FACULTY OF ENGINEERING AND TECHNOLOGY

UNDER GRADUATE PROGRAMMES

REGULATIONS - 2025

CHOICE BASED CREDIT SYSTEM (CBCS)

Effective from the Academic Year 2025-2026

IGNITE • INSPIRE • INNOVATE

St. PETER'S INSTITUTE OF HIGHER EDUCATION AND RESEARCH

(Deemed to be university U/S 3 of UGC Act 1956)

Accredited with Grade "A+" by NAAC | ISO 9001:2015 Certified| Approved by AICTE

AVADI, Chennai - 600054

TABLES OF CONTENTS

I. PREAMBLE

As per the recommendations of UGC, St. Peter's Institute of Higher Education and Research (SPIHER) has introduced Choice Based Credit System (CBCS) from the academic year 2015-16. Along with Choice Based Credit System the institution also adopted Outcome based Education (OBE) from 2015-16 academic year, with more emphasis on modified academic curriculum to meet corporate needs. Open electives, credits for internship, and semester abroad program are the measures taken to induce prolific quality component into the system. Continuous evaluation system is further strengthened with 40-60 percentage weightage that is in place for internal and external examinations respectively.

SPIHER has always strived to be a pioneer in delivering quality education. SPIHER has taken incremental steps in the right direction to provide holistic development to students through its academic curriculum. The four verticals namely knowledge, skill, self-development and learning to learn are considered while designing the curriculum. The curriculum is designed to facilitate multi-disciplinary learning, experiential learning through Project Based Learning as part of the learning process.

II. DEFINITIONS AND NOMENCLATURE

PRELIMINARY DEFINITIONS & NOMENCLATURE

i. **Degree**: Refers to the academic award conferred upon a student after the successful completion of the program within the stipulated period, fulfilling the required credits and prescribed procedures. The degree is an undergraduate program **Bachelor of Technology**, commonly referred to as **B.Tech**.

ii. **Programme**: Refers to the undergraduate degree program in engineering or technology.

iii. **Branch**: Denotes the specialization or discipline within the undergraduate degree program, such as Civil Engineering, Mechanical Engineering, etc.

iv. **Course**: Represents a unit of study within a semester, including theory, practical, laboratory-integrated theory, seminar, internship, or project work. Examples include subjects like English, Mathematics, Environmental Science, Engineering Graphics, and Electronic Devices.

v. **Institution**: Refers to **St. Peter’s Institute of Higher Education and Research, Avadi, Chennai**.

vi. **Academic Council**: The apex body responsible for all academic matters within the institution.

vii. **Director (Academic Affairs)**: The official responsible for implementing relevant academic rules and regulations across all academic activities.

viii. **Controller of Examinations (CoE)**: The official responsible for conducting examinations and declaring results.

ix. **Head of the Department (HoD)**: The head of the respective academic department.

x. **Minor**: A discipline outside the student's major field of study, chosen for secondary specialization.

xi. **UGC**: University Grants Commission.

xii. **AICTE**: All India Council for Technical Education.

xiii. **SWAYAM**: Study Webs of Active-Learning for Young Aspiring Minds—an Indian **Massive Open Online Course (MOOC)** platform.

ACADEMIC REGULATIONS 2025

Under Choice Based Credit System (CBCS)

1.0 VISION AND MISSION OF THE INSTITUTION

1.1 **Vision**:

To be a globally renowned institution in academic excellence, research and innovation by providing inspirational learning to produce socially conscious leaders capable of addressing future challenges with ethical values.

1.2 **Mission:**

- To provide a vibrant learning environment, fostering innovation and creativity inspired by cutting edge research.
- To instill ethical values, imbibe a sense of social responsibility and strive for societal wellbeing.
- To promote National and International alliances and collaborative initiatives to achieve global excellence.

2.0 ADMISSION

2.1 Candidates for admission to the first semester of the eight semester B. Tech. degree programme shall be required to have passed the Higher Secondary Examination of the 10+2 curriculum (Academic stream) prescribed by the appropriate authority or any other examination of any University or authority accepted by the Institution as equivalent thereto.

2.2 Candidate shall also write an entrance examination prescribed by the Institution for admission. The entrance examination shall test the proficiency of the candidate in the courses considered eligible for admission on the standards prescribed for 10+2 academic stream.

2.3 Candidates for admission to the third semester of the eight semester B.Tech. programme under lateral entry category shall be required to have passed minimum Three years / Two years (Lateral Entry) Diploma examination in any branch of Engineering / Technology or passed B.Sc. Degree from a recognized University as defined by UGC and passed 10+2 examination with Mathematics as a subject or

Passed three year Diploma of Vocation Stream (D.Voc) in the same or allied sector or any other examination of any other authority accepted by the Institution as equivalent thereto.

2.4 Multiple Entry options (Credit transfer through ABC), credit exemptions as per the direction of duly appointed expert committee in the respective department

2.5 The Institution shall offer suitable bridge courses in Mathematics, Physics, Engineering drawing, etc., for the students of diverse backgrounds.

2.6 The eligibility criteria such as marks, number of attempts and physical fitness shall be as prescribed by the Institution in adherence to the guidelines of regulatory authorities from time to time.

2.7 The duration of the programme for the Degree of Bachelor of Technology will be four academic years, with two semesters in each year. The duration of each semester will normally be 90 working days. However, a student may complete the programme at a slower pace by taking more time, but not more than seven years.

3.0 PROGRAMMES OF STUDY

Regulations are applicable to the following B.Tech. programmes in various branches of Engineering and Technology, each distributed over eight semesters, with two semesters per academic year.

S. No.	Programme	Discipline
1.	B.Tech.	Artificial Intelligence and Data Science
2.	B.Tech.	Biomedical Engineering
3.	B.Tech.	Civil Engineering
4.	B.Tech.	Computer Science and Engineering
5.	B.Tech.	Cyber Security
6.	B.Tech.	Electrical and Electronics Engineering
7.	B.Tech.	Electronics and Communication Engineering
8.	B.Tech.	Information Technology
9.	B.Tech.	Mechanical Engineering

4.0 STRUCTURE OF THE PROGRAMME

The detailed courses of study for a programme will be decided by the respective department's Board of Studies. As per NEP 2020, the structure and lengths of degree programmes are adjustable. The undergraduate degree will be of 4-year duration, with multiple entries/exit options as per AICTE/UGC guidelines.

The students are allowed to exit the programme after I or II or III or IV year with Undergraduate Certificate, Undergraduate Diploma, Undergraduate Degree (B.Sc) and Undergraduate B.Tech. respectively as per the regulations of NEP 2020, Government of India. Similarly, the students from other institutions can join SPIHER institution in the 3rd or 5th or 7th semester with an appropriate Undergraduate Certificate or Undergraduate Diploma or Undergraduate Degree Certificates respectively.

The 4-year multidisciplinary Bachelor's programme, however, shall be the preferred option since it allows the opportunity to experience the full range of holistic and multidisciplinary education in addition with the focus on the chosen major and minors as per the choices of the student. Every programme will have a curriculum with a syllabus consisting of theory, practical, Theory based practical, Project based theory, internship, project work, etc. for 161 credits.

4.1 Categorization of Courses

i. **Humanities, Social Sciences and Management Courses (HSC)** include English for communication, Employability Skills, Engineering Ethics and Human Values and Management courses.

ii. **Basic Science Courses (BSC)** include Mathematics, Physics, Chemistry, Biology, Environmental Science and Sustainability, etc.

iii. **Basic Engineering Courses (BEC)** include Engineering Practices, Engineering Drawing, Basics of Civil / Electrical / Electronics / Mechanical / Computer Engineering, Instrumentation etc.

iv. **Professional Core Courses (PCC)** include the core courses relevant to the chosen specialization/branch.

v. **Professional Elective Courses (PEC)** include the verticals with elective courses and elective courses relevant to the chosen specialization/ branch.

vi. **Open Elective Courses (OEC)** are Multidisciplinary courses that include the courses from Humanities and other disciplines of Engineering and Technology. Students can choose these courses from the list of Open Elective courses specified in the respective curriculum. Students may also choose courses from other disciplines from Swayam/NPTEL platform, including non-engineering courses.

vii. **Project Courses (PC)** Includes Project Work and/or Internship, Career Development Skills, Creative and Innovative Project, Seminar, Professional Practices, Case Study and Industrial/Practical Training

viii. Mandatory Audit Courses (MAC) Mandatory Audit Courses like Indian Constitution and Humanity Rights, NCC/YRC/NSS/Rotary Club, Yoga Behavioral Science and entrepreneurship and Startups are offered to all engineering programs of the Institution.

- The activities will include Practical / Field activities / Extension lectures. The activities shall be beyond class hours. The student participation shall be for a minimum period of 2 hours per week during the respective semester and the activities will be monitored by the respective faculty in charge.
- Grades will be awarded on the basis of participation, attendance, performance and behavior. Grades shall be entered in the Grade statement as given below:
  Very Good, Good, Satisfactory and Unsatisfactory
- The Grades awarded by the faculty in-charge shall be entered in the respective semester Grade Sheet. If a student gets an unsatisfactory Grade, he/she has to repeat the above activity in the subsequent years.

4.1.2 Online Courses for Credit Transfer

The department shall approve the list of online courses offered by approved external agencies such as SWAYAM / NPTEL / MOOC. While listing the courses, the department shall consider the following points:

a. The course evaluation is carried out by the same external agency

b. Equivalent grading mechanism to be arrived at by the department

A student can register up to a maximum of 32 credits (total) as online courses during the entire programme of study. These shall be treated as Elective courses (programme elective or open elective). Students may be allowed to register for one course per semester. The student shall produce a Pass Certificate from the respective agencies. The credits(s) earned by the students will be transferred to the concerned course in the Grade Sheet.

4.1.3 Value Added Courses

The students are permitted to pursue department approved online courses (excluding courses registered for credit transfer) or courses offered / approved by the department as value added courses. The details of the value-added course viz., syllabus, schedule of classes and the course faculty shall be sent to the Director (Academic) for approval. The students may also undergo the valued added courses offered by other departments with the consent of the Head of the Department offering the course. These value-added courses shall be specified in the consolidated mark sheet as additional courses pursued by the student over and above the curriculum during the period of study

4.1.4 Industry Internship

The students shall undergo training for a period as specified in the curriculum during the summer vacation in any industry relevant to the field of study. The students are also permitted to undergo internship at research organizations / eminent academic institutions for the period prescribed in the curriculum during the summer vacation, in lieu of Industrial training. In any case, the student shall obtain necessary approval from the Head of the Department / Dean Academic and the training has to be taken up at a stretch.

4.1.5 Industrial Visit

The student shall undergo at least one industrial visit every year from the second year of the programme. The Heads of Departments / Dean Academic shall ensure the same.

