Curriculum for

Mechanical 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 Competencies) covering core and elective courses, considered as beauty of OBE system in the international arena. At the same time, this curriculum framework would fulfill the purpose of meeting our

national, social and economic needs leading towards attainment of Sustainable Development Goals (SDGs-2030).

It would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards.

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

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

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

1. Engineering Curriculum Review & Development Committee (ECRDC)

PEC in its efforts towards quality engineering education, took up the challenge of curriculum review and development for engineering programs after due consent of HEC. A high-level Engineering Curriculum Review and Development Committee (ECRDC), led by Engr. Lt. Gen (Retd.) Javed Mahmood Bukhari, Member Governing Body/ Rector, NUST was constituted (for the term 2021-2024), whereas other eminent members from industry and academia were involved in the task of curricula review and updation, besides developing curriculum for new/ emerging fields. The main responsibility of ECRDC is to oversee the entire curriculum review and development process while setting policies and guidelines for the subject ECRDCs working in their respective domains. The 9th meeting of main ECRDC and first of this term, was held on 31st May 2022 at PEC Head Office Islamabad, wherein the Convener briefed the scope, objective and ToRs of the Committee and also endorsed the subject ECRDCs comprising of eminent engineers and professionals from academia and industry.

1.	Engr. Lt. Gen (Retd.) Javed Mahmood Bukhari Convener (ECRDC-Main)/ Member PEC Governing Body/ Rector NUST, Islamabad	Convener
2.	Engr. Prof. Dr. Altaf Mukati Vice President (Academics), SZABIST University, Karachi	Dy. Convener
3.	Engr. Prof. Dr. Bhawani Shankar Chowdhry, 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, Materials, Metallurgical, Mining, Petroleum and Gas 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

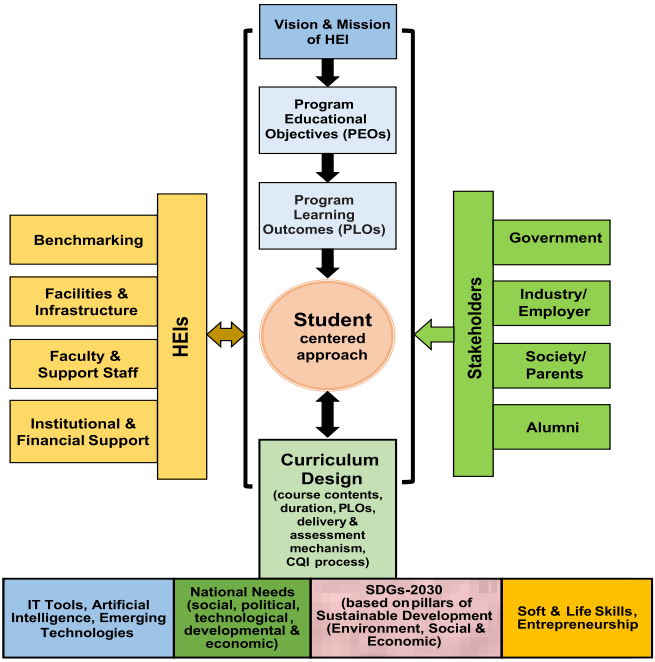
- The ECRDC is responsible to oversee the overall working of curriculum review and development for all engineering programs in terms of strategy, guidance & progress, and thereby submission to the relevant forum for adoption/ notification.

- 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

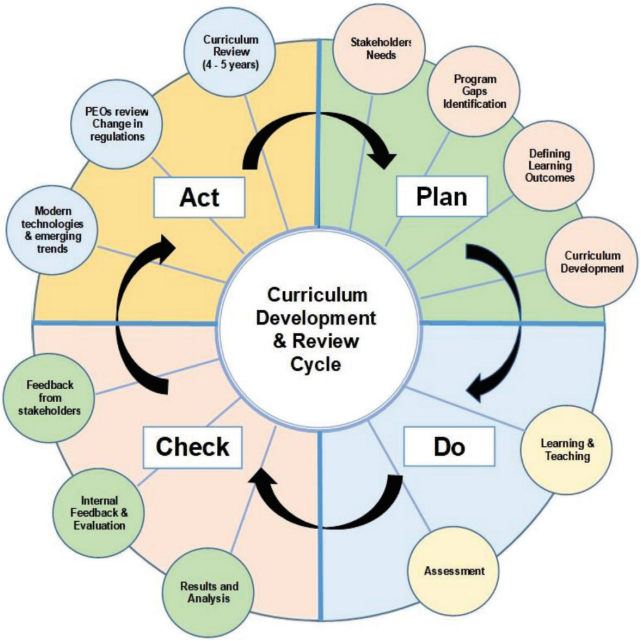
Outcome Based Education (OBE) is an approach of teaching and learning that focuses on what students should be able to attain at the end of the educational program. OBE is a student's centered system which concerns what the students will know and be able to do as learning outcomes. The curriculum development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

The PEC Engineering Curriculum Review and Development Committee (ECRDC) of Mechanical and Allied Engineering Disciplines took up the task to review and update the curriculum for the Bachelor of Mechanical Engineering degree program. The subject Committee had conducted several meetings besides multiple sessions of Sub-Groups and the concluding meeting of ECRDC (Mechanical & Allied Engineering Disciplines) was conducted on 08-3-2024 at PEC Head Office Islamabad. The Committee consisted of following members:

1.	Engr. Prof. Dr. Syed Mushtaq Shah Member, PEC Governing Body/ Vice Chancellor, Mir Chakar Khan Rind University, Sibi	Convener
2.	Engr. Prof. Dr. Riffat Asim Pasha Member, PEC Governing Body/ Chairman, Mechanical Engineering Department, UET Taxila	Member
3.	Engr. Dr. Ajaz Bashir Janjua Member, PEC Governing Body/ Director-IDePRO, Pakistan Ordinance Factories, Wah Cantt.	Member
4.	Engr. Dr. Shaikh Zahoor Sarwar Member, PEC Governing Body/ Sr. Associate Professor, Bahria University, Islamabad	Member
5.	Engr. Prof. Dr. Mirza Jahanzaib Member, PEC Governing Body/ Chairman Industrial and Manufacturing Engineering, UET Taxila	Member
6.	Engr. Mohsin Ali Khan Member, PEC Governing Body/ Ex-GM, Pakistan Steel Mill, Karachi	Member
7.	Engr. Muhammad Nasir Khalily Member, PEC Governing Body/ Divisional Superintendent, Pakistan Railways, Karachi	Member

8.	Engr. Hidayatullah Kasi HEC Representative	Member
9.	Engr. Dr. Abdul Rehman Abassi Principal Engineer, KANUPP Karachi	Member
10.	Engr. Dr. Hamid Zaigham GM, KRL Islamabad	Co-opted Member
11.	Engr. Dr. M. A Irfan Mufti Professor, UET Peshawar	Co-opted Member
12.	Engr. Dr. Khalid Rehman Professor, GIKI Topi, Swabi	Co-opted Member
13.	Engr. Dr. Sahar Noor Professor, UET Peshawar	Co-opted Member
14.	Engr. Dr. Nadeem Ahmed Mufti Professor, UET Lahore	Co-opted Member
15.	Engr. Dr. Muhammad Shakaib Professor, NED-UET Karachi	Co-opted Member
16.	Engr. Dr. Salim-Ur-Rehman Professor, SUIT Peshawar	Co-opted Member
17.	Engr. Prof. Dr. M. Shahid Khalil Ex-Dean, UET Taxila	Co-opted Member
18.	Engr. Dr. Saeed Badshah Professor, International Islamic University, Islamabad	Co-opted Member
19.	Engr. Niaz Ahmed Sr. Additional Registrar/ HoD-EAD	Secretary ECRDCs
20.	Engr. Osaf Mahmood Malik Section Head (Curriculum & Development)	Additional Registrar-EAD
21.	Engr. Syed Haider Abbas Bokhari	Assistant Registrar-EAD
22.	Engr. Muhammad Junaid Khan	Assistant Registrar-EAD
22.	Mr. Muhammad Irfan	Office Superintendent-EAD

The working on curriculum development of Mechanical Engineering was initiated in 2023 by previous EAD team comprising of Engr. Dr. Ashfaq Ahmed Sheikh (Sr. Additional Registrar), Engr. Ghulam Karim (Additional Registrar) and Engr. Daniyal Hameed (Assistant Registrar). The contribution of previous as well as current EAD team was highly acknowledged and appreciated by the Convener ECRDC Mechanical and Allied Engineering Disciplines.

Sub Group Mechanical Engineering

1.	Engr. Prof. Dr. Syed Mushtaq Shah Member, PEC Governing Body/ Vice Chancellor, Mir Chakar Khan Rind University Sibi	Convener/ Team Lead Sub-Group
2.	Engr. Osaf Mahmood Malik Additional Registrar- EAD	Secretary Sub-Group

Design & Materials

3.	Engr. Prof. Dr. Riffat Asim Pasha Member, PEC Governing Body/ Professor, UET Taxila	Lead
4.	Engr. Prof. Dr. Nadeem Ahmed Mufti Professor, UET Lahore	Member
5.	Engr. Mohsin Ali Khan Member, PEC Governing Body/ Ex-GM, Pakistan Steel Mill, Karachi	Member
6.	Engr. Dr. Saeed Badshah Professor, International Islamic University, Islamabad	Member
7.	Engr. Dr. M. Shakaib Professor, NED-UET Karachi	Member

Thermofields Engineering

1.	Engr. Dr. Hamid Zaigham GM, KRL Islamabad	Lead
2.	Engr. Prof. Dr. Nasir Hayat Pro-Vice Chancellor, U.E.T Lahore	Member
3.	Engr. Dr. M. Shakaib Professor, NED-UET Karachi	Member
4.	Engr. Dr. Nauman Qureshi Assistant Professor, DHA Suffa University, Karachi	Member
5.	Engr. Dr. Riaz Ahmad Mufti Professor, NUST Islamabad	Member

Manufacturing Engineering

1.	Engr. Dr. Mirza Jahanzaib Member, PEC Governing Body/ Professor, UET Taxila	Lead
2.	Engr. Dr. Aijaz Bashir Janjua Member, PEC Governing Body/ Director-IDePRO, Pakistan Ordinance Factories Wah Cantt.	Member
3.	Engr. Dr. Sheikh Zahoor Sarwar Member, PEC Governing Body/ Sr. Associate Professor, Bahria University Islamabad	Member
4.	Engr. Prof. Dr. Shahid Khalil Ex-Dean, UET Taxila	Member

5. Engr. Dr. Khalid Rehman — Member
Associate Professor, GIKI Swabi

The ECRDC Mechanical and Allied Engineering Disciplines appreciated the extraordinary efforts and contribution of Engr. Prof. Dr. Syed Mushtaq Shah (Convener), Engr. Prof. Dr. Riffat Asim Pasha (Member), Engr. Prof. Dr. Saeed Badshah (Member Sub-Group) & Engr. Osaf Mahmood Malik (Section Head Curriculum & Development) for compilation of course contents and proof reading of this curriculum booklet.

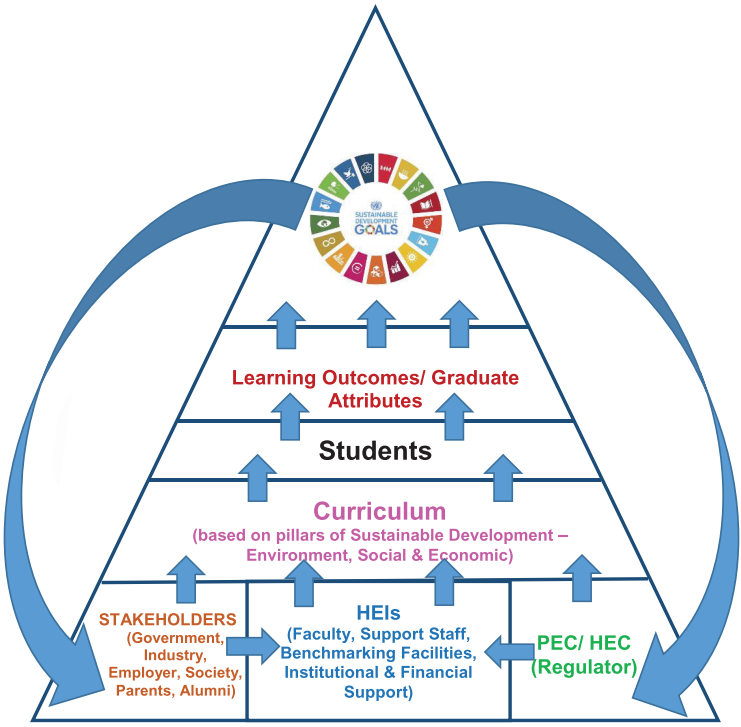
6. Agenda of ECRDC for Mechanical and Allied Engineering Disciplines

- The Subject ECRDC will work under the overall directions and supervision of main ECRDC comprising all Conveners.
- The key driving lines for the development of engineering curriculum for each discipline will be the overall policy of Pakistan Engineering Council in conjunction with international commitments (Washington Accord, IPEA etc.) and Government/ 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. Syed Mushtaq Shah 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.

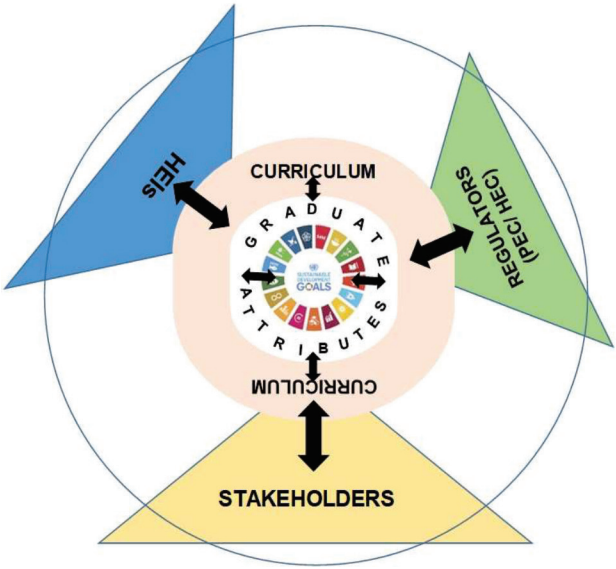


Figure 2: Consideration of UN SDGs in curriculum design

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** **Engineeringdesign and operations** **& WK7** **Engineering in Society**	Selected SDGs from SDG - 1 to 17 (relevance as per curriculum)

PLO-7 **Ethics:** Understanding and level of practice	**EC-8** **Ethics: No differentiation in this characteristic**	**WK-9** **Ethics, inclusive behavior and conduct**	SDG- 5, 10, 16
PLO-8 **Individual and Collaborative Team work:** Role 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, 10
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 Mechanical Engineering, foundation, breadth, depth and multidisciplinary courses (including safety) so that different streams could be encouraged within each discipline, enabling students to undertake a range of Complex Problem Solving and Complex Engineering Activities. The students may select electives from any of the streams with guidelines from their respective advisors. The knowledge areas of Non-Engineering and Engineering domains have been broadly mapped with 11x PLOs and 9x WKs using the guiding framework of IEA version 4.0 in the following table:

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

Engineering Domain				
Knowledge Profile (WK-1 to WK-9)	**Knowledge Area**	**Sub-Area**	**Courses**	**Credit Hours**
WK-2/ WK-4/ WK-5/	Advanced Computer and Information Sciences	ICT/AI/ Data Science/ Cyber Security		6-9
WK-2/ WK-3	Foundation Engg Courses		Specific to Program Objectives and outcome	22-24
WK-1/ WK-2/ WK-4	Core Breadth of Engg Disciplines		Specific to Program Objectives and outcome	22-24
WK-5/ WK-6	Core Depth of Engg Disciplines		Specific to Program Objectives and outcome	22-24
				Min 72
WK-1/ WK-2/ WK-3/ WK-4/ WK-7/ WK-9	Multi disciplinary Engg Courses		Specific to Program Objectives and outcome	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 inline with elective subjects/ specific streams
- Qualifying weightage: 70%
- At least 75% attendance is mandatory 10%
- Assessment report from the employer 50%
- Evaluation at relevant HEIs/ Deptt – presentation 40%

Final Year Design Project (FYDP)/ Capstone: FYDP aims to challenge innovative, creative, technical, management and presentation skills of a graduate to bring together the learning over the degree program.

