructure-property-performance relationship existing in advanced steels.
2. compare different routes for producing advanced steels.
3. determine which steel alloys are appropriate for use in the construction, automotive, aerospace, and biomedical industries depending on their properties.

COURSE CONTENT

Review of microstructure-property relationships in steels. Types of steels and their classification.

High strength low Alloy (HSLA), micro-alloyed, stainless steels, duplex, super duplex, high yield steels, IF (interstitial-free), Maraging Steels, TRIP steels, Ultra Low carbon steels, nitrogen containing fine grained steels, tool steels, die steels, Quenched and partitioned steels (QPS). Steels for low and high temperature applications, Orthopaedic steels, super alloys etc.

Production routes for advanced steels (VIM, VAR, ESR etc.), Processing of steels: thermo-mechanical processing, advantages and limitations, TMT steels, dual phase steels.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Advanced Steels: From Materials Science to Structural Engineering by W. Sha. 1st ed. Springer (2013)
2. Steels: Microstructure and Properties by H. Bhadeshia, R. Honeycombe. 4th ed. Butterworth-Heinemann (2017)
3. Advanced High-Strength Steels: Science, Technology, and Applications by M. Y. Demeri. ASM International (2013)

VACUUM TECHNOLOGY

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

This course explores vacuum technology, covering principles, equipment, measurement, and applications of vacuum systems. The students will also learn about the vacuum measuring devices such as manometers, McLoad gauges, ionization gauges etc. The course will end with a discussion on the application of vacuum technology in characterization of materials and their processing.

COURSE LEARNING OUTCOMES

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

- explain kinetic theory of gas and its relationship with gas properties.

1. select a suitable vacuum pump for a specific industrial or research application.
2. differentiate between different vacuum measuring instruments used in materials engineering.
3. design a full vacuum system for an engineering application.

COURSE CONTENT

Vacuum technology: Vacuum classification, Kinetic picture of a gas; Velocity Distribution, Mean free path, Collision frequency, Particle Flux, Monolayer Formation Time, Flow characteristics of gas (Knudsen number).

Vacuum pumps: Positive displacement pumps; Diaphragm pump, Water ring pump, rotary and roots pump, vapour ejector and vapour entrainment pumps, diffusion pump, turbo-molecular pump, ion pumps, sieve pumps, adsorption pumps.

Vacuum measuring devices: Manometers, McLoad gauge, Penning gauge, Pirani gauge, Ionization gauges.

Calculation of vacuum systems; conductance and throughput, effective pumping speed, gas flow through pipes and orifices. Sources of leakage, leakage detection and remedies.

Application of vacuum in materials characterization

Application of vacuum in materials processing; Vacuum induction melting, vacuum arc melting. Metal refining in vacuum, degassing in liquid state, vacuum sintering, vacuum coatings.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Vacuum Technology by A. Roth. North-Holland (2012)
2. Vacuum technology: practice for scientific instruments by N. Yoshimura. 1st ed. Springer (2007).
3. Vacuum Metallurgy by A. Choudhury. ASM International (1990)

FRACTURE MECHANICS AND FAILURE ANALYSIS

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

This course provides an in-depth analysis of fracture mechanics, and covers topics such as fracture and failure mechanisms, testing methods, and failure analysis techniques. Griffith's and Orowan's theories, as well as linear elastic and elastoplastic fracture mechanics will also be discussed. Students will also learn about the fracture toughness testing of composite materials.

COURSE LEARNING OUTCOMES

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

1. explain fracture theories regarding fracture behavior.
2. apply principles of linear elastic and elastoplastic fracture mechanics to analyze fracture behavior under different loading conditions.
3. analyze and compare different fracture toughness testing methods.
4. evaluate different failure analysis procedures used to identify the root causes of mechanical/industrial failures.

COURSE CONTENT

Fracture and its types, ductile, brittle (intergranular and transgranular), Plane stress and plane strain conditions, Griffith's and Orowon theory of fracture.

Linear elastic and elastoplastic fracture mechanics. Fracture Toughness Testing, stress intensity factor and its range. Paris Law. Determination of K1c, Compact Tension, J-integral and Crack Opening Displacement (COD) methods. Tensile, Creep, Fatigue and environmental fractures. Stress corrosion cracking. Ductile to Brittle Transition Temperature and its determination. Fracture toughness testing of composites materials. Fracture toughness testing of reinforced/composite materials.