4.2 CREDIT ASSIGNMENT FOR SEMESTER PROGRAM OF 15 WEEKS

Each course is normally assigned certain number of credits:

Lecture Hours (Theory)	1 Credit / 1 Lecture hour / week
Practical Hours	1 Credit / 2 Practical hours / week, 2 Credits / 4 Practical hours / week
Tutorial	1 Credit / 1 hour / week.
Courses with Project Based Learning Approach (PBLA)	1 Credit / 1 Lecture Hour / week
Project Work Phase I	6 Credits / 6 hours of project work (Phase-I) / week
Project Work Phase II	12 Credits / 18 hours of project work (Phase - II) / week
Internship/Entrepreneurship/ Consultancy/In plant training/	1 Credit / minimum 2 weeks during vacation

4.3 Each semester curriculum shall normally have a blend of lecture courses, laboratory courses, laboratory integrated theory courses, Project integrated theory courses, skill based courses etc.

4.3.1 Course Coordinator for Common Course

Each common theory course offered to more than one class or branch or group of branches, shall have a "course coordinator". The course coordinator will be nominated by the Dean in consultation with respective Head of the Department. The Course Coordinator will be normally a senior faculty member who is one among the teachers teaching the course.

The "Course Coordinator" shall meet the teachers handling the course, as often as possible and ensure

- A common teaching methodology is followed for the course.
- The study materials are prepared by the staff members and communicated to the students periodically.
- The involvement of students in course-based projects and assignments.
- To prepare common question paper for continuous internal assessment tests.
- For uniform evaluation of continuous internal assessments answer sheets by arriving at a common scheme of evaluation.

The course coordinator is responsible for evaluating the performance of the students in the continuous internal assessments and end semester examinations and analyse them to find suitable methodologies for improvement in the performance. The analysis should be submitted to the HoD and Dean for suitable action.

4.4 The medium of instruction, examinations and project report shall be in English, except for courses in languages other than English.

4.5 ENROLLMENT FOR B.Tech. (Honours) and B.Tech. minor with specialization in another discipline. (OPTIONAL)

4.5.1 B.Tech. (Hons.)

a) The students should have taken additional courses from a specified group of Professional Electives (vertical) or from any of the verticals of the same programme and earned a minimum of 18 credits.

b) Should have passed all the courses prescribed in the curriculum and additional courses in the first attempt.

c) Should have earned a minimum of 7.50 CGPA taking into account of all the courses prescribed in the curriculum and additional courses.

d) Lateral Entry students shall be permitted to register for the courses from Semester V onwards provided the students have earned a minimum CGPA of 7.50 until Semester III and have cleared all the courses in the first attempt.

e) If a student decides not to opt for Honor's, after completing certain number of additional courses, such additional courses studied shall be considered instead of the Professional Elective courses which are part of the curriculum.

If the student has studied more number of such courses than the number of Professional Elective courses required as per the curriculum, the courses with higher grades shall be considered for the calculation of CGPA. Remaining courses shall be printed in the grade sheet, however, they will not be considered for calculation of CGPA and the same shall be indicated in a foot note appropriately.

If the student has failed in the additional courses or faced shortage of attendance, they will not be printed in the grade sheet and will not be considered for CPGA calculation and classification of degree.

4.5.2 B.Tech. Minor with specialisation in another discipline:

The student should have earned additionally a minimum of 18 credits in any one of the verticals offered from other Engineering Disciplines / Science and Humanities / Management.

a) For these 18 credits students can optionally enroll and study a maximum of 6 credits in online mode from SWAYAM-NPTEL platform (in addition to the three online courses permitted for courses of curriculum), as approved by Head of the Department / Director Academic

b) B.Tech. (Hons.) and B.Tech. minor with specialization in another discipline will be optional for students and the students shall be permitted to select any one of them only.

c) For the category 4.5.2, the students, including Lateral Entry, will be permitted to register the courses from Semester V onwards provided the marks earned by the students until Semester III is CGPA 7.50 and above.

d) B.Tech. (Hons.) or B.Tech. Minor shall be offered by the Department irrespective of the number of students enrolled.

e) If a student decides not to opt for Minor, after completing certain number of courses, the additional courses studied shall be considered instead of Open Elective courses which are part of the curriculum.

If the student has studied more number of such courses than the number of open electives required as per the curriculum, the courses with higher grades shall be considered for calculation of CGPA. Remaining courses shall be printed in the grade sheet, however, they will not be considered for calculation of CGPA and the same shall be indicated in a foot note appropriately.

If the student has failed in the additional courses or faced shortage of attendance, they will not be printed in the grade sheet and will not be considered for CGPA calculation and classification of degree.

The student has to enroll for these additional courses separately and pay a tuition fee for studying these six additional courses and pay additional exam fee.

5.0 REGISTRATION AND ENROLLMENT

5.1 Each student, on admission, shall be assigned to a Mentor, who shall advise and counsel the student about the details of the academic programme and the choice of courses, considering the student's academic background and career objectives.

5.2 After registering for a course, a student shall attend the classes, satisfy the attendance requirements, earn continuous assessment marks and appear for the end semester examinations.

5.3 Each student on admission shall register for all the courses prescribed in the curriculum in the student's first Semester of study.

The enrollment for all the courses of curriculum from the Semesters II to VIII and additional courses for Honours and Minor from the semesters V and VIII will commence 5 working days prior to the commencement of the succeeding semester. The courses for Honours and Minor shall be registered separately under additional courses. The student shall enroll for the courses with the guidance of the student's Mentor. If the student wishes, the student may drop or add courses within 10 working days after the commencement of the concerned semester and complete the registration process duly authorized by the faculty in - charge within 30 days from the commencement of concerned semester. The list of students approved by the respective faculty-in-charge shall be final and would be considered for attendance, grades and calculation of CGPA and no changes shall be made thereafter.

5.4 For enrollment, a student MUST have

I. Cleared all the Institute and Hostel dues of the previous semesters and the current semester fees.

II. Not been debarred from registering for a specified period on disciplinary or any other ground.

5.5 Flexibility to Add or Drop courses:

5.5.1 A student has to earn the total number of credits specified in the curriculum of the respective programme of study in order to be eligible to obtain the degree. From the II to VII semesters, the student has the option of registering for additional courses or dropping existing courses in a semester. The total number of credits that a student can add or drop in a semester is limited to 8, subject to a maximum of 2 courses. Maximum number of credits enrolled in a semester (including Shortage of Attendance (SA), Honours and Minor) shall not exceed 30. The online courses registered shall be over and above this 30 credits.

5.5.2 If the student wishes to earn more than the total number of credits prescribed in the curriculum of the student's programme within the minimum duration of the programme, then he/she can enroll for such additional courses in any programme with the permission of Head of the Department to which student belongs and Head of the Department in which the course is offered by paying the examination fee. The credits earned will be neither considered for the computation of CGPA nor for the classification of the degree. The courses successfully completed will be printed in the grade sheet, however if there is shortage of attendance or failure, it shall neither be reflected in the grade sheet nor be considered for classification.

5.6 Choice of Professional Elective Courses

The professional Elective Courses are listed in the Curriculum in Table format as verticals (Specialisation groups). A student can choose all the Professional Elective Courses either from one of the verticals or a combination of courses from all verticals in a semester. However, students irrespective of enrolling for additional courses for B.Tech. (Hons.) are not permitted to choose more than one course from a row. Students are permitted to enroll more than one elective course from the same vertical in a semester. In the subsequent semesters students are permitted to enroll one more course in a row, provided if he/she has cleared the earlier course of the same row. For a professional elective course and open elective course, minimum number of students enrolment permitted shall be 10. However, the minimum number is not applicable for students enrolling B.Tech. (Hons) and B.Tech. Minor.

For each professional elective course at least two choices shall be offered.

5.7 Redoing a Course

Redoing a Course refers to the process of re-registering for a course, attending all classes, meeting the attendance requirements as per Clause 6, obtaining fresh Continuous Assessment marks, and appearing for the End Semester Examinations. A student is required to redo a course under the following conditions.

5.7.1 If a student is prevented from writing end semester examination of any core course due to lack of attendance, the student has to register for that course again when offered next and redo the course.

5.7.2 If a student is prevented from writing the end semester examination of any professional/open elective course due to lack of attendance, the student can opt to register for the same course again when offered next and redo the course, or he/she can opt to register for a different professional/open elective course when it is offered, attend the classes, fulfill the attendance requirements as per clause 6, secure Continuous Assessment marks and appear for the End Semester Examinations.

5.7.3 If the course in which a student fails to secure a pass is a professional/open elective course, then the student can opt for a different professional/ open elective course, register for the same when it is offered, attend classes, fulfill the attendance requirements as per clause 6, secure Continuous Assessment marks and appear for End Semester Examinations.

5.7.4 A student who fails in Project work shall register for the course again, when offered next, and redo the course. In this case, the student shall attend the reviews and fulfill the attendance requirements as per clause 6.

5.7.5 A student who fails in Seminar / Case Study and Creative and Innovative project, where such other courses are evaluated through 100% continuous assessment, shall register for the same in the subsequent semester and redo the course. In this case, the student shall attend the classes and fulfill the attendance requirements as per clause 7 and earn continuous assessment marks.

The student who fails in summer industrial training / internship shall attend the training / internship again and redo the course with the same organization or different organization with the approval of the HOD.

6.0 REQUIREMENTS FOR APPEARING THE END SEMESTER EXAMINATION OF A COURSE

A student who has fulfilled the following conditions (vide clause 6.1 and 6.2) shall be deemed to have satisfied the attendance requirements for appearing for the end semester examination of a particular course.

6.1 Ideally every student is expected to attend all periods and earn 100% attendance. However, the student shall secure not less than 75% attendance, course wise, taking into account the number of periods required for that course, as specified in the curriculum.

6.2 If a student secures attendance between 65% and less than 75% in any course in the current semester, due to medical reasons (hospitalization / accident / specific illness) or due to participation in the College / University / State / National / International level Sports events, with prior permission from the Chairman of Sports Board and Head of the Department concerned, the student shall be given exemption from the prescribed attendance requirement (75%) and the student shall be permitted to appear for the end semester examination of that course. A maximum of 10% shall be allowed under On Duty (OD) / Medical leave category. In all such cases, the students should submit the required documents on joining after the absence to the Head of the Department through the Faculty Coordinator. The HOD shall inform the course instructor to provide necessary attendance at the end of semester before finalizing attendance. Producing such documents while finalizing attendance at the end of semester shall not be accepted.

6.3 A student shall normally be permitted to appear for the end semester examination of the course if the student has satisfied the attendance requirements (vide Clause 6.1 – 6.2) and has registered for the examination in those courses of that semester by paying the prescribed fee.

6.4 Students who do not satisfy clause 6.1 and 6.2 and who secure **less than 65%** attendance in a course will not be permitted to write the end semester examination of that course. The student has to register and redo the course when it is offered next as per Clause 5.4. If the course in which the student has been prevented is a professional/ open elective, the student can opt to redo the same course or opt for different professional/ open elective course as per Clause 5.7.2.

6.5 If a student has shortage of attendance in all the registered courses of the current semester as per curriculum, he/she would not be permitted to move to the higher semester and has to repeat the current semester in the subsequent year.