- A final year design project (FYDP) is the confluence of an engineering

- 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 Mechanical 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 Mechanical 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-1/ WK-5/ WK-7/ WK-9	**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	
	Management Sciences	Professional Practice	Entrepreneurship **	2	0	2	**4**
			Project Management ***	2	0	2	
	Computer Sciences	Basic Computing	Applications of ICT **	2	1	3	**3**
WK-1/ WK-2	**Natural Sciences**	Mathematics	Calculus & Analytical Geometry	3	0	3	**12**
			Complex variables & Transforms	3	0	3	
			Linear Algebra & Differential Equations	3	0	3	
			Numerical Analysis	2	1	3	
		Natural Sciences	Applied Physics/ Applied Chemistry	2	1	3	**3**
Total (General Education/ Non-Engineering Domain)				**35**	**3**	**38**	**38**

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	Sub Area	Title of Course	Th	Lab	Cr. Hrs.	Total Credits
Engineering Domain							
WK-2/ WK-4/ WK-5/ WK-6	**Computer and Information Sciences**	ICT/AI/ Data Science/ Programming	Computer Systems and Programming	2	1	3	**6**
			Applied Artificial Intelligence and Machine Learning	2	1	3	
WK-2/ WK-3	**Engineering Foundation**		Engineering Drawing & Graphics	1	1	2	**24**
			Workshop Practice	1	1	2	
			Engineering Mechanics-I (Statics)	2	1	3	
			Engineering Mechanics-II (Dynamics)	2	0	2	
			Materials Engineering	2	0	2	
			Fluid Mechanics-I	3	0	3	
			Mechanics of Materials-I	3	0	3	
			Engineering Mechanics Lab	0	1	1	
			Thermodynamics-I	3	0	3	
			Computer Aided Drawing	0	1	1	
			Mechanics of Machines	2	0	2	
WK-1/ WK-2/ WK-4	**Major Based Core (Breadth)**		Fluid Mechanics-II	2	0	2	**23**
			Fluid Mechanics Lab	0	1	1	
			Manufacturing Processes	2	0	2	
			Machine Design-I	2	0	2	
			Thermodynamics-II	2	0	2	
			Thermodynamics Lab	0	1	1	

			Mechanics of Materials-II	3	0	3	
			Manufacturing Processes Lab	0	1	1	
			Mechanics of Materials Lab	0	1	1	
			Machine Design-II	2	0	2	
			Heat & Mass Transfer	3	0	3	
			HVAC and H&M Lab	0	1	1	
			Control Engineering	2	0	2	
WK-5/ WK-6	**Major Based Core (Depth)**		Heating, Ventilation and Air Conditioning	3	0	3	**22**
			Internal Combustion Engines	2	1	3	
			Mechanical Vibrations	3	0	3	
			Mechanisms & Mechanical Vibrations Lab	0	1	1	
			Finite Element Methods	2	1	3	
			Reverse Engineering and Inspection Techniques	2	1	3	
			Technical Elective-I	2/3	1/0	3	
			Technical Elective-II	2/3	1/0	3	
WK-1/ WK-2/ WK-3/ WK-4	**Multi-Disciplinary Engineering**		Electrical Engineering	2	0	2	**6**
			Electronics Engineering	2	0	2	
			Electrical and Electronics Engineering Lab	0	1	1	
			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	
WK-6/ WK-7	**Industrial Training**	6 – 8 weeks Industrial Training (Non-Credit)		**Mandatory & Qualifying**			
Total Engineering Domain				**62/ 64**	**25/ 23**	**87**	**87**
WK-1/ WK-2/ WK-3/ WK-4	**Flexible Engineering/ Non-Engineering Courses**	Measurement and Instrumentation		2	1	3	9
		Mechatronics and Robotics Engineering		2	1	3	
		Mathematics Elective		3	0	3	
Total Flexible Engineering/ Non-Engineering Domain				**7**	**2**	**9**	**9**
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) -Applications of AI						
Total (Credit Hours)						**134**	

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

12. Scheme of Studies for Mechanical Engineering Curriculum

1st Year				
First Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Islamic Studies/ Ethics	2	0	2
2.	Calculus and Analytical Geometry	3	0	3
3.	Functional English	3	0	3
4.	Applied Chemistry/ Applied Physics	2	1	3
5.	Applications of ICT	2	1	3
6.	Engineering Drawing and Graphics	1	1	2
7.	Workshop Practice	1	1	2
	Total	**14**	**4**	**18**

Second Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Linear Algebra & Differential Equations	3	0	3
2.	Electrical Engineering	2	0	2
3.	Computer Aided Drawing	0	1	1
4.	Engineering Mechanics-I: (Statics)	3	0	3
5.	Thermodynamics-I	3	0	3
6.	Materials Engineering	2	0	2
7.	Civics and Community Engagement	2	0	2
8.	Ideology and Constitution of Pakistan	2	0	2
	Total	**17**	**1**	**18**

2nd Year				
Third Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Engineering Mechanics-II: (Dynamics)	2	0	2
2.	Mechanics of Materials–I	3	0	3
3.	Computer Systems and Programming	2	1	3
4.	Complex Variables & Transforms	3	0	3
5.	Fluid Mechanics-I	3	0	3
6.	Thermodynamics-II	2	0	2
7.	Engineering Mechanics Lab	0	1	1
8.	Thermodynamics Lab	0	1	1
	Total	**15**	**3**	**18**

Fourth Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Measurement and Instrumentation	2	0	2
2.	Mechanics of Materials–II	3	0	3
3.	Fluid Mechanics-II	2	0	2
4.	Machine Design-I	2	0	2
5.	Electronics Engineering	2	0	2
6.	Electrical and Electronics Engineering Lab	0	1	1
7.	Expository Writing	3	0	3
8.	Fluid Mechanics Lab	0	1	1
9.	Mechanics of Materials Lab	0	1	1
	Total	**14**	**03**	**17**

3rd Year				
Fifth Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Manufacturing Processes	2	0	2
2.	Manufacturing Processes Lab	0	1	1
3.	Mechanics of Machines	2	0	2
4.	Control Engineering	2	0	2
5.	Heat & Mass Transfer	3	0	3
6.	Applied Artificial Intelligence & Machine Learning	2	1	3
7.	M&I and Control Lab	0	1	1
8.	Numerical Analysis	2	1	3
	Total	**13**	**4**	**17**

Sixth Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Social Sciences Elective **	2	0	2
2.	Heating, Ventilating and Air Conditioning	3	0	3
3.	Machine Design-II	2	0	2
4.	Finite Element Methods	2	1	3
5.	HVAC and H&M Lab	0	1	1
6.	Probability & Stochastic/ Math Elective ***	3	0	3
7.	Project Management	2	0	2
	Total	**14**	**2**	**16**

4th Year				
Seventh Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Mechanical Vibrations	3	0	3
2.	Internal Combustion Engines	2	1	3
3.	Technical Elective-I ****	3/2	0/1	3
4.	Arts and Humanities Elective *	2	0	2
5.	Mechanisms and Mechanical Vibration Lab	0	1	1
6.	Final Year Design Project-I	0	3	3
	Total	**10/9**	**5/6**	**15**

Eighth Semester				
Sr. No	**Course Title**	**(Credit Hours)**		**Total Credit Hours**
		Theory	**Lab**	
1.	Reverse Engineering and Inspection Techniques	2	1	3
2.	Mechatronics & Robotics Engineering	2	1	3
3.	Technical Elective-II ****	3/2	0/1	3
4.	Entrepreneurship	2	0	2
5.	Occupational Health & Safety	1	0	1
6.	Final Year Design Project-II	0	3	3
	Total	**10/9**	**5/6**	**15**

* List of Arts and Humanities Electives (2+0)	** List of Social Sciences Electives (2+0)	*** List of Mathematics Electives
• 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.	• Applied Statistics • Probability and Stochastic • Multivariable Calculus • Any other relevant course decided by the HEI as per requirement.

****List of Technical Electives (3 Cr hrs.)	
• Tribology • Mechanical Engineering Design Analysis • Stress Analysis • Composite Materials • Renewable Energy Technology • Gas Dynamics • Aerodynamics • Computational Fluid Dynamics	• Nuclear Engineering • Automotive Engineering • Advanced Manufacturing Systems • Maintenance Engineering • Product Design and Development • Micro-Electromechanical Systems (MEMS) • Power Plant • Any other relevant course decided by the HEI as per requirement.

13. Program Specific Labs

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

- CAD/CAM Lab (Computing Lab)
- Manufacturing/ Industrial Automation Lab
- Robotics Lab
- Engineering Workshop
- Engineering Drawing Lab
- Strength of Materials Lab
- Fluid Mechanics Lab
- Reverse Engineering and Inspection Techniques Lab
- Measurement & Instrumentation and Control
- Mechanism and Mechanical Vibration
- Engineering Mechanics
- Thermodynamics
- Mechanics of Materials
- Manufacturing Processes
- HVAC and H&M
- IC Engines
- Artificial Intelligence

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.).
- Structuring documents (introduction, body, conclusion and formatting).
- Inclusivity in communication (gender-neutral language, stereotypes, cross-cultural communication, etc.).
- Public speaking (overcoming stage fright, voice modulation and body language).
- Presentation skills (organization content, visual aids and engaging the audience).
- Informal communication (small talk, networking and conversational skills).
- Professional writing (business e-mails, memos, reports, formal letters, etc.).

PRACTICAL REQUIREMENT

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

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. "Understanding and Using English Grammar" by Betty Schrampfer Azar.
2. "English Grammar in Use" by Raymond Murphy.
3. "The Blue Book of Grammar and Punctuation" by Jane Straus.

4. “English for Specific Purposes: A Learning-Centered Approach” by Tom Hutchinson and Alan Waters.
5. “Cambridge English for Job-hunting” by Colm Downes.
6. “Practical English Usage” by Michael Swan.
7. “Reading Literature and Writing Argument” by Missy James and Alan P. Merickel.
8. “Improving Reading: Strategies, Resources, and Common Core Connections” by Jerry Johns and Susan Lenski.
9. “Comprehension: A Paradigm for Cognition” by Walter Kintsch.
10. “Communication Skills for Business Professionals” by J.P Verma and Meenakshi Raman.

EXPOSITORY WRITING
UGE Policy V1.1: General Education Course

Credits: 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.
10. "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 any 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. 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.

4. 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.

5. 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.

6. 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).

7. 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. “The Making of Pakistan: A Study in Nationalism” by K.K. Aziz.
14. “Pakistan: A New History” by Ian Talbot.
15. “Pakistan in the Twentieth Century: A Political History” by Lawrence Ziring.
16. “The Constitution of Pakistan 1973”. Original.
17. “Constitutional and Political Development of Pakistan” by Hamid Khan.
18. “The Parliament of Pakistan” by Mahboob Hussain.
19. “Constitutional Development in Pakistan “ by G.W. Choudhury.
20. “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

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.

COURSE LEARNING OUTCOME

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

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

COURSE OUTLINE

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

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

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.APhilosophy ofTechnology:FromTechnical Artefacts to Socio technical systems.
7. Mitcham,C.,and Munoz,D.2010.Humanitarian Engineering.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

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

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

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 BEHAVIOUR

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

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

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 Organization**
  - Introduction of Bureaucracy
  - Managerial Work
  - Contingency theory
  - Organizational Design
- **Individual and Work Learning**
  - Learning Theories
  - Learning and Work
- **Stress**
  - Types of Stress and Work
  - Occupational Stress Management

- **Individual Differences**
  - o Personality and its factors
  - o Personality dimensions and social learning Intelligence
- **Motivation and Job Satisfaction**
  - o Needs at Work
  - o Theories of Motivation and job satisfaction
  - o Correlates of Job satisfaction
- **Group and Work**
  - o Social Interaction
  - o Dramaturgy and
  - o Social Skill

Group and Inter group Behaviour

- o Group Structure & Norms
- o Group Processes
- o How throne Studies
- **Leadership**
  - o Leadership as an attribute
  - o Leadership Style
- **Patterns of Work**
  - o Work-the classical approach
  - o Marx, Weber, & The critique of labor
  - o Foucault & Disciplinary Power
  - o Conflict and Consent in Work
  - o The labor Process debate
  - o Work place control and resistance
  - o Industrial conflict and industrial relations
- **Organizational Culture**
  - o Organizational culture and strategic management
  - o Exploring organizational culture
- Evaluating concept of culture

SUGGESTED INSTRUCTIONAL/READING MATERIALS

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

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.
5. Learn how to enforce rights to intellectual property in the context of engineering.

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: 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
5. 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
- Conformity, Obedience
- Helping behavior
- 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

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: 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: 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: 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: 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

MANAGEMENT SCIENCES DOMAIN

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.

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4. Opportunity Recognition and Idea Generation:

- Opportunity identification, evaluation and exploitation;
- Idea generation techniques for entrepreneurial ventures.

5. Marketing and Sales:

- Target market identification and segmentation;
- Four P's of Marketing;
- Developing a marketing strategy;
- Branding.

6. 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.)

7. Team Building for Startups:

- Characteristics and features of effective teams;
- Team building and effective leadership for startups

8. 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 PowerPoint), spreadsheet software (e.g., Microsoft Excel) among such other tools students may be assigned practical tasks that require them to create documents, presentations and spreadsheets etc.
2. Assigning of tasks that involve creating, managing, and organizing files and folders on both local and cloud storage systems.. students will practice file naming conventions, creating directories, and using cloud storage solutions (e.g., Google Drive, OneDrive).
3. The use of online learning management systems (LMS) where students can access course materials, submit assignments, participate in discussion forums, and take quizzes or tests. This will provide students with the practical experience with online platforms commonly used in education and the workplace.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

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

CALCULUS AND ANALYTICAL GEOMETRY

Credit 3+0
Pre-Requisites: Nil

DESCRIPTION

Calculus and Analytical Geometry offers a comprehensive exploration of mathematical principles, covering analytical geometry with vector and scalar products, three-dimensional coordinates, and the equations of lines and planes. The course delves into functions, limits, continuity, and differentiation, including higher-order derivatives and applications like optimization and curvature. Integration techniques are examined in depth, along with their applications to areas, volumes, and center of mass calculations. Additionally, the course covers improper integrals, infinite sequences and series, and power and Taylor series, providing a robust foundation in calculus and its practical applications.

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

(i) Analytical Geometry:

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

(ii) 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

(iii) 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

(iv) 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

(v) 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

(vi) 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

(vii) Improper Integrals:

a. Improper Integral
b. Integrals and Singularities
c. Convergence of improper integrals

(viii) 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

(ix) 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. Swokowski, Onlinick & Pence, Calculus.
3. Robert T. Smith & Roland B. Minton, Calculus.
4. James Stewart, Calculus: Early Transcendentals, Brooks/Cole, USA.

COMPLEX VARIABLES & TRANSFORMS

Credits: 3+0
Pre-Requisites: Nil

DESCRIPTION

Complex Variables & Transforms covers the fundamentals of complex numbers and functions, with applications in engineering. The course explores complex differentiation and integration, including the Cauchy-Riemann equations and Cauchy's integral theorems. Students will delve into power series, conformal mappings, and residue theory, as well as Laplace transformations and their applications. Special functions and Fourier transforms are examined in depth, alongside Z-transforms and their use in solving difference equations.

COURSE LEARNING OUTCOMES

The knowledge units in this area collectively encompass the following:

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

COURSE OUTLINE

- **Introduction:**
  a. Review of complex numbers, Complex valued functions, Elementary functions (exponential and logarithmic functions, Trigonometric and hyperbolic functions and theirs inverses),
  b. Limits and continuity,
  c. Applications in Engineering
- **Complex Differentiation and Integration**
  a. Derivatives of complex valued functions, Differentiability,
  b. Analyticity, Cauchy Riemann Equations, Harmonic Functions,
  c. Complex integrals, Cauchy-Goursat Theorem, Independence of Path, Cauchy's Integral Formulas and Their Consequences, Applications
- **Power Series:**
  a. Taylor Series, Laurent Series, Singularities, Zeros and poles, Residue integration method, Residue theorem,
  b. Conformal mapping
- **Laplace Transformation:**
  a. Linearity, Scaling, First shifting theorem, Heaviside's Shifting theorem,

b. Inverse Laplace transformation, Properties of inverse Laplace,
c. Convolution theorem, Applications in relevant engineering discipline

- **Special functions and Fourier Transforms:**
  a. (Gamma, Beta functions, Periodic functions, Error function),
  b. Fourier Series, Fourier Sine and Cosine series,
  c. Fourier transform, Fourier cosine and sine transform, properties.
  d. Applications in relevant engineering discipline
- **Z-Transformation:**
  a. Z-transform, Properties of Z-transform, linearity and scaling, Standard Z-transform, Inverse Z-transform,
  b. Inverse Z- transform by using residue, convolution theorem of Z-transform,
  c. Formation of difference equation and its solution using Z-transform.

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Erwin Kreyszig, Advanced Engineering Mathematics, Latest Edition.
2. Churchill, Complex Variables and Applications, Latest Edition.
3. R. J. Beerends, Fourier and Laplace Transform, Cambridge University Press, Latest Edition.
4. Jeffry A., Advanced Engineering Mathematics, Elsevier, Latest Edition.

LINEAR ALGEBRA AND DIFFERENTIAL EQUATIONS

Credits: 3+0
Pre-Requisites: Nil

DESCRIPTION

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

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

COURSE OUTLINE

1. **System of Linear Equations and Applications**

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

2. **Vector Spaces and Transformations**

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

3. **Eigenvalues and Eigen Vectors**

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

4. **Application of Linear Algebra in Dynamical Systems**

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

5. **Basic Concepts and Modelling**

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

6. **Analytical Methods of Solution for First-order ODEs**

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

7. **Mathematical Models Based on Second-order ODEs**

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

8. **Analytical Methods of Solution for Second-order ODEs**

   a. Homogeneous linear ODEs, Method of reduction order , Wronskain determinant to check independence of the solution, and related examples

9. **Analytical Methods of Solution for Second-order ODEs**

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

10. **Laplace Transform**

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

11. **Partial Differential Equations**

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

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

NUMERICAL ANALYSIS

Credit: 2+1
Pre-Requisites: Nil

COURSE LEARNING OUTCOMES

Numerical Analysis delves into error analysis, interpolation techniques, and their applications in engineering, covering topics like Newton and Lagrange's interpolation methods. The course includes numerical differentiation and integration, exploring methods such as Trapezoidal and Simpson's rules. Students will learn solution techniques for linear and nonlinear equations, including Gauss elimination, LU factorization, and iterative methods. Additionally, the course addresses numerical methods for initial and boundary value problems, eigenvalue computations, and optimization methods, with a strong emphasis on practical engineering applications.

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)

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Richard L. Burden, J. Douglas Faires, Numerical Analysis, Latest Edition.
2. R.W. Hamming, Numerical Methods for Scientists and Engineers, Latest Edition.
3. Steven C. Chapra, R. P. Canale, Numerical Methods for Engineers, Latest Edition.

NATURAL SCIENCES DOMAIN
APPLIED PHYSICS

Credit: 2+1
Pre-Requisites: Nil

DESCRIPTION

Applied Physics covers fundamental and advanced concepts in physics with practical applications. The course begins with vector analysis, mechanics, and progresses through electrostatics and magnetism, including Gauss's and Ampere's laws. Semiconductor physics, waves and oscillations, optics and lasers are explored, along with modern physics topics like black body radiation, the photoelectric effect, and nuclear reactions. Students will engage in real-world problem-solving across various physical phenomena.