Failure analysis procedures; Fractography and Case studies of fractured components; different types of mechanical/industrial failures; root cause analysis and remedial actions

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Deformation and fracture mechanics of engineering materials by R. P. Vinci, R. W. Hertzberg, J. L. Hertzberg. 6th ed. Wiley (2021)
2. Fracture Mechanics by C. T. Sun, Z.-H. Jin. Academic Press (2012)
3. ASM Handbook on Failure Analysis and Prevention, Volume 11, Latest edition
4. ASM Handbook on Fractography, Volume 12, Latest edition

ADDITIVE MANUFACTURING

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

Starting with the evolution and comprehensive overview of additive manufacturing (AM), this course will then elaborate the fundamentals of AM, its advantages, and limitations. Students will also learn about different types of AM techniques. The course will conclude with the discussion on general features of products made from AM and recent developments in the field.

COURSE LEARNING OUTCOMES

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

1. analyse and compare additive and conventional manufacturing processes.
2. examine the role of different tools used in the AM.
3. differentiate between different techniques used for 3D printing of metallic, polymeric and other materials.
4. analyze the microstructure-property-performance relationship existing in 3D printed components.

COURSE CONTENT

An overview of additive manufacturing: how it is different from conventional manufacturing processes; history. Process fundamentals; structure shaping and creation; applications of additive manufacturing. Role of CAD and laser scanning. Final component geometry. Different techniques used for 3D printing of metallic (SLM, EBM, LMD, powder DED, wire DED, binder jetting, BPE etc.) polymeric (FDM, SLS, stereolithogrpahy etc.) and other materials. Design implications; surface finish; microstructure' mechanical and other properties; residual stresses and effects on fatigue life.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Additive Manufacturing by The Open University. The open learn (2019)
2. Introduction to Additive Manufacturing: technologies, materials, benefits, challenges and applications by N. Accialini. (2022)
3. Additive Manufacturing Technologies by I. Gibson, D. Rosen, B. Stucker, M. Khorasani. 3rd ed. Springer (2021)

FUNCTIONAL MATERIALS

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

This course explains the structure-property relationship existing in functional materials. Students will learn about a wide range of functional materials and analyze their electrical, thermal, optical, magnetic, and biological properties. The course will conclude with the discussion on challenges associated with the synthesis of functional materials.

COURSE LEARNING OUTCOMES

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

1. explain different functional materials along with their applications.
2. analyze the electrical, thermal, optical, and magnetic properties of functional materials.
3. assess the usefulness of various functional coatings applied to different materials for specific applications.
4. evaluate challenges associated with the synthesis of functional materials and their use in different applications.

COURSE CONTENT

Introduction to functional materials; Crystal structure and functional properties relationship. Quantum Theory.

Electrical and thermal (vibration and phonons) conduction mechanism. Insulation, electrical, optical, photovoltaic and magnetic properties and applications of functional materials. Design and selection of materials.

Surface properties; Surface and interfaces; growth of nano-structures; Photo-catalysis; antibacterial and biologically inert surfaces; Self-cleaning, easy-to-clean surfaces, bio ceramics. Functional materials coatings: anti-microbial coatings, air curable coatings, anti-ice coating; Functional coatings for metals, polymers and glasses: hydrophobic and hydrophilic surfaces; transparent conductive coating; barrier coatings; integrated functional coatings. Bio functional coatings: biocompatible and bioactive coatings.

Material challenges and their implementation in devices, an introduction to the synthesis of some common functional materials

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Advanced Functional Materials by A. Tiwari, L. Uzun. Wiley (2015)
2. Functional Materials: Electrical, Dielectric, Electromagnetic, Optical and Magnetic Applications by D. D. L. Chung. World Scientific (2010)
3. Functional Materials: Preparation, Processing and Applications by S. Banerjee, A. K. Tyagi. Elsevier (2012)
4. Biofunctional Surface Engineering by M. Scholz. 1st ed. Jenny Stanford Publishing (2014)
5. Handbook of Biofunctional Surfaces by W. Knoll. 1st ed. Jenny Stanford Publishing (2013)

HIGH TEMPERATURE MATERIALS

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

This course covers different high temperature materials and their applications with a focus on the challenges associated with elevated temperature environments. The mechanical and chemical properties of high temperature materials and their design aspects will be discussed.

COURSE LEARNING OUTCOMES

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

1. explain the plastic, fatigue, creep, and corrosive behavior of engineering materials at high temperatures.
2. Compare properties and applications of different high temperature materials.
3. Select the most suitable high temperature material for a given scenario.