6.6 In the case of reappearance (Arrear) registration for a course (the courses for which redo is not required), the attendance requirement as mentioned in Clauses 6.1 - 6.3 is not applicable. However, the student has to register for the examination in that course by paying the prescribed fee.

6.7 A student who has already appeared for a course in a semester and passed the examination is not entitled to reappear for the same course for improvement of letter grades / marks.

7.0 STUDENT COUNSELLING

To help students in planning their courses of study and for general advice on the academic programme and personal counselling, Faculty members are assigned.

7.1 MENTOR

To help the students in planning their courses of study and to render general advice regarding either the academic programme or any other activity, the Head of the Department concerned, will assign every year, a certain number of students from the first semester to a faculty member who will be called as Mentor. The set of students thus assigned will continue to be under the guidance of the Mentor till they complete the programme. Mentors will help the students on multiple exits, and also assess the proficiency of the student. Each student should have one-one interaction with the mentor at least once in a month.

7.2 FACULTY COORDINATOR

There is a Faculty Coordinator who will be the in-charge for a particular batch. He will coordinate with the mentors for assessing the proficiency of the batch and report to the Head of the Department. He will also collect the course registration forms from the students. He also ensures whether the student submitted feedback at the end of the semester for the courses he/she has taken.

8.0 CLASS COMMITTEE

a) Constitution of the Class Committee

For every class, a class committee shall be constituted by the Head of Department, as given below:

Chairman	A faculty member not teaching that particular class
Members	• Faculty of all the courses of study • Four student members from the class to be nominated by the Head of the Department.

b) Functions of the Class Committee

(i) The class committee shall meet thrice during the semester. The first meeting will be held within two weeks from the date of commencement of the semester in which the nature of the broad assessment procedure for the different courses will be discussed. The second and third meetings will be held six weeks and ten weeks respectively from the commencement of a semester to meaningfully interact and express opinions and suggestions to improve the effectiveness of teaching - learning process and analyze the performance of the students in the assessments. The chairperson of the class committee should send the minutes of the class committee meetings to the Dean through the Head of the Department, immediately after the meetings is over.

(ii) During the first meeting of the class committee, all the faculty members shall give their course plan to the class committee chairperson/chairman for approval and uploading into the ERP.

(iii) Any innovation in any course plan not agreed by the class committee or the HoD will be referred to the Dean for approval.

9.0 EXAMINATIONS AND ASSESSMENT

9.1 ASSESSMENTS

Continuous Internal Assessment

Continuous evaluation system is strengthened with 40-60 percentage weightage system in place for internal and external examinations. Three Continuous internal assessment will be conducted as per the academic calendar posted in our institution website. Internal mark for every course is awarded based on the performance in Continuous Internal Assessment and the assignments submitted.

9.1.1 Theory Courses

- There will be a minimum of 2 Continuous Internal Assessments and 1 Model Test for each theory course.

DISTRIBUTION OF CONTINUOUS INTERNAL ASSESSMENT (CIA) MARKS FOR A THEORY COURSE			
Evaluation Component	**Syllabus coverage**	**Duration of the Test**	**Max. Weightage (40 Marks)**
CIA-1	First 1.5 Units of the syllabus	2.0 Hours	7.5 Marks
CIA-2	Second 1.5 Units of the syllabus	2.0 Hours	7.5 Marks
Model Test	Full syllabus	3 Hours	15 Marks
Assignment/ Mini Project (or) Group Presentation	Two written assignments for each course / Written quiz (or) Presentation of a written Report (or) Case study / Multiple choice Objective Type Test or Technical Project involving not more than 3 students (or) any other Group Presentation related to the course.		5 Marks
Attendance			5 Marks

- The continuous assessment marks obtained by the candidate in the first appearance shall be retained, considered and valid for all subsequent attempts, till the candidate secures a pass.

9.1.2 Practical Courses

S. No.	Category	Maximum Marks
1.	Record	15
2.	Observation work	10
3.	Model Examination	15
Total		40

- For practical courses, the student will be evaluated on a continuous basis for 25 Marks (which will include performing all experiments, submitting observation and record note book in scheduled format and time), 15 marks for model exam at the end of the semester.

- For practical courses, if a student has been absent for some practical classes or has performed poorly, then the student will have to get permission from the lab in-charge and year coordinator to do the experiments, so that he/she meets all the requirements for the course and thereby allowed to appear for model and end semester practical exams
- If a student has not done all the experiments assigned for that lab, before the scheduled date will not be allowed to appear for the model and end semester practical exam. Such students will have to register the course again by doing all the experiments in the next semester when the course is offered.

9.1.3 End Semester Examinations (ESE)

- The end semester examinations shall be conducted at the end of the odd and even semester of the Academic year.
- End semester examinations will be conducted for a maximum of 100 marks. The marks secured in end semester exams will be converted to 60 marks.
- The evaluation of training will be made by a three member committee constituted by Head of the Department in consultation with Faculty Advisor and respective Training Coordinator. A presentation should be made by the student before the Committee, based on the Industrial Training or Professional Enrichment undergone.

Pattern of Question Paper (Theory) for Model and ESE

Particulars	Remarks
Maximum Marks	60 Marks
Duration	3 Hours
Part – A (Q.No. 1 to 10)	MCQ (10x1=10)
Part – B (Q.No. 11 to 15)	Short Answers (Either or Type) (5x10=50)

9.1.4 Project Work/ Semester long Internship

The student shall register for Project Work-I in pre-final semester and Project Work-II in final semester. Project work may be allotted to a single student or to a group of students not exceeding 4 per group. Project Work-II may/may not be a continuation of Project Work-I. If Project Work II is not a continuation of Project Work I, then the topic and constitution of the project team members need not be the same.

- The project review would be conducted by a review committee where the student/ team shall make a presentation on the progress made, before the committee. The Head of the department shall constitute the review committee for each branch in consultation with Director Academic, approved by CoE. The members of the review committee will evaluate the progress of the project and award marks.

- The guides would evaluate the students based on their performance and follow up.
- For Project work out of 100 marks, the maximum marks for Continuous Internal Assessment are fixed as 40 and the End Semester Examination (project report evaluation and viva-voce examination) carries 60 marks.

  There shall be **Three Continuous Internal Assessments** (each 100 marks) during the semester by a review committee. The student shall make presentation on the progress made before the committee. The Head of the Department shall constitute a review committee for each programme. There shall be a minimum of three members in the review committee. The committee shall consist of the supervisor, expert member from the department and a project co-ordinator from another department. The total marks obtained in the three Reviews shall be reduced to 40 marks.

Continuous Internal Assessment (40 Marks)				**End Semester Examinations (60 Marks)**			
Review 0	**Review I**	**Review II**	**Review III**	**Project Report & Presentation**		**Viva-Voce Examination**	
				Supervisor	External	Internal	External
10	10	10	10	20	20	10	10

- A student is expected to attend all the project reviews conducted by the institution on the scheduled dates. It is mandatory for every student to attend the reviews, even if they are working on a project in an industry, which is outside Chennai city. If a student does not attend any of the project reviews, he / she shall not be allowed for the successive reviews and thereby not allowed to appear for the final viva voce.
- The candidate is expected to submit the project report as per the guidelines of the institution on or before the last day of submission. If a candidate fails to submit the project report on or before the specified deadline, he/she can be granted an extension of time up to a maximum limit of 5 days for the submission of project work, by the Head of the Department.

- If he/she fails to submit the project report, even beyond the extended time, then he/she is deemed to have failed in the project work and shall register for the same in the subsequent semester and re-do the project after obtaining permission from the HoD and the respective Deans.

9.1.5 Assessment for Summer internship:

The summer Industrial / Practical Training/ summer internship/ summer project shall carry 100 marks and shall be evaluated through continuous assessment only. At the end of the summer Industrial / Practical Training/ summer internship/ summer project, the student shall submit a certificate from the organization where the student has undergone training and a brief report about the training. The evaluation will be made based on this report, presentation and a Viva-Voce Examination conducted by a three-member Departmental Committee constituted by the Head of the Department consisting of one co-ordinator and two faculty members. Certificates (issued by the Organization) submitted by the student shall be attached to the mark list and sent to the Controller of Examinations by the Head of the Department. The evaluation shall be carried out as per the procedure shown below.

Internship / Industrial Training		
Evaluation Marks (60)		
Report	Presentation	Viva Voce
40	10	10

9.1.6 Assessment for Online Courses

Students may be permitted to credit two online courses (which are provided with certificate), subject to a maximum of six credits. The online course of 3 credits can be considered instead of one elective course. These online courses shall be chosen from the SWAYAM platform, provided the offering organization conducts regular examination and provides marks. The credits earned shall be transferred and the marks earned shall be converted into grades and transferred, provided the student has passed in the examination as per the norms of the offering organization. The details regarding online courses taken up by the student and marks/credits earned and the approval for the course from Concerned Head of the Department shall be sent to the Controller of Examinations, in the subsequent semester(s) along with the details of the elective(s) to be dropped.

9.2 ASSESSMENT WEIGHTAGE:

There will be Continuous Internal Assessment and End Semester Examination for all courses of all programmes.

(i) Theory courses

Continuous Internal Assessment	: 40 Marks
End Semester Examination	: 60 Marks

(ii) Practical courses

Continuous Internal Assessment	: 40 Marks
End Semester Examination	: 60 Marks

(iii)Theory + Practical courses

Continuous Internal Assessment (Average of Theory and Practical)	: 40 Marks
End Semester Examination (Average of Theory and Practical)	: 60 Marks

10.0 EXAMINATIONS

10.1 RE-EXAMINATION

Re-examination requests shall be considered only for the Continuous Internal Assessment and the Examinations in the last instructional week of the semester based on medical reasons.

10.2 REVALUATION

A candidate can apply for revaluation of his/her End semester examination answer paper in a theory course, immediately after the declaration of results, on payment of a prescribed fee through the ERP. The Controller of Examinations will arrange for the revaluation and the result will be intimated to the candidate through website.

Revaluation is not permitted for practical courses and for project work.

10.3 SCRIBE FOR EXAMINATION

Divyangjan students or students with temporary physical disability or injury due to accident or illness can apply for a scribe (writer) with proof of disability as a medical certificate obtained from a Registered Medical Officer. The student shall be assigned a scribe by CoE to such student. The application for the scribe should be submitted in the CoE office well in advance or at least 2 days before the examination, to make necessary arrangements (Scriber, Separate Examination Hall etc.). The scribe assigned shall neither be a student nor a degree holder of any technical programme having similar competency.

Divyangjan students/ students with reading or writing disability, who can write at a slower speed as compared to a normal student would be allowed an extra time of 30 minutes to write the examination for each course. The proof of disability and application of extra time has to be submitted to the CoE office well in advance or 3 days before the start of the examination.

