CURRICULUM

OF

MECHANICAL ENGINEERING

For

Bachelor & Master Program

(Revised 2017)

HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

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PREFACE

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

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

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

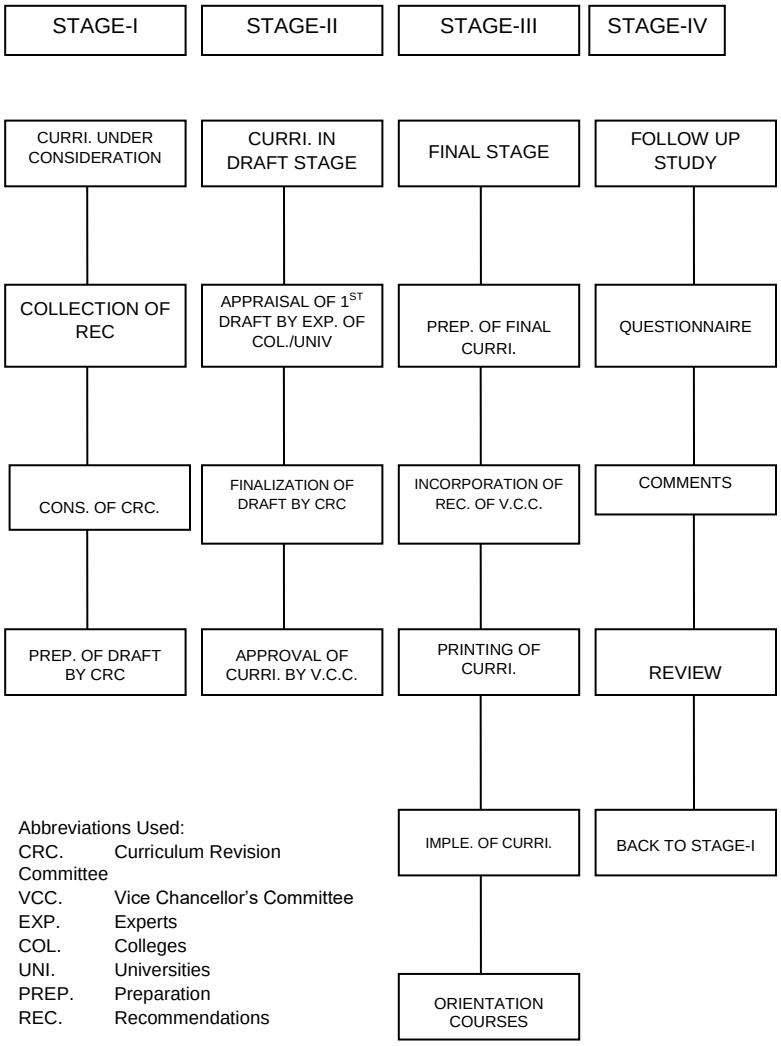
In order to impart quality education which is at par with indigenous needs and international standards, HEC NCRCs have developed unified framework/ templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture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

It is hoped that this curriculum document, prepared by the respective NCRC's, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC

http://hec.gov.pk/english/services/universities/RevisedCurricula/Pages/default.aspx

(Muhammad Raza Chohan)
Director General (Academics)

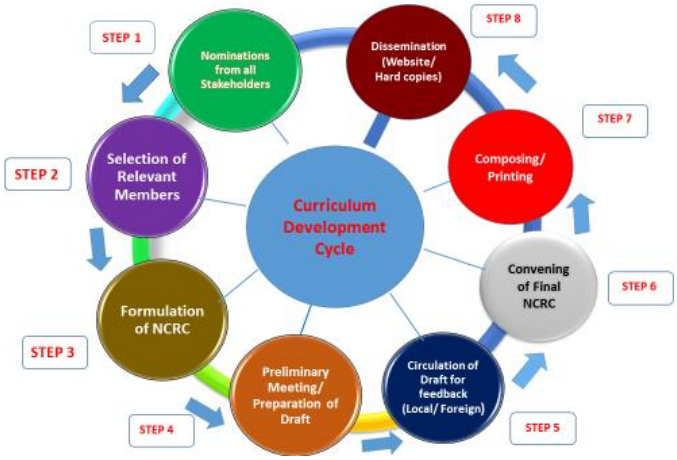
CURRICULUM DEVELOPMENT PROCESS



Abbreviations Used:

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

CURRICULUM DEVELOPMENT CYCLE



MINUTES OF FINAL MEETING OF NCRC (MECHANICAL ENGINEERING) FOR BACHELOR AND MASTERS DEGREE PROGRAMMES

The final meeting of National Curriculum Revision Committee (NCRC) in the discipline of Mechanical Engineering for Bachelor's and Master's Degree programmes was held from 15-17 May, 2017 (03 days) at HEC, Regional Center, Karachi. Experts from academia and industry participated in the meeting. Dr. Muhammad Idrees (Director, Academics Division, HEC, Pakistan) coordinated the NCRC meeting. The list of the participants of final meeting is as below:

S.N	Name & Institution	Position
1	Dr. S. Kamran Afaq (**Convener)** Chairman / Professor, Department of Mechanical Engineering, HITEC University, Museum Road, Taxila.	Convener
2	Dr. Taqi Ahmad Cheema (**Secretary)** Assistant Professor, Department of Mechanical Engineering, GIK Institute of Engineering Science & Technology, Topi, Swabi, KPK.	Secretary
3	Engr. Dr. Johar Khurshid Farooqi, Dean / Professor, Department of Mechanical Engineering, DHA Suffa University, Off Khayaban-e-Tufail, Phase-VII, DHA, Karachi.	Member
4	Prof. Dr. Muhammad Abid, Chairman /Professor, Department of Mechanical Engineering, COMSATS Institute of Information Tech, Chak Shahzad, Islamabad.	Member
5	Dr.-Ing. Syed Mushahid Hussain Hashmi (PEC Nominee) Chairman / Professor, Department of Automotive & Marine Engineering, NED University of Engineering & Technology, Karachi.	Member
6	Engr. Prof. Dr. Shahab Khushnood (PEC Nominee) Dean, Department of Mechanical Engineering, University of Engineering and Technology, Taxila.	Member

7	Dr. Faraz Junejo, HoD, Department of Mechatronics Engineering, Shaheed Zulfiqar Ali Bhutto Institute of Science & Technology, 90 & 100 Clifton, Karachi.	Member
8	Prof. Dr. Asif Israr, HoD, Department of Mechanical Engineering, Institute of Space & Technology, Islamabad Highway, Islamabad.	Member
9	Dr. Muhammad Rizwan Shad, HoD / Associate Professor, Department of Mechanical Engineering, University of Central Punjab, Johar Town, Lahore.	Member
10	Prof. Engr. Dr. M. Javed Hyder, Director (ORIC), Department of Mechanical Engineering, Pakistan Institute of Engineering & Applied Sciences, Nilore, Islamabad	Member
11	Engr. Prof. Dr. Babar Saeed (PEC Nominee) Professor, Department of Mechanical Engineering Air University, Islamabad.	Member
12	Dr. Khanji Harijan (PEC Nominee) Professor, Department of Mechanical Engineering Mehran University of Engineering & Technology, Jamshoro.	Member
13	Dr. Mubashir Ali Siddiqui Professor, Department of Mechanical Engineering, NED University of Engineering & Tech, University Road, Karachi.	Member
14	Dr. Jawaid Daudpoto, Professor, Department of Mechanical Engineering, Mehran University of Engineering & Technology, Jamshoro, Sindh.	Member
15	Prof. Dr. Naseer Ahmed, Professor, Department of Mechanical Engineering, CECOS University of IT &Emerging Sciences, Phase-VI, Hayatabad, Peshawar.	Member
16	Dr. Nadeem Ahmad Sheikh Associate Professor,	Member

	Department of Mechanical Engineering, Capital University of Science & Technology, Islamabad.	
17	Dr. Liaquat Ali Khan. Associate Professor, Department of Mechanical Engineering, Capital University of Science & Technology, Islamabad.	Member
18	Dr. Tipu Sultan Associate Professor, Department of Mechanical Engineering, University of Management & Technology, C-II, Johar Town, Lahore.	Member
19	Dr. Muhammad Kashif, Assistant Professor, Department of Mechanical Engineering, University of Central Punjab, Johar Town, Lahore.	Member
20	Dr. Tahir Abdul Hussain, Assistant Professor, Department of Mechatronics Engineering, Shaheed Zulfiqar Ali Bhutto Institute of Science & Technology, Clifton, Karachi.	Member
21	Engr. Dr. Muhammad Saleem Assistant Professor, Department of Mechanical Engineering, Sarhad University of Science & Information Technology, Peshawar.	Member
22	Dr. Muhammad Sajid, Assistant Professor, Department of Mechanical Engineering, School of Mechanical & Manufacturing Engineering, NUST, Islamabad.	Member
23	Dr. Muhammad Idrees Director (Curriculum) / Coordinator Higher Education Commission, Islamabad.	Coordinator

List of members who attended preliminary meeting but could not attend final meeting due to their personal engagements during these dates:-

1	Dr. Nasir Hayat, Professor, Department of Mechanical Engineering, University of Engineering & Technology, G. T. Road, Lahore.	Member
2	Dr. Bilal Akbar Assistant Professor, Department of Mechanical Engineering, Mirpur University of Science & Technology, Mirpur, AJK	Member

3	Dr. Zeshan Ahmad Assistant Professor, Department of Mechanical Engineering, University of Management & Technology, C-II, Johar Town, Lahore.	Member
4	Mr. Ghulam Mustafa Head of Quality Assurance Department Millat Tractors Ltd. Shekhupura Road, Lahore	Member

Dr. Mahrukh, Assistant Professor, Department of Mechanical Engineering, NED University of Engineering & Tech, University Road, Karachi attended final meeting only.

NCRC Agenda

The agenda of NCRC for Mechanical Engineering was as follows:

1. To revise/ finalize the Mechanical Engineering curriculum (2017) for Bachelors and Masters Degree Programmes according to indigenous needs and to bring it at par with international standards on Outcomes Based Education (OBE).
2. To revise/update preface/ preamble and rationale of the subject.
3. To develop and revise programme objectives, programme learning outcomes (PLOs), teaching methods and assessment criteria (formative & summative)
4. To incorporate/suggest latest reading materials/references (local & international) for every course.
5. To revise/finalize course contents keeping in view the uniformity across other disciplines and avoiding overlapping.
6. To make recommendations for promotion/development of the discipline, keeping in view the futuristic needs of the society and international trends.

The meeting started with recitation from the Holy Quran. Dr. Muhammad Idrees, Director, Academics Division, Higher Education Commission, Pakistan welcomed the participants. All the participants introduced themselves highlighting their qualification, experience and area of expertise within the discipline of Mechanical Engineering. Keeping with the tradition, Dr. Muhammad Idrees, offered the house to opt the Convener and Secretary of the preliminary NCRC for smooth functioning which was unanimously agreed.

Dr. Muhammad Idrees presented the agenda and objectives of the NCRC. He highlighted the importance of this meeting and emphasized for adaptation of general rules of curriculum development and revision like scope of the subject/programme, horizontal & vertical alignment, rule of flexibility and adaptability keeping in view the futuristic approach, market value/job market and societal needs. He also shared a template for revising/updating the curricula according to paradigm shift of Outcome Based Education (OBE). The template was unanimously accepted to be followed. It was also agreed to add preamble, programme objectives, programme learning outcomes, teaching methodology and assessment segments in the curricula.

On the first day, the house openly discussed the preliminary draft of the Bachelor in Mechanical engineering curriculum. Each course contents, course learning outcomes (CLOs) and their mapping with program learning outcomes (PLOs) was discussed in detail. After long deliberation, the committee finalized the nomenclature, framework/scheme of studies, the duration of the programme, number of semesters, number of weeks per semester, total number of credit hours, number of credit hours per semester, weightage of engineering and non- engineering courses and weightage of theory and practical of undergraduate 4-years programme for Mechanical Engineering. Furthermore, list of courses (core & elective) and semester wise breakup of courses were also discussed thoroughly and the same was unanimously finalized.
On second day, the courses of postgraduate programme of Mechanical Engineering were reviewed along with course outlines and text books of each course of postgraduate programme. After through discussion intake criteria, core and elective courses were finalized. It was decided that the draft curriculum of Mechanical Engineering would be circulated among the members for final review and the feedback will be incorporated on the third day.

On third day, the committee reviewed the whole draft for the last time and after minor changes were incorporated with the consent of the house. At the end, the committee also gave recommendations for further improvement.

In the end, Dr. Idrees thanked the Convener and Secretary and all members of the Committee for sparing their time and for their contribution to prepare the revised draft of the curriculum. He further stated that their efforts will go a long way in developing workable, useful and market oriented comprehensive degree programmes in Mechanical Engineering. The Convener of the NCRC also thanked the Secretary and members for their inputs in revising/updating the curriculum to make it more practical, competitive, efficient and realistic. The committee highly appreciated the efforts made by the officials of HEC Regional Centre, Karachi for making arrangements to facilitate the committee and their accommodation. The

meeting ended with the vote of thanks to HEC and Dr. Muhammad Idrees and his team from HEC for providing this academic and professional opportunity for national cause.

MISSION STATEMENT

The Mechanical Engineering Curriculum is designed to provide necessary knowledge, analytical skills, leadership abilities, critical thinking, research capabilities and ethical values to the graduates for meeting the technological challenges.

SCOPE

The scope of Mechanical Engineering Curriculum is based on existing needs of this discipline and a cushion for accommodation of courses / contents to address emerging / futuristic trends in the discipline of Mechanical Engineering. The role for Industry-Academia linkage to address problems facing industry and their indigenous solutions is also in the scope of this curriculum.

Bachelor in Mechanical Engineering

CURRICULUM AND LEARNING PROCESS

The genesis of any engineering program is the fusion of its stakeholders' perceptions. The academic curriculum of the program is designed to facilitate / ensure the achievement of program outcomes by all students. This is achieved by offering a balanced combination of technical and non-technical contents coupled with appropriate assessment and evaluation methods. This has a well-defined core of essential subjects supported by requisite compulsory as well as elective courses. It also invokes awareness and comprehension of societal problems amongst the students and motivating them to seek solutions for improving the quality of life. The theory content of the curriculum is supplemented with appropriate experimentation / laboratory work.

The program structure is covering the essential fundamental principles at the initial stages, leading to integrated studies in the final year of the program, in consonance with the approach and levels defined in Bloom's taxonomy, particularly in breadth & depth courses.

The hallmark of a curriculum is to infuse original thinking, resourcefulness and entrepreneurial spirits among students. This program is embodying foundation courses as well as the general and specialized professional content of adequate Breadth and Depth, including appropriate Humanities and Science components. The program scheme is designed to ensure acquisition of knowledge and skills, encouraging necessary exposure to inter-disciplinary areas.

The contents of each constituent courses of the curriculum has been updated to absorb recent technological and knowledge developments as per international practices and to meet the national needs. Efforts are also made that there should also be an effective relationship between the curricular content and practice in the field of specialization.

It is expected that the graduates are able to demonstrate professional ethics and competence in oral communication, scientific & quantitative reasoning, critical analysis, system design, logical thinking, creativity and capacity for life-long learning.

The delivery of subject matter and the assessment process employed is expected enabling the students to develop intellectual and practical skills effectively, as deemed essential in program outcomes assessment. Complex engineering problems which are not easily quantifiable, e.g. communication skills (oral / written), critical thinking, ethics, team work, etc. often require rubrics as a tool for their assessment (both in direct or indirect methods).

In addition to regular teaching / learning activities such as classroom interaction, PBL assignments, lab experimentation and faculty consultation, other aspects of student learning such as tutorial system, research / design projects, seminar / workshops and exposure to industrial practice should form an integral part of curriculum. Internal reviews of quality assurance procedures should be carried out periodically.
Program educational objectives (PEOs), Program learning outcomes (PLOs) and Course learning outcomes (CLOs) for a Bachelor in Mechanical Engineering program are given as follows.

Program Educational Objectives (PEOs)
The program offered by the institution should also have well defined program objectives. Program educational objectives (PEOs) are broad statements that describe what graduates are expected to achieve a few years after graduation. It should be ensured that the program objectives are aligned with the vision/mission of the institution. Program objectives should be articulated and made known to everyone in the institution through institutional publications and websites.

The successful pursuit and realization of the mission and objectives, and the means adopted to accomplish them bring out the quality of the institution and its programs. Program educational objectives are based on the needs of the program's constituencies and are linked to student learning outcomes and assessment process.

The objectives should be clear, concise, realistic and measurable within the context of the committed resources. A process should be developed to assess the level of attainment of the program objectives to evaluate effectiveness of the academic programs. It should include feedback from

faculty, employers, alumni and other stakeholders. The evaluation results should be utilized for redefining/improving the program objectives.

The program must demonstrate that following are in place:

a) Well-defined and published Program Mission
b) Program's educational objectives defined and consistent with the mission
c) Program's educational objectives based on the stakeholder's needs on program
d) A process in place to evaluate the attainment of educational objectives
e) Evaluation results used for continual improvement of the program

Program Learning Outcomes (PLOs)

Program outcomes are the narrower statements that describe what students are expected to have acquired, be able to demonstrate and practice by the time of graduation. These relate to the knowledge, skills and attitude that the students acquire while progressing through the program.

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. Specifically, it is to be demonstrated that the students have acquired the following graduate attributes:

The Program Learning Outcomes (PLOs) of Mechanical Engineering will cover PLO 01-12.

PLO-01: Engineering Knowledge: Ability to apply knowledge of mathematics, science and engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

PLO-02: Problem Analysis: Ability to identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PLO-03: Design/Development of Solutions: 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.

PLO-04: Investigation: Ability to investigate complex engineering problems in a methodical way including literature survey, design and conduct of experiments, analysis and interpretation of experimental data, and synthesis of information to derive valid conclusions.

PLO-05: Modern Tool Usage: Ability to create, select and apply appropriate techniques, resources, and modern engineering and IT tools,

including prediction and modeling, to complex engineering activities, with an understanding of the limitations.

PLO-06: The Engineer and Society: Ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solution to complex engineering problems.

PLO-07: Environment and Sustainability: Ability to understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

PLO-08: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PLO-09: Individual and Team Work: Ability to work effectively, as an individual or in a team, on multifaceted and/or multidisciplinary settings.

PLO-10: Communication: Ability to communicate effectively, orally as well as in writing on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentations, make effective presentations, and give and receive clear instructions.

PLO-11: Project Management: Ability to demonstrate management skills and apply engineering principles to one's own work, as a member and/or leader in a team to manage projects in a multidisciplinary environment.

PLO-12: Lifelong Learning: Ability to recognize importance of, and pursue lifelong learning in the broader context of innovation and technological developments.

In addition to incorporating the graduate attributes (PLO 1) to (PLO 12) listed above as the program learning outcomes, the educational institution may also include any additional outcomes if adopted.

Specific details relating to the processes adopted for assessing, evaluating and reviewing the program outcomes should be provided. The institution can also present the internal quality assessment cycle adopted by its Quality Enhancement Cell (QEC).

In particular, the program must demonstrate the following:

a) Well-defined and published Program Outcomes
b) Program Outcomes linked to the Program Objectives
c) Program Outcomes encompass desired outcomes listed above
d) Mapping of Program Outcomes to Course Learning Outcomes (CLOs)
e) Teaching, learning and assessment methods are appropriate and supportive to the attainment of Course Learning Outcomes
f) Quality of assessment mechanism to evaluate achievement levels for all the Program Outcomes by each student
g) Process in place by which assessment results are applied to further refine the assessment mechanism and/or redefine the program /

course outcomes, thus leading to continuous improvement of the program

Course Learning Outcomes (CLOs)

The courses included in Mechanical Engineering program are designed according to the Course Learning Outcomes (CLOs). It necessitates that upon successful completion of the course, the student will be able to achieve knowledge, demonstrate skills and attain attitude.