COURSE LEARNING OUTCOMES

The knowledge units in this area collectively encompass the following:

1. Apply vector calculus to solve physical problems involving gradient, divergence, curl, and integrals in various fields, including mechanics and electromagnetism.
2. Analyze and solve complex problems in mechanics, electrostatics, magnetism, semiconductor physics, and wave phenomena using fundamental principles and laws.
3. Explain and utilize the principles of modern physics, such as quantum mechanics, atomic structure, and nuclear reactions, and their applications in contemporary technologies and scientific research.

COURSE OUTLINE

Vectors:

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

Mechanics:

2. 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:

3. 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:

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

Waves And Oscillations:

5. 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:

6. 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:

7. 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.

COURSE OUTLINE (PRACTICALS)

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.

APPLIED CHEMISTRY

Credits: 2+1
Pre-Requisites: Nil

DESCRIPTION

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

COURSE LEARNING OUTCOMES

The knowledge units in this area collectively encompass the following:

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

COURSE OUTLINE

- Industrial Aspects of Inorganic Chemistry, study of selected inorganic industries, Sulfur industry, Industry dealing with nitrogen, phosphorus, chloralkaline and titanium oxide.

- Reaction mechanism and industrial applications of organic reactions such as sulfonation, Nitration, Hydrogenation, Amination, Halogenation, oxidation, polymerization.

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

COURSE OUTLINE (PRACTICALS)

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

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Applied Chemistry and Chemical Engineering" A. K. Haghi, Devrim Balkose, Omari V. Mukbaniani, Andrew G. Mercader, Apple Academic Press, 2018
2. Comprehensive Analytical Chemistry; Molecular Characterization and Analysis of Polymer, John M. Chalmers, Robert J. Meier, Elsevier **(2008)**
3. Green Chemistry in industry Mark Anthony Benvenuto, Heinz Plaumann, De Gruyter, Volume 3, 2018
4. Polymers, Polymer Blends, Polymer Composites and Filled Polymers, G. E. Zaikov, Nova **(2006)**
5. Biodegradable Polymer Blends and Composites from Renewable Resources, Long Yu, Wiley **(2008)**
6. Sustainable Industrial Chemistry: Principles, Tools and Industrial Examples.
7. Fabrizio cavani, Gabriele Centi, Siglinda Perathoner , Wiley Publishshers, 2009
8. Pavia, Lampman, Introduction to Spectroscopy, 4th edition, Brooks/Cole, 2009
9. H. Kuhn, Principles of Physical Chemistry, 2nd edition, Wiley, 2009
10. G.D. Christian, Analytical Chemistry, 7th edition, 2014, Wiley
11. D. W. H. Rankin, Norbert Mitzel, Carole Morrison, Structural Methods in Molecular Inorganic chemistry, Wiley, (2013)
12. Gary Wulfsberg, Foundations of Inorganic Chemistry, University Science Books, 2017 David Klein, Organic Chemistry , Wiley, 2017

14.2 Engineering Domain

COMPUTER SCIENCES DOMAIN

COMPUTER SYSTEM AND PROGRAMMING

Credits: 2+1
Prerequisite: Nil

DESCRIPTION

Computer Systems and Programming introduces the fundamentals of computer hardware and software, covering the history of computing, data representation, number systems, networks, memory, storage devices, and operating systems. The course also delves into basic programming concepts, including algorithms, flowcharts, pseudocode, control structures, arrays, loops, and the use of library functions and header files. Students will gain a solid foundation in both the theoretical and practical aspects of computing.

COURSE LEARNING OUTCOMES

1. Demonstrate basic knowledge of computer system, Networks, Operating System and commonly used its applications
2. Illustrate number systems, arithmetic and logic operations, binary codes, Boolean functions and their logic diagrams.
3. Apply the problem-solving skills through the use of flow charts, algorithms, and acquired knowledge to develop small scale computer programs.

Lab

1. Introduction to Computer Software's
2. Understand working and construction of various computer peripherals, Storage media and types of software.
3. Write, debug and execute programs in different programming languages

COURSE OUTLINE

Basics of Computer Software and Hardware: Computers& Applications, History of Computing, Introduction to Hardware and Software, Peripheral Devices, Data Representation, Number Systems, Conversion Methods, ASCII / Unicode, Networks, Memory, Storage Devices and operating System.

Basic Computer Programming: Algorithms, Flowcharts & Pseudocode, Assignment Operators, If Selection Statement, if Else Selection Statement, Nested Control Structures, switch Multiple-Selection Statement, Passing Arrays to Functions, Searching Arrays, loops, Library Functions and Header Files

PRACTICAL REQUIREMENT

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

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. J. Deitel, H. Deitel, C++ How to Program, 10th Edition, Pearson, 2017.
2. Peter Norton, Computer Fundamentals, 7th Edition.
3. Robert Lafore, Object-Oriented Programming in C++.
4. Nell Dale, John Lewis, Computer Science Illuminated.

APPLIED ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Credits: 2+1
Prerequisite: Nil

DESCRIPTION

Applied AI & Machine Learning course aim to equip the students' exposure to emerging trends in the field of AI and machine learning

COURSE LEARNING OUTCOMES

1. Apply problem solving techniques using machine learning in real-world situation.
2. Compare different AI-based problem-solving techniques.
3. Evaluate problem solving technique in a methodical way to establish valid conclusions

COURSE OUTLINE

Module 1:

1. Introduction to Artificial Intelligence

- **Foundations of AI**
- Introduction to the three foundations of AI (Logic, Computation and Probability).
- Make the students understand what each of the foundation encompasses.
- Examples from the real world to give a better understanding.
- **Agents and Environments**
- What are Agent and Environment?
- Description of Human Agent, Robotic Agent and a Software Agent.
- Introduction to performance of measure of an agent, behavior, percept, percept sequence and agent function.
- Types of Agents Simplex reflex agents, Model based reflex agents, Goal based agents and utility-based agents.
- Description of nature of environments.
- Properties of environments: Discrete/Continuous, Observable/Partially observable, Static/Dynamic, Single agent / Multiple agents, Accessible / Inaccessible, Deterministic / Non-deterministic, Episodic / Non-episodic.
- **Structure of Agents**
- Introduction to the three main components of an intelligent agent.
- Architecture
- Sensors
- Actuators
- Effectors
- Agent Function
- Agent program

- **Problem Solving Agents**
- Goal-based agents
- static world
- observable environment
- discrete states
- deterministic environment

- **Probability basics**
- To learn the concept of the sample space associated with a random experiment.
- To learn the concept of an event associated with a random experiment.
- To learn the concept of the probability of an event.

2.Reasoning and Knowledge Representation

- Introduction to Reasoning and Knowledge Representation
- Overview of reasoning and knowledge representation.
- Relationship between reasoning and knowledge
- Characteristics: Primitives, Meta-representation, Incompleteness, Definitions and universals vs. facts and defaults, non-monotonic reasoning, Expressive adequacy, Reasoning efficiency.
- What to represent in knowledge. (Object, event, performance, meta knowledge, facts, knowledge base)
- Types of knowledge
- Declarative Knowledge
- Procedural Knowledge
- Meta-knowledge
- Heuristic knowledge
- Structural knowledge

- **Propositional Logic**
- Introduction
- Basic examples
- Facts about propositional logic
- Syntax of propositional logic
- Logical connectives (AND, OR, if only if, implies, NOT)
- Truth tables
- Precedence of connectives
- Logical equivalence
- Properties
- Limitations
- **First order Logic**
- Introduction
- Examples

- Basic elements (constants, predicates, functions, variables, connectives, equality, quantifiers)
- Atomic Sentences
- Quantifiers in FOL (universal, existential)
- Properties of Quantifiers
- Free and Bound variables

- **Reasoning with Uncertainty & Probabilistic Reasoning**
- What is uncertainty?
- Causes of uncertainty
- Probabilistic Reasoning
- Need of Probabilistic reasoning in AI
- Simple Probability
- Conditional Probability
- Examples

- **Acting Under Uncertainty**
- Introduction
- Examples
- Need for acting under uncertainty
- Proposed methods

3. State estimation and uncertainty filters

- **Bayes Filters**
- Introduction
- Data
- Goal
- Models
- Graph
- Math
- Algorithm
- Limitations
- Example

- **Gaussian Filters**
- Introduction
- Need for Gaussian Filters
- Types of gaussian Filters
- Mathematical representation and it implementation
- Kalman Filter (introduction, variation from gaussian filters, working of Kalman filter)
- Limitations of gaussian Filters

- **Particle Filters**
- Introduction
- Need for Particle filter
- Basic principle of working (Heuristic like algorithms)
- Mathematical representation of particle filters
- Advantages of Particle filters
- Example from real world
- Limitations of particle filters

Module 2:

1.Machine Learning

- **Linear and Logistic Regression**
- Introduction to linear and logistic regression.
- Gradient descent
- What is activation function
- Activation function of linear and logistic regression.
- Limitations of both techniques
- Difference between the two techniques.
- Examples

- **Multiclass Classification and Regularization**
- What is multiclass classification?
- Linear and logistic regression with multiple variables for multi class classification.
- Examples
- Overfitting and underfitting
- Bias and Variance
- What is Regularization
- Regularization Techniques

- **Neural Networks**
- What is a neural network?
- How do neural networks work?
- Representations
- Learning
- Types of neural networks
- Neural networks vs. deep learning
- Related solutions
- Representations
- Learning
- Model Selection
- Evaluation (F1 score, accuracy, precision, recall)

- **Unsupervised Learning**
- Why use Unsupervised Learning?
- Working of Unsupervised Learning
- Types of Unsupervised Learning Algorithm
- Clustering
- Association
- **Unsupervised Learning algorithms**
- K-means clustering
- KNN (k-nearest neighbors)
- Hierarchal clustering
- Anomaly detection Neural Networks
- Principle Component Analysis
- Independent Component Analysis
- Apriori algorithm
- Singular value decomposition
- Advantages of Unsupervised Learning

- **Bayesian Systems**
- Introduction
- Need for Bayesian systems
- Advantages of Bayesian systems
- Types of Bayesian Systems
- Maximum Likelihood, Least-Squared Error Hypotheses
- Minimum Description Length Principle
- Bayes Optimal Classifier and Gibbs Algorithm
- Bayesian Belief Networks

- **Reinforcement Learning**
- Introduction
- Need for Bayesian systems
- Advantages of Bayesian systems
- Types of Bayesian Systems
- Q-learning
- Temporal Difference Learning
- Relationship to Dynamic Programming

Module 3:

1. Artificial Intelligence

- **Uninformed Search**
- What is uninformed Search

o Need for uninformed search
o Types
1. Breadth-first Search
2. Depth-first Search
3. Depth-Limited Search Algorithm
4. Uniform-cost Search Algorithm
5. Iterative deepening depth-first Search
6. Bidirectional Search Algorithm
o Detailed description of algorithm of each type of search
o Time and space complexity
o Advantages and disadvantages

• **Informed Search**
o What is informed Search
o Need for informed search
o Types
o Pure Heuristic Search
1. Best First Search Algorithm (Greedy search)
Detailed algorithm description with example
Space and time complexity
Advantages and disadvantages.

2. A* Search Algorithm
Detailed algorithm description with example
Space and time complexity
Advantages and disadvantages.

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Russell S., Norvig P., Artificial Intelligence – A Modern Approach, Latest Edition, Prentice Hall.
2. Luger G.F., Artificial Intelligence – Structures and Strategies for Complex Problem Solving, Latest Edition, Pearson Higher Education.
3. Hal Daume III, A Course in Machine Learning.
4. Tom M. Mitchell, Machine Learning.
5. Aurelien Geron, Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, 1st Edition, March 2017.

ENGINEERING DRAWING & GRAPHICS

Credits: 1+1
Prerequisite: Nil

DESCRIPTION

Computer Systems and Programming introduces the fundamentals of computer hardware and software, covering the history of computing, data representation, number systems, networks, memory, storage devices, and operating systems. The course also delves into basic programming concepts, including algorithms, flowcharts, pseudocode, control structures, arrays, loops, and the use of library functions and header files. Students will gain a solid foundation in both the theoretical and practical aspects of computing.

COURSE LEARNING OUTCOMES

1. Be able to understand technical part and assembly two dimensional drawings.
2. Be able to draw part and assembly drawings with sectional views using proper dimensioning techniques.

Learning Domains and Levels:

Maximum Level of Cognitive Domain	Maximum Level of Affective Domain	Maximum Level of Psychomotor Domain
C-3	A-2	P-3

1. Acquire the basic knowledge of drawing skills.
2. Apply the concepts of basic drawing techniques.
3. Analyze and explain the drawing schemes and dimensioning systems and apply the same for design of components.

Lab

1. Practice the basics of drawing skills.
2. Analyze and Apply the basic principles of engineering drawing to develop orthographic projections of different mechanical components.
3. Able to Communicate using acquired Drawing Techniques.

COURSE OUTLINE

Graphic Instruments and their use, Graphic geometry, Lettering, orthographic drawing, auxiliary views, sectional views and conventions, dimensions, notes, limits and precision, surface intersections, fundamentals of design, jigs fixtures, cams (optional), drawings for engineering design and construction (optional), welding representation.

PRACTICAL REQUIREMENT

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Thomas Ewing French, Charles J. Vierck, Robert Jay Foster, Engineering Drawing and Graphic Technology, Published by McGraw Hill.
2. Frederick E. Giesecke, Ivan L. Hill, Technical Drawing with Engineering Graphics, Published by Peachpit Press.
3. David A. Madsen, David P. Madsen, Engineering Drawing and Design, Published by Cengage Learning, 2016.
4. Dhananjay Jolhe, Engineering Drawing with an Introduction to AutoCAD, Published by Tata McGraw Hill.

WORKSHOP PRACTICE

Credits: 1+1
Prerequisite: Nil

DESCRIPTION

Workshop Practice introduces hands-on skills in various manufacturing and fabrication techniques, including benchwork, fitting, electrical shop tasks, casting, machining, welding, sheet metal work, carpentry, blacksmithing, and foundry operations. The course covers primary and secondary shaping processes, metal joining methods, and surface finishing. Students will also learn about modern tool usage, such as die casting and metal casting, essential for practical engineering applications.

COURSE LEARNING OUTCOMES

Learning Domains and Levels:

Maximum Level of Cognitive Domain	Maximum Level of Affective Domain	Maximum Level of Psychomotor Domain
C4	A2	P4

1. Identify different defects in timber and explain seasoning methods along with conversion techniques.
2. Describe tools/accessories and processes in fitting shop and electric Shop.
3. Explain the lathe machine operations.
4. Discuss types of welding, forging, and casting.
5. Prepare a project report to discuss various manufacturing processes.

Lab

1. Apply different workshop tools to perform various operations in machine, carpentry, and electric shops
2. Perform various operations in machine, carpentry, and electric shops to accomplish lab work under supervision
3. Respond to emergency situations and application of first aid box in machine, carpentry, and electric shops
4. Organize the work in team to arrange the Open-Ended Lab tasks.

COURSE OUTLINE

hand-working processes such as benchwork, fitting, electrical shop, Casting, Machining, arc welding, sheet metal work, carpentry, black smithy and foundry, primary and secondary shaping processes, metal joining methods, surface finishing.

Modern Tool usage:

Die Cast, Metal Cast

PRACTICAL REQUIREMENT

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Bruce J. Black, Workshop Processes, Practices and Materials.
2. C.S. Baladhiya & J.B. Raol, Workshop Practice.

ENGINEERING MECHANICS-I (STATICS)

Credits: 2+1
Prerequisite: Nil

DESCRIPTION

Engineering Mechanics-I (Statics) introduces fundamental concepts of mechanics, including force systems, equilibrium conditions, and structural analysis. Topics cover force vectors, moments, free body diagrams, equilibrium in two and three dimensions, trusses (2D and 3D), frames, machines, friction, and center of gravity. The course provides a solid foundation in statics essential for understanding structural and mechanical systems.

COURSE LEARNING OUTCOMES

1. Understand the basic concepts of vectors and scalars, forces, moments and couple
2. Apply the learned concepts of forces, moments and couples to solve problems of equilibrium in 2D and 3D
3. Investigate engineering structures such as trusses, frames and machines

COURSE OUTLINE

Introduction to Mechanics

Force System, Introduction to force system, force vectors, rectangular components, Free body diagrams, moment, couple and resultants (two-dimensional force systems),

Equilibrium

Mechanical system isolation and equilibrium condition in two dimensions

Equilibrium conditions-equilibrium in three dimensions,

Structures

Trusses 2D and 3D

Plane trusses

Method of joints

Method of sections and space trusses

Frames and machines,

Friction

Types of friction

Center of gravity

PRACTICAL REQUIREMENT

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. J L Meriam, L G Kraig, Engineering Mechanics (Statics), John Wiley & Sons Inc.
2. Beer & Johnston, Vector Mechanics for Engineers: Statics & Dynamics, McGraw Hill.
3. RC Hibbeler, Engineering Mechanics (Statics), Prentice Hall.
4. Anthony M Bedford, Wallace Fowler, Engineering Mechanics (Statics), Prentice Hall.
5. E. Nelson, Engineering Mechanics: Statics, Schaum's outline series, New York.

ENGINEERING MECHANICS-II (DYNAMICS)

Credits: 2+0
Prerequisite: Nil

DESCRIPTION

Engineering Mechanics-II (Dynamics) delves into Newtonian mechanics, covering kinematics and kinetics of particles and rigid bodies. Topics include rectilinear, curvilinear, and constrained motion, along with equations of motion, work-energy principles, linear impulse and momentum, impact analysis, angular momentum, and motion relative to moving reference frames. This course provides a comprehensive understanding of dynamic systems and their behavior in engineering applications.