10.4 ACADEMIC MALPRACTICE

Academic malpractice would be strictly prohibited and any student who is found indulging in such activity would be penalized as per the recommendations of the Malpractice Committee constituted by the CoE with the approval of the Director Academic. The Committee would inquire and decide on the action based on the norms and policy listed in the Examination Manual.

10.5 SUPPLEMENTARY EXAMINATION

Supplementary examination will be conducted only for the final semester students within 10 days from the date of publication of revaluation results for students who have backlogs to complete the programme. Only such students shall apply with the prescribed fee to the Controller of Examinations within the stipulated time.

11.0 REQUIREMENTS FOR APPEARING FOR UNIVERSITY EXAMINATIONS

A student shall normally be permitted to appear for the University Examinations for all the courses registered in the current semester if he/she has satisfied the semester completion requirements. Further, examination registration by a student is mandatory for all the courses in the current semester and all arrear(s) course(s) for the University examinations failing which, the student will not be permitted to move to the higher semester. A student who has already appeared for any course in a semester and passed the examination is not entitled to reappear in the same subject for improvement of grades.

12.0 PASSING REQUIREMENTS FOR COMPLETION OF A COURSE

- A candidate who secures not less than 50% of total marks prescribed for the courses (Continuous Assessment + End semester examination) with a minimum of 40% of the marks prescribed for the end-semester Examination in theory, theory with practical components (40% individually in theory and laboratory) and practical courses (including Project work), shall be declared to have passed in the Examination. However, if a student fails in any integrated theory and practical course, he/she should register and appear for the End semester examination in both theory and practical components of this course.

- If a student fails to secure a pass in a theory course / theory with laboratory/laboratory course (except electives), the student shall register and appear only for the end semester examination in the subsequent semester. In such case, the continuous assessment marks obtained by the candidate in the first appearance shall be retained and considered valid for all subsequent attempts till the candidate secure a pass. However, from the third attempt (current semester's end semester examination is considered as the first attempt) onwards if a candidate fails to obtain pass marks (IA + End Semester Examination), then the candidate shall be declared to have passed the examination if he/she secure a minimum of 50% marks prescribed for the university end semester examinations alone.

- If a student has submitted the project report but absent in the end semester examination of project work, the student is deemed to be failed. In this case and also if a student attends and fails in the End semester examination of Project work of B.Tech, he/she shall attend end semester examination again within 60 days from the date of declaration of the results. The subsequent viva-voce examination will be considered as reappearance with payment of exam fee. In case, the student fails in the subsequent viva-voce examination also, the student shall redo the course again, when offered next.
- If a student is absent during the viva - voce examination, it would be considered as fail. If a student fails to secure a pass in Project Work-I, the student shall register for the course again in the subsequent semester and can-do Project Work-I and II together.
- The passing requirement for the courses which are assessed only through continuous assessment, shall be fixed as minimum 50%.

13.0 WITHDRAWAL FROM EXAMINATIONS

- A candidate may, for valid reasons, (medically unfit / unexpected family situations) be granted permission to withdraw from appearing for the examination in any course or courses in any one of the semester examination during the entire duration of the degree programme.
- Withdrawal application shall be valid only if the candidate is otherwise normally eligible (if he/she satisfies Attendance requirements and should not be involved in Disciplinary issues or Malpractice in Exams) to write the examination and if it is made within FIVE days before the commencement of the examination in that course or courses and also recommended by the Director Academic through HoD.
- Notwithstanding the requirement of mandatory FIVE days' notice, applications for withdrawal for special cases under extraordinary conditions will be considered based on the merit of the case.
- Withdrawal shall not be considered as an appearance for deciding the eligibility of a candidate for the purpose of Classification of Degree.
- Withdrawal is NOT permitted for arrears examinations of the previous semesters.

14.0 AUTHORIZED BREAK OF STUDY

- This shall be granted by the Institution, only once during the full duration of study, for valid reasons for a maximum of one year during the entire period of study of the degree programme.
- A candidate is normally not permitted to temporarily break the period of study. However, if a candidate would like to discontinue the programme temporarily in the middle of duration of study for valid reasons (such as accident or hospitalization due to prolonged ill health), he / she shall apply through the Director Academic in advance (Not later than the Reopening Day of that semester) through the Head of the Department stating the reasons. He /She should also mention clearly, the Joining date and Semester for Continuation of Studies after completion of break of Study. In such cases, he/she will attend classes along with the Junior Batches. A student who availed break of study has to rejoin only in the same semester from where he/she left.
- The total period for completion of the programme shall not exceed more than 10 consecutive semesters from the time of commencement of the course irrespective of the period of break of study in order that he / she may be eligible for the award of the degree.
- If any student is not allowed to appear for End Semester Examinations for not satisfying Academic requirements and Disciplinary reasons, (Except due to Lack of Attendance), the period spent in that semester shall NOT be considered as permitted 'Break of Study' and is NOT applicable for Authorized Break of Study.
- In extraordinary situations, a candidate may apply for additional break of study not exceeding another one Semester by paying prescribed fee for break of study. Such extended break of study shall be counted for the purpose of classification of First Class Degree.
- If the candidate has not reported back to the department, even after the extended Break of Study, the name of the candidate shall be deleted permanently from the institution enrolment. Such candidates are not entitled to seek readmission under any circumstances.

- This shall be granted by the Institution, only once during the full duration of study, for valid reasons for a maximum of one year during the entire period of study of the degree programme.

15.0 PURSUING COURSES IN OTHER INDIAN INSTITUTIONS AND ABROAD

- A student can be selected, to get Professional Exposure in his/her area of Expertise in any Reputed Research Organization or Educational Institution of repute or any Universities in India andabroad.
- This is possible only with the List of Research Organizations, Educational Institutions in India and abroad approved by the Academic Council.
- The student can have the option of spending not more than three to Six months in the Final year or Pre - final year of his/her Degree. During this period, the student can do his/her Project work or register for courses which will be approved by the Class Committee and Director Academic, under the Guidance of a Project Supervisor who is employed in the Organization and Co-guided by a staff member from our Institution.
- Credit Transfer can be done by the CoE on submission of certificate through the HoD and Director Academic within 15 days of completion.
- The students who undergo training outside the Institution (either in India or Abroad) is expected to abide by all Rules and Regulations to be followed as per Indian and the respective Country Laws, and also should take care of Financial, Travel and Accommodation expenses.

16.0 AWARD OF LETTER GRADES

All assessments of a course will be done on absolute marks basis. However, for the purpose of reporting the performance of a candidate, letter grades, each carrying certain number of points, will be awarded as per the range of total marks (out of 100) obtained by the candidate in each course as detailed below:

RANGE OF MARKS FOR GRADES

Range of Marks	Letter Grade	Grade Point
90 -100	**O**	**10**
80 – 89	**A+**	**9**
70 – 79	**A**	**8**
60 – 69	**B+**	**7**
50 – 59	**B**	**6**
00-49 (Reappear)	**F**	**0**

ABSENT	**AAA**	**0**
Withdrawal	**W**	**0**
Authorised Break of Study	**ABS**	**0**

16.1 CUMULATIVE GRADE POINT AVERAGE CALCULATION

The CGPA calculation on a 10 Point scale is used to describe the overall performance of a student in all courses from first semester to the last semester. RA, AAA and W grades will be excluded for calculating GPA and CGPA.

$$\text{GPA} = \frac{\sum_{i=1}^{N} Ci\ GPi}{\sum_i Ci} \qquad \text{CGPA} = \frac{\sum_{i=1}^{N} Ci\ GPi}{\sum_i Ci}$$

Where

Ci – Credits for the course

GPi – Grade Point for the course

i – Sum of all courses successfully cleared during all the semesters

n - Number of all courses successfully cleared during the particular semester in the case of GPA and during all the semesters in the case of CGPA

16.2 GRADE SHEET

After revaluation results are declared in each semester, Grade Sheets will be issued to each student. At the end of programme a consolidated grade sheet also will be issued to each student. The grade sheet and consolidated grade sheet will contain the following details:

- The programme and degree in which the candidate has studied
- The list of courses enrolled during the semester and the grade secured
- The Grade Point Average (GPA) for the semester.

16.3 CLASSIFICATION OF DEGREE AWARDED

Final Degree is awarded based on the following

Range of CGPA	Classification of Degree
≥ 7.50	**First Class with Distinction**
≥ 6.00 <7.50	**First Class**
≥ 5.00 < 6.0	**Second Class**

Minimum requirements for award of Degree: A student should have obtained a minimum of 5.0 CGPA.

- A candidate who qualifies for the award of the Degree having passed the examination in all the courses of all the 8 semesters in his/her first appearance within a maximum of 10 consecutive semesters securing a overall CGPA of not less than

  7.5 (Calculated from 1st semester) shall be declared to have passed the examination in **First Class with Distinction**. Authorized Break of Study vide Clause 14, will be considered as an Appearance for Examinations, for award of First Class with Distinction. Withdrawal shall not be considered as an appearance for deciding the eligibility of a candidate for First Class with Distinction

- A candidate who qualifies for the award of the Degree having passed the examination in all the courses of all the 8 semesters within a maximum period of 10 consecutive semesters after his/her commencement of study securing a overall CGPA of not less than 6.0 (Calculated from 1st semester), shall be declared to have passed the examination in **First Class.** Authorized break of study vides Clause 14 (if availed of) or prevention from writing End semester examination due to lack of attendance will not be considered as Appearance in Examinations. For award of First class, the extra number of semesters than can be provided (in addition to four years for Normal UG programme) will be equal to the Number of semesters availed for Authorized Break of Study or Lack of Attendance. Withdrawal shall not be considered as an appearance for deciding the eligibility of a candidate for First Class.
- All other candidates who qualify for the award of the Degree having passed the examination in all the courses of all the 8 semesters within a maximum period of 10 consecutive semesters after his/her commencement of study securing a overall CGPA of not less than 5.0, (Calculated from 1st semester) shall be declared to have passed the examination in **Second Class**.
- A candidate who is absent in semester examination in a course/project work after having registered for the same, shall be considered to have appeared in that examination for the purpose of classification.

17.0 ELIGIBILITY FOR THE AWARD OF DEGREE

A student shall be declared to be eligible for the award of the Certificate / Diploma / UG Degree / UG Honours degree, provided the student has successfully completed all the requirements of the programme, and has passed all the prescribed examinations in all the I/II/III/IV year respectively within the maximum period specified in clause 2.7.

i) Successfully gained the required number of total credits as specified in the curriculum corresponding to his/her programme within the stipulated time.

ii) Successfully completed the programme requirements and has passed all the courses prescribed in all the semesters within a maximum period of 5 years reckoned from the commencement of the first semester to which the candidate was admitted.

iii) Successfully completed any additional courses prescribed by the Institution.

iv) has earned a CGPA of not less than 5

v) has no dues to the Institution, Library, Hostels, etc.,

vi) has no disciplinary action pending against him / her.

18.0 RANKING

- A candidate who qualifies for the UG degree programme passing all the examinations in the first attempt, within the minimum period prescribed for the programme of study from semester I through semester VIII to the programme shall be eligible for ranking. Such ranking will be confirmed to 10 percent of the total number of candidates qualified in that particular programme of study subject to a maximum of 10 ranks.