RATIONALE

The Curriculum of Mechanical Engineering has vertical and horizontal alignments. The vertical alignments include placing/offering of basic and/or prerequisite courses in the initial semesters of a degree and those comprising advanced contents in the senior level semesters. The vertical alignments also address the issues of flow or linear advancement of knowledge from intermediate, undergraduate and graduate level degrees. The horizontal alignments include coherence of Mechanical Engineering with other Engineering disciplines.

Evaluation of students' performance will be based on Bloom's Taxonomy of Learning Domains comprising Cognitive, Affective, and Psychomotor. Evaluation scores are given below. The lab part of the course will be evaluated based on RUBRICS for Lab that will include i) Lab Reports, ii) Lab Demonstration, and iii) Viva Voce. The lab part of the course will be assessed as a total of 100 to be converted to the ratio of actual lab score for the number of specified credit hours. The following table proposes typical calculations for scores of a course.

Activity	**Proportional Score**
Mid/Sessional exam	20%-40% of the total theory part
Quizzes, Assignments	10%-30% of the total theory part
Lab	Weightage of the lab is proportional to the credit hours of the theory and lab
Final	40%-60% of the total theory part

ELIGIBILITY CRITERIA FOR ADMISSION

Engineering Education Regulations of Pakistan Engineering Council should be adhered to admission criteria.

FRAMEWORK
BACHELORS ENGINEERING PROGRAM IN MECHANICAL ENGINEERING

Duration:	4 years
Number of Semesters:	8
Number of weeks per semester:	18 (16 for teaching and 2 for exams)
Total number of credit hours:	130-136
Engineering Courses:	65-75 per cent
Non-Engineering Courses:	25-35 per cent

Non-Engineering Domain

Knowledge Area	Subject Area	Course	Lec CH	Lab CH	CR	Total Courses	Total Credits	% Area	% overall
Humanities	English/ Language	English-I	2	0	2	3	6	15.8	4.41
		English-II	1	1	2				
		English-III	1	1	2				
		Foreign Language	**Non-credit but compulsory**						
	Culture	Pakistan Studies	2	0	2	2	4	10.5	2.94
		Islamic Studies/ Ethics	2	0	2				
	Social Science	Social Science	2	0	2	1	2	5.3	1.47
Management Sciences		Management Elective	2	0	2	4	6	15.8	4.41
		Entrepreneurship	1	0	1				
		Engineering Economics	2	0	2				

		Health, Safety and Environment	1	0	1				
Natural Sciences	Physics	Applied Physics	2	1	3	1	3	7.9	2.21
	Mathematics	Mathematics-1	3	0	3	5	15	39.5	11.03
		Mathematics-2	3	0	3				
		Mathematics-3	3	0	3				
		Mathematics-4	2	1	3				
		Mathematics-5	3	0	3				
	Chemistry	Applied Chemistry	2	0	2	1	2	5.3	1.47
		Total				**17**	**38**	**100.0**	**27.94**

Engineering Domain									
Knowledge Area	**Subject Area**	**Course**	**Lec CH**	**Lab CH**	**CR**	**Total Courses**	**Total Credits**	**% Area**	**% overall**
Computing	Fundamentals	Computer Systems and Programming	2	1	3	1	3	3.06	2.21
Engineering Foundation		Engineering Drawing and Graphics	1	1	2	14	35	35.71	26
		Computer Aided Drawing	0	1	1				
		Engineering Mechanics-I: Statics	3	0	3				

		Engineering Mechanics-II: Dynamics	3	0	3				
		Engineering Mechanics Lab	0	1	1				
		Mechanics of Materials-I	3	0	3				
		Thermodynamics-I	3	0	3				
		Workshop Practice	0	2	2				
		Mechanics of Machines	3	0	3				
		Fluid Mechanics-I	3	0	3				
		Manufacturing Processes	3	1	4				
		Instrumentation and Measurement	2	1	3				
		Introduction to Engineering	1	0	1				
		Engineering Materials	3	0	3				
Major Based (Core Breadth)		Machine Design-I	3	0	3	11	27	27.5	19.85
		Machine Design-II	2	0	2				
		Introduction to Finite Element Analysis	2	1	3				
		Fluid Mechanics-II	3	0	3				
		Fluid Mechanics Lab	0	1	1				
		Heat and Mass Transfer	3	0	3				
		Control Engineering	3	1	4				

		Thermodynamics-II	3	0	3				
		Thermodynamics Lab	0	1	1				
		Mechanics of Materials-II	3	0	3				
		Mechanics of Materials Lab	0	1	1				
Major Based (Core Depth)		Internal Combustion Engines	3	0	3	10	21	21.42	15.44
		Mechanical Vibrations	3	0	3				
		Mechanisms and Mechanical Vibration Lab	0	1	1				
		Heating, Ventilating and Air Conditioning	3	0	3				
		Power Plants	3	0	3				
		I.C Engines and Power Plants Lab	0	1	1				
		Heat Transfer and HVAC Lab	0	1	1				
		Technical Elective-I	2	0	2				
		Technical Elective-II	2	0	2				
		Technical Elective-III	2	0	2				
Interdisciplinary Engineering (Breadth)		Electrical Engineering	2	1	3	2	6	6.12	4.41
		Electronics Engineering	2	1	3				
Senior Design Project		Senior Design Project-I	0	3	3	2	6	6.12	4.41

		Senior Design Project-II	0	3	3				
Industrial Training			Non-credit						
Total						40	98	100	72.06

SECHEME OF STUDIES
BACHELORS (Mechanical Engineering)

Note: *A sample for distribution of courses in different semesters is provided, however universities/institutes may make changes according to their available faculty and schedule.* ***Each lab course will be treated as a separate course.***

Semester 1

Sr. No	Subjects	Credit Hrs		Credit Hours
		Theory	Lab	
1	Mathematics-1	3	0	3
2	Applied Physics	2	1	3
3	Applied Chemistry	2	0	2
4	Functional English	2	0	2
5	Computer Systems and Programming	2	1	3
6	Engineering Drawing and Graphics	1	1	2
7	Introduction to Engineering	1	0	1
Total		**13**	**3**	**16**

Semester 2

Sr. No	Subjects	Credit Hrs		Credit Hours
		Theory	Lab	
1	Computer Aided Drawing	0	1	1
2	Electrical Engineering	2	1	3
3	Mathematics-2	3	0	3
4	Communication Skills	1	1	2
5	Workshop Practice	0	2	2
6	Engineering Mechanics-I: Statics	3	0	3
7	Engineering Materials	3	0	3
Total		**12**	**5**	**17**

Semester 3

Sr. No	Subjects	Credit Hrs		Credit Hours
		Theory	Lab	
1	Pakistan Studies	2	0	2
2	Engineering Mechanics-II: Dynamics	3	0	3
3	Mechanics of Materials–I	3	0	3
4	Thermodynamics-I	3	0	3
5	Technical Report Writing and Presentation Skills	1	1	2
6	Engineering Mechanics Lab	0	1	1
7	Mathematics-3	3	0	3
Total		**15**	**2**	**17**

Semester 4

Sr. No	Subjects	Credit Hrs		Credit Hours
		Theory	Lab	
1	Electronics Engineering	2	1	3
2	Thermodynamics-II	3	0	3
3	Social Sciences (Elective)	2	0	2
4	Machine Design-I	3	0	3
5	Mechanics of Materials–II	3	0	3
6	Mechanics of Materials Lab	0	1	1
7	Fluid Mechanics-I	3	0	3
8	Thermodynamics Lab	0	1	1
Total		**16**	**3**	**19**

Semester 5

Sr. No	Subjects	Credit Hrs		Credit Hours
		Theory	Lab	
1	Fluid Mechanics-II	3	0	3
2	Mathematics-4	2	1	3
3	Machine Design -II	2	0	2
4	Instrumentation and Measurement	2	1	3
5	Heat & Mass Transfer	3	0	3
6	Manufacturing Processes	3	1	4
7	Fluid Mechanics Lab	0	1	1
Total		**15**	**4**	**19**

Semester 6

Sr. No	Subjects	Credit Hrs		Credit Hours
		Theory	Lab	
1	Engineering Statics	3	0	3
2	Technical Elective-I	2	0	2
3	Control Engineering	3	1	4
4	Mechanics of Machines	3	0	3
5	Heating, Ventilating and Air Conditioning	3	0	3
6	Heat Transfer and HVAC Lab	0	1	1
7	Health, Safety and Environment	1	0	1
Total		**15**	**2**	**17**

Semester 7

Sr. No	Subjects	Credit Hrs		Credit Hours
		Theory	Lab	
1	Engineering Economics	2	0	2
2	Mechanical Vibrations	3	0	3

3	Internal Combustion Engines	3	0	3
4	Technical Elective-II	2	0	2
5	Senior Design Project-I	0	3	3
6	Mechanisms and Mechanical Vibrations Lab	0	1	1
7	Introduction to Finite Element Analysis	2	1	3
Total		**12**	**5**	**17**

Semester 8

Sr. No	**Subjects**	**Credit Hrs**		**Credit Hours**
		Theory	**Lab**	
1	Islamic Studies/ Ethics	2	0	2
2	Technical Elective-III	2	0	2
3	Management Elective	2	0	2
4	Entrepreneurship	1	0	1
5	Power Plants	3	0	3
6	IC Engines & Power Plants Lab	0	1	1
7	Senior Design Project-II	0	3	3
Total		**10**	**4**	**14**
Grand Total		**108**	**28**	**136**

No. of credit hours (Non-Engineering Domain) = 38

No. of credit hours (Engineering Domain) = 98

Bachelor in Mechanical Engineering Program
Course Details

The course outlines of the Bachelor in Mechanical Engineering courses are given below as a guideline only. The course learning outcomes (CLOs) and their mapping with the program learning outcomes (PLOs) and the learning levels of each course are provided as a sample only. The universities/DAIs may make changes keeping in view their strengths, vision and mission.

Applied Physics

Contact Hours:	**Credit Hours:**
Theory =32	Theory =2**.0**
Practical = 48	Practical = **1.0**
Total = 80	Total = **3.0**

COURSE LEARNING OUTCOMES:

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

S.No	CLO Statement	Domain	Learning Level	PLO
1	**Comprehend** key concepts related to position, velocity and acceleration in Cartesian Coordinate System for particles.	Cognitive	2	1
2	**Comprehend** concepts related to kinetics including work, energy and momentum for particles.	Cognitive	2	1
3	**Apply** the key concepts of electrostatic force/field/potential; electric dipole; electric flux and magnetic dipole, magnetic field etc. to real world / engineering problems	Cognitive	3	2

4	**Analyze** the problems related to electromagnetics using different principles and techniques for their solution	Cognitive	4	2
5	**Perform** experiments in mechanics, oscillations and electromagnetism as per instructions.	Psychomotor	3	4

Course Outline

1. Measurement of Physical Quantities
2. Introduction to Mechanics
   a. Rectilinear Motion
   b. Vectors
   c. Motion in two and three Dimension
   d. Force and Motion
3. Kinetic Energy and Work
4. Coulomb's Law
5. Electric and Magnetic Fields
6. Gauss's Law

Practical Work

Experiments related to concepts learned in theory classes will be conducted.

Teaching Methodology

- Lecturing
- Problem Solving Sessions (Tutorial, Interactive)
- Written Assignments
- Practical Experiments for Lab Work

Assessment

Quizzes, Assignments, Mid Exam, Final Exam

Textbook and Reference Books

1. Halliday, Resnick and Walker, *Fundamentals of Physics*, John Wiley & Sons
2. Houg D. Young and Roger A. Freedman, *University Physics,* Addison-Weslay
3. Raymond A. Serway, John W. Jewett, Jr. *Physics for Scientists and Engineers with Modern Physics.*
4. Halliday, Rsenick, *Principles of Physics, International Student*

Version

5. Paul A. Tipler, GeneMosca, *Physics for Scientists and Engineers with Modern Physics*

APPLIED CHEMISTRY

Contact Hours:	**Credit Hours:**
Theory =32	Theory = **2.0**
Practical = 0	Practical = 0.0
Total = 32	Total = **2.0**

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Demonstrate** working knowledge of applied chemistry and its application to mechanical engineering field.	Cognitive	3	1
2.	**Identify** chemical compounds with harmful effects on environment and propose their control	Cognitive	1	7
3.	**Apply** the acquired knowledge to identify, formulate and solve engineering problems of chemical nature in field of mechanical engineering.	Cognitive	3	1

Course outline:

- **Physical Chemistry**: Properties of various groups and periods of periodic table.

- **Atomic Structure and Interatomic bonding**: Atomic structure, atomic bonding and mechanical bonding. Polymorphism and allotropic forms. Crystallography basics.
- **Basic Mechanical properties**: Structure of metals and ceramics.
- **Thermo-chemistry**: Chemical Thermodynamics, Hess's Law, heat of Formation and reaction, relation between H and U, measurement of heat reaction, Bomb calorimeter
- **Electrochemistry**: Laws of electrolysis
- **Industrial Chemistry**: Industrial chemistry introduction, manufacturing and uses of various hydrocarbons. Lubricants and oils. Production and application of paints, vulcanized rubber and fuels. Environmental pollution and control.
- **Water Treatment Methods**: Water softening, treatment of water for industrial purposes.

Teaching Methodology

- Lecturing
- Written Assignments
- Field Visits
- Report Writing

Assessment

Mid Term, Presentation, Assignments, Quizzes, Report Writing, Final Term

Text and Reference books:

1. W. H. Brown and L. S. Brown, *Chemistry for Engineering Students*, Cengage Learning.
2. O. V. Roussak, H. D. Gesser, *Applied Chemistry: A Textbook for Engineers and Technologists:* Springer.
3. S. S. Zumdahl, *Chemistry: An Atoms First Approach*, Cengage.
4. N. J. Tro, Chemistry: *A Molecular Approach,* Pearson.
5. M. J. Shultz, *Engineering Chemistry*, Cengage.
6. A. Bahl, B. S. Bahl, G. D. Tuli, *Essential of Physical Chemistry*, S. Chand Publishing, India.

ENGINEERING DRAWING & GRAPHICS

Contact Hours:	**Credit Hours:**
Theory =16	Theory = **1.0**
Practical = 48	Practical = 1.0
Total = 64	Total = **2.0**

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**ACQUIRE** the basic knowledge of drawing skills.	Cognitive	2	1
2.	**APPLY** the concepts of basic drawing techniques.	Cognitive	3	2
3.	**DEMONSTRATE** individually the drawings of plan, elevation and cross sections of machine parts	Psychomotor	3	3

Course outline:

Engineering Graphics (Theory)

1. **Orthographic Projection**
   Principle and Methods of projection, Orthographic projection, Planes of projection, First and Third-angle projection, Reference line
2. **Projection of Points**
   A point is situated in the first, second, third and fourth quadrant
3. **Projection of Straight Lines**
   Line parallel and perpendicular to one or both the planes, Line contained by one or both the planes, Projections of lines inclined to both the planes, True length of a straight line and its inclinations, Methods of determining traces of a line

4. **Projection of Planes (2D)**
   Types and Traces of planes, Projections of planes, Projections of oblique planes

5. **Projections on Auxiliary Planes (2D)**
   Types of auxiliary planes and views, Projection of a point on an auxiliary plane, Projections of lines and planes

6. **Projections of Solids (3D)**
   Types of solids and their projections, Projections of solids with axes inclined

7. **Section of Solids (3D)**
   Section of planes, prisms, pyramids, cylinders, cones, spheres, Methods of development, Triangulation development, Developments of lateral surfaces of right solids

8. **Isometric Projections (3D)**
   Isometric axes, lines, planes, and scale, Isometric drawing or isometric view, Isometric drawing of planes or plane figures, prisms and pyramids, cylinders, cones and sphere

Engineering Drawing (Lab):

1. **Introduction**
   Introduction to Engineering Drawing, I. S. specification for preparation of drawings, Use of drawing instruments and materials, Basic Tools, Lines: Types, configuration and application, Selection of line thickness,
2. **Lettering, Numbering and Dimensioning**
   Vertical and inclined single stroke letters, Lettering types and rules, Dimension lines, projection lines, leaders or pointer lines, Arrow heads, Dimensioning,
3. **Geometric Construction**
   Drawing simple geometric objects (polygon, pentagon and hexagons etc).
4. **Orthographic Projections of different Solids**
   I-beam etc.
5. **Orthographic Projections of Machine Elements**
   Rivets, Nut and bolts, Different kinds of threads, Lap and butt joints, Flange couplings, Journal bearing, Open bearing, Footstep bearing, Crankshaft, Bearings

Practical:

- Select a machine and study its operation and machine elements detail.
- Draw the 3D model of the machine and draw 2D drawings.
- Apply the real mechanism to the machine.

Teaching Methodology

- Lecturing
- Assignments
- Drafting

Assessment:

Mid Exam, Final Exam, Quizzes, Assignments, Presentation

Text and Reference books:

1. N.D Bhatt, *Engineering Drawing and Graphics*

2. B. Wiebe, M. Mohler ,*Technical Graphics Communication,* McGraw-Hill
3. Abbot, *Practical Geometry & Engineering Graphics*
4. Craft, Meyers & Boyer, *Engineering Graphics*
5. G. R. Bertoline, E. N. Wiebe, *Technical Graphics Communication*; McGraw-Hill
6. D.F. Rogers, J.A. Adams; *Mathematical Elements for Computer Graphics*, McGraw-Hill
7. A. C Parkinson, A First Year Engineering Drawing

INTRODUCTION TO ENGINEERING

Contact Hours:	**Credit Hours:**
Theory = 16	Theory = **1.0**
Practical = 0	Practical = 0.0
Total = 16	Total = **1.0**

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**ACQUIRE** the knowledge of different engineering disciplines to get technological exposure	Cognitive	2	1
2.	**UNDERSTAND** responsibility as an engineer to work closely with society for problems identification for future actions	Cognitive	2	6
3.	**ACQUIRE** the knowledge for Ethical Reasoning and to take appropriate actions	Cognitive	2	8

Course outline:

1. Introduction to Engineering
   a. Evolution of engineering, steam engine, electronics etc.
   b. Effect of global wars for technology advancement
   c. Existing materials/Evolution of emerging materials
2. Difference between Engineering, Science and Technology
3. The Disciplines of Engineering
4. Engineering Design
5. Interdisciplinary Engineering (Science, Technology and Society)
6. Global Engineering and the Future (Renewable energy)
7. Problem Solving Techniques in Engineering
8. Visualization and Graphics
9. Analytical Tools for Engineers
10. Professional Ethics and Engineering Management
11. Engineering Fundamentals (Statics, Dynamics, Thermodynamics, Circuitry, Economics)
12. Future Challenges for the betterment of society

Teaching Methodology

- Lecturing
- Class discussions
- Documentaries using Audio Visual Tools

- Field Visits to visualize real world problems
- Report Writing

Assessment
Mid Term, Quizzes, Reports, Assignments, Projects, Final Exams

Text and Reference books:
1. Paul H. Wright ,*Introduction to Engineering*
2. David Blockley, *Engineering: A Very Short Introduction*
3. Saeed Moaveni ,*Fundamentals: An Introduction to Engineering*

COMPUTER AIDED DRAWING (CAD)

Contact Hours:	**Credit Hours:**
Theory = 0	Theory = 0
Practical = 48	Practical = 1.0
Total = 48	Total = **1.0**

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.No	CLO	Domain	Taxonomy level	PLO
1.	**ACQUIRE** the basic knowledge of CAD drawing tools.	Cognitive	1	1
2.	**DEVELOP** different multi-views of an object.	Psychomotor	2	2
3.	**DEMONSTRATE** the 3D model of the machine elements.	Psychomotor	3	3

Course outline:
1. Introduction to CAD
2. 2D Drafting
3. 3D Modeling of Machine Elements (Part and Assembly)
4. Mechanisms and assembly

Practical:
- Select a machine and study its operation and machine elements detail.
- Draw the 3D model of the machine element and draw 2D drawings.