COURSE CONTENT

Introduction to high temperature materials; applications; the phenomena and problems associated with high temperatures applications of materials.

High Temperature behaviour of Materials: Plasticity, Fatigue and thermal fatigue, Creep.

High temperature chemical behaviour: Oxidation and Corrosion.

Design of alloys for high temperature. Refractory Metals, Inter-metallics, Stainless Steels, Nickel and Cobalt-based Superalloys, Ceramics and Cermets for High Temperature Applications. Alloy Theory, Heat Treatment and Hardening Mechanisms. Oxidation Resistant and Thermal Barrier Coatings.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. High Temperature materials and mechanisms edited by Y. Bar-Cohen. 1st ed. CRC Press (2017)
2. High Temperature Coatings by S. Bose. 2nd ed. Butterworth Heinemann (2018)
3. Materials for High Temperature Engineering Applications by G. W. Meetham, M. H. V. D. Voorde. Springer (2000).

EXTRACTIVE METALLURGY

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

Along with a thorough review of thermodynamic principles of metal extraction, the course offers a detailed explanation of the common extraction methods like hydrometallurgy, electrometallurgy, and pyrometallurgy. The course will especially focus on the extraction of different metals (non-ferrous) from oxide, sulfide, and halide sources. Course will conclude with the discussion on the environmental impacts of different extraction processes and approaches to sustainable production of different metals.

COURSE LEARNING OUTCOMES

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

1. describe the importance, sources, and extractive routes of important non-ferrous metals and ferroalloys.
2. apply fundamental principles of thermodynamics for the extraction of non-ferrous metals.
3. compare various extraction processes of nonferrous metals.
4. analyse environment and cost-related issues regarding the extraction processes of non-ferrous metals.

COURSE CONTENT

Brief history of ferrous and non-ferrous metals, Sources of ferrous/non-ferrous metals, Mineral Processing of ores. Principles of metals extraction: Thermodynamic principles, homogeneous and heterogeneous reactions, Ellingham diagrams, kinetic principles, principles of electro-chemistry. General methods of extraction: pyro-metallurgy, hydrometallurgy, and electrometallurgy. Charge and energy calculations. General methods of refining.

Extraction of metals from oxide sources: Basic approaches and special features of specific extraction processes, extraction of metals such as magnesium, aluminum, tin, chromium and ferro-alloying elements, production of ferro-alloys. Extraction of metals from sulphide ores: Pyro-metallurgy and hydro-metallurgy of sulphides, production of metals such as copper, lead, zinc, nickel etc. Extraction of metals from halides: Production of halides and refining methods, production of reactive and nuclear reactor metals. Methods of extraction of metals such as titanium, rare earths, uranium, thorium, plutonium, beryllium, zirconium etc. Production of precious metals: Methods applied for gold, silver, and Pt group metals. Secondary production of metals and utilization of wastes, Energy and environmental issues in nonferrous metals extraction.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Non-Ferrous Extractive Metallurgy - Industrial Practices by R. Rumbu. 2nd ed. CreateSpace Independent Publishing Platform (2010)
2. Extraction of Nonferrous Metals by H.S. Ray, R. Sridhar and K.P. Abraham. Affiliated East West Press Pvt Ltd., New Delhi, (2007).
3. Extraction of nuclear and non-ferrous metals, S.K. Dutta, D.R. Lodhari, ebook, Springer, (2018)
4. Principles of Extractive Metallurgy by T. Rosenqvist. 2nd ed. (reprinted), McGraw Hill, New York, (2004)

MINERAL PROCESSING

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

With an emphasis on Pakistan's mineral resources, this course provides a comprehensive overview of the minerals and mineral deposits, covering their classification, physico-chemical characteristics, and identification techniques. The objectives and techniques used for ore size reduction will also be discussed along with the methods used for particle size analysis and classification. The course will conclude with an in-depth discussion on different mineral separation techniques involving gravity concentration, magnetic separation, electrostatic separation etc.

COURSE LEARNING OUTCOMES

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

1. describe various mineral comminution (crushing, grinding) techniques and equipment.
2. compare different mineral enrichment/separation techniques.
3. select the most suitable mineral processing technique for a given scenario.

COURSE CONTENT

Minerals: Classification of minerals, Physico-chemical properties of minerals, Identification of minerals, Mineral resources in Pakistan

Mineral deposits and their occurrence: Igneous process, Sedimentary process, Metamorphic process.

Comminution: objectives and techniques.

Ore Sampling, Particle Size Analysis, Classification.