COURSE LEARNING OUTCOMES

1. Comprehend the concepts related to the motion of a particle and rigid body in terms of kinematics and kinetics principles
2. Analyse the kinematics/kinetics problems
3. Build a mini-project to exhibit the learned concepts in the semester

Lab

1. Perform experiments to demonstrate the effect of force and moment.
2. Build a truss structure for the given parameters.
3. Able to communicate the learned concepts orally.

COURSE OUTLINE

1. **Introduction to subject and Basic Concepts**
   a. Fundamental principles of Newtonian mechanics
2. **Kinematics of Particles**
   a. Rectilinear Motion
   b. Plane Curvilinear Motion
   c. Space Curvilinear Motion
   d. Motion Relative to Trans Axes
   e. Constrained Motion of Connected Particles
3. **Kinetics of Particles**
   a. Second Law & Equation of Motion
   b. Work and Energy
   c. Linear Impulse and Momentum
   d. Impact
   e. Angular Momentum
4. **Kinematics of Rigid Bodies**
   a. Plane Motion

b. Relative Velocity
c. Relative Acceleration

5. **Kinetics of Rigid Bodies**
   a. Kinetics of Rigid Bodies
6. **Motion relative to moving reference frames**

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. J L Meriam, L G Kraig. Engineering Mechanics (Dynamics), John Wiley & Sons Inc.
2. Beer & Johnston. Vector Mechanics for Engineers: Statics & Dynamics, McGraw-Hill.
3. RC Hibbeler. Engineering Mechanics (Dynamics), 13th Ed., Prentice Hall.
4. Anthony M Bedford, Wallace Fowler. Engineering Mechanics (Dynamics), Prentice Hall.
5. E. Nelson, Engineering Mechanics: Statics, Schaum's Outline Series, New York.

MATERIALS ENGINEERING

Credits: 2+0
Prerequisite: Nil

DESCRIPTION

Materials Engineering delves into the fundamentals of materials science, covering atomic bonding, crystalline structures, imperfections, and mechanical properties. The course also explores phase diagrams, phase transformations, and the development of microstructures. Additionally, it discusses the applications, processing, and testing of metallic, non-metallic, and composite materials, along with corrosion prevention methods and material degradation.

COURSE LEARNING OUTCOMES

1. Explain different material types in terms of bonding and crystal structure
2. Read and analyze Phase-Diagrams and effects of heat treatments on microstructure and mechanical properties of ferrous materials
3. Categorize the metallic materials, polymer, and composite based on structure, properties, and application
4. Describe materials effects in terms of environment and sustainability

COURSE OUTLINE

- Introduction to materials science and engineering
- Atomic bonding
- Structure and properties of crystalline solids (BCC, FCC, HCP)
- Imperfections in solids
- Mechanical properties of materials
- Phase diagrams
- Phase transformation and development of microstructures
- Applications and processing of metallic and non-metallic materials
- Structures, properties and applications of polymer materials
- Composite materials
- Destructive and non-destructive testing of materials
- Corrosion, corrosion types, and corrosion prevention methods
- Degradation of materials

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. William D. Callister, David G. Rethwisch. Materials Science and Engineering, Eighth Edition, SI Version, John Wiley & Sons.
2. William F. Smith. Introduction to Engineering Materials.
3. Roy A. Lindberg. Processes and Materials of Manufacturing.

FLUID MECHANICS-I

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

This course develops the basics of fluid mechanics and a prerequisite for subsequent courses in the thermal-fluid area. The course defines a fluid, describes its properties, and derives governing equations from basic principles. It also supports the students in mathematical development. Both integral and differential approaches are presented and simplifying assumptions and equations are discussed and applied.

COURSE LEARNING OUTCOMES

1. Understand the basic fluid properties, concepts of fluid statics, dynamics, and dimensional analysis.
2. Apply relevant governing equations to solve various engineering problems of fluid statics and dynamics.
3. Analyze various phenomena of fluid statics and dynamics through detailed design calculations.

COURSE OUTLINE

Introductory Concepts

- Dimensions, units, fluid mass and weight,
- Compressibility, vapor pressure, viscosity, surface tension

Fluid Statics

- Pressure, hydrostatic force on plane and curved surface
- Manometers, Plane and inclined manometers
- Buoyancy and Archimedes Principle

Elementary Fluid Dynamics

- Stream lines
- Bernoulli's Equation along the streamline and across the streamline
- Application of Bernoulli's Equation
- Static, stagnation and total Pressure and pitot tube
- Hydraulic grade line and energy grade line
- Assumption of Bernoulli's equation

Fluid Kinematics

- Velocity field, acceleration field, control volume,

- Material Derivative
- Reynolds's transport theorem

Finite Control Volume Analysis

- Conservation of Mass for a Control Volume
- Derivation and application of linear momentum equation
- Derivation and application of momentum of momentum equation
- Derivation and application of energy equation
- Comparison of equations

Differential Analysis of Fluid Flow

- Overview of types of motion and deformation a fluid element
- Differential form of continuity equation
- The stream function
- Deriving the equations of motion

Dimensional Analysis, Similitude, and Modeling

- Dimensional Analysis
- Buckingham Pi Theorem

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Munson, Bruce R., Donald F. Young, Theodore H. Okiishi, Wade W. Huebsch. Fundamentals of Fluid Mechanics, 6th Edition, John Wiley & Sons, Inc.
2. Çengel, Yunus A., John M. Cimbala. Fluid Mechanics: Fundamentals and Applications, 3rd Edition, McGraw-Hill.
3. Philip J. Pritchard, John C. Leylegian. Fox and McDonald's Introduction to Fluid Mechanics, J. Wiley & Sons.

MECHANICS OF MATERIALS-I

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

Mechanics of Materials-I delves into equilibrium principles, material behavior, and load types, covering direct stresses and strains, Hooke's law, and mechanical properties. The course also includes thermal stresses, failure modes, and stresses in simple and composite bars, along with torsion, bending stresses, beam deflection, and shear stresses in beams using various methods. Students gain a comprehensive understanding of structural analysis and material behavior under different conditions.

COURSE LEARNING OUTCOMES

1. Comprehend the mechanical properties of materials under loading conditions.
2. Compute the stresses and strains in mechanical structures.
3. Analyze problems related to bending, torsion and deflection in mechanical structures.

COURSE OUTLINE

- Three basic principles of equilibrium, geometric compatibility, and material behavior
- Types of loads
- Direct stresses and strains, shear stress & strain, elasticity, plasticity
- Hooke's law, stress strain relationship
- Mechanical properties of materials (fatigue, creep, hardness, stiffness, etc.)
- Thermal stresses
- Failure modes
- Stresses in simple bars
- Stresses in composite bars
- Moment of inertia
- Torsion of circular bars
- Shearing force and bending moment diagrams
- Bending stresses
- Beam deflection using various methods
- Shear stresses in beams

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Gere. Mechanics of Materials, Sixth Edition.
2. Hibbeler, R. C. Mechanics of Materials, Eighth Edition.
3. Rajput, R. K. Strength of Materials.
4. Nag, Debabrata, Abhijit Chanda. Mechanics of Materials.
5. Beer, Ferdinand P., Russel Johnston Jr. Mechanics of Materials, McGraw-Hill.

THERMODYNAMICS-I

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

Thermodynamics is an engineering science linked to most mechanical engineering applications. This course provides an introduction to the thermodynamic concepts, required in courses to follow as well in professional applications. The objective of the course is to develop understanding of energy systems such as engines and refrigeration systems.

COURSE LEARNING OUTCOMES

1. Describe the nature and role of the thermodynamic properties of matter and thermodynamic processes on appropriate thermodynamic diagrams.
2. Apply energy and entropy balances to the closed and open systems.
3. Analyze thermodynamic power cycles using air standard assumptions, energy principles, and property diagrams.

COURSE OUTLINE

Introductory Concepts

- Using Thermodynamics, Defining System
- Describing System and their Behavior
- Measuring Mass, Length and Force
- Specific Volume and Pressure

Energy and First Law of Thermodynamics

- Energy, Energy Transfer by Heat
- Energy Balance for Closed Systems
- Energy Analysis of Cycles

Evaluating Properties

- Fixing the states, p-v-T Relationships
- Retrieving Thermodynamics Properties
- Generalized Compressibility Charts
- Ideal Gas Model
- Internal Energy, Enthalpy, and Specific Heats of Ideal Gases
- Evaluating change in Δu and Δh
- Polytropic Process of an Ideal Gas

Control Volume Analysis Using Energy

- Conservation of Mass for a Control Volume
- Conservation of Energy for a Control Volume
- Analyzing Control Volumes at Steady states
- Transient Analysis

The Second Law of Thermodynamics

- Introducing the Second Law
- Identifying the Irreversibility
- Applying the Second Law to Thermodynamics Cycles
- Defining the Kelvin Temperature Scale
- Maximum Performance Measures for Cycles Operating between Two Reservoirs
- Carnot Cycle

Entropy

- Introducing Entropy, Defining Entropy Change
- Retrieving Entropy Data
- Entropy changes in Internally Reversible Processes
- Entropy Balance for Closed Systems
- Entropy Rate Balance for Control Volumes
- Isentropic Efficiencies of Turbines, Nozzles, Compressors, and Pumps
- Heat Transfer and Work in Internally Reversible, Steady-States Flow Processes

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Moran, Shapiro. Fundamentals of Engineering Thermodynamics, 6th Edition.
2. Cengel, Boles. Thermodynamics: An Engineering Approach, 6th Edition.
3. Sontagg, Borgnakke, Van Wylen. Fundamentals of Thermodynamics, 6th Edition.

COMPUTER AIDED DRAWING

Credits: 0+1
Prerequisite: Engineering Drawing and Graphics

COURSE LEARNING OUTCOMES

1. To understand the basic concepts of 2D drawings and 3D models using CAD tools.

2. To generate 3D models of different shapes.

Learning Domains and Levels:

Maximum Level of Cognitive Domain	Maximum Level of Affective Domain	Maximum Level of Psychomotor Domain
C-4	A-3	P-3

1. Use the computer based graphics to sketch mechanical components drawings.
2. Explain the concept of modeling tools used in the respective experiment.
3. Present the portfolio of modeled parts.

COURSE OUTLINE

Sketch Entities including Lines, Rectangles, Parallelogram, Circles, Arcs, Polygons, Sketch Editing Tool including Trimming, Extend Entities, Offset Entities, Move Entities, Copy Entities, Rotate Entities, Scale Entities, Stretch Entities, Mirror Entities, Linear Sketch Pattern, Circular Sketch Pattern, Building 3D Geometry including Extruded Boss/Base, Revolved Boss/Base, Lofted Boss/Base, Sweep Boss/Base, Mirroring, Linear Pattern, Circular Pattern, Removing Materials in 3D Geometry (Extruded Cut, Revolve Cut, Lofted Cut, Sweep Cut, Fillet and Chamfer, Shell, Draft), Assembly, Internal and External Threads, Drawing Template, Sheet Metal Work, Working with Equations.

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. SolidWorks Corporation. SolidWorks Essentials, Parts and Assemblies.
2. SolidWorks Corporation. SolidWorks Essentials, Drawings.
3. Thomas E. French, Charles J. Vierck, Robert J. Foster. Engineering Drawing and Graphic Technology, 14th Edition. McGraw-Hill, Inc.

MECHANICS OF MACHINES

Credits: 2+0
Prerequisite: Nil

DESCRIPTION

This course is about the design and synthesis of mechanisms, machines and the underlying concepts of kinematics. It starts with the discussion about fundamental concepts, for example links, joints, kinematics chains and degrees of freedom of the planar mechanisms. Special emphasis is given to enhance the student capability in building analytical models of mechanisms. This will enable students to characterize the mechanisms before making or bringing the mechanisms into realization.

COURSE LEARNING OUTCOMES

1. Apply the kinematic fundamentals for the graphical synthesis of linkages.
2. Analyze the position, velocity and acceleration of different mechanisms using graphical and analytical techniques.
3. Design and analyze mechanisms using linkages, cam-follower systems, gear trains and relate their analytical and graphical solutions

COURSE OUTLINE

Introduction to Mechanisms

Machine & Mechanisms, Mechanism Terminology, Kinematic Diagram, Kinematic Inversion, Four Bar Mechanism, Slider Crank Mechanism, Techniques of Mechanism Analysis

Vector, Position and Displacement Analysis

Motion, Vectors, Analytical Vector Methods Applied to the Displacement Analysis of Planar Linkages, Graphical Analysis, Complex-Number Methods Applied to the Displacement Analysis of Linkages, Spatial (Three-Dimensional) Linkages, Computer-Implemented Numerical Methods of Position Analysis

Velocity Analysis of Mechanisms

Average Speed in Mechanize Mechanism, Velocity of a Point in Mechanize Mechanism, Angular Velocity in Mechanize Mechanism, Motion of a Rigid Body about a Fixed Axis (Without Translation), Moving Coordinate Systems and Relative Velocity, Application of Analytical Vector and Matrix Methods to Linkages, Four-Bar Linkage, Complex-Number Methods Applied to Velocity Analysis

Acceleration Analysis of Mechanisms

Planar Motion, Spatial Motion, Relative Acceleration, Analysis of a Four-Bar Linkage by Analytical Vector Methods, Acceleration Analysis, Position Analysis, The Acceleration Polygon, Graphical Analysis of the Four-Bar Linkage, An Analytical Solution Based on the Acceleration Polygon, Graphical Analysis of Sliding Contact Linkages, Trial Solution Method Applied to Linkage Acceleration Analysis, Spatial Linkages, Acceleration Analysis of an RSSR

Design & Development Mechanism Design

Time Ratio, Timing Charts, Design of Slider Crank Mechanism, Design of Crank Shaper Mechanism, Mechanism to Move a Link Between Two Positions

Cams

Types of Cams & Followers, Follower Motion Schemes, Graphical Disk Cam Profile Design, Pressure Angle, Design Limitations

Governors

Types of Governors, Centrifugal Governors, Porter Governors, Parallel Governors, Spring Loaded Governors

Gears

Toothed Gearing, Gear Trains

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. David H. Myszka. Machines and Mechanisms.
2. Thomas Bevan. The Theory of Machines.
3. John J. Uicker, Gordon R. Pennock, Joseph E. Shigley. Theory of Machines and Mechanisms.
4. Robert Ferrier McKay. The Theory of Machines.
5. J. A. Collins. Mechanical Design of Machine Elements and Machines. J. Wiley.
6. W. B. Green. Theory of Machine.
7. R. L. Norton. Design of Machinery.

FLUID MECHANICS-II

Credits: 2+0
Prerequisite: Fluid Mechanics-I

DESCRIPTION

This course teaches two- and three-dimensional ideal fluid flow Potential flow, circulation, stream function and velocity potential, uniform flow, two dimensional source and sink, vortex, the doublet, lift and drag forces. Two- and three-dimensional viscous fluid flow Navier stokes equations of motion, two dimensional flow between parallel plates, flow in a circular pipe, creep flow, Reynold's equation, and hydrodynamic lubrication in journal bearing. Boundary layer theory Boundary layer theory, laminar & turbulent boundary layers, boundary layer control, airfoil cascades. Fluid machinery Similarity relations for turbo machines, specific speed, classification of turbo machines, impulse turbines, reaction turbines, hydraulic jacks, pumps and their performance curves.

COURSE LEARNING OUTCOMES

1. Apply governing equations to incompressible fluid flows
2. Design and Analyze the performance of various hydraulic devices

Lab

1. Perform the experiments and apply the fluid mechanics equations.
2. INVESTIGATE various fluid flow parameters using experimental setup and construct the characteristics curves of hydraulic machines
3. Respond against subject oriented knowledge affectively

COURSE OUTLINE

Viscous flow in Pipes

- Various characteristics of the low in pipes.
- Laminar and turbulent pipe low.
- Losses in straight portions of pipes as well as those in various pipe system components.
- Equations and principles to analyze a variety of pipe flow situations.
- Flowrate in a pipe by use of common flowmeters.

Flow over Immersed Bodies

- The features of external flow.

- Fundamental characteristics of a boundary layer, including laminar, transitional, and turbulent regimes.
- Boundary layer parameters for flow past a flat plate.
- Boundary layer separation.
- Lift and drag forces for various objects

Compressible flows

- Incompressible and compressible flows, and know when the
- Approximations associated with assuming fluid incompressibility.
- Categories of compressible
- Flows of ideal gases.
- Speed of sound and Mach number and their practical significance.
- Problems involving isentropic and non-isentropic flows including flows across normal shock waves.

Turbo-machines

- How and why a turbomachine works.
- Basic differences between a turbine and a pump.
- The importance of minimizing loss in a turbomachine.
- Class of turbomachine for a particular application.
- Fundamentals of sensibly scaling turbomachines that are larger or smaller than a prototype.
- Advanced engineering work involving the fluid mechanics of turbomachinery (e.g., design, development, research).

CFD – Six Lectures

- Introduction to CFD
- How CFD works?
- Domain discretization and boundary conditions
- Finite Volume Method (FVM)
- Using FVM to solve convection diffusion problems

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Fluid Mechanics by Munson, 7th Edition, John Wiley & Sons.
2. Fluid Mechanics: Fundamentals and Applications by Yunus A. Çengel, 3rd Edition, McGraw-Hill Education.

MANUFACTURING PROCESSES

Credits: 2+1
Prerequisite: Workshop Practice

DESCRIPTION

This course teaches about manufacturing processes like "Metal Casting Process & Equipment. Molding and molding sands, foundry practices, casting and its types, pattern and pattern making, molding tools and foundry equipment, permanent mold casting. "Forming & Shaping Plastics & Composite Materials. Extrusion, injection molding, blow molding, thermo-forming, processing elastomers, polymer foam processing and forming, processing metal matrix and ceramic matrix composites. "Powder Metallurgy. Production of metal powders, compaction, sintering, design considerations. "Forming & Shaping Processes and Equipment. Rolling, various rolling processes and milling, Extrusion and Drawing, Extrusion and drawing equipment, Forging. "Sheet Metal Forming. Sheet metal characteristics and formability, bending sheet and plate, tube bending, deep drawing, supper plastic forming, equipment for sheet metal forming.