19.0 DISCIPLINE

- Every student is required to observe disciplined and decorous behavior both inside and outside the Institution and not to indulge in any activity which will tend to bring down the prestige of the Institution. If a student indulges in malpractice in any of the end semester theory / practical examination, continuous assessment examinations he/she shall will be liable for disciplinary action as prescribed by the Institution from time to time.

20.0 STUDENT APPRAISAL

- It is mandatory for every student to submit the feedback on each and every course, he/she has undergone, at the end of every semester.

21.0 DECLARATION OF RESULTS

- The End Semester Examination results will be declared in institution website and the same is shared with the Head of the Department. In general, the results will be declared within 15 days from the date of last examination.

22.0 ACADEMIC BANK OF CREDITS (ABC)

- All the students who admitted in any one of the above programmes are mandatory to register in the Academic Bank of Credits (ABC) portal provided by the Ministry of Education (MoE), Government of India.

23.0 REVISION OF REGULATIONS / POWER TO MODIFY

- St. Peter's Institute of Higher Education and Research (Deemed to be University) may revise, amend, or modify the regulations, examination schemes, and syllabi as deemed necessary from time to time.

  Notwithstanding the provisions stated above, the Academic Council holds the authority to alter any or all of these regulations as required, subject to approval by the Executive Council.

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Dean Engg. Director Academic Registrar

DEPARTMENT OF MECHANICAL ENGINEERING

B.E. MECHANICAL ENGINEERING

(APPROVED BY AICTE)

I to VIII SEMESTERS

REGULATIONS AND SYLLABI

UNDER CHOICE BASED CREDIT SYSTEM

REGULATIONS 2025

EFFECTIVE FROM THE ACADEMIC YEAR 2025-2026

VISION & MISSION OF THE DEPARTMENT

VISION

To emerge as dynamic center for quality education and research, dedicated to produce outstanding Mechanical Engineers through strong theoretical knowledge and practical training.

MISSION

M1: Contemporary and effective educational experiences that develop the competent engineers.

M2: Achieving intellectual excellence by providing facilities for students for higher education and research.

M3: To inculcate technical skills with integrity and ethical standards in students.

M4: To impart entrepreneurship qualities to indulge in promoting sustainable development of the society.

PROGRAM EDUCATIONAL OBJECTIVES:

PEO1: Build a successful career in Mechanical Engineering and Allied Industries.

PEO2: Have expertise in the areas of Design, Thermal, Materials and Manufacturing.

PEO3: Contribute towards Technological Development through Academic Research and Industrial Practices.

PEO4: Practice their profession with good communication, leadership, ethics and social responsibility.

PEO5: Graduates will adapt to evolving technologies through Life-long Learning.

PROGRAM OUTCOMES (POs):

Engineering Graduates will be able to:

PO1: Engineering Knowledge: Apply knowledge of mathematics, science, and engineering fundamentals to solve complex problems.

PO2: Problem Analysis: Analyze complex engineering problems using first principles, reaching substantiated conclusions.

PO3: Design/Development of Solutions: Design solutions and systems for complex engineering problems, considering public health, safety, and environment.

PO4: Conduct Investigations of Complex Problems: Use research-based knowledge and methods to analyze data and provide valid conclusions.

PO5: Engineering Tool Usage: Create, select, and apply modern techniques, resources, and IT tools (including modeling).

PO6: The Engineer and The World: Evaluate the impact of engineering solutions on society, environment, and sustainability.

PO7: Ethics: Apply ethical principles, professional responsibilities, and inclusive behavior.

PO8: Individual and Collaborative Teamwork: Function effectively as an individual, and as a member or leader in diverse, inclusive teams.

PO9: Communication: Communicate complex engineering activities effectively within the profession and society.

PO10: Project Management and Finance: Apply engineering and management principles to manage projects in multidisciplinary environments.

PO11: Life-Long Learning: Engage in independent and life-long learning, including adaptability and technical awareness.

PROGRAMME SPECIFIC OUTCOMES (PSOs):

Bachelor of Engineering Programme in Mechanical Engineering is designed to prepare the graduates having aptitude and knowledge.

PSO1: Apply the principles of Engineering to Model, Analyze, Design and realize the cause and effects on machine elements, physical components, processes and systems.

PSO2: Work professionally and ethically in the Mechanical Systems.

PSO3: Ability to apply the acquired Mechanical Engineering knowledge for the advancement of Individual and Society.

Contribution 1: Reasonable 2: Significant 3: Strong

DEPARTMENT OF MECHANICAL ENGINEERING
FACULTY OF MECHANICAL ENGINEERING
UG PROGRAM (CBCS) – B.Tech. Mechanical Engineering
(2025–2026 Batch and onwards)

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcomes		SDG Goal	Instruction Hours /			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
I	25MAU108	Engineering Mathematics I	BSC	4.5	1,2	1-4	4	3	1	0	4	40	60	100
I	25PHU121	Engineering Physics	BSC	4.5	1,2	1,2,3,5	6	3	0	2	4	40	60	100
I	25EVS001	Environmental Science	BSC	4.5	1,2	1-6	3, 13	2	0	0	2	40	60	100
I	25ENU121	Technical English	HSC	4.5	1,2	1-5	4,8	3	0	2	4	40	60	100
I	25EEU101	Basics of Engineering	BEC	4.5	1,2	1-5	3	3	0	0	3	40	60	100
I	25MEU101	Engineering Graphics	BEC	4.5	1,2,4	1,2,3,5 10,12	4,9,12	1	2	0	3	40	60	100
I	25CSU121	Programming for Problem Solving	BEC	4.5	1,2	1-5	4,5 8, 9, 10, 17	2	0	4	4	40	60	100
I	25MAC111	NCC/YRC/NSS/Rotary Club	MAC	4.5	-	-	-	0	0	2	0	-	-	-
Semester Total											24	280	420	700

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcomes		SDG Goal	Instruction Hours / week			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
2	25MAU208	Engineering Mathematics II	BSC	4.5	1,2	1-4	4	3	1	0	4	40	60	100
2	25CHU221	Engineering Chemistry	BSC	4.5	1,2	1-5	4,6	3	0	2	4	40	60	100
2	25ITU222	Data Structures	BEC	4.5	1,2	1-5	4,9,11	3	0	2	4	40	60	100
2	25MEU201	Engineering Mechanics	PCC	4.5	1,2,4	9	3	3	1	0	4	40	60	100
2	25MEU202	Engineering Materials and Metallurgy	PCC	4.5	1,2,3,6	9,12	3	3	0	0	3	40	60	100
2	25IKS001	Introduction to Indian Knowledge System	IKS	4.5	1,2	7,9	3-5, 10, 16	2	0	0	2	40	60	100
2	25MEU211	Design Thinking and Innovations Lab	BEC	4.5	1,2	1-6, 11	4,8,9,11	1	0	2	2	40	60	100
2	25MAC201	Indian Constitution and Human Rights	MAC	4.5	1,2	7,8,9	4,16	2	0	0	2	40	60	100
Semester Total											25	320	480	800

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcomes		SDG Goal	Instruction Hours / week			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
3	25MAU301	Numerical Methods	BSC	5	1,2	1,2,4	4,9	3	1	0	4	40	60	100
3	25UHV001	Universal Human Values and Ethics	HSC	5	4,5	6,7,8	4,16	2	0	0	2	40	60	100
3	25MEU301	Manufacturing Technology	PCC	5	1,2	1,2,5,6	9,12	3	0	0	3	40	60	100
3	25MEU302	Engineering Thermodynamics	PCC	5	1,2	1,2,3	7,9,13	3	0	0	3	40	60	100
3	25MEU303	Kinematics of Machinery	PCC	5	1,2	1,2,4	9	3	0	0	3	40	60	100
3	25MEU321	Mechanics of Solids	PCC	5	1,2	1,2,4	9	3	0	2	4	40	60	100
3	25MEU311	Manufacturing Technology Laboratory	PCC	5	1,2	2,5,9,10	9,12	0	0	4	2	40	60	100
3	23VA271	Yoga For Human Excellence	MAC (Field)	5	4,5	7,8,9	3,4,16	0	0	1	0			
Semester Total											21	280	420	700

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcomes		SDG Goal	Instruction Hours / week			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
4	25MEU421	Thermal Engineering	PCC	5	1,2	1,2, 3	7,9,13	3	0	2	4	40	60	100
4	25MEU401	Design of Machine Elements	PCC	5	1,2	1,2, 3,5	9	3	0	0	3	40	60	100
4	25MEU422	Fluid Mechanics and Machinery	PCC	5	1,2	1,2, 4	6,7,9	3	0	2	4	40	60	100
4	25MEU402	Smart Mobility and New Generation Vehicles	PCC	5	2,3, 5	3,5, 6,11	9,11,13	3	0	0	3	40	60	100
4	25MEU411	Computer Aided Machine Drawing	PCC	5	1,2	1,2, 3,5	9	1	0	4	3	40	60	100
4	25IKS007	Material Science in Ancient India	IKS	5	2,4	6,8, 9	4,12,16	2	0	0	2	40	60	100
4	25MEU491	Exploratory Project	PRO	5	1,3, 5	3,5, 6,9, 11	8,9	0	0	4	2	40	60	100
Semester Total											21	280	420	700

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcomes		SDG Goal	Instruction Hours / week			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
5	25MEU521	Design of Transmission Systems	PCC	6	1,2	1,2,3,5	9	3	1	0	4	40	60	100
5	25MEU522	Dynamics of Machines	PCC	6	1,2	1,2,4	4,9	3	0	2	4	40	60	100
5	25MEU523	Metrology and Measurements	PCC	6	1,2	1,2,6,10	9	3	0	2	4	40	60	100
5		Professional Elective 1	PEC	6	-	-	-	3	0	0	3	40	60	100
5		Professional Elective 2	PEC	6	-	-	-	3	0	0	3	40	60	100
5		Open Elective 1	OEC	6	-	-	-	3	0	0	3	40	60	100
5	25MEU581	Industry Internship I	IAS	6	1,3	2,5,6,11	8	0	0	2	1	40	60	100
5	25MAC501	Entrepreneurship and Startups	MAC	6	4,5	7,8,9	8,9, 17	3	0	0	3	40	60	100
Semester Total											25	320	480	800

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcomes		SDG Goal	Instruction Hours / week			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
6	25MEU601	CAD/CAM	PCC	6	1,2,5	1,2,5,10	9	3	0	0	3	40	60	100
6	25MEU621	Heat and Mass Transfer	PCC	6	1,2	1,2,3	7,9,13	3	0	2	4	40	60	100
6	25MEU622	Hydraulics and Pneumatics	PCC	6	1,2	1,2,5	9	3	1	0	4	40	60	100
6		Professional Elective 3	PEC	6	-	-	-	3	0	0	3	40	60	100
6		Professional Elective 4	PEC	6	-	-	-	3	0	0	3	40	60	100
6		Open Elective 2 (Online)	OEC	6	-	-	-	3	0	0	3	40	60	100
6	25MEU611	CAD/CAM Laboratory	PCC	6	1,2,5	2,5,9,10	9	0	0	4	2	40	60	100
Semester Total											22	280	420	700