Teaching Methodology

- Lecturing
- Assignments
- Design Project

Assessment:

Mid Exam, Final Exam, Quizzes, Assignments, Presentation

Text and Reference books:

1. R. Lal, R. Rana, *A Textbook of Engineering Drawing: Along with an Introduction to AutoCAD*.
2. T. Jeyapoovan, *Engineering Drawing and Graphics Using AutoCAD.*
3. Z. A. Siddiqui, M. Ashraf and S. A. Siddiqui. *Basics of Engineering Drawing*
4. D. A. Jolhe, *Engineering Drawing with an introduction to AutoCAD*

Workshop Practice

Contact Hours:	**Credit Hours:**
Theory =0	Theory = **0.0**
Practical = 96	Practical = 2.0
Total = 96	Total = **2.0**

Course outline:

Fitter Shop: Assembly/disassembly of basic mechanical components, e.g. bearings, keys, belts, etc. Basic Processes in **Wood Work Shop**: Timber, its defects and preservation methods, different types of wood joints. Basics of **Electric Shop**: Types and uses of cables. Study of household electrical appliances. Functions of Forge & **Foundry Shop**: Brief introduction, tools and accessories, furnace types, heat treatment furnaces. Carbon dioxide casting. **Machine Shop**: Introduction to machine tools, basic lathe operations including turning, facing, screw cutting. **Welding**: Introduction to soldering, brazing and welding, brief details of gas, and electric arc welding.

Teaching Methodology

- Demonstration
- Lab Report Writing

Assessment

Lab performance, Quizzes, Lab Report, Lab Exams, Lab Assignments

Text and Reference books:

1. Lab Manual
2. W A J Chapman, Workshop Technology Part-I, 5th ed, Butterworth-Heinemann, 1972, ISBN 0713132698
3. H P Schwan, Electrical Wiring, McGraw Hill, 1982
4. Wiring Manual, Pak Cables Limited. ME-201 ENGINEER

ENGINEERING MECHANICS-I: STATICS

Contact Hours:	**Credit Hours:**
Theory =48	Theory =**3.0**
Practical =00	Practical = **0.0**
Total =48	Total = **3.0**

COURSE LEARNING OUTCOMES:

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

S.No	CLO Statement	Domain	Taxonomy Level	PLO
1	**COMPREHEND** concepts of vectors and scalars, forces, moments and couples.	Cognitive	2	1
2	**APPLY** the learned concepts of forces, moments and couples to solve problems of equilibrium in 2-D and 3-D	Cognitive	3	2
3	**ANALYZE** structures such as plain trusses, frames and machines for reaction forces	Cognitive	4	2
4	**APPLY** the concepts of mechanics to solve problems of friction	Cognitive	3	2

Course outline:

1. Introduction to subject
2. Force System
   a. Introduction to Force System

b. Rectangular components, Moment, Couple and Resultants (Two dimensional Force systems)

3. Equilibrium
   a. Mechanical system isolation and Equilibrium condition in two dimensions
   b. Equilibrium Conditions-Equilibrium in three Dimensions
4. Structures
   a. Plane Trusses
   b. Method of joints
   c. Method of Sections and Space Trusses
   d. Frames and Machines
5. Friction
   a. Types of Friction

Teaching Methodology

- Lecturing
- Problem Solving Sessions
  - Tutorial
  - Interactive
- Written Assignments

Assessment

Quizzes, Assignments, Mid Exam, Final Exam

Text and Reference books:

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 MATERIALS

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=**3.0**
Practical	=00	Practical	=**0.0**
Total	=48	Total	=**3.0**

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.No	CLO Statement	Domain	Level	PLO
1	**Explain** different material types in terms of bonding and crystal structure.	Cognitive	2	1
2	**Identify** the difference and application of different types of microscopic techniques that are available for investigating the microstructure.	Cognitive	1	4
3	Read and **interpret** Phase-Diagrams and effects of heat treatments on microstructure of ferrous materials.	Cognitive	2	2
4	**Analyze** the effect of micro-structure and heat treatment on end use properties/mechanical properties of materials.	Cognitive	4	4
5	**Differentiate** the property differences between Metals, Polymers & Composites and their implications in terms of environment and sustainability	Cognitive	4	7

Course Outline / Contents

1. Introduction to Materials Science and Engineering
2. Atomic Bonding
3. Structure of Crystalline Solids
4. Imperfections in Solids
5. Phase Diagrams
6. Phase Transformation and Development of Microstructures
7. Applications and Processing of Metallic Materials
8. Structure, Properties and Applications of Polymer Materials
9. Composite Materials

10. Corrosion and degradation of Materials

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Quizzes, Assignments, Mid Exam, Final Exam

Text and Reference books:

1. J. T. Black , Ronald A. Kohser, *DeGarmo's Materials and Processes in Manufacturing*, Wiley
2. Roy A. Lindberg, *Processes And Materials of Manufacturing*

ENGINEERING MECHANICS-II: DYNAMICS

Contact Hours:	**Credit Hours:**
Theory =48	Theory =**3.0**
Practical =00	Practical =**0.0**
Total =48	Total =**3.0**

COURSE LEARNING OUTCOMES:

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

S.No	CLO Statement	Domain	Taxonomy Level	PLO
1	**Comprehend** key concepts related to kinematics and kinetics of particles in different Coordinate Systems.	Cognitive	2	1
2	**Solve** problems related to kinematics and kinetics of particles.	Cognitive	3	2
3	**Calculate** various motion parameters related to the kinematics of rigid bodies under translation and rotation / general plane motion.	Cognitive	3	2

4	**Analyse** and solve the problems related to kinetics of rigid bodies using different principles and techniques for their solution	Cognitive	4	2

Course Outline

1. **Introduction to subject and Basic Concepts**
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

Teaching Methodology

- Lecturing
- Problem Solving Sessions
  - Tutorial
  - Interactive
- Written Assignments

Assessment

Quizzes, Assignments, Mid Exam, Final Exam

Textbook and Reference Books:

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.

Mechanics of Materials-I

Contact Hours:	**Credit Hours:**
Theory =48	Theory =**3.0**
Practical =0	Practical =**0**
Total =48	Total =**3.0**

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the basics of mechanics of materials and their mechanical properties	Cognitive	1	1
2.	**Calculate** the stresses and strains in mechanical structures.	Cognitive	2	2
3.	**Solve** problems related to bending, torsion and deflection in mechanical structures.	Cognitive	4	2

Course outline:
1. Mechanical properties of materials; tensile, compressive and shear stress & strain
2. Moment of inertia
3. Axial loading, Hooke's law, stress strain relationship
4. Thermal stresses
5. Torsion of circular bars,
6. Pure bending of beams, shear stresses in beams
7. Shearing force and bending moment
8. Beam deflection using various methods
9. Residual stresses and stress concentration in various engineering applications
10. Analysis of statically indeterminate problems,
11. Thin and thick curved bars,
12. Thin walled pressure vessels.

Teaching Methodology

- Lecturing
- Written Assignments
- Report writing

Assessment

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

Text books and Reference books:

1. James M. Gere, Barry J. Goodno, *Mechanics of Materials*
2. Ferdinand P. Beer & Russel Johnston Jr., *Mechanics of Materials* McGraw-Hill
3. R. C. Hibbeler, *Mechanics of Materials*
4. P. P. Benham& R. J. Crawford, *Mechanics of Engineering Materials*, Longman
5. Popov, *Mechanics of Materials*.
6. W. A. Nashi, *Static and Mechanics of Materials*, Schaum's outline series New York.

THERMODYNAMICS-I

Contact Hours:	**Credit Hours:**
Theory =48	Theory =**3.0**
Practical =0	Practical =0.0
Total =48	Total =**3.0**

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the nature and role of the thermodynamics properties of matter and processes on appropriate diagrams.	Cognitive	2	1
2.	**Apply** energy and entropy balances to the closed and open systems.	Cognitive	3	1
3.	**Analyze** implications and limitations of the Second Law of Thermodynamics.	Cognitive	4	2

Course outline:

1. **Introduction and Basic Concepts**
   a. First law of thermodynamics and its applications
   b. System and boundary
   c. Specific volume, pressure and temperature
2. **Energy, Energy Transfer, and General Energy Analysis**
   a. Equilibrium state, processes
   b. Methods to solve thermodynamics problems
3. **Properties of Pure Substances**
   a. Phase change processes, P-v-T relation
   b. Property diagrams
   c. Equation of state, specific heats
   d. Compressibility polytropic process relation.
4. **Energy Analysis of Closed Systems**
   a. Energy balance of closed system
5. **Mass and Energy Analysis of Control Volumes**
   a. Energy analysis of power, refrigeration and heat pump cycles
6. **The Second Law of Thermodynamics**
   a. Spontaneous and non-spontaneous processes
   b. Thermodynamic cycles, irreversible and reversible process, and Carnot cycle
   c. Clausius inequality.
7. **Entropy**
   a. Entropy change, T-s diagram, entropy generation
   b. Increase of entropy principle, entropy rate balance of closed systems and control volumes
   c. Isentropic efficiencies

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Exam, Final Exam, Assignments, Quizzes, Computational assignments

Text and Reference books:

1. Yunus A. Cengel, Michael A., *Thermodynamics: An Engineering Approach*, McGraw-Hill.
2. M. J. Moran and H. O. Shapiro, *Fundamentals of Engineering Thermodynamics*, John Wiley & Sons.
3. Sonntang, Borgnakke, Van Wylen John, *Fundamentals of Thermodynamics*, Wiley & Sons.

4. T. D. Eastop and A. McConkey, *Applied Thermodynamics for Engineering Technologists*, Pearson.

ENGINEERING MECHANICS LAB

Contact Hours:	**Credit Hours:**
Theory =0.0	Theory =0**.0**
Practical =48	Practical =**1.0**
Total =48	Total =1**.0**

Course Outlines

Experiments related to Engineering Statics and Engineering Dynamics will be covered.

Teaching Methodology

- Demonstration followed by hands-on experiments

Assessment

Lab Work, Lab reports, Viva / Oral test, Lab Exam

Text and Reference books:

Lab Manual

THERMODYNAMICS-II

Contact Hours:	**Credit Hours:**
Theory =48	Theory =**3.0**
Practical =0	Practical =0.0
Total =48	Total =**3.0**

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Analyze** thermodynamics cycles of power, refrigeration, and air-conditioning using energy and exergy principles.	Cognitive	4	2

2.	**Apply** the laws of thermodynamics to the chemical and phase equilibrium problems.	Cognitive	3	2
3	**Understand** the implications of thermodynamics power, refrigeration, and air-conditioning systems on the environmental and future sustainability.	Cognitive	2	7

Course outline:

1. Review of Thermodynamics I
- a. Energetics
- b. Efficiency

2. Exergy
- a. Exergy balance
- b. Exergetic efficiency

3. Gas Power Cycles
- a. Air-Standard-Otto cycle
- b. Diesel cycle,
- c. Dual and Brayton cycle
- d. Regenerative gas turbines with reheat & inter cooling
- e. Combined cycles

4. Vapor and Combined Power Cycles
- a. Modeling and analyzing
- b. Superheat and Reheat vapor power cycles
- c. Regenerative vapor power cycles
- d. Other vapor cycle aspects

5. Refrigeration Cycles
- a. Vapor compression refrigeration systems
- b. Cascade and Multistage systems
- c. Absorption refrigeration, Heat pump, and Gas refrigeration systems

6. Thermodynamic Property Relations and Gas Mixtures
- a. Mixture composition
- b. P-v-T relations for gas mixtures
- c. U, H, S and specific heats for gas mixtures.

7. Chemical Reactions
- a. Combustion process and conservation of energy in reacting systems
- b. Importance of mathematical relations

8. Chemical and Phase Equilibrium
- a. Equilibrium fundamentals

b. Chemical potential and equilibrium.

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Exam, Final Exam, Assignments, Quizzes, Computational Assignment

Text and Reference books:

1. Yunus A. Cengel and Michael A. Boles, *Thermodynamics, An Engineering Approach,* McGraw-Hill.
2. M. J. Moran and H. O. Shapiro*, Fundamentals of Engineering Thermodynamics*, John Wiley & Sons.
3. Sonntang, Borgnakke, and Van Wylen, *Fundamentals of Thermodynamics*, John Wiley & Sons.
4. Ibrahim Dincer and Marc A. Rosen, *Exergy: Energy, Environment, and Sustainable Development,* Springer.
5. T.D. Eastop and A. McConkey, *Applied Thermodynamics for Engineering Technologists*, Pearson.

MACHINE DESIGN-I

Contact Hours:	**Credit Hours:**
Theory = 32	Theory = **2.0**
Practical = 00	Practical = **0.0**
Total = 32	Total = **3.0**

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Explain** the application of design standards and the importance of dimensional parameters in manufacturing aspects of mechanical design	Cognitive	2	1
2.	**Analyze** different types of structural joints, power	Cognitive	4	3

	transmitting shafts and mechanical springs			
3.	**Present** the design aspects effectively through oral presentation	Affective	2	10

Course outline:

Introduction

1. Design philosophy
2. Types of design

Mechanical behaviour of materials

1. Concepts of stress and strain
2. Different types of stress and strain in a machine element
3. Stress-strain diagram
4. Actual and permissible stresses
5. Factor of safety

Design of keys and coupling

1. Basic concepts
2. Methodology

Design of Riveted joint, Welded joints, Bolted joints

1. Basic concepts
2. Methodology

Design of Springs, Shafts

1. Basic concepts
2. Methodology

Metal fits and tolerances and Design Standards

1. Basic concepts of tolerance
2. Types of fits
3. ISO standard fits charts

Teaching Methodology

1. Lecturing
2. Written Assignments
3. Guest Speaker
4. Report Writing and Presentation

Assessment

Mid Exam, Final Exam, Assignments, Quizzes, Computational Assignment

Text and Reference books (Latest Editions):

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*

Mechanics of Material-II

Contact Hours:	**Credit Hours:**
Theory =48	Theory = **3.0**
Practical = 0	Practical = 0.0
Total = 48	Total = **3.0**

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Analyse** stresses and strains for two- and three-dimensional cases using and various technique.	Cognitive	3	2
2.	**Understand** theory of failure of materials	Cognitive	1	1
3.	**Solve** problems related to early failure of materials under special conditions like fatigue, creep etc	Cognitive	2	2
4.	**Analyze** stresses in thick walled cylinders and columns	Cognitive	4	2

Course outline:

1. Analysis of stress and strain in two and three dimensions
2. Principal stresses and strains
3. Mohr's circle for stress and strain
4. Thick walled pressure vessels
5. Symmetrical and asymmetrical loading
6. Introduction to fracture mechanics
7. Impact loading
8. Fatigue and creep
9. Virtual work
10. Theories of elastic failure
11. Theory of columns

Teaching Methodology

- Lecturing
- Written Assignments
- Field Visits

- Report Writing

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

Text and Reference Books:

1. E J Hearn, *Mechanics of Materials Volume 1 & 2*
2. Ferdinand P. Beer & Russel Johnston Jr., *Mechanics of Materials*, McGraw-Hill
3. Popov, *Mechanics of Materials*
4. P. P. Benham & R. J. Crawford, *Mechanics of Engineering Materials*, Longman Sci & Tech
5. Boresi, Arthur P., Schmidt, Richard J. Sidebottom, Omar M., *Advanced Mechanics of Materials*
6. R. C. Hibbeler, Mechanics of Materials
7. Andrew Pytel and F. L. Singer, *Strength of Materials*
8. W. F. Riley, L. D. Sturges and D. H. Morris, *Mechanics of Materials*.
9. W. A. Nashi, *Statics and Mechanics of Materials*, Schaum's outline series New York.

Mechanics of Material-Lab

Contact Hours:	**Credit Hours:**
Theory =0	Theory = **0.0**
Practical = 48	Practical = 1.0
Total = 48	Total = **1.0**

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Understand** methods to demonstrate the basic concepts of Mechanics of Materials by applying them to various problems	Cognitive	1	1
2.	**Analyze** relevant Mechanical Systems by applying fundamental knowledge	Psychomotor	2	2

Course outline:
Experiments related to the Mechanics of Materials-I & II will be covered.

Teaching Methodology
- Demonstration
- Lab Report Writing

Assessment
Lab performance, Quizzes, Lab Report, Lab Exams, Lab Assignments

Text and Reference books:
Lab Manual

FLUID MECHANICS - I

Contact Hours:	**Credit Hours:**
Theory =48	Theory = **3.0**
Practical = 0	Practical = 0.0
Total = 48	Total = **3.0**

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.No	CLO	Domain	Taxonomy level	PLO
1.	**APPLY** the basic concepts to hydrostatic fluid problems.	Cognitive	3	1
2.	**Analyze** the fluid kinematics and dynamics parameters using basic laws of mechanics.	Cognitive	4	2
3.	**Solve** the pipe flow problems using Bernoulli and energy equation.	Cognitive	3	2
4.	**Understand** the concept of dimensional analysis	Cognitive	2	1

Course outline:

1. **Fluid Properties**
   a. Definition of fluid and its classification
   b. Concept of continuum.
   c. Properties of the fluid.
2. **Fluid Statics**
   a. Concept of Pressure and basic equations for compressible and incompressible
   b. Pressure measurements and devices.
   c. Hydrostatics forces on plane and curved surfaces.
   d. Buoyancy and Stability.
   e. Pressure variation in fluid with rigid body motion.
3. **Fluid Kinematics**
   a. Flow characteristics, Descriptions of Velocity and acceleration field (Streamlines, streak lines and path lines).
   b. Control volume and representation of system.
   c. Reynolds transport theorem (RTT).
4. **Fluid Dynamics**
   a. Application of Newton's 2nd law in fluids.
   b. Total, stagnation and dynamic pressure.
   c. Deriving Bernoulli equation and its applications.
5. **Integral Analysis of Fluid Flow**
   a. Continuity equation using RTT.
   b. Linear momentum equation using RTT.
   c. Moment of momentum equation using RTT.
6. **Dimensional Analysis, Similitude and Modeling**
   a. Dimensional analysis
   b. Buckingham Pi theorem and determination of Pi terms
7. **Flow in Pipes**
   a. Characteristics of pipe flow laminar and turbulent.
   b. Calculating friction factor and wall shear stresses.
   c. Solving pipe flow network problems

Teaching Methodology

- Lecturing
- Written Assignments
- Field Visits
- Report Writing

Assessment

Mid Exam, Final Exam, Quizzes, Assignments,

Text and Reference books:

1. Munson, Young And Okiishi HT John, *Fundamentals Of Fluid Mechanics*, J. Wiley & Sons.
2. Philip J. Pritchard and John C. Leylegian, *Fox and McDonald's Introduction to Fluid Mechanics*, J. Wiley & Sons.
3. Frank M White, *Fluid Mechanics*. McGraw-Hill.