COURSE LEARNING OUTCOMES

Learning Outcomes:

1. Recall the basic knowledge of workshop practice and learn manufacturing processes via shaping, forming, joining, machining, additive manufacturing in more depth and extent.

2. Identification of the known and unknown parameters in Manufacturing Processes and making efficient use of boundary conditions to solve problems.

3. Redesign and develop products by selecting/Applying appropriate manufacturing processes and analyzing the conditions.

Learning Domains and Levels:

Maximum Level of Cognitive Domain	Maximum Level of Affective Domain	Maximum Level of Psychomotor Domain
C-4	A-3	P-3

1. Describe casting and recommend the techniques for surface treatment of ferrous and non-ferrous metals.

2. Design a machining process by analyzing the tool types, material properties, and machine characteristics.
3. Design a method for processing for bulk metallic deformation and sheet metal shaping.
4. Structure a process for electronics, MEMS and NEMS fabrication.
5. Apply rapid prototyping and modern manufacturing techniques to develop functional prototypes.

Lab

1. Choose manufacturing parameters and select appropriate tools to manufacture the parts.
2. Develop a workflow to make parts by introducing advanced manufacturing processes.
3. Practice to make a mechanical assembly by applying appropriate welding techniques.

COURSE OUTLINE

Introduction to metal processing and manufacturing processes, structure and properties of metals, casting and molding, stress strain analysis, forging and its analysis, extrusion process and its analysis, wire and bar drawing, sheet rolling and its analysis, conventional machining turning, milling, grinding, non-conventional and precision machining processes, adhesive and joining processes, composite manufacturing processes, additive manufacturing techniques, economic modelling and cost analysis, process selection

PRACTICAL REQUIREMENT

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

Text Book:

1. Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes and Systems, John Wiley.
2. S. Kalpakjian, S. R. Schmid, Manufacturing Processes for Engineering Materials, Pearson.
3. Stanley A. Komacek, Ann E. Lawson, Andrew C. Horton, Manufacturing Technology, Glencoe/McGraw-Hill.

Recommended Reference Books:

1. B. Beddoes, Principles of Metal Manufacturing.
2. Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight, Product Design for Manufacture and Assembly.

MACHINE DESIGN -I

Credits: 2+0
Prerequisite: Nil

DESCRIPTION

Machine Design and CAD-I is the first course offered to ME students that introduces them with the design standards and designs of basic machine components. The course first introduces the philosophy of design procedure and design standards and then gradually covers the design of common machine elements. The students are expected to prepare professional quality solutions and communicate theresults of analysis and design, effectively

COURSE LEARNING OUTCOMES

1. Understand the principles and the process for design of machine elements like keys, couplings, brakes, clutches, and flywheeels.
2. Analyze the machine design problems which is interrelated to fastening techniques and power transmitting shafts.
3. Present the design aspects effectively through oral presentation.

COURSE OUTLINE

Introduction
- Design philosophy 2. Types of design

Mechanical behavior of materials
- Concepts of stress and strain
- Different types of stress and strain in a machine element
- Stress-strain diagram
- Actual and permissible stresses
- Factor of safety Design of keys and coupling

Design of Riveted joints, Welded joints, Bolted joints
- Basic concepts
- Methodology Design of Riveted joint

Design of Springs, Shafts
- Basic concepts
- Methodology

Metal fits and tolerances and Design Standards
- Basic concepts of tolerance
- Types of fits
- ISO standard fits charts

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Robert L. Mott, Machine Elements in Mechanical Design.
2. Robert L. Norton, Design of Machinery.
3. R. S. Khurmi, J. K. Gupta, A Textbook of Machine Design.
4. Joseph E. Shigley, Theory of Machines & Mechanisms.

THERMODYNAMICS-II

Credits: 2+0
Prerequisite: Thermodynamics-I

DESCRIPTION

This course teaches the application of Thermodynamics and prepares students for subsequent courses in the thermal-fluid area. The course prepares the student to apply the principles of Thermodynamics in power plants and Refrigeration cycles systems. It also supports the students in mathematical development. Both integral and differential approaches are presented and simplifying assumptions and equations are discussed and applied.

COURSE LEARNING OUTCOMES

This course based on the application of Thermodynamics and is a pre-requisite for subsequent courses in the thermal-fluid area. The course prepares the student to apply the principles of Thermodynamics in power plants and Refrigeration cycles systems. It also delivers the concepts in mathematical model development, both in integral and differential approaches with simplifying assumptions and equations.

1. Describe the construction/working of thermal machinery using the fundamentals of thermodynamics.
2. Analyze different thermodynamic systems applying fundamental laws and compatibility equations.
3. Apply the thermodynamic property relations to study the gas mixtures.

Lab

1. Demonstrate the fundamental principles of thermodynamics by operating the related apparatus and analyzing the experimental data.
2. Discuss the construction and working of various types of internal combustion engines.
3. Perform the experiments and investigate the related parameters using thermal machinery (Gas nozzle, Positive Displacement, Turbine, Compressors and Boilers).

COURSE OUTLINE

Exergy Analysis

- Defining exergy, Closed system exergy balance
- Flow exergy, Exergy rate balance for control volumes
- Exegetic (Second Law) efficiency

Vapor Power Systems

- Modeling and analyzing vapor power systems
- Superheat and reheat
- Regenerative vapor power cycle

Gas Power Systems

- Air-Standard-Otto cycle, -Diesel cycle, -Dual cycle, -Brayton cycle
- Regenerative gas turbines with reheat & inter cooling
- Gas turbines for aircraft propulsion
- Combined cycle, Ericsson and Stirling cycles
- Nozzles and Compressors

Refrigeration and Heat Pump Systems

- Vapor refrigeration systems, Cascade and multistage systems
- Absorption refrigeration, Gas refrigeration systems
- Heat pump systems and

Ideal Gas Mixtures and Psychometric Applications

- Mixture composition
- p-V-T relations for ideal gas mixtures
- U, H, S and specific heats for ideal gas mixtures
- Psychrometric principles and charts
- Analyzing air-conditioning processes
- Cooling towers

Reacting Mixtures and Combustion

- Combustion process
- Conservation of energy in reacting systems
- Adiabatic flame temperature
- Fuel cells

SUGGESTED INSTRUCTIONAL/ READING MATERIALS

1. Moran, M. J., & Shapiro, H. N., Fundamentals of Engineering Thermodynamics, 6th Edition, John Wiley & Sons.
2. Çengel, Y. A., & Boles, M. A., Thermodynamics: An Engineering Approach, 6th Edition, McGraw-Hill Education.
3. Sonntag, R. E., Borgnakke, C., & Van Wylen, G. J., Fundamentals of Thermodynamics, 6th Edition, John Wiley & Sons.

MECHANICS OF MATERIALS-II

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

This course continues the development of elastic solid mechanics. Areas covered are shear stresses in bending, stress transformation and principal stresses, deflection of statically determinate beams and an introduction to the analysis of statically indeterminate beams, elastic buckling of columns. Engineering design concepts are integrated throughout the course.

COURSE LEARNING OUTCOMES

1. Analyze stresses and strains to be used in mechanical engineering applications for two- and three- dimensional cases.
2. Identify techniques to solve problems regarding failure of materials under various conditions.
3. Exhibit the presentation skills on assigned topics.

Lab

1. Perform the experiments to investigate the mechanical properties of materials under various loading conditions.
2. Investigate the experimental parameters as individual and team work.
3. Communicate the acquired concepts orally

COURSE OUTLINE

- Analysis of statically indeterminate beams.
- Thin and thick curved bars.
- Thin walled pressure vessels.
- Analysis of stresses and strains.
- Stress transformation equations.
- Principle planes & principle stresses, principal strains.
- Mohr's Circle for Stresses and strains.
- Stresses and strains in Columns.
- Introduction to Thin Walled Pressure Vessels (cylindrical and spherical).
- Introduction to Thick cylinders and Compound Cylinders.
- Introduction to fracture mechanics.
- Principal of Virtual Work.
- Theories of failure.

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Beer, F. P., & Johnston, R., Mechanics of Materials, McGraw-Hill.
2. Gere, J. M., Mechanics of Materials, 6th Edition.
3. Hibbeler, R. C., Mechanics of Materials, 8th Edition.
4. Rajput, R. K., Strength of Materials.
5. Nag, D., & Chanda, A., Mechanics of Materials.
6. Benham, P. P., & Crawford, R. J., Mechanics of Engineering Materials, Longman.

MACHINE DESIGN-II

Credits: 2+0
Prerequisite: Nil

DESCRIPTION

Machine design is a core course that equips students with the basics of mechanical engineering design. It prepares students for the engineering problems encountered and everyday life. Knowledge of Statics, Dynamics and Mechanics of Materials is a pre-requisite for a better understanding of fundamental design concepts.

COURSE LEARNING OUTCOMES

1. Calculate stresses in gear teeth, power screws.
2. Identify the parameters for the selection of standard machine elements, such as journal bearings, rolling contact bearings, pulleys.
3. Design and analyze the machine elements for desired outputs, including springs, gears and bearings.

COURSE OUTLINE

Spur, Helical, Bevel and Worm Gears
Stress analysis on gear teeth
Power transmission by the gears
Design of Flywheels
Concepts of designing flywheels for different requirements
Selection of bearings
Selection procedures of sliding contact bearings and rolling contact bearings
Design of Brake / Clutches
Different types of clutches and designing concepts
Different types of brakes and designing concepts
Design of Power Screws / Translation Screws
Introduction to power / translational screws
Stresses in power / translational screws
Efficiency of power / translational screws
Applications of power / translational screws
Selection of Standard Machine Elements
Selection of flat belts, V belts, chain drive and rope drives

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Mott, R. L., Machine Elements in Mechanical Design.
2. Norton, R. L., Design of Machinery.
3. Shigley, J. E., Theory of Machines & Mechanisms.
4. Khurmi, R. S., Machine Design.

HEAT AND MASS TRANSFER

Credits: 3+0
Prerequisite: Thermodynamics-II / Fluid Mechanics II

DESCRIPTION

This course teaches the basics of Heat and Mass Transfer and prepares students for subsequent courses in the thermal-fluid area. The course provides detailed understanding of modes of heat transfer i.e. Conduction, Convection and Radiations. This course also covers boiling and condensation, Mass Transfer and Heat exchangers.

COURSE LEARNING OUTCOMES

1. Apply 1-D conduction heat transfer problems in Cartesian, cylindrical and spherical coordinates using governing equations.
2. SOLVE simple forced and free convection based engineering heat transfer problems using governing equations as well as non-dimensional criteria
3. Relate engineering design quantities (power, requirements, insulation thickness, thermal conductivity, exchanger size, etc) required for design of thermal engineering devices & systems such as heat exchangers etc.
4. Investigate temperature variation along the rectangular/ cylindrical/ spherical profile

COURSE OUTLINE

Introduction
- Physical origins of heat transfer
- Modes of heat transfer
- Thermodynamic relationships.

Introduction to Conduction
- The Conduction Rate Equation.
- The Thermal Properties of Matter.
- Thermal Conductivity.
- The Heat Diffusion Equation.
- Boundary and Initial Conditions.

One-Dimensional, Steady State Conduction
- The Plane Wall.
- An Alternative Conduction Analysis.
- Radial Systems
- Conduction with Thermal Energy Generation
- Heat Transfer from Extended Surfaces

Two-Dimensional, Steady State Conduction
- Concept of shape factors for heat transfer application.
- Numerical methods for simple heat transfer applications

Two-Dimensional, Steady State Conduction
- Concept of shape factors for heat transfer application.
- Numerical methods for simple heat transfer applications.

Transient Conduction – Three Lectures
- The Lumped Capacitance Method.
- Validity of the Lumped Capacitance Method.

Introduction to Convection
- The Convection Boundary Layers.
- Local and Average Convection Coefficients.
- Laminar and Turbulent Flow.
- The Boundary Layer Equations.
- Physical Interpretation of the Dimensionless Parameters.
- Boundary Layer Analogies.

External Flow
- The Flat Plate in Parallel Flow.
- The Cylinder in Cross Flow.
- Flow over Sphere.
- Flow across Banks of Tubes.

Internal Flow
- Hydrodynamic Considerations.
- Thermal Considerations.
- The Energy Balance.
- Laminar Flow in Circular Tubes: Thermal Analysis and Convection Correlations.
- Convection Correlations: Turbulent Flow in Circular Tubes.

Free Convection
- The Governing Equations for Laminar Boundary Layers.
- Laminar Free Convection on a Vertical Surface.
- The Effects of Turbulence.
- Free Convection Within Parallel Plate Channels.
- Free Convection over cylinder and spheres.

Boiling and Condensation
- Boiling Mode.
- Modes of Pool Boiling.

Heat Exchangers
- Heat Exchanger Types.
- Heat Exchanger Analysis: Use of the LMTD.
- Heat Exchanger Analysis: The Effectiveness–NTU Method.
- Heat Exchanger Design and Performance Calculations.

Radiations
- Fundamental Concepts.
- Radiation Heat Fluxes.
- Blackbody Radiation.
- Emission from Real Surfaces.

- The Gray Surface.
- Environmental Radiation.

Radiation Exchange between Surfaces

- The View Factor.
- Blackbody Radiation Exchange.
- Radiation Exchange between Opaque, Diffuse, Gray Surfaces in an Enclosure.

Diffusion Mass Transfer

- Fick's Law of Diffusion

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Bergman, T. L., Levine, M. S., Fundamentals of Heat and Mass Transfer, 8th Edition, John Wiley & Sons.
2. Holman, J. P., Heat Transfer, 10th Edition, McGraw-Hill.
3. Çengel, Y. A., Heat and Mass Transfer: Fundamentals and Applications, 5th Edition, McGraw-Hill.

CONTROL ENGINEERING

Credits: 2+0
Prerequisite: Nil

DESCRIPTION

This class introduces students to the modeling, analysis and design of linear feedback control systems. Students gain experience in applying a variety of modeling techniques and analyzing system performance from several perspectives to include the time and frequency domains as well as state space formulations. Students learn to synthesize linear controllers capable of satisfying a variety of stability and response criteria by using both classical and modern design techniques

COURSE LEARNING OUTCOMES

1. UNDERSTAND the fundamentals of control systems
2. ANALYZE control systems using mathematical models
3. DESIGN a controller to achieve the desired response from the system

COURSE OUTLINE

1.Introduction: Basics of control system, Open-loop and closed-loop control systems, Block diagram terminology, Example of system for block diagrams, Signal flow graphs

2. Dynamic System modeling: Mechanical Translational & Rotational Systems, Electrical Active & Passive Systems, Electromechanical Systems, Conversion of Electrical System to Equivalent Mechanical Systems and vice versa, Thermal system and fluid systems

3. Laplace Transforms and Transfer Function: Mason Gain Formula to find transfer function, Mason's formula application of electrical and mechanical systems, Development of nodal equations from signal flow graph, Development of signal flow graph from nodal equations

4. State Space Formulation: State space formulation from differential equations, State Space formulation from block diagram and signal flow graphs, Control and Observer Canonical form of block diagrams and state space, Types of inputs like impulse, step, ramp and sinusoidal input, Solution of state space for different responses, System linearization and its applications

5. Time Response of 1st and 2nd Order System: Time response of the 1st and 2nd order systems (impulse, step, ramp etc.), Time response characteristics, Frequency response of 1st and 2nd order systems, Time response of higher order systems

6. Study of System Stability: Introduction to stability, Poles and Zeros concept, Ruth-Hurwitz stability criteria and its applications, Concept of Root-Locus

7. Root Locus Design: Root Locus design, System stability by pole placement, Compensator Design (Lead and Lag Compensator), Design of PID Controller (P, PI and PID Controllers), different PID Controller Tuning method

8. Frequency Design: Introduction to frequency plots, Bode Plots, System Stability using Bode Plots

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Phillips, C. L., Harbor, R. D., Feedback Control Systems, Prentice-Hall.
2. Ogata, K., Modern Control Engineering, Prentice-Hall.
3. Nise, N. S., Modern Control Engineering, John Wiley & Sons.

HEATING, VENTILATION AND AIR CONDITIONING

Credits: 3+0
Prerequisite: Heat & Mass Transfer

DESCRIPTION

This course is an introduction to the design of thermal systems for indoor climate control. The concepts, design, application and control of air conditioning and refrigeration are introduced through the use of fundamentals of thermo-fluids. The course is designed to provide a balance among theory and practical design principles and to introduce the students with real world problems of air conditioning and refrigeration design and applications.