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcomes		SDG Goal	Instruction Hours / week			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
7	25MEU721	Mechatronics and IoT	PCC	7	1,2, 5	1,2,3,5, 10	9,11	3	0	0	3	40	60	100
7		Professional Elective 5	PEC	7	-	-	-	3	0	0	3	40	60	100
7		Professional Elective 6	PEC	7	-	-	-	3	0	0	3	40	60	100
7	25MEU711	Geometric Modelling and Simulation Laboratory	PCC	7	1,2, 5	2,5,9,10	9	0	0	4	2	40	60	100
7	25MEU781	Industry Internship II	IAS	7	1,3	2,5,6,11	8	0	0	2	1	40	60	100
7	25MEU791	Capstone Project (Phase-I)	PRO	7	1,3, 5	3,5,6,9, 11,12	9,11	0	0	12	6	40	60	100
7		Open Elective 3	OEC	7	-	-	-	3	0	0	3	40	60	100
Semester Total											21	280	420	700

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcomes		SDG Goal	Instruction Hours / week			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
8	25MEU891	Capstone Project (Phase-II)	PRO	7	1,3,5	3,5,6,9, 11,12	9,11	0	0	24	12	40	60	100
8		Open Elective 4 (Online)	OEC	7	-	-	-	3	0	0	3	40	60	100
Semester Total											15	80	120	200

Total Credits: 174

Credit Distribution

S.No	Category	I	II	III	IV	V	VI	VII	VIII	Total
1	Basic Science Courses (BSC)	10	8	4						22
2	Basic Engineering Courses (BEC)	10	5							15
3	Humanities and Social Science Courses (HSC)	4		2						6
4	Program Core Courses (PCC)		7	15	17	12	13	6		70
5	Program Elective Courses (PEC)					6	6	6		18
6	Multidisciplinary Open Elective Courses (OEC)					3	3	3	3	12
7	Projects (PRO)				2		0	6	12	20
8	Internships / Seminars (IAS)					1		1		2
9	Indian Knowledge System (IKS)		2		2					4
10	Mandatory Audit courses (MAC)	0	2			3				5
11	Skill-Based Courses (SBC)									0
	TOTAL	24	24	21	21	25	22	22	15	**174**

PROGRAMME ELECTIVE COURSES

S.NO	STREAM: DESIGN		STREAM: PRODUCTION AND INDUSTRIAL ENGINEERING		STREAM: THERMAL ENGINEERING		STREAM: ENGINEERING MATERIALS		STREAM: INTELLIGENT SYSTEMS	
	Course Code	**Course Title**	**Course Code**	**Course Title**	**Course Code**	**Course Title**	**Course Code**	**Course Title**	**Course Code**	**Course Title**
1	25MEU531A	Design for Manufacturing	25MEU531B	3D Printing and Design	25MEU531C	Refrigeration and Air Conditioning	25MEU531D	Polymer Science And Engineering	25MEU531E	Machine Learning and Artificial Intelligence for Mechanical Engineers using Python
2	25MEU532A	Product Design and Development	25MEU532B	Micro and Nano Machining	25MEU532C	Turbo Machinery	25MEU532D	Characterization of Materials	25MEU532E	IOT & Smart Manufacturing
3	25MEU533A	Modern Concepts of Engineering Design	25MEU533B	Unconventional Machining Techniques	25MEU533C	Advanced Internal Combustion Engineering	25MEU533D	Powder Metallurgy	25MEU533E	Industrial Process Automation
4	25MEU631A	Dynamics and Control	25MEU631B	Non-destructive Evaluation of Materials	25MEU631C	Biofuels	25MEU631D	Composite Materials and Mechanics	25MEU631E	MEMS and Microsystems
5	25MEU632A	Mechanical Vibrations and Noise Control	25MEU632B	Casting and Welding Processes	25MEU632C	Energy Efficient Mechanical Systems For Buildings	25MEU632D	Mechanical Metallurgy	25MEU632E	Virtual Reality and Augmented Reality
6	25MEU633A	Applied Finite Element Analysis	25MEU634B	Management & Organizational Behaviour	25MEU633C	Gas Dynamics for Space Propulsion	25MEU633D	Smart Materials: Application of Nanomaterial For Batteries, Solar And Fuel Cells	25MEU633E	Intelligent Manufacturing Systems

S.NO	STREAM: DESIGN		STREAM: PRODUCTION AND INDUSTRIAL ENGINEERING		STREAM: THERMAL ENGINEERING		STREAM: ENGINEERING MATERIALS		STREAM: INTELLIGENT SYSTEMS	
	Course Code	**Course Title**	**Course Code**	**Course Title**	**Course Code**	**Course Title**	**Course Code**	**Course Title**	**Course Code**	**Course Title**
7	25MEU731A	Design of Jigs, Fixtures and Press Tools	25MEU731B	Computer Integrated manufacturing	25MEU731C	Solar Energy Technology	25MEU731D	Heat Treatment of Metals And Alloys	25MEU731E	Robot Dynamics and Applications
8	25MEU732A	Tribology In Design	25MEU732B	Maintenance Engineering	25MEU732C	Marine Propellers and Propulsion	25MEU732D	Creep And Fatigue Behavior of Materials	25MEU732E	Python Programming for Mechanical Engineers
9	25MEU733A	Design of Heat Exchangers	25MEU733B	Production Planning and Control	25MEU733C	Nanotechnology for Energy Systems	25MEU733D	Fracture Mechanics and Failure Analysis		
10	25MEU734A	Computational Techniques for Fluid Dynamics	25MEU734B	Safety in Process Industries	25MEU734C	Waste to Energy Conversion				
11	25MEU735A	Piping Engineering	25MEU735B	Quality and Reliability Engineering	25MEU735C	Cryogenic Engineering				
12			25MEU736B	Precision Manufacturing	25MEU736C	Energy Conservation in Industries				
13			25MEU737B	Lean Six Sigma	25MEU737C	Energy Storage Systems for Electric Vehicles				
14			25MEU738B	Enterprise Resource Planning						

OPEN ELECTIVE COURSES

Sl.no	Course Code	Course Title	Hours per week			Credits
			L	T	P	
1	25MEU041	Applied Ergonomics	3	0	0	3
2	25MEU042	Structure and Properties of Materials	3	0	0	3
3	25MEU043	International Supply Chain Management	3	0	0	3
4	25MEU044	Intellectual Property Rights	3	0	0	3
5	25MEU045	Energy Systems	3	0	0	3
6	25MEU046	Engineering Ethics & Sustainable Development	3	0	0	3
7	25MEU047	Bio Mechanical Engineering	3	0	0	3
8	25MEU048	Fleet Management	3	0	0	3
9	25MEU049	Drone Design and Development	3	0	0	3
10	25MEU050	Engineering Innovation for SDG Impact	3	0	0	3

Semester – 1

25MAU108 **ENGINEERING MATHEMATICS -I** **4H – 4C**

Instruction Hours / week: L: 3 T: 1 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Develop the uses of matrix algebra techniques that is needed by engineers for practical applications.
- Differentiate continuity and differentiability under differential calculus.
- Identify functions of several variables. This is required in many branches of engineering.
- Solve the problems under integral calculus.
- Acquaint the student with mathematical tools needed in evaluating multiple integrals and their applications.

Course Outcomes (COs)

At the completion of the course the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Use the matrix algebra methods for solving practical problems	Apply
CO2	Use differential calculus ideas on several variable functions	Apply
CO3	Apply the concept of several variable functions in calculus	Understand
CO4	Apply the concept of integral calculus	Apply
CO5	Apply multiple integral ideas in solving areas, volumes and other applications	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	-	-	-	-	-	1	2	1	-	3
CO2	3	3	1	2	2	-	-	-	-	-	1	2	1	-	3
CO3	2	2	1	1	1	-	-	-	-	-	1	1	1	-	2
CO4	3	2	1	2	2	-	-	-	-	-	1	2	1	-	3
CO5	3	3	2	2	2	1	-	-	-	-	1	2	2	1	3

1 - low, 2 - medium, 3 - high

Unit I – MATRICES

Eigenvalues and Eigenvectors of a real matrix – Characteristic equation – Properties of Eigen values and Eigen vectors – Cayley-Hamilton theorem – Diagonalization of matrices by orthogonal transformation – Reduction of a quadratic form to canonical form by orthogonal transformation – Nature of quadratic forms – Applications: Stretching of an elastic membrane.

Unit II – DIFFERENTIAL CALCULUS

Representation of functions – Limit of a function – Continuity – Derivatives – Differentiation rules (sum, product, quotient, chain rules) – Implicit differentiation – Logarithmic differentiation – Applications: Maxima and Minima of functions of one variable.

Unit III – FUNCTIONS OF SEVERAL VARIABLES

Partial differentiation – Homogeneous functions and Euler’s theorem – Total derivative – Change of variables – Jacobians – Partial differentiation of implicit functions – Taylor’s series for functions of two variables – Applications: Maxima and minima of functions of two variables, Lagrange’s method of undetermined multipliers.

Unit IV –INTEGRAL CALCULUS
Definite and Indefinite integrals — Substitution rule — Techniques of Integration — Integration by parts, Trigonometric integrals, Trigonometric substitutions, Integration of rational functions by partial fraction, Integration of irrational functions — Improper integrals.

Unit V – MULTIPLE INTEGRALS
Double integrals – Change of order of integration – Double integrals in polar coordinates – Area enclosed by plane curves – Triple integrals – Volume of solids – Change of variables in double and triple integrals – Applications: Moments and centres of mass, moment of inertia.

SUGGESTED READINGS

1. Kreyszig, E. (2016). Advanced Engineering Mathematics. 10th Edition, John Wiley and Sons.
2. Grewal, B.S. (2018). Higher Engineering Mathematics. 44th Edition, Khanna Publishers.
3. Bali, N., Goyal, M., & Watkins, C. (2009). Advanced Engineering Mathematics. 7th Edition, Firewall Media.
4. Jain, R.K. & Iyengar, S.R.K. (2016). Advanced Engineering Mathematics. 5th Edition, Narosa Publications.
5. Narayanan, S. & Manicavachagom Pillai, T.K. (2009). Calculus, Volume I and II, S. Viswanathan Publishers.

Semester – 1

25PHU121 **EMGINEERING PHYSICS** **5H – 4C**

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Provide a foundational understanding of the electrical properties of materials
- Introduce the fundamental concepts and behaviour of semiconductor materials
- Develop a conceptual and mathematical understanding of elasticity
- Explain the thermal properties of engineering materials
- Examine experimental evidence such as electron diffraction.