THERMODYNAMICS-LAB

Contact Hours:	**Credit Hours:**
Theory = 0	Theory = **0.0**
Practical = 48	Practical = 1.0
Total = 48	Total = **1.0**

Course outline:

Experiments related to Thermodynamics I and II will be covered.

Teaching Methodology

- Lecturing
- Demonstration

Assessment

Lab Exam (Written/Practical Assessments), Lab Reports, Lab Assignments, Lab Session Performance, Problem Based Learning/Open Ended Lab Assessment (Optional)

Text and Reference books:

Lab Manual.

FLUID MECHANICS - II

Contact Hours:	**Credit Hours:**
Theory =48	Theory = **3.0**
Practical = 0	Practical = 0.0
Total = 48	Total = **3.0**

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**APPLY** governing equations to incompressible and compressible fluid flows.	Cognitive	3	2
2.	**CALCULATE** fluid flow parameters for various geometries.	Cognitive	3	2
3.	**Analyze** the performance of various fluid devices using scaling laws.	Cognitive	4	3

Course outline:

1. Differential Analysis of Fluid Flow
   a. Deriving continuity equation by applying conservation of mass principle.
   b. Evaluating velocity and acceleration field using material derivative.
   c. Deriving Navier-Stokes equation and some simple analytical solution

2. Potential flow theory
   a. Concept of vorticity, Circulation, Inviscid and Irrotational flow field
   b. Basic velocity potential function and its superposition.
   c. Prediction of Lift and drag using potential flow theory

3. Flow over immersed bodies
   a. Boundary layer theory and its thicknesses.
   b. Concept of local and average drag coefficient.
   c. Calculating drag and lift forces due to pressure and velocity field.

4. Introduction to Computational Fluid Dynamics
   a. Finite difference formulation

b. Solving basic fluid flow problems using available CFD code.

5. Compressible Flows

a. Mach number and speed of sound
b. Isentropic flow of an ideal gas
c. Convergent divergent Nozzle

6. Turbomachinery

a. Fans, Pumps, turbines and other flow devices.
b. Deriving Euler's equation and solving of turbo-machine problems using velocity triangle
c. Pump and turbine performance characteristic curves.

Teaching Methodology

- Lecturing
- Written Assignments
- Field Visits
- Report Writing

Assessment

Mid Exam, Final Exam, Quizzes, Assignments, Presentation

Text and Reference books:

1. Munson, Young, Okiishi, HT John, *Fundamentals Of Fluid Mechanics*, J. Wiley & Sons.
2. Philip J. Pritchard and John C. Leylegian, *Fox And McDonald's Introduction To Fluid Mechanics,* Wiley & Sons.
3. Frank M White, Fluid Mechanics, Mc-Graw Hill

MACHINE DESIGN-II

Contact Hours:	**Credit Hours:**
Theory = 32	Theory = **2.0**
Practical = 00	Practical = **0.0**
Total = 32	Total = **3.0**

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Calculate** stresses in gear teeth, flywheels, power screws, etc	Cognitive	3	2
2.	**Identify** the parameters for the selection of standard machine elements, such as journal bearings, rolling contact bearings, chains, belts, clutches and brakes.	Cognitive	4	2
3.	**Design** the machine elements for desired outputs, including gears, flywheels, clutches, brakes, journal bearings, rolling contact bearings, power screws, chains and belts etc	Cognitive	5	3

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

Teaching Methodology

- Lecturing
- Design/Selection Assignments

Assessment

Mid Exam, Final Exam, Quizzes, Assignments, Presentation

Text and Reference books (Latest Editions):

1. Robert L. Mott, *Machine Elements in Mechanical Design*
2. Robert L. Norton, *Design of Machinery*
3. Joseph E. Shigley, *Theory of Machines & Mechanisms*

Instrumentation and Measurement

Contact Hours:	**Credit**
Theory = 32	Theory = **2**
Practical = 48	Practical = 1
Total = 80	Total = **3**

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the basic concepts related to measurement	Cognitive	2	1
2	**UNDERSTAND** the construction, working and applications of various sensors.	Cognitive	2	1
3	**Interface** sensors to data acquisition device	Psychomotor	3	5
4	**ANALYZE** the sensor data	Cognitive	4	2
5	**Develop** sensor based solution	Cognitive	3	3

Course outline:

- **Introduction to measurement and instrumentation**. Significance of measurement, planning of experiments, general measurement system, calibration
- **Static and dynamic characteristics of instruments**: measurement sensitivity, range, accuracy, precision, repeatability, and uncertainty of instruments, measurement errors
- **Measurement** of length, displacement, force, torque, strain, frequency, pressure, flow, and temperature.
- **Introduction to data acquisition systems**, signal conditioning, display elements.

Lab Outline:
Experiments related to the Instrumentation and Measurement will be covered in the Lab class.

Teaching Methodology
- Lecturing
- Written Assignments
- Lab. Reports

Assessment
Mid Term, Quizzes, Assignments, Final Term

Text and Reference books:
1. E. Doeblin, *Measurement Systems Applications and Design*, McGraw Hill
2. D. G. Alciatore, M. B. Histand, *Introduction to Mechatronics and Measurement Systems*.

HEAT & MASS TRANSFER

Contact Hours:	**Credit Hours:**
Theory =48	Theory = **3.0**
Practical = 0	Practical = 0.0
Total = 48	Total = **3.0**

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Apply** governing equations of heat transfer to various thermal systems.	Cognitive	3	1
2.	**Analyze** the performance and thermal design of heat exchangers under various conditions.	Cognitive	4	3
2.	**SOLVE** the real life complex engineering problems related to heat transfer.	Cognitive	3	2

Course outline:

1. Introduction to Heat transfer

a. Review of the concepts of equilibrium, steady state, heat and thermodynamics.
b. Basic modes of heat transfer and their mechanisms.

2. Conduction

a. Deriving heat conduction equation using principle.
b. Solving heat conduction problems using equivalent electrical networks.
c. Extended surfaces and their performance parameters.
d. Transient heat conduction and lumped heat capacity method and its corresponding electrical analogy.

3. Radiation

a. Fundamental characteristics of thermal radiation and surfaces
b. Laws of black body radiation
c. Intensity of radiation
d. Solving problems of radiative heat transfer between surfaces and enclosures using equivalent electrical networks.

4. Convection

a. Deriving energy equation for convection
b. Heat transfer rate for laminar, turbulent and mixed boundary layers for external flow and internal flow problems.
c. Buoyancy driven flows and their heat transfer rate for external flow problems and enclosed spaces.
d. Heat transfer rate for phase change processes i.e. Boiling and condensation.

5. Heat Exchangers

a. Classification and types of Heat exchangers.
b. LMTD method
c. NTU-effectiveness method

6. **Mass transfer**

a. Fick's law of diffusion and mass diffusivity.
b. Concept of concentration boundary layer.
c. Solving mass transfer problems using convective heat transfer analogy.

Teaching Methodology

- Lecturing
- Written Assignments
- Field Visits
- Report Writing

Assessment

Mid Exam, Final Exam, Quizzes, Assignments, Presentation

Text and Reference books:

1. Incropera & DeWitt, Wiley, *Fundamentals of Heat and Mass Transfer*
2. Mills & Ganesan, Heat Transfer.
3. Frank Kreith, *Principles of Heat Transfer*.
4. J.P. Holman, *Heat and mass transfer*
5. Yunus Cengel, *Heat transfer*
6. Ozisik, *Heat Transfer*
7. D. Pitts, L. E. Sissom, *Heat Transfer*, Schaum's outline series New York.

MANUFACTURING PROCESSES

Contact Hours:	**Credit Hours:**
Theory =48	Theory = **3.0**
Practical = 48	Practical = 1.0
Total = 96	Total = **4.0**

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.NO	CLO	Domain	Taxonomy level	PLO
1.	**Understand** various manufacturing processes	Cognitive	2	1
2.	**Identify** the right type of operation and its parameters for performing manufacturing processes	Cognitive	4	2
3.	**Apply** effectively various manufacturing techniques/operations in broad spectrum of engineering and manufacturing companies	Cognitive	3	2

Course outline:

1. Introduction: Basic concepts of manufacturing processes
2. Casting and Moulding: Metal casting processes and equipment, Powder metallurgy, Plastics
3. Forming: Extrusion and drawing, sheet metal forming, forming and shaping plastics and composite materials
4. Machining: Conventional and non-conventional machining processes
5. Joining: Welding, brazing, soldering, sintering, adhesive bonding, fastening, Press fitting
6. Additive Manufacturing: 3D Printing

Lab Outline:

Experiments related to the Manufacturing Processes will be covered in the Lab class.

Teaching Methodology

- Lecturing
- Written Assignments
- Report Writing
- Video lectures

Assessment

Mid Exam, Final Exam, Quizzes, Assignments, Presentation

Text and Reference books:

1. Mikell P Groover, *Fundamental 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.

Fluid Mechanics Lab

Contact Hours:	**Credit Hours:**
Theory =0	Theory = **0.0**
Practical = 48	Practical = 1.0
Total = 48	Total = **1.0**

Course outline:

Experiments related to the Fluid Mechanics-I & II will be covered.

Teaching Methodology

- Demonstration
- Lab Report Writing

Assessment

Lab performance, Quizzes, Lab Report, Lab Exams, Lab Assignments

Text and Reference books:

Lab Manual

CONTROL ENGINEERING

Contact Hours:	**Credit Hours:**
Theory = 48	Theory = **3.0**
Practical = 0	Practical = 0**.0**
Total = 48	Total = **3.0**

COURSE LEARNING OUTCOMES:

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

S.NO	CLO	Domain	Taxonomy level	PLO
1.	**Develop** mathematical models of different physical system.	Cognitive	5	3

2.	**ANALYSE** complex engineering problems using mathematical models to examine different properties of the system	Cognitive	4	2
3.	**DEVELOP** a controller to achieve the desired response from the system	Cognitive	5	3

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

Teaching Methodology

- Lecturing
- Tutorial sessions
- Discussions

Assessment

Quizzes, OHTs/Mid Term, Assignments, Final Exam

Text and Reference books:

1. Charles Phillips & Royce Harbor ,*Feedback Control Systems*, Prentice-Hall
2. Katsuhiko Ogata, *Modern Control Engineering.*
3. Norman S Nise, *Modern Control Engineering.*

MECHANICS OF MACHINES

Contact Hours:		**Credit Hours:**	
Theory	= 48	Theory	= **3.0**
Practical	= 0	Practical	= 0**.0**
Total	= 48	Total	= **3.0**

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the concepts of mechanics for the design of machine elements.	Cognitive	2	1
2.	**CALCULATE** the kinematic characteristics of mechanisms such as linkages, cams, gears, governors and unbalance masses.	Cognitive	3	2

3.	**RELATE** analytical and/or graphical solutions to complex engineering problems in various machines and mechanisms.	Cognitive	4	3

Course outline:

1. **Introduction to Mechanisms**
   Machine & Mechanisms, Mechanism Terminology, Kinematic Diagram, Kinematic Inversion, Four Bar Mechanism, Slider Crank Mechanism, Techniques of Mechanism Analysis
2. **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
3. **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
4. **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
5. **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

Teaching Methodology

- Lecturing
- Tutorial sessions
- Discussions

Assessment

Quizzes, Mid Term/One hour tests (OHTs), Term Project, Final Exam

Text and Reference books:

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*

HEATING, VENTILATION AND AIR CONDITIONING

Contact Hours:	**Credit Hours:**
Theory = 48	**Theory =3.0**
Practical = 0	**Practical = 0.0**
Total = 48	**Total = 3.0**

Course Learning Outcome (CLOs)

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Identify** the various components of the refrigeration and air-conditioning systems by resuming the basic knowledge	Cognitive	1	1

2.	**Apply** the fundamental concepts related to design and selection of various components (Evaporator, condensers etc.) of refrigeration and HVAC systems.	Cognitive	3	2
3	**Analyze** the factors affecting thermal comfort in AC zones and air treatment/handling requirements for public buildings	Cognitive	4	7
4	**Calculate** the heating and cooling load for various structures/buildings	Cognitive	3	3

Course outline:

1. Pure substance properties:
   a. Important properties of saturated and superheated vapours
   b. Properties of liquid-vapour mixtures

2. Refrigeration system basics:
   a. basics of vapour compression system
   b. Pressure-enthalpy chart
   c. coefficient of Performance
   d. Cycle diagrams and the simple saturated cycle
   e. Single stage and multi-stage compression cycle
   f. Steam jet refrigeration cycle
   g. Air refrigeration cycle

3. Refrigeration system analysis:
   a. vapor absorption refrigeration cycle
   b. Comparison of actual and theoretical refrigeration cycle
   c. Heat pump
   d. Types and properties of refrigerants
   e. Condensers and evaporators
   f. Compressors, Refrigerant flow control devices

4. Refrigeration load estimation (Refrigeration)
   a. Product load
   b. Air Change load
   c. Heat gain through walls
   d. Internal heat gain

5. Psychrometric properties of air:
   a. Composition of air

b. Dalton's Law of partial pressure
c. Dew point temperature
d. Dry bulb and wet bulb temperatures
e. Psychrometric charts
f. Heating and humidification
g. Cooling and dehumidification

6. HVAC basics,

a. Thermal Comfort and Indoor environment Health
b. Water and vapour mixture
c. Air ventilation
d. calculation of fresh air supply of a building
e. air handling unit for untreated fresh air
f. Forced convection based air ventilator design
g. Air treatment fundamentals
h. indoor air quality

7. HVAC systems:

a. Essential components design of central air-conditioning plant
b. Water chiller and water heater
c. Air handling unit
d. Chilled water and hot water recirculation system
e. All-air systems basics
f. Single zone and reheat system
g. Variable Volume
h. Dual duct and multi-zone system

8. Heating and Cooling Load:

a. Space heating and cooling load
b. Design conditions
c. Transmission heat losses
d. Infiltration, ventilation and other heat loss and gain sources
e. Thermal radiation
f. Solar irradiation
g. Heat gain through fenestrations
h. Design conditions
i. Internal heat gain

8. Pressure loss, Duct design and Air flow balancing

Teaching Methodology:

- Lecturing
- Written Assignments
- Field Visits
- Report Writing

Assessment:
Mid Exam, Final Exam, Quizzes, Assignments, Presentation

Text and Reference books:

1. McQuiston, Parker and Spitler, *Heating, Ventilating, and Air-Conditioning Analysis and Design,* John Wiley & Sons
2. W. F. Stoecker ,*Refrigeration and Air Conditioning*
3. Ed. Kreider, Curtiss &Rabl, *Heating and Cooling of Buildings* ,Mc-Graw-Hill
4. Dossat, R. J., John Wiley, Principles of Refrigeration.
5. Haines, Roger W. Wilson, Lewis, *HVAC Systems Design Handbook*, McGraw-Hill Companies
6. Dincer, Ibrahim, Ratlamwala, Tahir Abdul Hussain ,*Integrated Absorption Refrigeration Systems, Comparative Energy and Exergy Analyses*, Springer
7. *ASHRAE Fundamentals Handbook*
8. Shan K. Wang, *Handbook of Air Conditioning and Refrigeration*.

Heat Transfer and HVAC Lab

Contact Hours:	**Credit Hours:**
Theory =0	Theory = **0.0**
Practical = 48	Practical = 1.0
Total = 48	Total = **1.0**

Course outline:
Experiments related to the Heat Transfer and HVAC lab will be covered.

Teaching Methodology
- Demonstration
- Lab Report Writing

Assessment
Lab performance, Quizzes, Lab Report, Lab Exams, Lab Assignments

Text and Reference books:
Lab Manual

ENGINEERING ECONOMICS

Contact Hours:	**Credit Hours:**
Theory =32	Theory = **2.0**
Practical = 0.0	Practical = 0.0
Total = 32	Total = **2.0**

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the basic knowledge of cost and taxation concepts	Cognitive	2	1
2.	**Develop** the cash flow diagrams based on the time value of money	Cognitive	3	2
3.	S**olve** economics problems involving comparison and selection of alternatives by using variety of analytical and computational techniques.	Cognitive	3	5

Course outline:

1. Introduction
   a. Engineering Costs
   b. Estimation Models & Cash Flow Diagram
   c. Life cycle cost

2. Time value of Money
   a. Time value of money, equivalence, use of spread sheet, simple and compound interest
   b. Uniform series & Arithmetic & geometric gradient
   c. Nominal & effective, continuous compounding Economic criteria,
   d. Present Worth, future worth and annuity

3. Rate of Return
   a. Minimum acceptable rate of return(MARR),
   b. Internal rate of return, External rate of return
   c. Choosing the best alternative
   d. Incremental Analysis

4. Benefits and Cost ratio and Payback period
   a. Benefit and cost ratio (B/C Ratio), discounted benefit and cost ratio
   b. Simple payback period, discounted payback period
   c. Sensitivity & breakeven analysis
   d. Principle of comparative advantage

5. Depreciation
- a. Depreciation
- b. Depreciation using Unit of Production
- c. Depreciation using straight line method
- d. Depreciation using Depletion

6. Taxes
- a. Income Taxes, After tax RoR

7. Replacement analysis
- a. Design life, salvage value
- b. Up gradation Vs replacement

8. Risk and Uncertainty
- a. Estimation of future events
- b. Monte Carlo Simulation
- c. Bayes theorem

9. Concepts of Imports and Exports
- a. Basic concepts of import and export
- b. Dumping and anti-dumping and related laws

Teaching Methodology
- Lecturing
- Written Assignments
- Presentation

Assessment
Mid Exam, Quizzes, Final Exam, Assignments, Presentations.

Text and Reference books:

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

MECHANICAL VIBRATIONS

Contact Hours:		**Credit Hours:**	
Theory	= 48	Theory	= **3.0**
Practical	= 0	Practical	= 0**.0**
Total	= 48	Total	= **3.0**

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.No	CLO	Domain	Taxonomy level	PLO
1.	**USE** different techniques to model vibrating systems for one/two/multi Degree of Freedom.	Cognitive	3	1
2.	**ANALYZE** the physical parameters involved in natural frequency and system response to free and forced or impulse inputs.	Cognitive	4	2
3.	**CONSTRUCT** engineering structures and mechanical systems under dynamic conditions.	Cognitive	3	3

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, Vibration Isolation, 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 Undamped Systems
   b. Coordinate Coupling, Free Vibration Analysis of Damped systems
   c. Forced Harmonic Vibration of an Undamped Systems

d. Forced Harmonic Vibration of Damped Systems

6. Multi Degree of Freedom Systems

a. Eigen Values and Eigen Vectors, Dunkerley's Method, Rayleigh's Method
b. Influence co-efficients, Matrix Iteration Method
c. Stodola's Method, Holzer's Method

Teaching Methodology

- Lecturing
- Tutorial sessions
- Discussions

Assessment

Quizzes, Mid Exams, Assignments, Term Project, Final Exam

Text and Reference books:

1. W. T. Thomson and M. D. Dahleh, *Theory of Vibration with Applications*
2. S. S. Rao, *Mechanical Vibrations*
3. D. J. Inman, *Engineering Vibration*

INTERNAL COMBUSTION ENGINES

Contact Hours:	**Credit Hours:**
Theory =48	Theory = **3.0**
Practical = 0	Practical = **0.0**
Total = 48	Total = **3.0**

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Explain** the basic knowledge, construction and working of various types of IC engines and its components.	Cognitive	2	1
2.	**Solve** numerical problems related to the design and operation of IC engines.	Cognitive	3	3

3.	**Analyze** the design and operation of various IC Engine systems including preparation of air/fuel mixture, combustion control and emission reduction.	Cognitive	4	7
4.	**Analyze** the effect of engine operating parameters (air/fuel ratio, ignition timing, fuel properties etc.) on engine performance and emissions.	Cognitive	4	4

Course outline

1. Introduction to I.C engines:
   a. History of I.C engine development
   b. Engine classifications
   c. Engine components and terminologies
   d. Working principle of turbo-charged, supercharged engine, its performance characteristics.