Enrichment/Separation Methods: Gravity concentration techniques, Electrostatic separation, Magnetic Separation techniques, Froth Flotation, Selective flocculation.

Leaching processes. Agglomeration processes

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Wills' Mineral Processing Technology: An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery by B. A. Wills, J. A. Finch. 8th ed., Butterworth-Heinemann, (2015)
2. Principles of Mineral Processing by M. C. Fuerstenau, K. N. Han. Society for Mining Metallurgy & Exploration (2003)

3. Introductory Mining Engineering by H. L. Hartman, J. M. Mutmansky.2nd ed. Wiley (2002)
4. Mineral Processing Plant Design, Practice, and Control edited by A. L. Mular, D. J. Barratt, D. N. Halbe. Society for Mining, Metallurgy, and Exploration, Inc. (2022)

THIN FILMS AND COATINGS TECHNIQUES

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

This course provides a detailed introduction to thin-film technology, focusing on different deposition techniques and their applications. The course will address the tribological, mechanical and functional properties of different thin film coatings. The discussion on the real-world uses of thin-film materials and deposition methods will conclude the course.

COURSE LEARNING OUTCOMES

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

1. describe the basics of thin film technology.
2. compare different thin film deposition techniques.
3. examine the tribological, mechanical and functional properties of thin films.
4. select the most suitable thin film technique as per given requirement/ application.

COURSE CONTENT

Introduction to thin film technology. Thin film deposition and growth mechanism by Physical vapour deposition (PVD) techniques like evaporation, sputtering, ion-plating etc. Chemical coating methods such as chemical vapour deposition (CVD) and atomic layer deposition (ALD). Plasma based methods for thin film deposition. Molecular Beam Epitaxial (MBE) growth. Different physical and chemical processes. Substrate effects of coating deposition. Tribological and hard thin coatings. Functional coatings for devices. Models for nucleation and film growth. Morphology and texture. Applications of thin film materials and deposition technologies.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Thin Film Coatings: Properties, Deposition, and Applications by F. M. Mwema, T.-C. Jen, L. Zhu. 1st ed. CRC Press (2022)
2. Handbook of Thin Film Technology by H. Frey, H. R. Khan. 1st ed. Springer (2015)
3. Recent Advances in Thin Films edited by S. Kumar, D. K. Aswa. 1st ed. Springer (2020)

NUCLEAR MATERIALS

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

This course starts with a detailed introduction to nuclear energy and the principles of nuclear fission reactions as well as different nuclear fission reactors. Nuclear fuel materials, structural materials, moderators, reflectors, blankets, control elements, coolants, and shielding materials will also be covered in this course. Throughout the course, special attention will be given to understand the effects of radiations on materials mechanical, thermal, and corrosion properties.

COURSE LEARNING OUTCOMES

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

1. compare various nuclear power reactor systems and their role in environment and sustainability of future energy demands.
2. describe the processes happening in nuclear reactors.
3. evaluate the required properties of nuclear components and select suitable materials for construction of nuclear reactors.
4. analyze various nuclear reactor fuels and their processing.

COURSE CONTENT

Introduction of nuclear energy, Nuclear fission reaction, Breeding ratio, breeding gain.

Classification of nuclear fission reactors, Gas cooled reactors, Light water reactors, Heavy water reactors, Liquid metal fast breeder reactors.

Nuclear fuel materials, structural materials, moderator, reflector and blanket materials, Control element materials, coolants, shielding materials

Crystal imperfections or defects, Radiation effects or damages by fast neutron, irradiation effect on nuclear, physical, and thermal properties, Irradiation effect on mechanical properties, Creep, Fatigue, and Corrosion.

General properties in the selection of nuclear reactor materials, Special properties in the selection of nuclear reactor materials

Classification of primary components and main materials for nuclear fission reactors. Structural Materials (cladding), Moderator, Reflector, Blanket and Coolant Materials

Metallic uranium as fuel, Ceramics uranium fuels, Plutonium fuel, Thorium as fuel.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Nuclear Material Science by K. Whittle. 2nd ed. IOP Publishing (2020)
2. Nuclear Materials by M. P. Hemsworth. Nova science PUB inc. (2011)
3. Introduction to Nuclear Reactor Theory by J. Lemarsh. Addison-Wesley, (2002)

CONSTRUCTION MATERIALS

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

This course provides an extensive review of materials used in construction and building projects. The students will learn about the challenges, properties, and prospects of a wide range of building materials. To promote awareness of sustainable practices in the construction sector, the course will also cover the principles of green construction and building materials, as well as techniques for recycling construction waste.