Course Outcomes (COs)

At the completion of the course the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Discuss the basic electrical properties of materials and classify materials based on band theory.	Understand, Apply
CO2	Explain the properties of semiconductor materials and determine the band gap using appropriate experimental methods.	Understand, Apply
CO3	Calculate different moduli of elasticity and explain their applications in engineering and materials science.	Apply
CO4	Describe the thermal properties of materials and their applications, such as thermal expansion in joints and the functioning of heat exchangers.	Remember, Apply
CO5	Interpret the concept of wave-particle duality and describe experimental evidence, such as electron diffraction, that supports this duality.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	-	-	-	-	-	1	2	1	-	3
CO2	3	3	1	2	2	-	-	-	-	-	1	2	2	-	3
CO3	3	2	1	2	2	-	-	-	-	-	1	2	1	-	3
CO4	2	2	1	1	1	1	-	-	-	-	1	1	1	-	2
CO5	2	2	-	1	1	-	-	-	-	-	2	1	1	-	2

1 - low, 2 - medium, 3 - high

Unit-I ELECTRICAL PROPERTIES OF MATERIALS

Classical free electron theory-Expression for Electrical conductivity-thermal conductivity-expression-Wiedmann Franz law- success and failure-electrons in metals-Particle in three dimensional box-degenerate state- Fermi Dirac Statistics-Density of Energy states-Electron in periodic potential-Bloch Theorem-Metals and Insulators-Energy bands in solids-Effective mass of electron- Concept of holes.

Unit II SEMICONDUCTORS AND TRANSPORT PHYSICS

Intrinsic semiconductors- Carrier concentration derivation– Fermi level – variation of Fermi level with temperature –electrical conductivity – band gap determination -extrinsic semiconductors - Carrier concentration in N-type & P-type semiconductors – Variation of fermi level with temperature and impurity concentration.

Unit III PROPERTIES OF MATTER

Elasticity – Poisson's ratio and relationship between moduli (qualitative) - stress-strain diagram for ductile and brittle materials, uses - factors affecting elastic modulus and tensile strength - bending of beams - cantilever - bending moment - Young's modulus determination - theory and experiment - uniform and non-uniform bending - I shaped girders - twisting couple torsion pendulum - determination of rigidity modulus- moment of inertia of a body .

Unit IV THERMAL PHYSICS

Transfer of heat energy – thermal expansion of solids and liquids – expansion joints - bimetallic strips - thermal conduction, convection and radiation – heat conductions in solids – thermal conductivity - Forbe's and Lee's disc method: theory and experiment - conduction through compound media (series and parallel) – thermal insulation – applications: heat exchangers, refrigerators, ovens and solar water heaters.

Unit V QUANTUM PHYSICS

Black body radiation – Planck's theory (derivation) – Compton effect: theory and experimental verification – wave particle duality – electron diffraction – concept of wave function and its physical significance – Schrödinger's wave equation – time independent and time dependent equations – particle in a one- dimensional rigid box – tunnelling (qualitative) - scanning tunneling microscope.

SUGGESTED READINGS

1. Charles Kittel – Introduction to Solid State Physics, 8th Edition (2018) Publisher: Wiley
2. Brij Lal and N.Subramaniam, Properties of Matter S. Chand & Co., New Delhi (1994)
3. G. Aruldhas's Quantum Mechanics is the Second Edition, published by PHI Learning in 2008.
4. Donald A. Neamen's Semiconductor Physics and Devices: Basic Principles is the 4th Edition, published in 2012 by McGraw-Hill.
5. Halliday, D., Resnick, R. & Walker, J. "Principles of Physics". Wiley, 2015.
6. R. Shankar's Principles of Quantum Mechanics is the Second Edition, published in 1994 by Plenum Press
7. Dr. S. Stella Mary, 'Practical Engineering Physics' R. K. Publications, 2013
8. C.C. Ouseph, U.J. Rao, V. Vijayendran, 'Practical Physics and Electronics', S. Viswanathan Printers and Publishers Pvt. Ltd., 2011

Semester – 1

25EVS001 **ENVIRONMENTAL SCIENCE** **2H – 2C**

Instruction Hours / week: L: 2 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Understand the scope and significance of the environment, raise public awareness about various environmental hazards and the structure and function of ecosystems
- Introduce the concept of biodiversity, its different types and the importance of its conservation at global, national, and local levels.
- Understand the causes, effects, and control measures of various environmental hazards, solid waste and disaster management, role of individuals in pollution prevention.
- Understand the need for new and renewable energy sources, focusing on energy management and conservation, and their applications.
- Understand the concepts of global and local environmental issues, various environmental protection laws

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Define the environment and its significance, different environmental hazards, and the roles of producers, consumers, and decomposers in ecosystems, energy flow and the Structure of food chains, food webs, and ecological pyramids in various ecosystems.	Understand
CO2	Define biodiversity and its various levels, biodiversity hotspots, threats to biodiversity, and the importance of conserving endangered and endemic species in India using in- situ and ex-situ methods.	Understand
CO3	Identify the causes, effects control of different environmental hazards (air, water, marine, soil, noise, thermal, and nuclear pollution), importance of solid waste management and disaster management (floods, earthquakes, cyclones, and landslides), the role of individuals in preventing pollution and pollution case studies.	Remember
CO4	Explore the role and potential of new and renewable energy sources, different types of renewable energy and their applications, particularly hydrogen, ocean, tidal, and geothermal energy, the concepts and technology behind energy management and conservation.	Understand
CO5	Identify key environmental issues and the role of environmental protection laws in safeguarding ecosystems, wildlife, and forests.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	1	1	3	1	-	-	-	2	1	1	-	2
CO2	2	2	1	1	1	3	1	-	-	-	2	1	1	-	2
CO3	2	3	2	2	2	3	2	1	1	-	2	1	2	1	2
CO4	2	2	2	1	2	3	1	-	1	1	2	2	2	1	2
CO5	2	2	2	1	1	3	3	-	1	-	2	1	1	-	2

1 - low, 2 - medium, 3 – high

Unit I – ENVIRONMENT AND ECOSYSTEM

Environment – Definition, scope and significance - Public awareness: Risk and hazards - Chemical hazards, Physical hazards, Biological hazards in the environment. Ecosystem - concept -structure and function - producers, consumers and decomposers - Food chain - Food web - Ecological pyramids - Energy flow - Forest, Grassland, desert and aquatic ecosystem

Unit II – BIODIVERSITY AND ITS CONSERVATION

Introduction to Biodiversity - Definition - genetic, species and ecosystem diversity - Values and uses of biodiversity - biodiversity at global, national (India) and local levels - Hotspots, threats to biodiversity - Endangered and endemic species of India - conservation of biodiversity - *In-situ* & *Ex-situ.*

Unit III – ENVIRONMENTAL POLLUTION AND MANAGEMENT

Definition, Causes - Effects and control measures of Air, Water, Marine, soil, Noise, thermal and nuclear hazards, Solid waste Management : Causes, effects and control measures of urban and industrial wastes- Role of an individual in prevention of pollution- Pollution case studies- Disaster management : floods, earthquake, cyclone and landslides

Unit IV – RENEWABLE SOURCES OF ENERGY

Role and potential of new and renewable source- Energy management and conservation, New Energy Sources: Need of new sources. Different types of new energy sources. Applications of- Hydrogen energy, Ocean energy resources, Tidal energy conversion. Concept, origin and power plants of geothermal energy

Unit V – ENVIRONMENTAL PROTECTION

Climate change- Global, Regional and local environmental issues. Environmental Impact Assessment. Environment protection act, wildlife protection act. and forest conservation act.

SUGGESTED READINGS

1. Gilbert M.Masters "Introduction to Environmental Engineering and Science", 2nd edition, Pearson Education (2004).
2. Benny Joseph, "Environmental Science and Engineering", Tata McGraw-Hill, New Delhi (2006).
3. Trivedi.R.K., "Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards", Vol. I and II, Enviro Media, 3rd edition, BPB publication (2010).
4. Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 6th Edition, New Age International Publishers, 2018.
5. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.
6. Bradley. A.S; Adebayo, A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning
7. Environment Impact Assessment Guidelines, Notification of Government of India, 2006.
8. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998.
9. Dharmendra S. Sengar, 'Environmental law', Prentice hall of India PVT. LTD, New Delhi, 2007.
10. Rajagopalan, R, 'Environmental Studies-From Crisis to Cure', Oxford University Press, 2005
11. Erach Bharucha "Textbook of Environmental Studies for Undergraduate Courses" Orient Blackswan Pvt. Ltd. 2013

Semester – 1

25ENU121 **TECHNICAL ENGLISH** **5H – 4C**

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Enhance the communicative competence of learners.
- Assist learners in using language effectively in academic/work contexts.
- Strengthen students' English language skills by engaging them in listening, speaking, and grammar learning activities that are relevant to authentic contexts.
- Develop analytical thinking skills for problem-solving in communicative contexts
- Equip them with writing skills needed for academic as well as workplace contexts.

Course Outcomes (COs)

At the completion of the course the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Listen and comprehend complex academic texts.	Remember
CO2	Read and infer the denotative and connotative meanings of technical texts.	Apply
CO3	Write definitions, descriptions narrations and essays on various topics.	Apply
CO4	Speak fluently and accurately and informal communicative contexts.	Apply
CO5	Express their opinions effectively in both oral and written medium of communication.	Create

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	-	-	1	-	1	1	3	-	2	1	-	-	1
CO2	1	2	-	1	1	-	1	1	3	-	2	1	-	-	1
CO3	1	2	1	1	1	-	1	1	3	1	2	1	1	-	1
CO4	-	1	-	-	1	-	2	2	3	1	2	1	1	-	-
CO5	1	2	1	1	1	1	2	2	3	1					1

1 - low, 2 - medium, 3 - high

Unit I INTRODUCTION TO COMMUNICATION SKILLS

Listening–for general information-specific details-conversation: Introduction to classmates.
Speaking - Self Introduction; Introducing a friend; Conversation - politeness strategies; Telephone conversation. Reading - Reading brochures (technical context). Writing-Writing emails/letters introducing oneself, Paragraph Writing, Reading Comprehension.Grammar – Parts of Speech, Sentence kinds. Wh- Questions forms and Tags.Vocabulary-Synonyms; One word substitution; Abbreviations &Acronyms (as used in technical contexts).

Unit II: REPORTING AND NARRATIONS

Listening- Listening to podcast, anecdotes/stories/event narration; documentaries and interviews. Speaking- Narrating personal experiences/events; Interviewing a celebrity; Reporting and summarizing of documentaries/podcasts/interviews.Reading- Reading biographies, travelogues, newspaper reports, Excerpts from literature, travel and technical blogs. Writing – Report Writing - Short Report on an event. Grammar- Sentence Structures, Tenses. Vocabulary– Antonyms, Word Formation (prefixes & suffixes).

Unit III: ACADEMIC DEVELOPMENT AND COMMERCIAL REVIEWS

Listening- Listen to a classroom lecture. Speaking–Picture description; Giving instruction to use the product; Presenting a product and summarizing a lecture. Reading – Reading advertisements, gadget reviews; user manuals. Writing - Writing definitions; Instructions. Grammar-Active & Passive Voice, The Impersonal Passive., Subject-Verb Agreement; Infinitive and Gerunds. Vocabulary -Compound Words, Homonyms; and Homophones.