2. SI & CI engines systems:
   Basic engine cycle and operation
   a. Two and four stroke engines
   b. Engine operating characteristics (engine speed, compression ratio, sfc, A/F, F/A, etc)
   c. Engine parameters (efficiency, MEP, Power, torque, etc)
   d. Carburetors
   e. Fuel injectors
   f. Ignition system
   g. Electronic control unit, Engine management system
   h. Otto, Diesel and Dual cycle and their comparison

3. Fuel and combustion:
   a. Hydrocarbon fuels and their properties
   b. Thermochemistry and Chemical equilibrium
   c. Self-ignition and engine knock
   d. Ignition delay
   e. Octane and Cetane Numbers

4. Gas exchange processes and mixture preparation:
   a. Intake Manifold
   b. Volumetric efficiency
   c. Intake valves
   d. Variable valve Control
   e. Fuel injection, EFI systems (PFI, MPFI, GDI and Common-rail)

f. Super-charging and turbo-charging
g. Fluid Motion within combustion chamber
h. Turbulence, Swirl, Squish and Tumble
i. Crevice Flow and blowby

5. Combustion in SI and CI engines:
a. Ignition and flame development
b. abnormal combustion and knock
c. Spark timing and Maximum brake torque spark timing
d. Diesel Fuel injection and mixture preparation
e. Phases of combustion and ignition delay
f. Injection timing, injection pressure
g. common rail fuel injection

6. Exhaust Flow:
a. Turbocharging
b. Exhaust manifold
c. Exhaust gas recirculation

7. Pollution control,
a. engine emissions
b. pollutant formation
c. after treatment
d. catalytic converters
e. soot traps

8. Heat Transfer in Engines and engine cooling system

9. Friction and Lubrication of engine, Lubrication systems

Teaching Methodology:
- Lecturing
- Written Assignments
- Video showing components and operation of IC engine
- Assembling and dis-assembling of IC engines
- Field Visits
- Report Writing

Assessment:
Mid Exam, Final Exam, Quizzes, Assignments, Presentation

Text and Reference books:

1. W. W. Pulkrabek, *Engineering Fundamentals of IC engine*, Pearson Education Inc, USA
2. J. B. Heywood, *Internal Combustion Engine Fundamentals*, Heywood McGraw-Hill
3. Richard Stone Palgrave Macmillan, *Introduction to I. C. Engines*
4. C. F Taylor, *Internal combustion engines*. MIT Press.
5. R. V. Schäfer, F. Schäfer, *Internal Combustion Engine Handbook - Basics, Components, Systems, and Perspectives*, Fred SAE International.

6. C. R. Ferguson, *Internal Combustion Engines: Applied Thermo-sciences*, Wiley Science

MECHANISMS AND MECHANICAL VIBRATIONS LAB

Contact Hours:	**Credit Hours:**
Theory = 0	Theory = **0.0**
Practical= 48	Practical = 1**.0**
Total = 48	Total = 1**.0**

Course Outline:
Experiments related to Mechanics of Machines and Mechanical Vibrations.

Teaching Methodology
- Demonstration
- Lab Report Writing

Assessment
Lab performance, Quizzes, Lab Report, Lab Exams, Lab Assignments

Text and Reference books:
Lab Manual

ENTERPRENUERSHIP

Contact Hours:	**Credit Hours:**
Theory = 16	Theory = **1.0**
Practical = 0	Practical = 0.0
Total = 16	Total = **1.0**

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.No	CLO	Domain	Taxonomy level	PLO
1.	**ACQUIRE** basic concepts of Entrepreneurship, its characteristics, factors affecting entrepreneurship growth, entrepreneur and a manager,	Cognitive	1	1

	starting new enterprise, E-commerce, Business plan and issues, marketing strategies, franchising			
2.	**APPLY** knowledge for different business plans as case studies	Cognitive	2	2
4.	**DEMONSTRATE** individually and as team member during assignments, and projects for different case studies	Psychomotor	3	3

Course outline:

1. Evolution of the concept of entrepreneur, Characteristics of an entrepreneur, Distinction between an entrepreneur and a Manager, Economic Development, Factors affecting entrepreneurial growth (economic, Non-Economic and Government factors)
2. Critical factors for stalling a new enterprise. Ingredients for a successful new business. Self-assessment and feedback, Personal entrepreneurial competencies. Goal setting.
3. Creativity and sources of new business ideas, the difference between ideas and opportunity and creativity. Assessing business opportunities in Pakistan. Screening and evaluating opportunities Product planning and development process. Creating parallel competition by developing a similar product or service, Product life cycle, finding sponsorship. Acquiring a going concern, E-Commerce and business start-up and growth.
4. Marketing as a philosophy, marketing management: Creating a marketing plan, Analyze the environmental situation and the market opportunity, Setting marketing objective, formulating a marketing strategy.
5. The business plan as selling document, reasons for writing a business plan your company: What's your identity, Field work started, Marketing issues: Who are your buyers? Product issues: What are you selling?, Production exercise, Sales and Promotion: Financial issues: Targeting and writing the plan: Business Plan compilation exercise.
6. What is franchising? Becoming a franchisee versus starting a stand-alone business, The franchisee contract, Non-contractual

considerations of buying a franchise, Limitations of franchising, Conclusion, Course evaluation.

Teaching Methodology

- Lecturing
- Written Assignments and projects (individual and as group)
- Report Writing

Assessment

Mid Term, Quizzes, Assignments, Project, Final Exams

Text and Reference books:

1. Rober D. Hisrich and Michael P. Peter, Entrepreneurship/lip,5th Edition, McGraw Hill
2. S.S. Khanka, Entrepreneurial Development
3. Irving Burstiner, The small Businesses Handbook
4. Bruce A. Kirchhoff, Entrepreneurship and Dynamic Capitalism
5. Modern Business Management, A System & Environment Approach by McGraw-Hill
6. William D. Bygrave, The Portable MBA in Entrepreneurship/lip Entrepreneurship CEFE, Germany, Development Manual

INTRODUCTION TO FINITE ELEMENT ANALYSIS

Contact Hours:	**Credit Hours:**
Theory = 32	Theory = **2.0**
Practical = 48	Practical = 1.0
Total = 80	Total = **3.0**

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the basic knowledge of FEA, Software tools; element performance, FEA methods, formulations of 1-D, 2-D and 3-D elements	Cognitive	2	1

2.	**APPLY** knowledge for linear, structural, thermal, dynamic and couple field problems	Cognitive	2	5
3.	**ANALYZE** structural, thermal, dynamic problems	Cognitive	4	2
4.	**Work** individually and as team member during assignments, and projects using software.	Affective	3	9

Course outline:

a. Introduction to FEA and Element Performance

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

5. Dynamic Analysis

a. Introduction to different types of dynamic analysis
b. Modal Analysis, Frequency Response Analysis, Transient Response Analysis, Master Degrees of Freedom

Lab work (1 credit)

FEA software based analysis may be conducted in the lab.

Teaching Methodology

- Lecturing
- Written Assignments and projects (individual and as group)
- Report Writing

Assessment

Mid Term, Quizzes, Assignments, Project, Final Exams

Text and Reference books:

1. Richard G. Budynass, *Advanced Strength and Applied Stress Analysis*, McGraw-Hill
2. Saeed Moaveni, *Finite Element Analysis – Theory and Applications with ANSYS* , Prentice Hall
3. M J Fagan ,*Finite Element Analysis – Theory and Practice* ,Pearson Publications

POWER PLANTS

Contact Hours:	**Credit Hours:**
Theory = 48	**Theory =3.0**
Practical = 0.0	**Practical = 0.0**
Total = 48	**Total = 3.0**

Course Outcome:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Review** different energy resources, environmental impacts of power generation and flue gas cleaning techniques.	Cognitive	2	7
2.	**Analyze** strengths and weaknesses of different types of power plants by performing its thermodynamic calculations.	Cognitive	4	2
3	**Illustrate** the construction and operation of different components of a power plant.	Cognitive	4	2

4	**Design** of the major components or systems of a conventional or alternative energy power plant.	Cognitive	5	3

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

Teaching Methodology:
1. Lecturing
2. Written Assignments
3. Field Visits
4. Report Writing

Assessment:
Mid Exam, Final Exam, Quizzes, Assignments, Presentation

Text and Reference books:

1. Pedersen, E.S., *Nuclear Power, Ann Arbor Science*
2. El-Wakil, M.M., *Power Plant Technology*, McGraw-Hill
3. I. Dincer, C. Zamfirescu, *Advanced Power generation systems*, Elseveir
4. Larry Drbal, Pat Boston, "Powerplant Engineering", CBS Publishers
5. Black, Veatch, "*Power Plant Engineering*", Springer.
6. P.K. Nag, "*Power Plant Engineering*", McGraw-Hill.
7. Everett Woodruff, Herbert Lammers, Thomas Lammers, *"Steam Plant Operation"*, McGraw-Hill.
8. Thomas Elliott, Kao Chen, Robert Swanekamp, "*Standard Handbook of Powerplant Engineering*", McGraw-Hill.

I.C ENGINES AND POWER PLANTS LAB

Contact Hours:	**Credit Hours:**
Theory =0	Theory = **0.0**
Practical = 48	Practical = 1.0
Total = 48	Total = **1.0**

Course outline:
Experiments related to the I.C Engines and Power Plants will be covered.

Teaching Methodology
- Demonstration
- Lab Report Writing

Assessment
Lab performance, Quizzes, Lab Report, Lab Exams, Lab Assignments

Text and Reference books:
Lab Manual

SAFETY, HEALTH AND ENVIRONMENT

Contact Hours:	**Credit Hours:**
Theory = 16	Theory = **1.0**
Practical = 0	Practical = 0**.0**
Total = 16	Total = **1.0**

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Demonstrate** knowledge of Safety Health and Environment	Cognitive	3	6
2.	**ANALYZE** various types of hazards at work and living places.	Cognitive	4	2

Course outline:

1. **Introduction of Health and Safety:** Industrial Safety: introduction objectives of Safety, Importance of Safety in an industry, Industrial accidents, Effects of accidents, Types of accidents incidence of fire. Fire prevention and control.
2. **Techniques of Safety Management**: Principles of accident prevention, hazard analysis. Legal, humanitarian and economic reason for action. Safety inspection procedures. Safety training, First aid and emergency procedures.
3. **Environment and Health**: Introduction: importance of clean environment, Scale of Environmental Pollution. Environmental Act. Health and Safety Act.
4. **Atmospheric Pollution**: Types of Atmospheric pollution, Their Causes and Effects on Human Health, Available Technologies for Controlling Pollution.
5. **Industrial Waste**: Solid Waste, Industrial Effluents and Waste Gases, waste treatment plants.
6. **Noise Pollution**: Measurement of Noise level, Effect of excessive noise on human health. Remedial Measures.
7. **ISO Standards** for Safety and Health and Environment

Teaching Methodology

- Lecturing
- Tutorial sessions
- Discussions

Assessment

Quizzes, Mid Exams, Assignments, Term Project, Final Exam

Text and Reference books:

1. J. Ridley and J. Channing, *Safety at Works*, Routledge.
2. K. G. Lockyer, *Factory & Production Management*, Pitman Publishing.

ELECTIVE COURSES

Some of the technical and management electives are being suggested. However, the universities/DAIs may offer any other elective course keeping in view the faculty strength and availability. Interdisciplinary courses may be taken as elective courses.

Technical Electives

1. Renewable Energy Technology

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 non-renewable 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.

Recommended Books:

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

2. Gas Dynamics

Basic governing laws of conservation of mass, momentum and energy, limitations. Sub-sonic and supersonic gas flow. Mach number and Mach angle. Isentropic Flow and Applications; Operation of nozzles under varying pressure ratios. Normal and oblique shocks, Prandtl-Meyer compression and expansion with applications. Rayleigh flow and Fanno flow, Busemann's shock polar diagram.

Recommended Books

1. M. J. Zucrow and J.D. Hoffman, Gas Dynamics, John Wiley & Sons, 1976

2. A. H. Shapiro, R. Wiley, *The Dynamics and Thermodynamics of Compressible Fluid Flow*-Vol. 1, 1st Edition
3. J. E. John, Allyn and Bacon, *Gas Dynamics*, 2nd Edition
4. B.W. Imrie, *Compressible Flow*

3. Aerodynamics

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

Recommended Books

1. El. Houghton, A. E. Brock, St. Mortin, *Aerodynamics for Engineering Students*, Cambridge University Press, 2003
2. L. J. Clancy, Hallstead Pr., *Aerodynamics*

4. Computational Fluid Dynamics (CFD)

Types of ordinary and partial differential equations, solution of equation sets, boundary value and initial value problems, control volume approach, time stepping, accuracy, stability, consistency, linearization, diffusion, dispersion, vorticity stream function and primitive variable formulations. Turbulence modeling. Examples of external flow across various configuration, internal flows through pipes, ducts and valves.

Recommended Books:

1. J. D. Anderson Jr., *Computational Fluid Dynamics*, 1st Edition, McGraw-Hill Science

5. Maintenance Engineering

Introduction and types: Preventive maintenance, its objectives, benefits and economics, inspection and implementation. Routine maintenance and monitoring of fault indicators, main concepts and implementation. Proper assembly/disassembly, alignment aspects, machine handling. Record keeping and maintenance scheduling, stocking spares and cost effectiveness, safety in maintenance. Basic repairs of electro-mechanical equipment, fault diagnosis and assessment. Introduction to predictive maintenance. Condition base monitoring.

Basic Repairs. Replacement/refurbishment of defectiveness parts e.g. bearings, brakes, shafts.

Recommended Books:

1. L. R. Higgins, L. C. Morrow, Maintenance Engineering Handbook, 3rd Edition, McGraw-Hill
2. B.J. Lewis, Management Handbook for Plant Engineers 2nd Edition, McGraw-Hill.

6. Introduction to Mechatronics

Sensors. transducers, transducer characteristics, sensors for measuring displacement, strain, force, pressure, temperature and motion.

Actuators. Motors and their types. Stepper motors. Permanent magnet DC motors. Servo Systems.

Interfacing. Ports, Input/Output, Analog to Digital converter, sampling theory, Digital to Analog converter. Sample and hold, multiplexer. Interfacing switches, LEDs, stepper motors and DC motors to micro-controllers.

Recommended Books:

1. K. Stiffler, *Design with Microprocessors for Mechanical Engineers*, McGraw-Hill 1992
2. Goankr, *Microprocessor Architecture, Programming and Applications*, 5th Edition, Prentice Hall

7. Automation and Robotics

Robotics: Basic concepts in robotics, classification and structure of robotic system, drive and control system, coordinate transformation, kinematics dynamic analysis and trajectory interpolation, interfacing with micro controllers and PLCs, applications of robots.

Robotics and Automated Guided Vehicles. Basic robot motion, path control, robot drive system sensors, robot-computer interface, robot programming, Automated Guided Vehicles (AGV) types.

Programmeable logic controller (PLC). Basics components and terminologies, ladder diagram elements, relay sequencing, processor input and output modules, programming unit and programming procedures with machines or assembly language.

Microcontroller. Basic elements of microcontroller, types of microcontroller, microprocessor and PLC, overview of architecture and principles of operations, assembly, machine and high level programming languages for microcontroller, input and output peripherals for specific application in mechanical engineering with interfacing techniques. Actuators, sensor, input signals, output signals, signal conditioning.

Automations: Introduction to automations, automation strategies, economics of automations, partial automations, group technology and flexible manufacturing. Use of sensors and actuators in automations.

Recommended Books:

1. Y. Korem, *Robotics for Engineers*, 1985
2. J. Craig, *Introduction to Robotics*, 3rd Edition, Prentice Hall

3. D. G. Alciatore, M. B. Histand, *Introduction to Mechatronics & Measurement Systems*, 2nd Edition, McGraw-Hill
4. C. D. Johnson, *Process Control Instrumentation Technology*, 7th Edition, Prentice Hall
5. C. R. Asfahd, *Robotics and Manufacturing Automation*, John Wiley & Sons
6. M. P. Groover, *Automation Production Systems*, 1987

8. Tribology

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, oil whirl, Hydrodynamic and elasto-hydrodynamics lubrication of journal bearing. Solid lubricants, self-lubricating fuel, tribology in manufacturing, tribology in automobiles.

Recommended Books:

1. A Cameron, *Basic Lubrication Theory*,
2. D.D. Fuller, *Theory and Practice of Lubrication for Engineers*, John Wiley & Sons Inc. 1956
3. B. Bhushan, *Modern Tribology Handbook*, Vol-I, CRC Press, 2001

9. Nuclear Engineering

Review of nuclear physics, reactor physics, reactor heat transport. Types of nuclear reactors, and power plants. Reactor material. Nuclear fuels, enrichment and reprocessing; handling of fuels. Safety aspects.

Recommended Books:

1. J.P. Lamarsh, *Introduction to Nuclear Engineering*, Prentice Hall 2001
2. M. M. El Wakil, *Nuclear Power Engineering*, McGraw-Hill 1962

10. **Mechanical Engineering Design**

Philosophy and concept of engineering design. Engineering creativity, phases and procedure in design. Management of engineering project. Computer aided design. Modeling and similitude, optimization and reliability. Application of industrial design codes.

Recommended Books:

1. W. Eder, S. Hosnell, Design Engineering: A manual for enhanced creativity, CRC Press, 2007

2. A. H. Burr, J. B. Cheatham, Mechanical Analysis and Design, Prentice Hall.
3. D. G. Ullman, The mechanical design process, McGraw Hill.

MANAGEMENT ELECTIVES

1. Operations Management

Basics of managing manufacturing and service organizations; strategic decision making; facility location and layout; job design and work compensation; demand forecasting; capacity and material planning; scheduling in various environments; emerging trends in managing operations. Focus on selection and use of quantitative management tools after introducing fundamental concepts.

Recommended Books:

1. W. J. Stevenson, *Operations Management*, 12th Edition 2015, McGraw Hill
2. A. Greasley, *Operations Management*, 3rd Edition, 2013,Wiley

2. Total Quality Management

Fundamental principles; Standards; Techniques for quality analysis and improvements; statistical methods and SPC. Acceptance sampling; QFD; Value engineering; Cross-functional management and benchmarking; ISO-9000 application, clauses, and implementation issues

Recommended Books:

1. A. Rao, Lawrence P. Carr, I. Dambolena, R. J. Kopp, J. Martin, F. Rafii, P. Fineman Schlesinger, *Total Quality Management: A Cross Functional Perspective*, 1996, Wiley
2. S. Ramasamy, Total Quality Management, McGraw Hill Education, 2012

3. Project Management

Fundamental principles; Project life cycle; Project organization and human resource management; PM planning; Work breakdown structure; Estimating time and cost; Precedence relationships; Project scheduling and control techniques; Project risk analysis; Time compression and resource leveling; Computerized project management; special software packages

Recommended Books:

1. Project Management - A Contemporary Approach, Darren Dalcher, WELEY, 2014
2. Managing High-Technology Programs and Projects, 3rd Edition, Russell D. Archibal, WILEY, 2003
3. Project Management, Gary R. Heerkens, PMP McGraw-Hill, 2002

4. Operations Research

Operations research techniques and basics, Linear programming, graphical method, simplex method, geometric programming, dynamic programming, sensitivity and post-optimal analysis, transportation models, Queuing theory (weighting live models). Replacement Models. Simulation. basic principles, discrete models vs. continuous system simulation, applications, use of digital computer for simulation, languages of simulation, introduction to GPSS (General Purpose System Simulation) language, practical applications of GPSS.