COURSE LEARNING OUTCOMES

1. APPLY fundamental concepts and SOLVE PROBLEMS related the processes of refrigeration and air conditioning
2. PERFORM the heating and cooling load calculations of residential and public buildings for Designing an Air Conditioning System
3. ANALYSE the factors affecting ENVIRONMENT AND SUSTAINABILITY through refrigeration and air conditioning applications.
4. Understand technological advancements in refrigeration and air conditioning systems

COURSE OUTLINE

Applications of Heating Ventilation and Air Conditioning

Thermal Principles

- Concepts, Models, and Laws
- Thermodynamic Properties & Processes

Psychrometry and Wetted-Surface Heat Transfer

- Psychrometric Chart
- Relative Hu midity
- Humidity Ratio
- Adiabatic Saturation and Thermodynamic Wet-Bulb Temperature

Heating- and Cooling-Load Calculations

- Health and Comfort Criteria
- Thermal Comfort
- Estimating Heat Loss and Heat Gain
- Procedure for Estimating Heating Loads
- Procedures for Estimating Cooling Loads

Air-Conditioning Systems

- Thermal Distribution Systems
- Classic Single-Zone System
- Variable-Air-Volume Systems
- Water Systems

Fan and Duct Systems

- Conveying Air
- Pressure Drop in Straight Ducts
- Velocity Method
- Equal-Friction Method

Pumps and Pumping

- Water and Refrigerant Piping
- Pump Characteristics and Selection

Cooling and Dehumidifying Coils

- Types of Cooling and Dehumidifying Coils

The Vapor-Compression Cycle

- Carnot Refrigeration Cycle
- Coefficient of Performance
- Performance of the Standard Vapor-Compression Cycle
- Actual Vapor-Compression Cycle

Compressors

- Types of Compressors

Expansion Devices

- Purpose and Types of Expansion Devices

Refrigerants

- Primary and Secondary Refrigerants
- Thermodynamic Comparison of Some Common Refrigerants
- Physical and Chemical Comparison

Multi-pressure Systems

- The Performance of Refrigeration Systems
- Intercooling

Absorption Refrigeration

- The Absorption Cycle
- Thermal Analysis of Simple Absorption System

Heat Pumps

- Types of Heat Pumps

Cooling Towers and Evaporative Condensers

- Heat Rejection to Atmosphere
- Cooling Towers

Evaporative Condensers and Coolers

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Stoecker, W. F., Jones, J. W., Refrigeration and Air Conditioning, 2nd Edition, McGraw-Hill Book Co.
2. McQuiston, F. C., Parker, J. D., Spitler, J. D., Heating, Ventilating, and Air-Conditioning: Analysis and Design, 6th Edition, John Wiley & Sons.
3. Kreider, J. F., Curtiss, P. S., Rabl, A., Heating and Cooling of Buildings: Design for Efficiency, 2nd Edition, CRC Press.
4. ASHRAE Handbook Fundamentals, 2017, ASHRAE, USA.

INTERNAL COMBUSTION ENGINES

Credits: 2+1
Prerequisite: Nil

DESCRIPTION

The course provides introductory overview of spark ignition and compression ignition engines. Describes combustion chemistry, and identifies the parameters and engine operations to develop understanding of the thermodynamics and combustion process for a quantitative analysis of internal combustion engines. Detail of gas exchange and inflow and outflow of gases explained. Engine classification, engine cycle, combustion processes, reaction of engine fuels, release of energy and ultimate conversion into useful work is illustrated. A concise discussion on topics like performance of engines, Knocking, Octane number, Cetane number, engine valve timing, ignition advance/ retard, and working principle of turbo-charged engine is also included. Highlighting that Internal Combustion Engines are a source of pollution and controlling the emissions is emphasized.

COURSE LEARNING OUTCOMES

1. Explain the basic knowledge, construction and working of various types of IC engines and its components.
2. Solve numerical problems related to the design and operation of IC engines.
3. Describe the effect of engine operating parameters (air/fuel ratio, ignition timing, and fuel properties) on engine emissions.
4. Evaluate the currently adopted engine technological developments using already developed theories and models.

COURSE OUTLINE

Engine Basics: Introduction and definition of IC Engines. Brief history of engines with their classification and terminologies used in engine technology. Description of many common engine components both for 2-stroke and 4-stroke engines.

Engine Cycles: Study of the basic cycles of operations in a reciprocating IC Engine for both 4-stroke and 2-stroke design. Analysis of the most common 4-stroke SI and CI engine cycles in detail based on air-standard cycle.

Operating Characteristics: Examination of the operating characteristic of reciprocating IC Engines including the mechanical output parameters of work, torque power and input requirements of air, fuel, combustion efficiency and emission requirements of engine exhaust

Thermo-Chemistry & Fuels: Review of the basic thermo-chemistry principles in consideration to IC Engines. Description of the octane number of SI fuel and Cetane number of CI fuels. Discussion about gasoline and other possible alternative fuels and their comparison study.

Air & Fuel Induction: Detailed discussion of the intake systems of IC Engines as to how the air-fuel as a mixture or individually are delivered into the cylinder for combustion. The objective of the intake system and its effect on engine efficiency. Differentiation between intake system for SI & CI engine along with their required component of each either naturally aspirated or forced charged.

Combustion & Exhaust Flow: Examination of the complex process of combustion that occurs in the combustion chamber of an IC Engine. Simplified models are used to describe this phenomenon. Study of the broad operating parameters such as pressure, temperature, fuel, knock, engine speed … etc. Difference between the combustion process in a CI and SI engine

Friction and Lubrication: Engine Cooling System and Component Lubrication System

Pollution control: Engine emissions and standards, Pollutant formation, After treatment devices

PRACTICAL REQUIREMENT

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Pulkrabek, William W., Engineering Fundamentals of the Internal Combustion Engines
2. Heywood, J.B., Internal Combustion Engines Fundamentals, 2nd Edition, McGraw Internal.
3. Taylor, C.F., Combustion Engines in Theory and Practice
4. Schäfer, R. V., Schäfer, F., Internal Combustion Engine Handbook - Basics, Components, Systems, and Perspectives, SAE International.

MECHANICAL VIBRATIONS

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

This course deals with observation, analysis, and modification of vibration in mechanical systems. In addition to analysis and experimentation, practical applications and design considerations related to modifying the vibrational behaviour of mechanical devices and structures will also be studied. This understanding is important for humans, particularly engineers, as there are desirable types of vibration and undesirable vibrations. The course gives knowledge of vibrations in rotating and oscillating bodies. Fundamental analysis in frequency and in time domain. Response analysis, of free and forced vibrations.

COURSE LEARNING OUTCOMES

1. Apply different modelling techniques to vibration systems
2. Investigate the physical parameters involved in natural frequency calculations under dynamic conditions
3. Apply effective reading, listening and presentation skills on different engineering topics

COURSE OUTLINE

1. Introduction
- a. Fundamentals of Vibrations, Degrees of Freedom
- b. Discrete and Continuous Systems, SHM, Vibration Analysis Procedure

2. Single Degree of Freedom Systems - Free Vibratory Systems
- a. Newton's Method, Energy Method
- b. Viscously Damped Free Vibration
- c. Logarithmic Decrement, Springs and dampers in Combination

3. Single Degree of Freedom Systems – Forced Vibratory Systems
- a. Forced Harmonic Vibration, Rotating Unbalance
- b. Base Excitation, Energy Dissipation by Damping
- c. Whirling of Rotating shafts

4. Transient Vibration
- a. Impulse Response Function, Response to an Arbitrary Input

5. Systems with Two Degrees of Freedom
- a. The Normal Mode Analysis, Free Vibration Analysis of an Un-damped Systems

b. Coordinate Coupling, Free Vibration Analysis of Damped systems
c. Forced Harmonic Vibration of an Un-damped Systems
d. Forced Harmonic Vibration of Damped Systems

6. Multi Degree of Freedom Systems
a. Eigen Values and Eigen Vectors
b. Influence co-efficient, Matrix Iteration Method
c. Holzer's Method

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Thompson, W.T., Mechanical Vibrations: Theory and Applications, 5th Edition, Prentice Hall.
2. Rao, S.S., Mechanical Vibrations, 3rd Edition, McGraw-Hill.
3. Meirovitch, Leonard, Elements of Vibration Analysis, McGraw Hill, 2001.
4. Thomson, W.T., Dahleh, M.D., Theory of Vibration with Applications.

FINITE ELEMENT METHODS

Credits: 2+1
Prerequisite: Nil

DESCRIPTION

The course provides advanced knowledge on the application of finite element analysis to engineering applications in linear structural mechanics and heat transfer problems. The course analyses critically problems involving one, two- and three-dimensional idealizations. The topics covered include steps in finite element modelling process, behavior of spring, truss, beam, plane stress/strain and three dimensional finite element modelling approaches in structural mechanics. The heat transfer part of the course examines the conduction and convection behavior and analyzing these mechanisms using finite element analysis.

COURSE LEARNING OUTCOMES

1. Understand the basic knowledge of FEA, Software tools; element performance, FEA methods, formulations of 1-D, 2-D and 3-D elements
2. Able to use modern engineering tools, for linear, structural, thermal, dynamic and couple field problems.
3. Analyze structural, thermal, dynamic problems.

Lab

1. Display an ability to model, assemble and simulate performance of mechanical components
2. Explain the concept of modeling and simulation tools used in the respective experiment
3. Recognize the need to undertake lifelong learning in technical knowledge using FEA software tools.

COURSE OUTLINE

1.Introduction to FEA and Element Performance

a. Introduction to Finite Element Modeling and preliminary decisions
b. Element types and their properties
c. Basic concepts of equilibrium & compatibility
d. General factors affecting element performance – Sources of errors
e. Convergence.

2. FE Methods, Shape Functions, Stiffness Matrix and Transformation

a. Direct Stiffness Method, Energy Methods
b. Shape Function: Linear and Quadratic Element
c. Beam Elements, Truss Elements, Linear and Planar elements
d. Stiffness matrix, Local to Global Co-ordinate Transformation Assembly

3. Static Structural Analysis

Modeling and analysis of 1D, 2D and 3D structures under static loading

4. Heat Transfer and Thermal Stress Analysis:

a. Introduction to Heat transfer, Thermal and Thermal Stress analysis concepts

b. Selection of Boundary Conditions based on the identification of problem

c. Thermal Analysis (Steady State)

d. Thermal stress Analysis

PRACTICAL REQUIREMENT

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Moaveni, Saeed, Finite Element Analysis: Theory and Application with ANSYS.
2. Logan, Daryl, A First Course in the Finite Element Method, Fifth Edition.
3. Budynas, Richard G., Advanced Strength and Applied Stress Analysis, McGraw-Hill.

REVERSE ENGINEERING AND INSPECTION TECHNIQUES

Credits: 2+1
Prerequisite: Basic Mathematic, Engineering Drawing

COURSE LEARNING OUTCOMES

1. Demonstrate a deep understanding of reverse engineering principles, processes, and inspection techniques.
2. Analyze and interpret complex scan data, identifying design features and potential improvements in existing products and systems.
3. Apply reverse engineering and inspection techniques to real-world industrial scenarios, contributing to product improvement and innovation.

Learning Domains and Levels:

Maximum Level of Cognitive Domain	Maximum Level of Affective Domain	Maximum Level of Psychomotor Domain
C-4	A-	N.A. for Theory

Type of Course: Minor Course, Depth

COURSE OUTLINE

Introduction to Reverse Engineering (Definition and significance, Applications in industrial engineering, Legal and ethical considerations); Reverse Engineering Process(Data acquisition methods (3D scanning, coordinate measuring), Point cloud data processing, CAD modeling from scan data); Inspection Techniques (Geometric dimensioning and tolerancing (GD&T), Coordinate measuring machines (CMM), Optical and non-contact inspection methods); Surface and Material Analysis (Surface roughness measurement, Material composition analysis, Non-destructive testing methods); Metrology and Measurement Standards (Introduction to metrology, International measurement standards, Calibration and traceability); Reverse Engineering Software Tools (Introduction to software for data processing and CAD modeling, Hands-on experience with software tools); Applications of Reverse Engineering under Industry 4.0 Perspective; Case studies in various industries (e.g., automotive, aerospace), Practical projects in reverse engineering and inspection under fourth industrial revolution

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Messler, Robert W. Reverse Engineering: Mechanisms, Structures, Systems & Materials. McGraw Hill Education.
2. Wang, Wego. Reverse Engineering: Technology of Reinvention. CRC Press.
3. Raheja, Amar. Reverse Engineering: An Industrial Perspective. Springer Nature.

****List of Technical Electives (3 Cr hrs.)
• Tribology
• Mechanical Engineering Design Analysis
• Stress Analysis
• Composite Materials
• Renewable Energy Technology
• Gas Dynamics
• Aerodynamics
• Computational Fluid Dynamics
• Nuclear Engineering
• Automotive Engineering
• Advanced Manufacturing Systems
• Maintenance Engineering
• Product Design and Development
• Micro-Electromechanical Systems (MEMS)
• Power Plant

TRIBOLOGY

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

Friction; wear mechanism; wear debris classification; surface roughness; friction and wear measurement techniques; lubrication of sliding and rolling parts; Types of lubricants, grades and their properties; theories of lubrication; hydrodynamic and elasto-hydrodynamics lubrication of journal bearing and squeeze film bearings; Tribological considerations in various applications.

COURSE LEARNING OUTCOMES

- IDENTIFY causes of wears and friction in different contact surfaces and DESCRIBE their measurement techniques.
- APPLY the concepts of hydrostatic and hydrodynamic lubrication to basic tribological problems.
- ANALYZE the performance of bearings and other tribological systems.

COURSE OUTLINE

- Introduction to Tribology
- Wear Mechanisms, Wear Testing
- Roughness, Hardness, Friction
- Mechanics of Solid Contacts
- Reynold's Equation and its application
- Properties of Lubricants.
- Lubrication Regimes
- Design of Lubricants.
- Tribological Testing includes instrumentation and Methods used for testing.
- Application and Case Studies: Engine Tribology, Marine Tribology, Sliding contacts, rolling contacts, plain bearing journal.

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Stachowiak, Gwidon W., and Andrew W. Batchelor. Engineering Tribology. Elsevier.
2. Hutchings, Ian, and Philip Shipway. Tribology. Butterworth-Heinemann.
3. Wen, Shizhu, and Ping Huang. Principles of Tribology. Tsinghua University Press.

MECHANICAL ENGINEERING DESIGN ANALYSIS

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

This course is aimed at providing both basic and advanced exposure to design and analysis of mechanical systems

COURSE LEARNING OUTCOMES

1. Apply knowledge for linear, structural, thermal, dynamic and couple field problems.
2. Analyze structural, thermal, dynamic problems.
3. Work individually and as team member during assignments, and projects using software.

COURSE OUTLINE

- Analysis of the mechanical systems and components using the technique of Finite Element Analysis (FEA).
- Stress analysis for one & two-dimensional problems of structures
- Linear and Nonlinear Behavior of Mechanical Structures
- Modeling and Simulation of Mechanical Systems
- Heat transfer and fluid mass transport analysis
- Thermal stress analysis,
- Design analysis with the aid of advanced mathematical tools and management techniques.

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Moaveni, Saeed. Finite Element Analysis: Theory and Application with ANSYS.
2. Logan, Daryl. A First Course in the Finite Element Method. Fifth Edition.
3. Budynas, Richard G. Advanced Strength and Applied Stress Analysis. McGraw-Hill.

STRESS ANALYSIS

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

Review of mechanics of materials, Stress transformations, general 3Dstress state, Mohr's circle in 3D, strain transformations, generalized stress-strain relationship, equilibrium and compatibility, introductory topics from theory of elasticity, Airy stress functions, Prandtl's stress functions for torsion, shear flow, torsion of thin-walled tubes, bending of unsymmetrical beams: stress & deflection, bending of thin flat plates, axisymmetric circular plates in bending, thickwalled cylinders & rotating disks, contact stresses. Overview of Experimental Stress Analysis, Stress analysis –Experimental approaches, Specific domain of these approaches, Advantages and disadvantages

COURSE LEARNING OUTCOMES

1. Understand the concepts of Elementary theory of elasticity, stress and their transformation and Airy's stress function
2. Understand the concepts related to strain experimental stress analysis and strain measurements
3. Understand the concepts related to Finite Element Analysis, theory of plasticity, non-linear elasticity and vicso-elasticity

COURSE OUTLINE

Stress and Strain Relationship
- Stresses on an inclined angle
- Strain equations for transformation
- Relations in Cartesian and polar coordinates
- Stress due to various combined loading

Plane Elasticity Theory
- The plane elastic problem
- The plane strain approach
- Airy's stress function
- Stress distribution in a thin infinite plate with circulate hole

Yielding of Ductile Isotropic Materials
- Elastic-perfectly plastic deformation behavior
- Classical theories of plasticity
- Strain hardening, elastic-plastic bending of beams
- Viscoelastic behavior of solids

Fracture Mechanics
- The three modes of loading
- Westergaard stress function

- Crack tip plasticity
- Shape of plastic zone
- Construction and working of electrical resistance strain gauge
- Strain sensitivity of metallic alloy and strain gauge
- Strain gauge circuits with applications
- Rosettes and its different configurations

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Dally, J.W., & Riley, W.F. Experimental Stress Analysis. McGrawHill.
2. Sharpe, W.N. (Ed.). Springer Handbook of Experimental Solid Mechanics. Springer.
3. Srinath, L.S., Raghavan, M.R., Lingaiah, K., Gargesa, G., Pant, B., & Ramachandra, K. Experimental Stress Analysis. Tata McGraw Hill.
4. Javidinejad, A. Essentials of Mechanical Stress Analysis. 2nd Ed., CRC Press, 2023.

COMPOSITE MATERIALS

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

This course is aimed at providing both basic and advanced concepts of composite materials and relevant applications exposure to emerging trends in the field

COURSE LEARNING OUTCOMES

1. Identify, describe and evaluate the properties of fiber reinforcements, polymer matrix materials and commercial composites.
2. Develop competency in one or more common composite manufacturing techniques and be able to predict the appropriate technique for manufacture of fibre-reinforced composite products.
3. Apply knowledge of composite mechanical performance and manufacturing methods to a composites design project

COURSE OUTLINE

- Introduction
- Classification of composites
- Particle reinforced composites
  1. Large particle composites
  2. Rule of mixtures
- Dispersion – Strengthened composites
- Fiber-Reinforced Composites
- Influence of fiber strength
- Influence of fiber orientation and concentration
- The Fiber Phase
- The Matrix Phase
- Polymer matrix composites
  1. Glass fiber reinforced composites
  2. Carbon fiber reinforced composites
  3. Aramid fiber reinforced composites
- Metal matrix composites
- Ceramic matrix composites
- Carbon-Carbon Composites
- Hybrid Composites
- Process of fiber-reinforced composites

- **Engineering Intervention for Social Stratification**

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

- Structural Composites
  1. Laminar Composites
  2. Sandwich Panel
- Nano Composites

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Callister, William D., Jr., & Rethwisch, David G. Materials Science and Engineering. 10th Edition.
2. Hull, D., & Clyne, T.W. An Introduction to Composite Materials. Cambridge University Press.
3. Matthews, F.L., & Rawlings, R.D. Composite Materials: Engineering & Science. Chapman & Hall.