COURSE LEARNING OUTCOMES

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

1. compare different construction materials and their properties.
2. analyze manufacturing processes used for different construction materials.
3. evaluate the effects that conventional building materials have on the environment and determine whether green building materials can replace them.
4. examine the challenges involved in recycling construction and building materials.

COURSE CONTENT

Overview: Materials for construction and building, principal properties, and classification. Evaluation of materials' choices and their impact. Processing/ Manufacturing, properties, practice, challenges/issues, and future of construction and building materials: Wood, sands, clay, stones, aggregates, asphalt and bituminous materials, bricks and blocks, tiles, glass, cements, admixtures, mortars, concretes, pavement materials, pozzolanas, thermal insulations, and finishings. Concretes: Materials for making concrete, concrete mix designs, reinforcements, special concretes. Green construction and building materials. Recycling of construction and building materials.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Building Materials by S. K. Duggal, 3rd revised ed. New Age International Publishers, (2021).
2. Construction Materials: Their Nature and Behaviour edited by M. Soutsos, P. Domone 5th ed. CRC Press (2010).

DESIGN AND SELECTION OF MATERIALS

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

This course provides details of the basic principles, tools, and strategies involved in designing and selecting materials for a specific situation. Topics such as materials information, properties charts, and selection strategies for materials are part of this course. Using case studies, students will also be provided insights into the application of materials selection principles in the real world. By the end of this course, students will have the knowledge to select materials for a specific requirement.

COURSE LEARNING OUTCOMES

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

1. explain various resources available for selection and design of a material for a specific application.
2. design or select material for a specific application using modern tools.
3. analyze conflicting goals and constraints while selecting materials.
4. examine case studies to understand the application of materials selection principles in the real world and to identify optimal practices.

COURSE CONTENT

Introduction – Materials and design: Materials design, the design process, types of design, design tools and materials data. Function, material, shape and process

Elements of materials selection: Materials information for design, material property charts, selection strategy, attribute limits and material index, the selection procedure, computer-aided selection, Material selector, materials data resources (ASM, ASME standards and codes references, websites) the structural index. Effect of process on properties and cost

Constraints and conflicting objectives: Selection and multiple constraints, conflicting objectives. Material life-cycle and its assessment, sustainability. Case studies

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Materials Selection in Mechanical Design by M. F. Ashby. 4th ed. Butterworth-Heinemann (2011).
2. Materials: Engineering, Science, Processing and Design by M. F. Ashby, H. Shercliff, D. Cebon. 4th ed. Butterworth-Heinemann (2018).

3. Materials and the Environment: Eco-informed Material Choice by M. F. Ashby. 2nd ed. Butterworth-Heinemann (2013).
4. Materials and Design: The Art and Science of Material Selection in Product Design by M. F. Ashby, K. Johnson. 3rd ed. Butterworth-Heinemann (2014)

METALWORKING PROCESSES

Credits: 2+0
Pre-Requisite: Nil

DESCRIPTION

This course offers a comprehensive exploration of the techniques and principles of metal forming processes. The course will contain theoretical discussions as well as practical examples to help students learn how to design, analyze, and optimize metal-forming processes for a wide range of applications.

COURSE LEARNING OUTCOMES

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

1. Explain basic metal working processes including rolling, forging, extrusion, drawing and sheet metal forming.
2. Investigate metalworking processes by identifying key factors affecting process effectiveness and efficiency.
3. Design a metalworking process according to the requirements.
4. Select a suitable metalworking process as per given scenario.

COURSE CONTENT

Principles of metal forming processes, Softening and Hardening Mechanism, Metal-Working in the Re-crystallization, Non-recrystallization and Two-Phase regions, Concept of dynamic, static recovery & re-crystallization, Aspect Ratio.

Rolling, process and equipment, forces in rolling, metal flow, defects and their prevention.

Forging, process and equipment, Forces in Forging, grain flow, forging defects and their prevention.

Extrusion, Processes and equipment, extrusion-defects. Wire-drawing.

Sheet-metal working, stretch forming, deep drawing, continuous roll forming.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Manufacturing Processes for Engineering Materials by S. Kalpakjian, S. R. Schmid. 6th ed. Pearson (2021)
2. Introduction to Manufacturing Processes by M. P. Groover. 1st ed. Wiley (2011)
3. Mechanical Metallurgy by George E. Dieter. SI metric edition. McGraw Hill, (2002)

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