Recommended Books:

1. H. A. Taha, *Operations Research***,** 7th Edition, Maxwell Macmillan International
2. *J.A. Chisman*, *Introduction To Simulation Modeling Using GPSS/PC,* Prentice-Hall, 1992
3. *M. Anderson, Lievano*, R.J. Kent, *Quantitative Management: An Introduction*, Publishing Co.

5. Engineering Law

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.

Recommended Books:

1. Allen, Business Law for Engineers
2. A. R. Dick, Engineering Law, 5th Edition, University Press

SCHEME OF STUDIES FOR
MASTER IN MECHANICAL ENGINEERING

Admission/Intake Criterion

- Bachelor in the relevant Engineering disciplines accredited by the Pakistan Engineering Council.

Degree Requirements

- Option 1: Minimum 30 Credit hours course work.
- Option 2: Minimum 24 Credit hours course work and 6 credit hours thesis.
- List of Master/PhD. courses is presented.
- In any specialization, the concerned departments may select a course(s) available in the above list to serve a core course(s) (minimum 4 courses).
- Any new course added/launched/included by a university may be routed through the statutory bodies to the (NCRC) at HEC for inclusion in the existing list.
- The above recommendations may be forwarded to the MS/Ph.D. monitoring committee of HEC.

List of Courses

S.No	Course Title	Credit Hours
1	Research Methodology	**0(0-0)**
2	Continuum Mechanics	**3(3-0)**
3	Advanced Fluid Mechanics	**3(3-0)**
4	Advanced Heat Transfer	**3(3-0)**
5	Advanced Thermodynamics	**3(3-0)**
6	Advanced Stress Analysis	**3(3-0)**
7	Advanced Manufacturing Processes	**3(3-0)**
8	Advanced Finite Element Methods	**3(3-0)**
9	Design Optimization and Analysis Techniques	**3(3-0)**
10	Design of Experiments	**3(3-0)**
11	System Dynamics and Controls	**3(3-0)**
12	Advanced Solid Mechanics	**3(3-0)**
13	Theory of Plates and Shells	**3(3-0)**
14	Condition Monitoring of Rotating Machines	**3(3-0)**
15	Computational Fluid Dynamics	**3(3-0)**
16	Turbulence Modeling	**3(3-0)**
17	Fracture Mechanics	**3(3-0)**

18	Advanced Numerical Analysis	**3(3-0)**
19	Information Systems Analysis and Design	**3(3-0)**
20	Mechanics of Composite Materials	**3(3-0)**
21	Supply Chain Management in Engineering	**3(3-0)**
22	Corrosion Engineering	**3(3-0)**
23	Advanced Aerodynamics	**3(3-0)**
24	Transport Processes in Energy Systems	**3(3-0)**
25	Advance Fatigue Fracture Analysis	**3(3-0)**
26	Micro electromechanical Systems	**3(3-0)**
27	Casting and Solidification of Materials	**3(3-0)**
28	Operations Research	**3(3-0)**
29	Advanced Transport Phenomena	**3(3-0)**
30	Processing of Composites	**3(3-0)**
31	Materials for High Temperature Applications	**3(3-0)**
32	Advanced Turbomachinery	**3(3-0)**
33	Welding & Nondestructive Testing	**3(3-0)**
34	Advanced Power Plant Systems	**3(3-0)**
35	Project Management	**3(3-0)**
36	Renewable Energy Systems	**3(3-0)**
37	Advanced Measurements and Instrumentation	**3(3-0)**
38	Robotics and Parallel Mechanisms	**3(3-0)**
39	Hydrogen and Fuel Cell Engineering	**3(3-0)**
40	Combustion and Environment	**3(3-0)**
41	Theory of Plasticity	**3(3-0)**
42	Theory of Elasticity	**3(3-0)**
43	Reliability and Quality Engineering	**3(3-0)**
44	Non-linear Heat Transfer	**3(3-0)**
45	Non-linear Vibration	**3(3-0)**

COURSE OUTLINE FOR MASTERS IN MECHANICAL ENGINEERING

Continuum Mechanics

Course Outline

Introduction, basic assumptions, vectors and tensors, tensor analysis, state of stress, kinematics of deformation. General principles of mechanics and thermodynamics. Constitutive equations of large-deformation elasticity, development of mathematical tools, Kinematics of a continuum stresses general principles. Theory of constitutive equations. Basic material laws. Curvilinear coordinate systems in tensors.

Recommended Books

1. *Introduction to the Mechanics of a Continuous Medium* L. E. Malvern Prentice Hall.
2. A. J. M. Spencer, Longman, *Continuum Mechanics*.

Advanced Fluid Mechanics

Course Outline

Fluid Dynamics: Laminar and turbulent boundary layer flow with and without heat transfer, boundary layer separation stability transition and control.

Kinematics and dynamics of flow of continuous media, Navier-Stokes equation, simplification, exact and approximate solution. Irrational of hydrodynamics stability, turbulence, free shear flows, chemical reactions, and shock expansion.

Rotating Fluid Machinery: Aero dynamics of compressors & turbines, subsonic, transonic and supersonic flow characteristics, secondary flow and stall stability, components matching of total non-dimensional representation of performance.

Recommended Books

1. William Graebel, *Advanced Fluid Mechanics*, Academic Press
2. K. Muralidhar, GautamBiswas, *Advanced Engineering Fluid Mechanics*, Alpha Science International.
3. Arved Jaan Raudkivi, Robert A. Callander, *Advanced Fluid Mechanics: An Introduction,* John Wiley & Sons, Incorporated.

Advanced Heat Transfer

Course Outline

An advanced study of the transmission of heat by conduction, convection and radiation. Conduction and convection:derivation and application of

their equations governing steady and unsteady conduction heat transfer, transient conduction, and numerical solutions are examined with selected topics. Governing equations for forced and natural convection; dimensional analysis and similarity transforms are applied. Radiation: physical properties of radiation, thermal radiation laws, characteristics of real and ideal systems, geometric shape factors, grey and non-grey system analysis, energy transfer in absorbing media and luminous gases, solar radiation.

Recommended Texts

1. Amir Faghri, Yuwen Zhang, John R. Howell, *Advanced Heat and Mass Transfer*

Advanced Thermodynamics

Course Outline

Equilibrium of thermodynamics systems: spontaneous changes, criterion of stability, equilibrium of system. System of constant chemical composition: thermodynamic properties, equation of state, law of corresponding states, relations for pure substance, the third law of thermodynamics, Gibbs free energy equation, heats of reaction or calorific values, adiabatic combustion, heats of formation and Hess's law, entropy of ideal gas mixtures. Gas mixtures of variable composition: chemical potential, stoichiometery and dissociation, chemical equilibrium, equilibrium constant and heat of reaction, Van't Hoff's equation, temperature rise due to combustion reaction, Lighthill ideal dissociating gas, ionization of monatomic gases, non -equilibrium processes, equilibrium and frozen flows, Special systems: application of thermodynamics to elastic systems, systems with surface tension, reversible cell, fuel cell, magnetic systems, thermodynamics of irreversible processes, thermo-electricity.

Recommended Texts

1. Ibrahim Dincer and Marc A. Rosen, Elsevier, *Exergy: Energy, Environment and Sustainable Development*.
2. DE Winterbone, *Advanced thermodynamics for Engineers*, Arnold, 1997.
3. K. Annamalai, I. K. Puri, *Advanced thermodynamics engineering*, CRC Press, 2002.
4. Ibrahim Dincer and Tahir Abdul Hussain Ratlamwala, *Integrated Absorption Refrigeration Systems: Comparative Energy and Exergy Analyses*, Springer.

Advanced Stress Analysis

Course Outline

Overview of Experimental Stress Analysis, Stress analysis – Analytical, Numerical and Experimental approaches, Specific domain of these approaches, Advantages and disadvantages. Theory and applications of methods in experimental mechanics for measuring static and dynamic deformation of 2-D and 3-D models and bending of plates and shells. Techniques of electric resistance strain gage, photoelasticity, moire, holographic interferometry, laser speckle interferometry, moire interferometry, caustics, optical correlation by computer vision. Introduction to Three-Dimensional Photoelasticity and Digital Photoelasticity. Applications to problems in fracture mechanics, composite mechanics, interface mechanics and micromechanics.

Recommended Texts

1. K. Ramesh, *Digital Photoelasticity – Advanced Techniques and Applications*, Springer.
2. W.N. Sharpe (Ed.), *Springer Handbook of Experimental Solid Mechanics*, Springer.
3. J.W. Dally and W.F. Riley, *Experimental Stress Analysis*, McGraw-Hill.
4. L.S. Srinath, M.R. Raghavan, K. Lingaiah, G. Gargesa, B. Pant, and K. Ramachandra, *Experimental Stress Analysis*, Tata McGraw Hill.

Advanced Manufacturing Processes

Course Outline

Fundamentals and advanced techniques related to manufacturing processes. Applied aspects of manufacturing processes, a sound analytical basis for some of the processes will be taught. Through the use of analytical approaches you will learn how to control a manufacturing process for optimal production. This course builds a foundation of capability for the solution, analysis and synthesis of a wide variety of manufacturing problems.

Recommended Texts

1. E.P. DeGarmo, J. T Black, R.A.Kohser, *Materials and Processes in Manufacturing,* Prentice Hall of India, New Delhi .
2. Ghosh, and A.K. Mallik, *Manufacturing Science,* Affiliated East-West Press Pvt. Ltd. New Delhi.
3. G. F. Benedict, Marcel Dekker, *Non-traditional Manufacturing Processes*, Inc. New York

Advanced Product Design

Course Outline

Principles of Automated Design, Principles of DFA (Design for Assembly), Projects on DFA, Principles of DFD (Design for Disassembly), Principles of DFM (Design for Manufacturability). Issues of Concurrent Design, Automated Design.

Recommended Texts

1. O. Molloy, S. Tilley, E. Warman, *Design for Manufacturing and Assembly, Concepts, architectures and implementation*.
2. Geoffrey Boothroyd, Peter Dewhurst and Winston A. Knight, *Product Design for Manufacture and Assembly.*
3. Corrado Poli, *Design for Manufacturing: A Structured Approach*.
4. James Bralla, *Design for Manufacturability Handbook*.

Advanced Finite Element Methods

Course Outline:

General concepts of FEM, Galerkin/weighted residual method, Rayleigh-Ritz/ variational method, Shape functions, Iso-parametric elements, 1D problems: trusses, beams and frames, 2D problems: plane stress, plane strain and axisymmetric problems, 3D stress analysis, Heat transfer, Fluid flow problems, Numerical integration: Gaussian quadrature, Reduced integration, The Patch test, Finite element error analysis, Error estimates, Convergence and accuracy of solutions, Infinite and singularity elements, Time Dependant problems, Semi-discrete FEM, Time approximations, Computer implementation.

Recommended Texts

1. O. C. Zienkewicz, R. L. Taylor. *The Finite Element Method*
2. F. L. Stasa, *Applied Finite Element Analysis for Engineers*, Int'l Thomson Pub.
3. S. S. Rao. *Finite Element Method in Engineering*, 3rd ed., Pergamon Press.
4. I. M. Smith, *Programming the Finite Element Method*. John Wiley & Sons.

Design Optimization and Analysis Techniques

Course Outline

Modelling: Mathematical model. Nature of design process. Analysis and design models. Optimal design. Formal optimization model. Boundedness, Feasibility and constraint activity. Topography of the design

space. Mathematical review. Notation. Multi-variable functions. Continuity gradient and definite matrices. Convergence of algorithms. Conditions of optimality: necessary and sufficient conditions for unconstrained and constrained optima. Meeting of LaGrange multipliers. Methods of unconstrained optima. One dimensional minimization. Bisection and golden section initial bracketing, Polynomial interpolation. Multi-dimensional minimization. Steepest descent. Conjugate direction & conjugate gradient methods. Newton's method and its modifications. Quasi-Newton methods. Scaling. Stopping criteria. Methods for constrained optima. Interior and exterior penalty method. Augmented lagrangian method. Direct methods.

Recommended Books

1. *Principles of Optimal Design by Papalambros & Press, USA*. Wilde, McGraw-Hill
2. J. Arora, *Introduction To Optimum Design*.

Design of Experiments

Course Outline

Review of Statistics and Probability, Probability Distributions, Sampling Distributions, Design of Experiments, Single and Multi-Factor Analysis of Variance (ANOVA), Factorial Design of Experiments, 2^k and 3^k designs, 2^k designs with Center Points, Response Surface Methodology, Simple and Multiple Regression

Recommended Books

1. Jiju Antony, *Design of Experiments for Engineers and Scientists*,

System Dynamics and Controls

Course Outline

Introduction to Process Control; Process Dynamics and Laplace Transform; First Order Systems; Second Order Systems; Inverse Response and Time Delay; Frequency Domain; Linearization and Nonlinear Systems; Stability; Process Identification; Feedback Control Systems; Conventional Design; Inverse Response and Time Delay; Feed forward, Inverse Response, and Time Delay; Model-based Control; Digital Control - Sampling; Z Transforms and Digital Block Diagrams; Digital Controller Design; Model Predictive Control; Multivariable Control; RGA and Modal Analysis; SVD and Decoupling; Multivariable Examples.

Recommended Books

1. Smith, C. A, Corripio, A. B, *Principles and Practice of Automatic Process Control*, John Wiley.
2. Marlin, T.E., *Process Control*, McGraw Hill Book Co
3. Ogunnaike, B. A., et al., *Process Dynamics, Modeling, and Control*,

Oxford University Press.

Advanced Solid Mechanics

Course Outline

Review of mechanics of materials, Stress transformations, general 3D stress 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, transverse shear, composite beams in bending, curved beams, bending of thin flat plates, axisymmetric circular plates in bending, thick-walled cylinders & rotating disks, contact stresses, distributed contact surfaces, contact between curved surfaces. Energy techniques.

Recommended Books

1. F P Beer, E R Johnston, J T Dewolf, D E Mazurek, *Mechanics of Materials*, McGraw-Hill.
2. P PBenham, R J Crawford, C G Armstrong, *Mechanics of Engineering Materials*,
3. R G Budynas, *Advanced Strength and Stress Analysis*, 2nd ed, McGraw Hill.

Theory of Plates and Shells

Course Outline

Preliminaries of linear, three-dimensional elasticity theory, Reduction of the elasticity theory to theories of plates and shells, Anisotropy, Nonlinear theories, Effects of discontinuities on the stress distribution in plates and shells, Design construction features of plates and shells, Applications.

Recommended Books

1. J.F. Harvey, Van Nostrand, *Theory and Design of Modern Pressure Vessels*, Reinhold Co., New York.
2. Timoshenko, S. Woinowsky-Krieger, *Theory of Plates & Shells*, McGraw-Hill.
3. E. Ventsel, *Thin Plates and Shells, Theory, Analysis and Application*, CRC Press.

Condition Monitoring of Rotating Machines

Course Outline

Introduction to vibration technology, Vibration, causes and its effects on machine life, Maintenance philosophies, condition monitoring technologies, Vibration as a predictive maintenance tool, Components of

Vibration Analysis (VA) Program and its additional applications, components of a mechanical system, free(without and with damping) and forced (without and with damping) single, two and multiple degree of freedom system, characteristic of Vibration including amplitude, frequency and phase analysis with their significance in VA, Vibration Severity Standards and guidelines, setting of machine alarms, bearing and gears fault diagnosis techniques like spike energy and Peak Value, vibration transducers including displacement probes, velocity pickups and accelerometers, their construction, selection and mounting techniques, Vibration frequency analyzers, FFT spectrum analysis, spectral parameters of FFT, directional and non-directional vibrations, identification of most common machinery problems using FFT spectrum like unbalance, misalignment, looseness, resonance, aerodynamic/hydraulic problems of pumps and fans, bearing and gear problems, drive belt problems, rotor and stator problems in electric motor, eccentricity and bent shaft problems, general consideration and pitfalls, implementation of a successful predictive maintenance program.

Recommended Books

1. James E. Berry, *Introduction to Vibration Technology*, Entek IRD International, USA.
2. M. L. Adams Jr., *Rotating machinery problem from analysis to Troubleshooting*, Marcel Dekker Inc
3. James Taylor*, The Vibration Analysis* Handbook VCI Pub.

Computational Fluid Dynamics

Course Outline

Governing Differential Equations: continuity, momentum, turbulence and energy balance equations; The generic form of governing equations.; Basic steps for numerical solution: geometry definition, grid, boundary conditions, solutions, post-processing; Finite Difference Method in CFD: Forward, Backward, Central Difference and Upwind Schemes for advection-diffusion and wave equations, discussion of round- off and numerical errors and stability of various schemes; Finite Volume Method in CFD: General guidelines and various interpolation schemes, derivation of discretization equations for diffusion, advection-diffusion and full Navier-Stokes Equations; pressure-velocity coupling algorithms, SIMPLE, SIMPLER, SIMPLEC etc, Implementation of boundary conditions, discussion of methods of solution, convergence and tools for accelerating convergence. Introduction to Finite Element Method for CFD: element shapes and shape functions, derivation of finite element equations for potential flow using weighted residual approach. An introduction to modern commercial and open-source CFD codes and practical case studies using these codes.

Recommended Books

1. Tu, J., Yeoh, G. H., and Liu, C., *Computational Fluid Dynamics, A Practical Approach*, Butterworth & Heiemann.
2. Patankar. S. V. *Numerical heat transfer and fluid flow,* Hemisphere.
3. Malalasekra, W. and Versteeg, H., *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, Prentice Hall.
4. Anderson, J., *Computational Fluid Dynamics*, McGraw Hill Book Co.

Turbulence Modelling

Course Outline

Introduction to Turbulence: Observation of different turbulent Flows, Characteristics of turbulent flows, Turbulent wall-bounded flows, Turbulent free-shear flows, Turbulent equilibrium flows, Near-wall region, Turbulent flows and drag reduction. Mathematical Background Review: Tensor Operations, Fourier-transformation, Buckingham theorem. Continuum Mechanics & Turbulence: Balance equations, Transport equations of turbulent flows, transport equation for velocity field, transport equation for scalar field. The Eddy Viscosity concept: Boussinessq Analogy, The eddy viscosity, short-coming of eddy viscosity concept Zero Equation Models: Prescribed Eddy viscosity, Mixing-length hypothesis, Pro & cons of zero equation model One Equation Models: Exact equation for k, Modeled equation for k, Determination of model coefficients, specification of mixing length Scalar-flux models: The turbulent Prandtl number, scalar-flux transport equation, algebraic scalar-flux models, introduction to advanced models and use of CFD codes. Introduction to LES and DES.

Recommended Books

1. David C. Wilcox , "*Turbulence Modelling for CFD*", DCW Industries, 2006.
2. Stephen B Pope, "*Turbulent flows*", Cambridge University press, 2000.