RENEWABLE ENERGY TECHNOLOGY

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

Introduction to types of renewable energy, solar energy, wind energy, geothermal energy, ocean thermal energy, tidal wave and geothermal energy, biomass energy. Fuel cell and heat pump systems, energy efficiency issues and energy storage. Potential of using renewable energy resources as supplement of conventional energy resources. Renewable and nonrenewable energies used as hybrid energy systems, Modern renewable energy plants. Wind energy, wind turbine design specifications, compatible electric generators and major operational issues of the wind mill for electric power generation. Wind mills design usage for pumping water. Biomass energy conversion methods, detailed description of biomass energy conversion plant, operational and maintenance problems and their remedies.

COURSE LEARNING OUTCOMES

1. Apply basic concepts and formulation through SOLVING PROBLEMS of renewable energy systems
2. Design and Analyze Solar PV and Thermal Systems for a specified capacity.
3. Perform model-based transient analysis of renewable energy systems through modern tools like TRNSYS
4. Determine the factors affecting environmental and sustainability aspects through renewable energy systems

COURSE OUTLINE

Principles of Renewable Energy

- Energy and sustainable development
- Introduction to types of renewable energy technologies
- Fuel cell and heat pump systems
- Renewable and non-renewable energies used as hybrid energy systems
- Scientific principles of renewable energy
- Technical implications

Photovoltaic (PV) Energy

- Components of radiation
- Site estimation of solar radiation
- Photovoltaic circuit properties
- Solar cell and module manufacturing

Solar Water Heating

- Heat balance equations
- Flat-plate collectors
- Systems with separate storage
- Solar concentrators

Wind Power Technology

- Characteristics of wind
- Turbine types and terms
- Linear and angular momentum theory
- Power extraction by a turbine
- Operational issues of the wind mill for electric power generation

Biomass Resources and Bioenergy

- Biomass energy conversion methods
- Biomass energy conversion plant
- Biofuel classification
- Biodiesel from vegetable oils and algae

Wave and Tidal power

- Wave speed and energy
- Wave and Tidal power devices
- Social, economic and environmental aspect

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Boyle, G. Renewable Energy. 2nd Edition. Oxford University Press.
2. Twidell, J., & Weir, T. Renewable Energy Resources. Spon Press.

GAS DYNAMICS

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

This course deals with the application of mechanics and thermodynamics principles to study and understand a variety of compressible fluid flow problems. Topics to be covered include conservation laws, propagation of disturbances, isentropic flow, compressible flow in ducts with area changes, normal and oblique shock waves and applications, Prandtl-Meyer expansion waves, simple flows such as Fanno flow and Rayleigh flow. The emphasis will be on the physical understanding of the phenomena using basic analytical and computer simulations results.

COURSE LEARNING OUTCOMES

- Apply the compressible flow principles to study the flow in variable area duct with/without shockwaves/expansion waves.
- Analyze the compressible flow problems in constant area duct involving friction/heat transfer with/without shockwaves/expansion waves.
- Evaluate compressible flow problems that involves normal or oblique shockwaves through computer simulation and compare the results with theory.

COURSE OUTLINE

Introduction

- Governing equations for compressible fluid flow
- Sonic velocity and Mach number
- Propagation of sound waves
- Equations for perfect gases in terms of Mach number

Isentropic Flow of a Perfect Gas

- Effect of area change on flow properties
- Flow in convergent and convergent-divergent nozzles
- Limiting conditions (choking)

Formation of Shock Waves

- Weak and Strong waves, stationary and moving shock waves
- Working equations for perfect gases
- Operating characteristics of converging diverging nozzle
- Supersonic diffusers and pitot tube

Two-Dimensional Supersonic Flow

- Oblique shock waves and Prandtl-Meyer flow

- Variation of properties across oblique shock and expansion wave
- Expansion of supersonic flow over successive corners and convex surfaces

Compressible Flow with Friction in a duct

- Assumptions in Fanno flow
- Effect of friction in subsonic and supersonic flow
- Isothermal flow in long ducts

Flow in Ducts with Heat Transfer

- Derivation of Rayleigh flow equations
- Thermal choking due to heating
- Correlation with shocks

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Zucrow, M. J., & Hoffman, J. D. Gas Dynamics. John Wiley and Sons, 1976.
2. Shapiro, A. H. The Dynamics and Thermodynamics of Compressible Fluid Flow (Vol 1). 1st Edition. Ronald Wiley.
3. Zucker, R. D. Fundamentals of Gas Dynamics. 3rd Edition. Wiley, 2019.
4. Imrie, B. W. Compressible Flow.

AERODYNAMICS

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

Introduction, aerodynamics of incompressible flow, compressible and ideal fluid flow, airfoils theory, finite wing aerodynamics, blade element theory and aircraft propellers, Cascade aerodynamics, jet propulsion, intake and nozzle performance, aircraft performance measurement.

COURSE LEARNING OUTCOMES

- **Comprehend** the fundamental concept of aerodynamics and
- explain the working principle involved in Aerodynamic forces and
- moments
- **Evaluate** the aerodynamic related problems for different flight parameters using computational skills.
- **Design** mechanical component on the basis of aerodynamic principles with required objectives and given constraints

COURSE OUTLINE

- Review of Continuity, momentum and energy equations
- Stream function and Velocity Potential
- Vorticity and Circulation

Inviscid and Incompressible low

- Governing equation for irrotational and incompressible Flow
- Simple plane potential lows
- The Kutta-Joukowski Theorem and the Generation of Lift

Incompressible Flow over Airfoils and Wings

- Airfoil nomenclature and characteristics
- Classical thin airfoil theory: the symmetric airfoil
- The chambered airfoil
- Flow separation and drag calculations
- Boundary layer equations for incompressible lows
- 2D incompressible laminar lows
- 2D incompressible turbulent lows
- Boundary layer Separation phenomena in laminar lows
- Interactive boundary layer theory

Compressible Isentropic low

- Effect of area change on low properties
- Flow through nozzles, diffusers, and wind tunnels
- Governing equations for quasi-one-dimensional low

Non-isentropic fows

- The basic normal shock equations
- Supersonic flow over wedges and cones
- Detached shock wave in front of a blunt body

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Anderson, J. D. Fundamentals of Aerodynamics. McGraw Hill International.
2. Bertin, J. J. Aerodynamics for Engineers. Prentice Hall Edition.
3. White, F. M. Fluid Mechanics. McGraw Hill International.
4. Schlichting, H. Boundary Layer Theory. McGraw Hill International.
5. Collicott, S. H. Aerodynamics for Engineering Students. 7th Edition. Butterworth-Heinemann, 2016.

COMPUTATIONAL FLUID DYNAMICS

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

Computational Fluid Dynamics Course provides an introduction to the methods and analysis techniques used in computational solutions of fluid mechanics and heat transfer problems. This course introduces the students to the finite difference and finite volume method as a means of solving different type of differential equations that arise in fluid dynamics.

COURSE LEARNING OUTCOMES

1. Apply the fundamental conservation laws to model the governing equations of fluid dynamics and turbulence
2. Analyze the diffusion and the convection-diffusion problems using finite volume methods
3. Evaluate the solution of steady/unsteady diffusion and convection-diffusion problems using different discretization schemes

COURSE OUTLINE

Introduction

- Basic steps in CFD analysis (Preprocessing, solving and post-processing)
- Computational domain and grid generation
- Solution methods and initialization
- Interpretation of the CFD results

Classification of problems and boundary conditions

- Time-dependent and equilibrium problems
- Elliptic, parabolic and hyperbolic partial differential equations
- Dirichlet, Nuemann, and mixed type boundary conditions.

Numerical solution methods

- Explicit and implicit methods
- Properties of discretization schemes
- Upwind differencing, Power law, QUICK scheme,
- SIMPLE and SIMPLEC algorithm

Solution of discretized equations

- The TDMA method
- Point-iterative methods

- Jacobi iteration method
- Gauss–Seidel iteration method

Case studies of flow problems

- Turbulence modeling
- External flow across various configurations
- Internal flows through pipes, ducts and valves

Errors and uncertainties

- Truncation, round-off and discretization errors
- Input uncertainty
- Physical model uncertainty
- Verification and validation

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Anderson Jr., J. D. Computational Fluid Dynamics. 1st Edition. McGraw-Hill Science.
2. Pozrikidis, C. Fluid Dynamics: Theory, Computation, and Numerical Simulation. Springer, 2017.
3. Versteeg, H., & Malalasekera, W. An Introduction to Computational Fluid Dynamics: The Finite Volume Method. 2nd Edition. Pearson, 2007.

NUCLEAR ENGINEERING

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

Nuclear Engineering has emerged as solution provider in broader spectrum other than defence in the last three decades. Nuclear Engineering has a core role in development of nuclear reactors to produce electricity in bulk quantities with lesser carbon footprint. The general objective is to provide students with a broad understanding of Nuclear Engineering in electricity generation process and equipment, agriculture and health sciences. Students will also be able to understand the environmental aspects on Nuclear Engineering and obligations required for safety and proliferation.

COURSE LEARNING OUTCOMES

After the successful completion of the course, the students should be able to:

1. Analyze the Nuclear Engineering Applications in Nuclear power plants and Biomedical and Agriculture Science
2. Analyze various types of nuclear power plants with respect to effect of releases to the environment
3. Select the feasible nuclear Engineering solutions for power generation, health sciences and agriculture, within available natural resources and justify the impact of proposed solution on the society through report and oral presentation

COURSE OUTLINE

- Review of Basic Concepts – Nuclear Engineering applications in, Electric Generation, Health Sciences, Agriculture, Propulsion and Space – Two Lectures
- Nuclear Reactors – Various types/ designs for various Applications, and their accessories, Safety and International Atomic Energy regulations – Three Lectures
- Fuel for Nuclear Reactors – Types of fuel and limitations, various techniques of fuel preparation etc. – Four Lectures
- Heavy water Reactors/Pressure less Reactors (HWR) – Design and construction details, Advantages and limitations. Materials used in such reactors. Indigenous development of HWR and Heavy Water. Infrastructure requirements for HWRs – Four Lectures
- Heavy Water synthesis Process details and allied equipment requirements. Safety measures and Environmental Impact. Indeciduous development of nuclear fuel for HWR and its processing details. – Four Lectures

- Pressurized Water Reactors (PWR) – Design and construction details, Advantages and limitations. Materials used in such reactors. Indigenous development of PWR and its fuel. Infrastructure requirements for PWRs. Safety measures and Environmental Impact. Indeciduous development of nuclear fuel for HWR and its processing details. – Four Lectures
- Nuclear Fuel Enrichment Techniques for PWR and Processing Plants details. Indigenous developments. – Four Lectures
- Fast Breeder Nuclear Reactors and types. Nuclear Applications in Propulsion and Space – Four Lectures
- IAE regulatory Authority member ship and regulations. Introduction to Nuclear Supply Group – Two Lectures

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. El-Wakil, M. M. Power Plant Technology. McGraw Hill, 1985.
2. Black and Veatch. Power Plant Engineering. Springer.
3. Wiseman, Joel, & Eckart, Roy. Modern Power Plant Engineering. Prentice Hall, 1985.
4. Nag, P. K. Power Plant Engineering. 4th Edition. McGraw Hill.
5. Morse, F. T. Power Plant Engineering and Design.

AUTOMOTIVE ENGINEERING

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

This course provides an insight to components of automotives, vehicle dynamics and need for efficient vehicles.

COURSE LEARNING OUTCOMES

1. Explain theoretical concepts related to Automotive Engineering
2. Analyze vehicle dynamics problems
3. Apply the concepts for efficient automobile

COURSE OUTLINE

Course Contents:

Definition of automobiles; Classifications of automobiles: based on wheels, based on intended use; national and international classifications; Historical development: From basic carriages to modern vehicles, Growth and refinements. Types of engines: Spark ignition engines, Compression ignition engines, Two and four stroke engines; Arrangement and functions of the main components of the engine: Cylinder head assembly, Cylinder block assembly, Intake and exhaust, Turbo charger / Super chargers, Valves. Basic principles and operations of fuel delivery system, Carburetor system, Electronic fuel injection (EFI) system, Fuel pump and filter, Fuel tanks and piping. Basic purpose of lubrication, Elements of lubrication system: Types of bearings and their function, Lubricants types and selection for optimal use. Elements of cooling system: Coolants and additives, Water pump, Radiators, Fan and shroud, Hoses. Functions and configurations of transmission and drives, Elements of drive train: Friction clutches, Gear theory and types, Manual transmissions, Automatic transmissions, Continuously Variable Transmission (CVT), Drive shafts, Transmission case, Four / All wheel drives. Classification of steering systems: Worm and wheel, Rack and pinion, Power steering. Steering Dynamics, Vehicle rollover, Steering geometry. Classification of suspension systems: Solid axle, Independent, Macpherson struts; Suspension system components: Leaf springs, Coil springs, Torsion bars, Pneumatic springs, Dampers / Shock absorbers; Suspension roll center analysis. Introduction of braking systems, braking dynamics, Types of brakes: Mechanical brakes, Hydraulic brakes, Anti-locking Braking System (ABS), Traction Control System (TCS); Tires: Types / Construction, Tire designation, Tire force and tire wear; Wheels: Steel wheel and rims, Alloy wheels; Wheel balancing. Body structure, Body materials, Body finishing, chassis Types, Automotive glasses, Body locking systems, Safety parameters crash tests.

Issues faced by the industry: Fuel prices, Emissions, Safety. Stake holders in the automotive industry, Global automotive industry, Regional automotive industry, National automotive industry, and SWOT analysis.

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Daines, James R., Rickert, Paul R., & Brown, Robert Dean. Introduction to Automotive Technology.
2. Vashist, Devendra, & Ahmad, Mukthar. Automobile Engineering.

ADVANCE MANUFACTURING SYSTEMS

Credits: 2+0
Prerequisite: Manufacturing Processes

DESCRIPTION

This course is aimed at providing advanced exposure to emerging trends in the field Manufacturing Systems

COURSE LEARNING OUTCOMES

Learning Domains and Levels:

Maximum Level of Cognitive Domain	Maximum Level of Affective Domain	Maximum Level of Psychomotor Domain
C-4	N/A	N/A

Type of Course:

- Major Course
- Breadth Course

COURSE OUTLINE

Manufacturing System Thinking, Manufacturing Automation Systems, Flexible Manufacturing Systems, Group Technology, Additive Manufacturing Systems, Computer Aided Manufacturing, Factory Models, WIP Limiting Control Strategies, Simulation of Manufacturing Systems, Smart Manufacturing Systems, Manufacturing Quality Control and Productivity (Optional)

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Hitomi, K. Manufacturing Systems Engineering, 2nd Edition.
2. Groover, Mikell P. Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 5th Edition, Wiley Publication.
3. Harik, Ramy, & Wuest, Thorsten. Introduction to Advanced Manufacturing. SAE International, 2019.

MAINTENANCE ENGINEERING

Credits: 2+1
Prerequisite: Nil

DESCRIPTION

This course is aimed at providing exposure to concepts of Maintenance Engineering and relevant application.

COURSE LEARNING OUTCOMES

1. To increase functional reliability and useful life of the equipment.
2. To minimize frequency of Interruption and total production cost.
3. To enhance safety of manpower.

Learning Domains and Levels:

Maximum Level of Cognitive Domain	Maximum Level of Affective Domain	Maximum Level of Psychomotor Domain
C1	A3	P2

Type of Course:

- Major Course

Modern Tool Usage:

- Data base management through Industry 4.0 to check the life of different equipment used in the machine/ apparatus.

COURSE OUTLINE

Maintenance Control Systems, Maintenance Mathematics, Estimating Materials Costs in Maintenance Work, Maintenance Planning and Scheduling, Diagnostic Techniques, Computerized Maintenance, Inventory Control of Maintenance Materials, Maintenance Management and Control, Preventive and Corrective Maintenance, Reliability Centered Maintenance, Inventory Control in Maintenance, Quality and Safety in Maintenance, Reliability, Maintainability, Methods and Tools in Maintenance.

PRACTICAL REQUIREMENTS

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Dhillon, B.S., Engineering Maintenance: A Modern Approach, 2019.
2. Niebel, Benjamin W., Engineering Maintenance Management, 1994.
3. Department of Defense, Maintenance Engineering Techniques, Washington, D.C., 1975.
4. Engineering Maintenance Management, Marcel Dekker, New York, 1994.

PRODUCT DESIGN AND DEVELOPMENT

Credits: 2+1
Prerequisite: Computer Aided Design, Manufacturing Processes

DESCRIPTION

This course is aimed at providing exposure to concepts of Product Design and Development

COURSE LEARNING OUTCOMES

Learning Domains and Levels:

Maximum Level of Cognitive Domain	Maximum Level of Affective Domain	Maximum Level of Psychomotor Domain
C-6	A-3	P-3

Type of Course:

- Major Course
- Breadth course

COURSE OUTLINE

Product Development Process, Opportunity Identification, Product Planning, Identifying Customer Needs, Product Design Specifications, Product Concept Creation, Selection, and Testing, Industrial Design, Design for Manufacture and Environment, Prototyping, Service Design, Economic Sustainability in Product Design and Development, Project Management (Optional)

PRACTICAL REQUIREMENTS

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Ulrich, Karl, and Steven Eppinger, Product Design and Development, 3rd ed., McGraw-Hill, 2003. ISBN: 9780072471465.
2. Ulrich, Karl, Steven Eppinger, and Maria C. Yang, Product Design and Development, 7th ed., 2020.