Fracture Mechanics

Course Outline

Basic problems and concepts, Mechanisms of fracture and crack growth. The elastic crack-tip stress field, the crack tip plastic zone, The energy principle, Dynamics and crack arrest, Plane strain fracture toughness, Plane stress and transitional behavior, Elastic-plastic fracture, Fatigue crack propagation, Fracture resistance of maltreats, Fail-safety and damage tolerance, Determination of stress intensity factors, Practical problems, Fracture of structures, Stiffened-sheet structures, Prediction of fatigue crack growth.

Recommended Books

1. David Broek, *Elementary Engineering Fracture Mechanics*, 4thed, Martinus Nijhoff Pub.
2. C. R. Brooks, A. Choudhury *Failure Analysis of Engineering Materials,* The McGraw-Hill Companies.
3. Van Dereck, Fr. Gechette, *Failure Analysis of Brittle Materials*, The American Ceramic Society.
4. T. L. Anderson, *Fracture Mechanics: Fundamentals and Applications,* CRC Press.

Advanced Numerical Analysis

Course Outline

Numerical Technique to solve Linear and Non-Linear systems, Generalized Newton's Method. Finite difference Method, Finite Volume Method for PDEs. Upwind Schemes, TVD Schemes, Marker and Cell Method, Multi grid Method, Pseudo-spectral Method. Matlab applications for solving PDEs.

Recommended Books

1. F. B. Hildebrand, *Introduction to Numerical Analysis*.

Information Systems Analysis and Design

Course Outline

The concepts, strategies, techniques, and tools for identifying and specifying information systems requirements and for developing designs.

Recommended Books

1. Langer, Arthur M., *Analysis and Design of Information Systems*.
2. Shouhong Wang and Hai Wang, *Information Systems Analysis and Design*
3. V. Rajaraman, *Analysis and Design of Information Systems*

Mechanics of Composite Materials

Course Outline

Definition and classification, natural composites, property enhancement by reinforcement and orientation, matrix interface, Constitutive relations for anisotropic materials; Stiffness and compliance matrices of lamina; Effective moduli of lamina; Macro-mechanical behavior of cross-ply and angle-ply laminates; Interlaminar strength; Symmetric and anti-symmetric laminates; Failure theories for lamina and laminate; Micromechanics of single-fiber-composite; Statistical aspects of fiber strength; Viscous and dynamic behavior.

Recommended Books

1. R. E. Shalin., *Polymer Matrix Composites*, Chapman& Hall.
2. Matthews & Rawlings, *Composite Materials: Engineering and Science*, Chapman& Hall.
3. Ramesh Talreja and Jan-Anders E. Manson; *Polymer Matrix Composites*, Elsevier.
4. Sperling, L. H.: *Polymeric Multi-component Materials*, John Wiley.
5. Hull, D. and Clyne, T.W., *An Introduction to Composite Materials*, 2nd Ed. Cambridge University Press.
6. Ochiai, S. *Mechanical Properties of Metallic Composites*, Marcel Dekker.
7. Vigo, TL & Kinzig BJ, *Composite Applications: The Role of Matrix, Fiber, and Interface*, VCH Publishers.
8. Surace, G., Carpinteri, A. and Sih. G.C., *Advanced Technology for Design and Fabrication of Composite Materials and Structures* Kluwer Academic Publications.
9. Matthews, F. L. and Rawlings, R. D., *Composite Materials: Engineering & Science*, Chapman & Hall.

Supply Chain Management in Engineering

Course Outline

Defining supply chain systems complexity, opportunities, and pit-falls of management inventory theories, transportation and supply chain dynamics. The organizational models to develop, implement and sustain supplier management.

Recommended Books

1. Samuel H. Huang, *Supply Chain Management for Engineers*
2. Marc Goetschalckx, *Supply Chain Engineering (International Series in Operations Research & Management Science*
3. Dolgui, Alexandre, Proth and Jean-Marie, *Supply Chain Engineering Useful Methods and Techniques*
4. A. Ravi Ravindran, Donald P. and Warsing, Jr. *Supply Chain Engineering: Models and Applications*.

Corrosion Engineering

Course Outline

Applications of thermodynamics and kinetics to engineering aspects of corrosion and corrosion control; introduction to forms and mechanisms of corrosion; applications of cathodic protection, anodic protection, corrosion inhibitors, coatings and materials selection for corrosion control and design.

Recommended Books

1. Pierre R. Roberge, *Handbook of Corrosion Engineering*
2. R. Winston Revie, Herbert H. Uhlig, *Corrosion and Corrosion Control: An Introduction to Corrosion Science and Engineering*.
3. Zaki Ahmad, *Principles of Corrosion Engineering and Corrosion Control.*

Advanced Aerodynamics

Course Outline

Introduction, Fundamental principles and equations, Circulation, Stream function, Velocity Potential, Dynamics of incompressible inviscid flow-field, Characteristic parameters for airfoil and wing aerodynamics, Airfoil nomenclature, Incompressible flow around airfoils, Incompressible flow about wings, Boundary layer flows, Boundary layer equations for incompressible flows, 2D incompressible laminar flows, 2D incompressible turbulent flows, Boundary layer Separation phenomena in laminar flows, Interactive boundary layer theory, Experimental external flows

Recommended Books

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. Young, A. D., *Boundary Layers,* AIAA.

Transport Processes in Energy Systems

Course Outline

Transport processes from a multiscale and Multiphysics perspective, and the application to the analysis of energy engineering systems. The equations describing the mechanisms for mass, momentum, charge, and energy transport. Approaches for the evaluation of material properties and constitutive relations holistic view of transport processes as combinations of transient, advective, diffusive, and reactive phenomena. Applications associated to energy generation.

Recommended Books

1. FrankKreith, Susan Krumdieck, *Principles of Sustainable Energy Systems*.
2. Mamoru Ishii, Takashi Hibiki, *Thermo-Fluid Dynamics of Two-Phase Flow*.
3. Daniel E. Rosner, *Transport Processes in Chemically Reacting Flow Systems*.

Advance Fatigue Fracture Analysis

Course Outline

Fatigue behaviour of materials, structural damage assessment, fracture design and failure analysis for monotonic and cyclic loaded components, the stress intensity factor and J integral for monotonic and cyclic loading, fatigue and fracture data statistical analysis, practical case studies and applications, fatigue crack initiation, crack growth rate, and fatigue life prediction of both un-notched and notched engineering components subjected to the uniaxial and multiaxial fatigue loading conditions.

Recommended Books

1. Yung-Li Lee, *Fatigue Testing and Analysis: Theory and Practice.*
2. Dieter Radaj, Michael Vormwald, *Advanced Methods of Fatigue Assessment.*

Microelectromechanical Systems

Course Outline

Introduction to MEMS: Fundamentals of MEMS design, analysis and fabrication. Materials and manufacturing of MEMS: Basic IC-processing. Engineering mechanics of microsystem design: Residual stresses, Static bending of thin plates, Mechanical vibration, Thermo-mechanics, Fracture mechanics, Thin-film mechanics, General material considerations. Scaling laws in MEMS. Sensors: Force and pressure sensors, resonant sensors, Thermofluid sensors. Actuators: Fundamentals of microactuation. Parallel plate electrostatic actuation. Electrostatic pressure, Comb drive actuator. Mathematical modeling: Kinematics and kinetics of MEMS. Determination of force components, Analysis of dynamic effects and frictional effects in MEMS. Design of MEMS: CAD and FEM for MEMS. Hands on practice using available MEMS software. MEMS Packaging. Introduction to Nanotechnology. Future trends in MEMS/NEMS.

Recommended Books

1. N Maluf, *Introduction to Microelectromechanical Systems Engineering*.
2. T-R Hsu, *MEMS & Microsystems: Design and Manufacture*, McGraw Hill.
3. M Elwenspoek, R Wiegerink, *Mechanical Microsensors*, Springer-Verlag.
4. S D Senturia, *Microsystem Design*, Kluwer.
5. M. Gad-El-Hak, *The MEMS Handbook*, CRC Press.

Casting and Solidification of Materials

Course Outline

Melt Interactions. Fluid Dynamics, Mould Dynamics and Solidification Dynamics. Solidification Shrinkage. Near-net-shape Processes. Linear Contraction and Casting Accuracy. Structure, Defects and Properties of the Finished Casting. Case Studies in Mathematical Modelling and Solidification Processing.

Recommended Books

1. Kuang-Oscar Yu (Editor) *Modeling for Casting and Solidification Processing (Materials Engineering)*
2. Brian Cantor, K O'Reilly, *Solidification and Casting: (Materials Science and Engineering).*
3. Hasse Fredriksson, Ulla Åkerlind, *Materials Processing During Casting*
4. Hasse Fredriksson, Ulla Akerlind, *Solidification and Crystallization Processing in Metals and Alloys.*
5. Glicksman and Martin Eden, *Principles of Solidification: An Introduction to Modern Casting and Crystal Growth Concepts.*

Operations Research

Course Outline

Formulation and analysis of probabilistic models in operations research. Poisson processes, renewal processes, Markov chains, queuing theory, Markovian decision processes, and time series analysis. Application areas reliability, traffic flows, production, and inventory

Recommended Books

1. C. Richard Cassady, Joel A. Nachlas, *Probability Models in Operations Research*
2. Wayne L. Winston, Introduction to Probability Models: Operations Research

Advanced Transport Phenomena

Course Outline

Momentum Transport: Derivation of equation of continuity and motion; Application to laminar flow problems. Energy Transport: Derivation of energy equation; Application to heat Transfer Problems involving conduction, forced and free convection. Mass Transport: Derivation of species conservation equations for binary and multi-component mixtures; Application to mass transfer problems with and without chemical reactions.

Recommended Books

1. Bird, R. B, Stewart, W. E, and Lightfoot, E. N, *Transport Phenomenon*, John Wiley,
2. Welty, J. R., et al., *Fundamentals of Momentum, Heat, and Mass Transfer*, John Wiley .

Processing of Composites

Course Outline

Definition and classification, natural composites, property enhancement by reinforcement and orientation, matrix interface, Constitutive relations for anisotropic materials; Stiffness and compliance matrices of lamina; Effective moduli of lamina; Macro-mechanical behavior of cross-ply and angle-ply laminates; Interlaminar strength; Symmetric and anti-symmetric laminates; Failure theories for lamina and laminate; Micromechanics of single-fiber-composite; Statistical aspects of fiber strength; Viscous and dynamic behavior.

Recommended Books

1. R. E. Shalin., *Polymer Matrix Composites*, Chapman& Hall.
2 Matthews& Rawlings, *Composite Materials: Engineering and Science*, Chapman& Hall.
3. RameshTalreja and Jan-Anders E. Manson; *Polymer Matrix Composites*, Elsevier.
4. Sperling, L. H.: *Polymeric Multi-component Materials*, John Wiley.
5. Hull, D. and Clyne, T.W., *An Introduction to Composite Materials*, Cambridge University Press.
6. Ochiai, S. *Mechanical Properties of Metallic Composites*, Marcel Dekker.
7. Vigo, TL &Kinzig BJ, *Composite Applications: The Role of Matrix, Fiber, and Interface*, VCH Publishers.
8. Surace, G., Carpinteri, A. and Sih. G.C., *Advanced Technology for Design and Fabrication of CompositeMaterials and Structures* Kluwer Academic Publications.
9. Matthews, F. L. and Rawlings, R. D., *Composite Materials: Engineering & Science*, Chapman & Hall.

Materials for High Temperature Applications

Course Outline

Introduction and Elevated temperature characteristics of engineering materials, Corrosion at elevated temperatures, High temperature creep, thermal and thermomechanical fatigue of structural alloys, Elevated temperature crack growth and creep-fatigue interaction, Elevated temperature mechanical characteristics of carbon alloy steels and Stainless steels, Elevated temperature corrosion properties of carbon

alloy steels and Stainless steels, Elevated temperature mechanical and corrosion properties of high alloy cast steels, Super-alloys: their processing, high temperature mechanical properties, corrosion behavior, microstructural degradation behavior of super alloys, Titanium and titanium alloys, Refractory metals, alloys and Structural inter-metallic.

Recommended Books

1. M. N. Rahman, Mercel Dekker, *Ceramic Processing and Sintering*
2. *Handbook of Advanced Ceramics, Parts 1 and 2*, S. Somiya, Aacdemic Press.
3. Nell Birks, Gerald H. Meier, *Introduction to the High Temperature Oxidation of Metals* Frederick S. Pettit (Paperback - Jul 23, 2009)
4. Roger C. Reed, *the Super-alloys: Fundamentals and Applications*, Cambridge University Press.
5. Sudhansu Bose, Butterworth-Heinemann, *High Temperature Coatings*.

Advanced Turbomachinery

Course Outline

Principle of operation of gas turbines, work done and pressure rise, diffuser, compressibility effects, non-dimensional quantities for plotting compressor characteristics, computerized design procedures, factors affecting stage pressure ratio, degree of reaction, 3D flow, design process, blade design, calculation of stage performance, vortex theory, choice of blade profile, pitch and chord, blade cooling, radial flow turbine, off design performance of single shaft gas turbine, free turbine engine and jet engine, incorporation of variable pressure losses, prediction of performance of turbo-machinery.

Recommended Books

1. C.A. Norman, R.H. Zimmerman, *Introduction to Gas Turbine and Jet Propulsion Design*, Harper & Brothers.
2. D.G. Wilson, *the Design of high efficiency turbo-machinery and gas turbines*, Prentice Hall.
3. Boyce, *Gas Turbine Engineering Handbook*, GPP.
4. J.D. Mattingley, *Aircraft engine design*, AIAA Education series.

Welding & Non-destructive Testing

Course Outline

Welding techniques, Manual Arc Welding, Gas Shielded Arc Welding, Submerged Arc Welding, Microstructure of Weld and Heat-Affected Zones, Pre- and Post-Weld Heat Treatments, Weld Joint Design, Welding of aluminum alloys, Non-destructive testing: Radiography, Magnetic-particle inspection, Fluorescent die-penetration inspection, Principles and

Applications of Ultrasonic Inspection, Eddy current inspection.

Recommended Books

1. Linnert, G.E., *Welding Metallurgy*, American Welding Society.
2. Easterling, K., *Introduction to the Physical Metallurgy of Welding*, Butterworth-Heinemann.
3. Hull, J.B. and V.B.John, *Non-Destructive Testing*, Macmillan Education, Ltd.,.
4. Silk, M. G., *Ultrasonic Transducers for Nondestructive Testing*, Adam Hilger Ltd., Bristol.

Advanced Power Plant Systems

Course Outline

Layout of thermal power plants; Containment buildings; Primary containment vessels; Structure of reactor core; and mechanical stress in various structures. Description and analysis of power plant systems and components including steam generator, steam dryer and separator, pressurizer, reheater, heat exchanger, condenser, demineralizer, pumps, turbine, generator, cooling tower; Auxiliary cooling systems. Fuel handling mechanisms; Control and mechanisms; Radiation waste systems; Electrical Systems; Reactor grid interface and load following. Basic considerations in nuclear plant design; Components of nuclear power cost; Economic comparison of nuclear and fossil fuelled plants; Dual and multipurpose nuclear power plants; Future trends in nuclear power cost.

Recommended Books

1. El-Wakil, M.M., *Power Plant Technology*, McGraw-Hill, 1984.
2. Lish, K.C., *Nuclear Power Plant Systems & Equipment*, Industrial Press Inc.
3. I. Dincer, C. Zamfirescu, Advanced Power Generation, Elseveir

Project Management

Course Outline

Introduction to project management, Strategic relevance of project management, Project Management in the organizational context, How projects come into being, Project selection techniques and project portfolios, Project initiation, Project planning, Project implementation, Project monitoring and control, Project leadership, communication and teamwork, Performance Monitoring and Evaluation, Cultural issues in project management, Case studies of project management, Application of Microsoft Project/ Primavera

Recommended Books

1. Gray, Clifford F., Larson, Erik, W., *Project Management: The*

Managerial Process, McGraw Hill.
2. Cleland, David I. and Ireland, Lewis R., *Project Management: Strategic Design and Implementation*, McGraw-Hill Professional Book Group.
3. *A Guide to Project Management Body of Knowledge (PMBOK)*, 3rd ed, Project Management Institute.
4. Wysocki, Robert K., Beck, Robert Jr. and Crane, David B., *Project Management: How to Plan, Manage, andDeliver Projects on Time and within Budge*t, John Wiley & Sons Inc.
5. Meredith, Jack R. and Muntel, Samuel J. Jr., *Project Management: A Managerial Approach*, John Wiley & Sons Inc.
6. Ghattas, R. G. and McKee, Sandra L., *Practical Project Management*, Pearson Education Inc.

Renewable Energy Systems

Course Outline

Solar irradiation, its nature and measurement, Insulation on tiled surfaces, Application of the principle of heat transfer and thermodynamics to the theoretical and experimental analysis of solar energy components used in the heating and cooling of buildings as well as hot water heating devices. Theoretical consideration of thermal storage devices, solar collectors and solar-augmented heat pumps, Approximate techniques and other research topics. Renewable and non-renewable energies used as hybrid energy systems, modern renewable energy plants. Wind energy, wind turbine design specifications, compatible electric generators and major operational, wind mills design usage for pumping water. Biomass energy conversion methods, detailed description of synthetic gas, biodiesel, biomass and biogas, operational and maintenance problems and their remedies.

Recommended Books

1. Ibrahim Dincer and Marc A. Rosen, Elsevier, Exergy: Energy, Environment and Sustainable Development.
2. J.A. Duffie, W.A. Beckman, *Solar Engineering of Thermal Processes*, John Wiley & Sons.
3. Godfrey Boyle, *Renewable Energy*, Oxford University Press
4. John Twidell, Tony Weir, *Renewable Energy Resources*, Spon Press.
5. Bent Sorensen, *Renewable Energy Conversion*, Transmission and Storage.

Advanced Measurements and Instrumentation

Course Outline

General measurement system, Static and dynamic characteristics of

measurements systems, Error analysis, Loading effects and two port network modeling, Signal and noise in measurement systems, Reliability analysis, Transducer elements, Motion measurement and seismic analysis, Force measurement, Pressure measurement, Temperature measurement, Flow measurement, Torque and shaft power measurement, Transducer interfacing.

Recommended Books

1. J. P. Bentley, *Principles of Measurement Systems*, Longmann Scientific & Technical Publishing.
2. Ernest O. Doeblin, *Measurement System, Application and Design*, McGraw-Hill Publishing International.

Robotics and Parallel Mechanisms

Course Outline

An overview of Robotics, Drive methods, Sensors for robots. Spatial description and transformation, Forward kinematics Inverse Kinematics Jacobian, Denavit-Hartenherg coordinate transformations, Force/Torque relations, Trajectory planning, Dynamics, Lagrange equations, Position control, PID control, Inverse dynamics feed forward control, Nonlinear and two parts control. open-Loop Manipulators, Closed Loop Linkages, Epicyclical Gear Drives, Wrist Mechanisms, Tendon Driven Robotics Hands. Robot Sensors including contact sensors and proximity sensors, Machine vision systems Robotics application growth and cost.