MICROELECTROMECHANICAL SYSTEMS (MEMS)

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

This course aims to develop an understanding of Microelectromechanical Systems (MEMS), covering their historical significance, applications in various fields, microscale mechanics, fabrication techniques, sensors and actuators principles, MEMS design tools, and practical case studies.

COURSE LEARNING OUTCOMES

1. Understand Microelectromechanical Systems (MEMS), covering their historical significance
2. Analysis of microstructures and mechanical properties of microscale materials. Resonant structures and their applications
3. Design MEMS with an emphasis on mechanical engineering perspectives

COURSE OUTLINE

Introduction: Evolution of What is MEMS? Definitions and Classifications History Applications. Established MEMS Applications. New MEMS Applications. MEMS Market. Miniaturization Issues

Fabrication: Photolithography, Materials for Micromachining, Bulk Micromachining, Surface Micromachining, High-Aspect-Ratio-Micromachining

Computer Aided Design of MEMS: Modelling, Analysis and Simulation, MEMS Design Layout, MEMS Design Simulation using Finite Element Analysis.

MEMS Transducers**:** Mechanical Transducers, Radiation Transducers, Thermal Transducers, Magnetic Transducers, Chemical and Biological Transducers, Microfluidic Devices

Future of MEMS

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Prime Faraday Technology Watch, An Introduction to MEMS (Micro-electromechanical Systems).
2. Chang Liu, Foundations of MEMS.
3. Stephen D. Senturia, Microsystem Design.
4. Marc Madou, Fundamentals of Microfabrication.
5. Nadim Maluf, An Introduction to Microelectromechanical Systems Engineering.
6. Mohamed Gad-el-Hak, MEMS Handbook.

POWER PLANTS

Credits: 2+0
Prerequisite: Nil

DESCRIPTION

Electricity is the only form of energy which is easy to produce, easy to transport, easy to use and easy to control. Electricity in bulk quantities is produced in power plants, which can be, thermal using fossil fuel, nuclear, hydraulic, Gas turbine and Geothermal. 80% electricity is produced by thermal power plants using fossil fuels. The general objective is to provide students with a broad understanding of electricity generation process and equipment. At the end of the course, student should be able to understand principles of energy conversion from fossil fuels, such as coal, oil, gas, nuclear fuels and other alternates of energy production. Students will also be able to understand the environmental aspects on production of electrical energy.

COURSE LEARNING OUTCOMES

- Analyze the power plant operation and dependency of various plant parameters on efficiency and heat rate of the power plant
- Select the most feasible solution for power generation within available natural resources through report and oral presentation.
- Analyze various types of power plants with respect to effect of releases to the environment.

COURSE OUTLINE

Introduction: Review of mass and energy balances for steady flow devices, energy sources and classification; Fossil fuels; composition, ranking and analysis; combustion calculations; environmental pollution

Steam Generators and Turbines: Combustion equipment and firing methods, boiler types and their applications; boiler components, boiler operation and safety, water treatment. Impulse and reaction turbines; Pressure and Velocity Compounding, Turbine governing and controls

Steam Powerplants: Rankine Cycle, Superheat, Reheat; Regenerative Cycle, Open Type Feed Water Heaters (FWH), Closed Type FWHs with Drains Cascaded Backwards and Pumped Forward

Gas Turbine Powerplants: Gas turbine (Brayton) cycle, regeneration, intercooling

Combined Cycle Powerplants: Topping and bottoming cycles, combined cycle efficiency

Cogeneration Cogeneration of power and process heat, Back Pressure and Extraction Turbines

Diesel Engine Powerplant: General layout, Site selection criterion, performance characteristics & environmental impact consideration

Nuclear Power Plant: Nuclear fuels, nuclear reaction types, Components, reactor types, Site selection criterion, safety and environmental considerations

Renewable Energy Powerplants: Introduction to Solar, Wind, Hydro and Geothermal Powerplants

Powerplant Economics and Management: Effect of variable load, load curve, economics of thermal power plants, energy conservation and management

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Pedersen, E.S., Nuclear Power, Ann Arbor Science.
2. El-Wakil, M.M., Power Plant Technology, McGraw-Hill.
3. P.K. Nag, Power Plant Engineering, McGraw-Hill.
4. Everett Woodruff, H. Lammers, Thomas Lammers, Steam Plant Operation, McGraw-Hill.
5. T. D. Eastop, J. McConkey, Applied Thermodynamics for Engineering Technologists.

ELECTRICAL ENGINEERING

Credits: 2+0
Prerequisite: Nil

DESCRIPTION

This course covers the fundamental concepts of electrical engineering as listed below in course outline/lecture schedule. Being used and implied by Mechanical Engineering students during their course of study and application of Mechanical Engineering.

COURSE LEARNING OUTCOMES

1. Aquire knowledge of basic circuit laws and circuit theorms to compute current through and voltage across an element in linear circuits.
2. Explain the fundamental concepts of magnetism, working principles, construction, and equivalent circuits of electrical machines i.e. transformer, AC motors and generators, DC motors and generators.
3. Demonstrate the characteristics such as voltage-current, torque-speed, volatge vs speed regulation, and efficiency of different electrical machines.

COURSE OUTLINE

Introduction and Basic Electrical Definitions, Series and Parallel Circuits, Resistance, Capacitance and Inductance Properties, Network Theorems, Network Theorems, Power Factor, Power Factor Measurement and its effects on Electrical Systems, Current and Voltage relations in AC lines, RLC Circuits, AC Motors working Principle and Characteristics, Applications and Types of AC motors, Working principle of Transformer, Types of Connections in Transformers, Types and applications of Transformer, Losses and Efficiency of Transformer, DC Motors construction and Working, Types of DC Motors, Characteristics and types of different DC Motor

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. William H. Hayt, Jack Kemmerly, and Steven M. Durbin, Engineering Circuit Analysis, Seventh Edition, McGraw-Hill, 2006.
2. J. David Irwin and Robert M. Nelms, Basic Engineering Circuit Analysis, Eighth Edition, John Wiley & Sons, 2006.
3. Robert L. Boylestad, Introductory Circuit Analysis, Eleventh Edition, Prentice Hall, 2004.

ELECTRONICS ENGINEERING

Credits: 2+0
Prerequisite: Nil

DESCRIPTION

This course covers the fundamental concepts of electronics engineering as listed below in course outline/lecture schedule. Being used and implied by Mechanical Engineering students during their course of study and application of Mechanical Engineering.

COURSE LEARNING OUTCOMES

1. Disseminate the basic concepts of electronics, P-N junction and its working principle
2. Develop the understanding of electronic devices and their applications.

COURSE OUTLINE

Semiconductor Devices, Diodes and Applications, Bipolar Junction transistors (BJTs), BJT Bias Circuits, BJT Amplifiers, Number Systems, Digital Logic Gates, Boolean Algebra and Logic Simplification, Combinational Logic Circuits and Analysis, Sequential Logic Circuits and Analysis.

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. Thomas L. Floyd, Electronic Devices (Conventional Current Version), 7th Edition, Prentice Hall, 2005.
2. Thomas L. Floyd, Digital Fundamentals, 9th Edition, Prentice Hall, 2006.

OCCUPATIONAL HEALTH AND SAFETY

Credits: 1+0
Prerequisite: Nil

DESCRIPTION

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

COURSE LEARNING OUTCOMES

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

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

COURSE OUTLINE

(1) Health and Safety Foundations:
(a) Nature and scope of health and safety
(b) Reasons/benefits and barriers for good practices of health and safety
(c) Legal frame work and OHS Management System

(2) Fostering a Safety Culture:
(a) Four principles of safety- RAMP (Recognize, Assess, Minimize, Prepare)
(b) Re-thinking safety-learning from incidents
(c) Safety ethics and rules
(d) Roles and responsibilities towards safety
(e) Building positive attitude towards safety
(f) Safety cultures in academic institutions

(3) Recognizing and Communicating Hazards:
(a) Hazards and Risk

(b) 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.
(c) Learning the language of safety: Signs, symbols and labels

(4) Finding Hazard Information

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

(5) Accidents & Their Effect on Industry

(a) Costs of accidents
(b) Time lost
(c) Work injuries, parts of the body injured on the job
(d) Chemical burn injuries
(e) Construction injuries
(f) Fire injuries

(6) Assessing and Minimizing the Risks from Hazards

(a) Risk Concept and Terminology
(b) Risk assessment procedure
(c) Risk Metric's
(d) Risk Estimation and Acceptability Criteria
(e) Principles of risk prevention
(f) Selection and implementation of appropriate Risk controls
(g) Hierarchy of controls

(7) Preparing for Emergency Response Procedures

(a) Fire
(b) Chemical Spill
(c) First Aid
(d) Safety Drills / Trainings:
(e) Firefighting
(f) Evacuation in case of emergency

(8) Stress and Safety at Work environment

(a) Workplace stress and sources
(b) Human reaction to workplace stress
(c) Measurement of workplace stress
(d) Shift work, stress and safety
(e) Improving safety by reducing stress
(f) Stress in safety managers
(g) Stress and workers compensation

(9) Incident Investigation

(a) Importance of investigation
(b) Recording and reporting
(c) Techniques of investigation
(d) Monitoring
(e) Review
(f) Auditing Health and Safety

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Jeremy Stranks, The A-Z of Health and Safety, 2006.
2. Jeremy Stranks, The Manager's Guide to Health & Safety at Work, 8th Edition, 2006.
3. Ogletree, Deakins, Nash, Smoak and Stewarts, Occupational Safety and Health Law Handbook, 2nd Edition, 2008.

MEASUREMENTS AND INSTRUMENTATION

Credits: 2+1
Prerequisite: Basic Mathematics and Physics Courses

DESCRIPTION

Introduction to measurement standards, design of experiment, major blocks of a measurement system, introduction to instruments, statics and dynamic characteristics of instruments, analog and digital signals, active and passive filters, temperature measurement, pressure measurement, position measurement, hall-effect sensing and application, piezoelectric sensors and applications, design of a sensor, data acquisition systems and post-processing/data analysis, test rig development

COURSE LEARNING OUTCOMES

1. Demonstrate a deep understanding of measurement and instrumentation principles by explaining how various sensors and transducers work and their applications in industrial engineering.
2. Analyze complex measurement data sets from real-world industrial scenarios, identifying trends, patterns, and potential sources of error.
3. Evaluate the effectiveness and limitations of different measurement and instrumentation techniques and instruments in specific industrial applications, making informed judgments based on critical analysis.

Maximum Level of Cognitive Domain	Maximum Level of Affective Domain	Maximum Level of Psychomotor Domain
C-4	N.A. in Theory	N.A. in Theory

1. UNDERSTAND the basic concepts / principles related to measurement and working of sensors
2. ANALYZE the sensor data
3. DESIGN sensor-based solution

COURSE OUTLINE

Introduction to Measurement and Instrumentation: Overview of measurement and instrumentation, Importance in industrial engineering, Units and standards of measurement; Measurement Errors and Uncertainty: Types of errors in measurements, Sources of error and their reduction, Uncertainty analysis; Sensors and Transducers: Classification of sensors, Principles of operation, Types of transducers (resistive, capacitive, inductive, etc.); Signal Conditioning and Amplification: Signal conditioning circuits, Amplifiers and their types, Filtering and noise reduction techniques; Data Acquisition Systems: Analog-to-digital converters (ADC), Digital-to-analog converters (DAC), Sampling and quantization; Calibration and Metrology: Importance of calibration,

Calibration methods and standards, Metrological traceability; Instrumentation for Process control instruments (pressure, temperature, low, level); Emerging Trends in Measurement and Instrumentation under the Context of Industry 4.0: Wireless and IoT-based instrumentation, Remote monitoring and control, Case studies and real-world applications

Modern Tools which can used:

- Matlab
- LabView

PRACTICAL REQUIREMENTS

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

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. John L. Sluder, Process Instrumentation, Pearson, Latest Edition.
2. Alan S. Morris and Reza Langari, Measurement and Instrumentation: Theory and Application, Academic Press, Latest Edition.
3. John P. Bentley and William G. Carr, Principles of Measurement Systems, Pearson.
4. Robert B. Northrop, Introduction to Instrumentation and Measurements, CRC Press.

MECHATRONICS AND ROBOTICS ENGINEERING

Credits: 2+0
Prerequisite: Nil

DESCRIPTION

This course is aimed to acquire fundamental knowledge for electro-mechanical design and to develop synergistic integration of mechanical, electrical, electronic engineering applications.

COURSE LEARNING OUTCOMES

1. Understand the basics of robotics and its components
2. Solve the kinematics of a robotic system.
3. Design a robot system to meet kinematics requirements.

COURSE OUTLINE

Introduction to Mechatronics, component of Mechatronics, Mechatronics systems, data acquisitions systems and software interface, sensors, actuators, and current trends in robotics.

Types of robots, Types of joints used in robots, Degree of freedom and constraints, Denavit-Hartenherg coordinate transformations, Transformations from one system to the other, Forward and Inverse kinematics, Jacobian, Velocity and Force Analysis, Dynamics of robots, Path planning and trajectory analysis, Linear control of manipulators.

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. W. Bolten, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, 4th Edition.
2. David Alciatore, Introduction to Mechatronics and Measurement Systems, Latest Edition.
3. Devdas Shetty and Richard Kolk, Mechatronics System Design, Brooks/ Cole CENGAGE Learning, Latest Edition.
4. J. Craig, Introduction to Robotics, 3rd Edition, Prentice Hall.

*** List of Mathematics Electives (3+0)
• Applied Statistics • Probability and Stochastic • Multivariable Calculus

APPLIED STATISTICS

Credits: 3+0
Prerequisite: Nil

DESCRIPTION

This course is aimed to acquire fundamental knowledge of Statistics keeping in view its application in Engineering domain.

COURSE LEARNING OUTCOMES

1. Understand the basic concept of statistics and probability and their need in engineering
2. Apply probability concept in understanding and anylsis of different mechanical engineering problems.
3. Develop the decision-making ability, in the presence of uncertain situations

COURSE OUTLINE

Basic Probability
Probabilistic Model, Conditional Probability, Total Probability Theorem, Multiplicative and Additive Rules of Probability, Dependent and Independent Events, and Bayes' Rule.

Random Variables
Basic Concepts, Probability Mass Functions, Functions of Random Variables, Expectation, Mean, and Variance, Joint PMFs of Multiple Random Variables, Conditioning, Independence,
Continuous Random Variables and PDFs, Cumulative Distribution Functions, Normal Random Variables, Joint PDFs of Multiple Random Variables, Conditioning, The Continuous Bayes' Rule.
Derived Distributions, Covariance and Correlation, Conditional Expectation and Variance Revisited, Transforms, Sum of a Random Number of Independent Random Variables.

Probability Distributions
Binomial Distribution, Poisson Prob. Distribution, Poisson Process, Normal Distribution, Exponential Distribution. The Bernoulli Process, The Poisson Process, Summary and Discussion Problems,

Regression Correlation
Regression by Least Square Method, Linear , Quadratic, Power and Exponential Models, Its Application in Mechanical engineering, Correlation Coefficient and Its application.

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. William Mendenhall and Terry Sincich, Statistics for Engineers.
2. Prof. Share Muh. Chaudhry, Introduction to Statistical Theory Part-I and Part-II.
3. Ronald E. Walpol, Probability and Statistics for Engineers and Scientists.

PROBABILITY AND STOCHASTIC

Credit: 3+0
Placement: Nil

DESCRIPTION

This course provides the students with a deeper understanding about the theory of probability and the concepts of stochastics theory and analysis.

COURSE LEARNING OUTCOMES

1. Apply concepts of probability for Discrete Random Variable and Continuous Random Variables
2. Apply the Exponential Distribution and Poisson Process to Stochastic Models.

COURSE OUTLINE

- Set theory,
- basic concepts of probability,
- conditional probability,
- independent events,
- Baye's formula,
- discrete and continuous random variables,
- distributions and density functions,
- probability distributions (binomial, Poisson, Hypergeometric, Gaussian, uniform and exponential) functions,
- mean,
- variance
- standard deviations,
- moments and moment generating functions,
- linear regression and curve fitting,
- limits theorems, stochastic processes,
- first and second order characteristics,
- applications,
- Convergence of Sequence,
- Convergence of RVs,
- Norm of Vectors and Function,
- Convergence of RV's,
- Inequalities,
- Markov Chains

RECOMMENDED TEXT AND REFERENCE BOOKS

1. Sher Muhammad Chaudhary, Introduction to Statistical Theory Part 1, Latest Edition.
2. Erwin Kreyszig, Advanced Engineering Mathematics, Latest Edition.
3. Antony Hayter, Probability and Statistics for Engineers and Scientists.
4. Bluman, Elementary Statistics.

MULTIVARIATE CALCULUS

Credit: 3+0=3
Placement: Nil

DESCRIPTION

This course is aimed to acquire fundamental knowledge of Multivariate Calculus and its engineering application

COURSE LEARNING OUTCOMES

1. Analysis of Geometry of Space, Vector-Valued Functions and Motion in Space
2. Solve problems of PDEs and multiple integrals
3. Analyze problems of vectors fields integration

COURSE OUTLINE

Introduction to function of several variables. Elements of three-dimensional geometry and coordinate systems. Limits and continuity of function of several variables with geometrical interpretations. Partial derivatives, geometric meanings and related results and theorems. Introduction to vectors and vector triple products. Tangent planes and normal lines. Extrema of functions of several variables, their examples and related results and theorems. Use of integrals and double integrals with examples. Polar coordinate systems their sketching and double integrals in polar coordinates with examples. Vector valued functions, their limits and change of parameters. Exact differential and line integral with examples. Scalar field with examples. Higher order derivatives and Leibniz theorem. Taylor and Maclaurin series. Numerical integration.

RECOMMENDED TEXT AND REFERENCE BOOKS

1. James Stewart, Multivariable Calculus, 7th Edition.
2. Tom M. Apostol, Multi-Variable Calculus and Linear Algebra with Applications to Differential Equations and Probability.

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