Recommended Books

1. Robotics: Modelling, Planning and Control *Advanced Textbooks in Control and Signal Processing*, Lorenzo Sciavicco, Springer,.
2. Springer Handbook of Robotics *Gale virtual reference library, edited by* Bruno Siciliano, Oussama Khatib, Springer
3. Introduction to Robotics: Mechanics and Control By John J. Craig, Prentice Hall

Hydrogen and Fuel Cell Engineering

Course Outline

Hydrogen: Global energy scenario, energy security, hydrogen as energy carrier, hydrogen economy, impact on environment, hydrogen properties, hydrogen safety and standards. Hydrogen production and storage: Hydrogen production technologies, Electrolysers, Reformers, Out-board and on-board fuel processing, renewable hydrogen production, hydrogen storage by compressed gas, cryogenic liquid, hydride storage, hydrogen delivery infrastructure. Fuel cell fundamentals: Principle, classification of fuel cells and their fuels, Faraday's Laws, thermodynamics of fuel cell, Nernst equation, Efficiency of fuel cell. Fuel cell irreversibilities: Fuel cell

reaction kinetics, activation polarization, Ohmic losses, mass transport losses, Butler–Volmer Equation, Tafel Equation, polarization curve. Proton Exchange Membrane (PEM) fuel cell**:** Hydrogen PEM fuel cell, PEM fuel cell membrane, catalyst, electrodes and their materials, water and thermal management, flow field configurations and stack design. High temperature fuel cells: Phosphoric Acid Fuel Cell (PAFC), Molten Carbonate Fuel Cell (MCFC), and Solid Oxide Fuel Cell (SOFC). Fuel cell characterization: Electrochemical characterization techniques, Electrical analogues, fuel cell modelling strategies.

Recommended Books

1. M. M. Mench, "*Fuel cell engines"*, 2nd edition, John Wiley & Sons, 2008.
2. R. P. O'Hayre et. al., "*Fuel cell fundamentals"*, John Wiley & Sons, 2006.
3. M. Ball, Wietschel, Martin, "*The hydrogen economy opportunities and challenges*", Cambridge University Press, 2009.
4. J. Larminie, A. Dicks, " *Fuel cell systems explained"*, J. Wiley, 2003.
5. W. Vielstich, Lamm, Arnold., Gasteiger, Hubert A., "*Handbook of fuel cells:Fundamentals, Technology, Applications, 4 volume Set"*,J. Wiley, 2003.

Combustion and Environment

Course Outline

Principles of Combustion: Thermochemistry, equilibrium, chemical kinetics, flame temperature, flame velocity, flame stability, diffusion flames, spry combustion, detonation, equations of motion including reaction, heat and diffusion. Application of Combustion: Discussion of combustion problem including pollution fire explosion hazards furnace combustion chambers combustors for reciprocating engines, jets and rockets. Boiler: Modular sectional and condensing types, burners for fuel, gases liquid and solid fuels and part load characteristics, safety supply, storage, solid fuel storage, mechanical handling, automatic stockers and ash disposals. Fuels and chimney natural and forced draught operation with and without acid condensation. Flue dilution systems, gas analysis for efficiency and pollution monitoring. Control application and feedback the theory to produce practical systems for plant and zone / emitter output controls on off. Step and analogue controls, centralized systems and modern computer control using optimization, self-adaptive and self-tuning conditions and energy monitoring. Standard, legal aspects, codes of practice for design, installation, operation, insurance and safety. Environmental Issues: Flue emissions, CO, CO_2, NOx, particulates and combustible emissions, acid, rains, asbestos removal.

Recommended Books

1. *Combustion and Incineration Processes*, Walter R. Niessen
2. *Combustion,* Irvin Glassman, Richard Yetter and Nick Glumac
3. Combustion Engineering, Gary L Borman, Keneth W Ragland, Mc Graw-Hill.
4. Environmental Engineering, Joseph A. Salvateo, Nelson L. Nemerow, Franklin J Agarady.
5. Energy, Environment and Sustainable Development, M.Aslam Uqaili, and Khanji Harijan, Springer Verlag.

Theory of Plasticity

Course Outline

Stress strain curve, General theorems, Solution of plastic-elastic problems, Plane plastic-strain and theory of the slip-line field, Two-dimensional problems of steady motion, Non-steady motion problems in two dimensions.

Recommended Text

1. R. Hill, *The Mathematical Theory of Plasticity*, Oxford at the Clarendon press.

Theory of Elasticity

Course Outline

Review of concepts of stress & strain, Index notation, Plane stress and plane strain, problems in rectangular coordinates and polar coordinates, Two dimensional problems in curvilinear coordinates, Analysis of stress and strain in three dimensions, General theorems, Elementary problems of elasticity in three dimensions, Torsion, Bending of bar, Thermal stress, Application of finite difference equation in elasticity

Recommended Texts

1. S. P. Timoshenko and J. N. Goodier, *Theory of Elasticity*, McGraw-Hill Book Company.
2. S. F. Borg Stevens *Fundamentals of Engineering Elasticity*, Inst. Tech.
3. W. S. Slaughter, *The Linearized Theory of Elasticity*, Birkhäuser Boston.

Reliability and Quality Engineering

Course Outline

Reliability Measures: The reliability Function; Expected Life; Failure Rate and Hazard Function; Reliability and Hazard Function for distributions

such as Exponential; Normal, Log Normal, Weibull, and Gamma Distributions; Hazard Models and Product Life; Constant Hazard Function, Linearly Increasing Hazard Function, Piecewise Linear Bathtub Hazard Function, Power Function Model, Exponential Model. Static Reliability Model: Series System, Parallel System, Series & Parallel Combinations, Complex System Analysis, Reliability Considerations in Design. Reliability Modelling and Design: Series Parallel System, Reliability Considerations in Design. Reliability Design Methodology, Strength and Stress Distributions, Safety Factors and Reliability, Reliability Bounds in Probabilistic Design, Error Analysis, Statistical Tolerancing. Reliability in Design and Testing: Dynamic Reliability Models, Reliability Estimation, Sequential Life Testing, Bayesian Reliability in Design and Testing, Reliability Optimization. Control Charts: Properties of the distribution of sample means, control charts for mean & range, control charts for mean & standard deviation, control charts for proportion defective & defects per assembly, Tests of significance to compute confidence limits. Acceptance Sampling: Introduction, OC curve, consumer & producer risks, AQL & LTPD, acceptance sampling for continuous production, acceptance by variables, single, double, & sequential sampling. Quality, Reliability, & Maintainability: Definitions, management of quality control, economic aspects of quality decisions, capability & variability analysis, various aspects of life testing, reliability, & maintainability, Introduction to ISO standards.

Recommended Books

1. John Bentley, "*Introduction to Reliability and Quality Engineering*" Longman Pub Group,1993.
2. BS Dhillon*,"Reliability, Quality, and Safety for Engineer*s", CRC Press, 2004.
3. Bernd Bertsche, "*Reliability in Automotive and Mechanical Engineering-Determination of component and system Reliability*" Springer; 2008

Recommendations by NCRC

The following recommendations must be forwarded to the all concerned policy making divisions of HEC.

1. It is proposed to change eligibility criteria for admission in PhD from CGPA 3.0 to 2.75 in Master.
2. The previous policy of HEC needs to be resumed to allow the students having less than the required CGPA may improve CGPA for the purpose of admission in PhD only, through continuing mode.
3. Maximum time duration for completion of Master degree may be extended to 5 years.
4. Universities may be encouraged to compensate their faculty members for teaching Master/PhD courses.
5. For B. Tech Hons/ BS Technology applicants for Masters in Engineering, the minimum requirement proposed is to complete credit hours equivalent to two semesters of undergraduate courses plus final year project as recommended by the departmental committee determining deficiency courses. This recommendation may be forwarded to the relevant HEC and PEC committees.
6. In case, a new scenario is developed on the scientific, technological or social front of the country, the NCRC may be called within six (6) months.
7. HEC quality assurance member must be present at least in the final meeting of NCRC.
8. HEC may ensure the feedback from concerned institute on the revised curriculum every two years.
9. The decision-making departments of HEC are recommended to consult the concerned academicians and working professors especially in academics related policies and decisions.
10. Community services may be part of the curriculum (at least 48 hours) with non-credits.
11. Teaching duration per semester must be within 15-16 weeks.
12. Mandatory industrial training/internships (non-credit) must be of 6-8 weeks.
13. All official notifications containing academic decisions by HEC must be made available online.
14. Humanities, natural sciences and social sciences curriculum experts may please be invited in NCRC meeting in formulating the non-engineering domain of the curriculum.

15. NCRC recommends adopting option 3 for degree requirement of Master in Mechanical Engineering, i.e. Minimum 21 Credit hours' course work and 9 credit hours thesis with one journal paper publication in HEC recognized journal (W category minimum).
16. The universities may have same level of MS and PhD courses.
17. Provisional PhD admission may be allowed for one year without qualifying GAT-subject test/Admission test/equivalent.

ANNEXURE - A

English I (Functional English)

Objectives: Enhance language skills and develop critical thinking.

Course Contents

Basics of Grammar

Parts of speech and use of articles

Sentence structure, active and passive voice

Practice in unified sentence

Analysis of phrase, clause and sentence structure

Transitive and intransitive verbs

Punctuation and spelling

Comprehension

Answers to questions on a given text

Discussion

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

Listening

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

Translation skills

Urdu to English

Paragraph writing

Topics to be chosen at the discretion of the teacher

Presentation skills

Introduction

Note: Extensive reading is required for vocabulary building

Recommended Books

1. **Functional English**

a) Grammar

1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492

2. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506

b) Writing

1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.

c) Reading/Comprehension

1. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.

d) Speaking

English II (Communication Skills)

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

Course Contents:

Paragraph writing

Practice in writing a good, unified and coherent paragraph

Essay writing

Introduction

CV and job application

Translation skills

Urdu to English

Study skills

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

Academic skills

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

Presentation skills

Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

Recommended Books

Communication Skills

a) Grammar

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

b) Writing

1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).

c) Reading

1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.

2. Reading and Study Skills by John Langan

3. Study Skills by Richard York.

English III (Technical Writing and Presentation Skills)

Objectives: Enhance language skills and develop critical thinking

Course Contents

Presentation skills

Essay writing

Descriptive, narrative, discursive, argumentative

Academic writing

How to write a proposal for research paper/term paper

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

Technical Report writing

Progress report writing

Note: Extensive reading is required for vocabulary building

Recommended Books

Technical Writing and Presentation Skills

a) Essay Writing and Academic Writing

1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3

(particularly suitable for discursive, descriptive, argumentative and report writing).

2. College Writing Skills by John Langan. McGraw-Hill Higher Education. 2004.
3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.

b) Presentation Skills

c) Reading

The Mercury Reader. A Custom Publication. Compiled by Northern Illinois University. General Editors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

ANNEXURE - B

Pakistan Studies (Compulsory)

Introduction/Objectives

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

Course Outline

1. **Historical Perspective**

   a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.

   b. Factors leading to Muslim separatism

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

2. **Government and Politics in Pakistan**

   Political and constitutional phases:

   a. 1947-58
   b. 1958-71
   c. 1971-77
   d. 1977-88
   e. 1988-99
   f. 1999 onward

3. **Contemporary Pakistan**

   a. Economic institutions and issues
   b. Society and social structure
   c. Ethnicity
   d. Foreign policy of Pakistan and challenges
   e. Futuristic outlook of Pakistan

Recommended Books

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

ANNEXURE - C

ISLAMIC STUDIES
(Compulsory)

Objectives

This course is aimed at:

1 To provide Basic information about Islamic Studies

2 To enhance understanding of the students regarding Islamic Civilization

3 To improve Students skill to perform prayers and other worships

4 To enhance the skill of the students for understanding of issues related to faith and religious life.

Detail of Courses

Introduction to Quranic Studies

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

Study of Selected Text of Holly Quran

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

Study of Selected Text of Holly Quran

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

3. Verses of Surah Al-Saf Related to Tafakar, Tadabar (Verse No-1,14)

Seerat of Holy Prophet (S.A.W) I

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

Seerat of Holy Prophet (S.A.W) II

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

Introduction to Sunnah

1. Basic Concepts of Hadith
2. History of Hadith
3. Kinds of Hadith
4. Uloom –ul-Hadith
5. Sunnah & Hadith
6. Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction to Islamic Law & Jurisprudence

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

Islamic Culture & Civilization

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

Islam & Science

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

Islamic Economic System

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

Political System of Islam

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

Islamic History

1. Period of Khlaft-E-Rashida
2. Period of Ummayyads
3. Period of Abbasids

Social System of Islam

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

Reference Books

1. Hameed ullah Muhammad, "Emergence of Islam" , IRI, Islamabad
2. Hameed ullah Muhammad, "Muslim Conduct of State"
3. Hameed ullah Muhammad, 'Introduction to Islam
4. Mulana Muhammad Yousaf Islahi,"
5. Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication Islamabad, Pakistan.

6 Ahmad Hasan, "Principles of Islamic Jurisprudence" Islamic Research Institute, International Islamic University, Islamabad (1993)

7 Mir Waliullah, "Muslim Jurisprudence and the Quranic Law of Crimes" Islamic Book Service (1982)

8 H. S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep & Deep Publications New Delhi (1989)

9 Dr. Muhammad Zia-ul-Haq, "Introduction to Al Sharia Al Islamia" Allama Iqbal Open University, Islamabad (2001)

ANNEXURE – D

Calculus I

Course Outline:

Functions of one variable, limits and continuity, differentiation of functions of one variable, properties of differentiable functions, differentials and linear approximation, maxima minima & curvature, applied optimization problems of functions of one variable, indefinite integrals and techniques of integration, definite integrals and fundamental theorem of calculus, applications of definite integrals, polar coordinates and polar curves, parametric functions and curves, conic sections and their parametric representations, properties of famous plane curves, algebra of complex numbers and some applications of complex numbers.

Recommended Text:

1. G. B. Thomas Jr., M. D. Weir, J. R. Hass, "*Thomas' Calculus*", 12th Edition, 2002. Pearson, USA.
2. J. Stewart. "*Calculus: Early Transcendentals*", 6th Edition, 2008, Brooks/Cole USA.
3. E. Swokowski, M. Olinick, D. D. Pence "*Calculus*", 6th Edition 1994. PWS, USA.

Calculus II

Course Outline:

Infinite sequences and series, convergence of infinite sequences and series, general properties of convergent sequences and series, tests of convergence, power series, Taylor's series, analytical geometry of three dimensions, planes and straight lines in space, quadric surfaces, functions of several variables, continuity of functions of several variables, partial derivatives and partial differentials, chain rule, directional derivatives and gradient, extreme values, Lagrange multipliers, applied optimization problems, double and triple integrals and their evaluation, cylindrical and spherical coordinates, applications of double and triple integrals, vector calculus including line and surface integrals and theorems of Green, Gauss and Stokes.

Recommended Text:

1. G. B. Thomas Jr., M. D. Weir, J. R. Hass, "Thomas' Calculus", 12th Edition, 2002. Pearson, USA.
2. J. Stewart. "Calculus: Early Transcendentals", 6th Edition, 2008, Brooks/Cole USA.
3. E. Swokowski, M. Olinick, D. D. Pence "Calculus", 6th Edition 1994. PWS, USA.

4. G. B. Thomas, R. L. Finny, “Calculus and Analytic Geometry”, 9th Edition, 1995, Addison Wesley.

Differential Equations and Linear Algebra

Course Outline:

Matrix algebra and general properties of matrices, elementary row operations, reduction of matrices into echelon and reduced echelon form, rank of a matrix, determinants and their properties, solution of system of linear algebraic equations, Gaussian elimination and Gauss-Jordan method, vector spaces, linear dependent and independent vectors, basis, eigenvalue and eigenvectors, first and second differential equations and their solution techniques, higher order linear differential equations, applications of differential equations, power series solutions and systems of linear differential equations.

Recommended Text:

1. *A First Course in Differential Equations with Modeling Applications* by Dennis G. Zill, Brooks Cole USA (10th edition 2013).
2. *Advanced Engineering Mathematics*, by Erwin Kreyszig, Wiley USA (10th Edition 2011).

Numerical Analysis

Course Outline:

Error and computer arithmetic, root-finding for non-linear equations, interpolation and polynomial approximation, solution of system of linear equations, numerical differentiation and integration and numerical solution of ordinary differential equations.

Recommended Text:

1. *Numerical Analysis (9th edition)* by R. L. Burden and J. D. Fairs, Books/Cole.
2. *Numerical Analysis* by D. Kincaid and W. Cheney.
3. *Numerical Methods, for Computer Science, Engineering and Mathematics* by John H. Mathew.

ANNEXURE - E

Engineering Statistics

Course Outline:

Review of set algebra and combinatorial analysis, sample space and events, axiomatic definition of probability, rules of calculation of probabilities, conditional probability and probability of the composite random events, independent experiments, discrete and continuous random variables, binomial, Poisson, multinomial, exponential and normal distribution, data analysis and descriptive statistics, introduction to inferential statistics, point estimation, methods of moments and methods of maximum likelihood, confidence intervals, tests of hypothesis, first and second types of errors, tests for mean, proportion and variance, chi-square and student's t-test.

Recommended Text:

1. *Probability and Statistics for Engineering and Sciences by* Jay L. Devore, (8th Edition, Brooks/Cole USA, 2012).
2. *Applied Statistics and Probability for Engineers by* Douglas C. Montgomery, George C. Runger, (5th Edition, John Wiley & Sons USA, 2011).
3. *Statistics and Probability for Engineering Applications* by W. J. DeCoursey, (1st Edition, Elsevier Science USA, 2003).

ANNEXURE – F

Computer Systems and Programming

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, Microprocessors, Memory, Storage Devices.

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, Pointers, Library Functions and Header Files

Recommended Text:

1. P. J. Deitel, H. Deitel, *C++ How to Program*, 10th Edition, 2017, Pearson.

ANNEXURE - G

Electrical Engineering

Course Outline:

Basic Concepts: System of Units, Basic Quantities, Circuit Elements, **Resistive Circuits:** Ohm's Law, Kirchhoff's Laws, Single-Loop Circuits, Single-Node-Pair Circuits, Series and Parallel Resistor Combinations, Circuits with Series and Parallel Combinations of Resistors, Wye Delta Transformations, Circuits with Dependent Sources, Resistor Technologies for Electronic Manufacturing, **Nodal and Loop Analysis Techniques:** Nodal Analysis, Loop Analysis. **Operational Amplifier:** Op-Amp Model, Fundamental Op-Amp Circuits, Comparators. **Additional Analysis Techniques:** Superposition, Thévenin's and Norton's Theorems, Maximum Power Transfer. **Capacitance and Inductance:** Capacitors, Inductors, Capacitor and Inductor Combinations, RC Operational Amplifier Circuits. **First and Second Order Transient Circuits:** Introduction, First-Order Circuits, Second-Order Circuits. **AC Steady State Analysis:** Sinusoids, Sinusoidal and Complex Forcing Functions, Phasors, Phasor Relationships for Circuit Elements, Impedance and Admittance, Phasor Diagrams, Basic Analysis Using Kirchhoff's Laws, Analysis Techniques.

Recommended Text:

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

Electronics Engineering

Course Outline:

Semiconductor Basics: Intrinsic & Extrinsic Materials, n-type & p-type Materials, **Semiconductor Diode**: Construction, Diode equivalent Circuits, Zener Diode, Diode Applications e.g. Clipper, Clampers, Rectifier (Half-Wave & Full-Wave). **Bipolar Junction Transistors (BJTs)**: Construction, Region of Operations, Different Configuration, Transistor Switching Networksalong with DC Biasing. **Field Effect Transistor (FET)**: Construction and Characteristics, Different Configurations along with DC Biasing. **BJT and FET Small Signal Equivalent Circuit**: Modeling & Different Configurations.

Recommended Text:

1. Robert Boylestad and Louis Nashelsky, "Electronic Devices and

Circuit Theory," Ninth Edition, 2006, Prentice Hall.
2. Robert Paynter, "Introductory Electronic Devices and Circuits: Electron Flow Version," Seventh Edition, 2006, Prentice Hall.