Unit IV: SCIENTIFIC REPORTS AND PRESENTATION TECHNIQUES

Listening – Listening to TED Talks; Scientific lectures and educational videos. Speaking – Small Talk; Mini presentations and making recommendations. Reading–Newspaper articles; Journal reports–and Non Verbal Communication (tables, pie charts etc,).Writing–Writing recommendations; Transferring information from non -verbal (chart, graph etc, to verbal mode), Checklists. Grammar–Error correction; If conditional sentences. Vocabulary- Discourse markers, Connectives, Articles.

Unit V: POINT OF VIEW AND PLACEMENTS.

Listening–Listening to debates/discussions; different viewpoints on an issue; and panel discussions. Speaking–Group discussions, Debates, and Expressing opinions through Simulations &Role play. Reading – Reading Editorials and Opinion Blogs. Writing–Job/ application–Cover letter& Resume. Grammar–Numerical adjectives, Punctuation. Vocabulary- Cause & Effect Expressions

PRACTICAL EXERCISES

1. Group Discussion: Practical based on Accurate and Current Grammatical Patterns.
2. Conversational Skills for Interviews under suitable Professional Communication Lab conditions with emphasis on Kinesics
3. Communication Skills for Seminars/Conferences/Workshops with emphasis on Paralinguistic/ Kinesics. Presentation Skills for Technical Paper/Project Reports/ Professional Reports based on proper Stress and Intonation Mechanics.
4. Official/Public Speaking based on suitable Rhythmic Patterns.
5. Argumentative Skills/Role Play Presentation with Stress and Intonation

SUGGESTED READINGS

1. English for Engineers &Technologists Orient Blackswan Private Ltd. Department of English, Anna University,(2020 edition)
2. English for Science &Technology Cambridge University Press, 2021.
3. Technical Communication–Principles And Practices by Meenakshi Raman &Sangeeta Sharma
4. Dr.S.Uma Maheswari. English Workbook for Engineers and Technologists
5. Lakshmi Narayanan,Course Book on Technical English

Semester – 1

25EEU101 **BASICS OF ENGINEERING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- To understand the basic calculations and measurements in DC circuits.
- To familiarize with working and characteristics of different DC and AC machines.
- To impart knowledge on the fundamentals of measuring electrical and electronic quantities, various sensors and transducers to measure non-electrical quantities.
- Demonstrate the fundamentals and scope of Mechanical Engineering, covering its core principles, key domains, and emerging technologies
- Identify basic and modern construction materials, explain their engineering properties,

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	**Course Outcomes**	**Blooms Level**
CO1	Perform the basic calculations in DC circuits and measure the various quantities associated with DC circuits.	Understand
CO2	Choose appropriate motor for specific applications based on the motor characteristics	Analyze
CO3	Analyze the functional blocks of a measurement system and the principles of various electrical and electronic instruments,	Analyze
CO4	Describe the scope of Civil Engineering and identify basic and modern construction materials along with their properties	Understand
CO5	Distinguish between different Steams of Mechanical Engineering and to gain foundational knowledge of mechanical systems, tools, and applications.	Understand

CO-PO Mapping

CO / PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	2	2	-	-	-	1	-	1	2	1	-	3	2
CO2	3	3	2	2	2	1	-	-	1	1	1	2	2	1	3	3
CO3	3	3	1	2	3	-	-	-	1	-	1	2	2	-	3	3
CO4	2	1	2	1	1	2	1	-	1	-	1	1	1	-	2	1
CO5	2	1	1	1	1	1	-	-	1	-	2	1	2	1	2	1

1 - low, 2 - medium, 3 - high

Unit I: DC CIRCUITS AND MEASUREMENTS

The concept of voltage and current-Electric circuit elements: R, L, C – Independent and dependent sources – Ohm's law- Kirchhoff's law- series and parallel resistive circuits – Voltage and current division – Star-delta transformation - Mesh and nodal analysis of resistive circuits – simple problems - Measurement of voltage, current and power in DC circuits.

Unit II: ELECTRICAL MACHINES

Construction, principle of operation, basic equations, characteristics and applications of DC generators, DC motors, single phase transformers and Single phase induction motors. Working principle of BLDC Motor and its applications in home appliances.

Unit III: ELECTRICAL AND ELECTRONIC INSTRUMENTATION

Functional blocks of a measurement system - types of measurements - Direct and indirect measurements – Classification of instruments – Induction type – dynamometer type wattmeter's- Types of indicating Instruments Principles of Electrical Instruments – Multimeters,Oscilloscopes - Static and Dynamic characteristics of an instrumentation system – Errors in Measurement – Calibration and Standards.. Classification of Transducers: Resistive, Inductive, Capacitive, Thermoelectric, piezoelectric, photoelectric, Hall Effect – electromagnetic flow transducers

Unit IV: INTRODUCTION TO CIVIL ENGINEERING AND MATERIALS

Introduction to Civil Engineering- Basic Construction Materials- Properties of Engineering Materials- Selection of Materials for Construction- Modern Materials in Construction

Unit V SCOPE AND CORE PRINCIPLES OF MECHANICAL ENGINEERING

Design, Manufacturing, Materials, Energy and Power Systems, Kinematics and Robotics, Instrumentation and Control, Emerging Trends, and Smart Applications.

SUGGESTED READINGS

1.D P Kothari and I.J Nagarath, "Basic Electrical and Electronics Engineering", McGraw Hill Education (India) Private Limited, Third Reprint, 2016.
2. Giorgio Rizzoni, "Principles and Applications of Electrical Engineering", McGraw Hill Education (India) Private Limited, 2010.
3. S.K.Bhattacharya, "Basic Electrical and Electronics Engineering", Pearson India, 2011.
4. Del Toro, "Electrical Engineering Fundamentals", Pearson Education, New Delhi, 2015.
5. Leonard S Bobrow, "Foundations of Electrical Engineering", Oxford University Press, 2013.
6. Rajendra Prasad, "Fundamentals of Electrical engineering", Prentice Hall of India, 2006.
7. Mittle N., "Basic Electrical Engineering", Tata McGraw Hill Edition, 24th reprint 2016.
8. Sawhney, A. K., and Puneet Sawhney "A Course in Electrical and Electronic Measurements and Instrumentation" Dhanpat Rai & Company, 2016.
9. Jonathan Wickert & Kemper Lewis, An Introduction to Mechanical Engineering Cengage Learning Publication (Enhanced SI Edition, 4th Edition), 2021.
10. Author: S.K. Duggal Publication : New Age International Publishers Edition: 4th or 5th edition

Semester – 1

25MEU101 **ENGINEERING GRAPHICS** **3H – 3C**

Instruction Hours / week: L: 1 T: 2 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Communicate the concepts, ideas and design of engineering products through graphic skills.
- Acquaint the national standards related to technical drawings.
- Comprehend Orthographic, Isometric and perspective projection to represent the objects in two and three-dimensions.

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Sketch and distinguish between conic curves, cycloids, and involutes, and construct appropriate scales for engineering applications.	Apply
CO2	Identify and apply projection techniques to represent points, lines, and plane surfaces in first angle orthographic views.	Apply
CO3	Assemble and design accurate projections of solid geometries and truncated forms using appropriate methods.	Create
CO4	Prepare developments and sections of solids with holes and cut-outs, and evaluate the true shape of these sections.	Analyze
CO5	Create isometric and perspective projections of simple and compound solids, and utilize CAD tools for visualization.	Create

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	–	2	–	–	–	1	–	–	–	–	–
CO2	3	2	2	–	3	–	–	–	1	–	–	–	–	–
CO3	3	3	3	2	3	–	–	1	1	–	–	–	–	–
CO4	2	3	2	3	2	–	–	1	–	–	–	–	–	–
CO5	2	2	3	2	3	2	–	1	2	–	–	–	–	–

1 - low, 2 - medium, 3 - high

Unit I – PLANE CURVES AND FREE HAND SKETCHING

Basic Geometrical constructions, Curves used in engineering practices: Conics – Construction of ellipse, parabola and hyperbola by eccentricity method – Construction of cycloid – construction of involutes of square and circle – Drawing of tangents and normal to the above curves, Scales: Construction of Diagonal and Vernier scales. Visualization concepts and Free Hand sketching: Visualization principles –Representation of Three Dimensional objects – Layout of views- Free hand sketching of multiple views from pictorial views of objects.

Unit II – PROJECTION OF POINTS, LINES AND PLANE SURFACES

Orthographic projection- principles-Principal planes-First angle projection-projection of points. Projection of straight lines (only First angle projections) inclined to both the principal planes - Determination of true lengths and true inclinations by rotating line method and traces Projection of planes (polygonal and circular surfaces) inclined to both the principal planes by rotating object method.

Unit III – PROJECTION OF SOLIDS

Projection of simple solids like prisms, pyramids, cylinder, cone and truncated solids when the axis is inclined to one of the principal planes by rotating object method and auxiliary plane method.

Unit IV – PROJECTION OF SECTIONED SOLIDS AND DEVELOPMENT OF SURFACES

Sectioning of above solids in simple vertical position when the cutting plane is inclined to the one of the principal planes and perpendicular to the other – obtaining true shape of section. Development of lateral surfaces of simple and sectioned solids – Prisms, pyramids cylinders and cones. Development of lateral surfaces of solids with cut-outs and holes.

Unit V – ISOMETRIC AND PERSPECTIVE PROJECTIONS

Principles of isometric projection – isometric scale –Isometric projections of simple solids and truncated solids - Prisms, pyramids, cylinders, cones- combination of two solid objects in simple vertical positions and miscellaneous problems. Perspective projection of simple solids-Prisms, pyramids and cylinders by visual ray method.

COMPUTER AIDED DRAFTING (Demonstration Only)

Introduction to drafting packages and demonstration of their use.

SUGGESTED READINGS

1. Parthasarathy,N.S.and Vela Murali, "Engineering Drawing", Oxford University Press, 2015.
2. Bhatt N.D. and Panchal V.M., "Engineering Drawing", Charotar Publishing House, 53rd Edition,2014.
3. Gopalakrishna K.R., "Engineering Drawing"m(Vol. I&II combined), Subhas Stores, Bangalore,(2017).
4. Venugopal K. and Prabhu Raja V., "Engineering graphics", New Age International (P) Limited,(2008).
5. Natrajan K.V., "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, (2012).

Semester – 1

25CSU121 PROGRAMMING FOR PROBLEM SOLVING 6H – 4C

Instruction Hours / week: L: 2 T: 0 P: 4 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Develop the foundational understanding of problem-solving techniques, algorithm design, and programming basics using C and Python.
- Apply conditional and iterative constructs effectively for developing logical, flow-controlled programs in both C and Python.
- Impart knowledge of function-based and modular programming approaches for creating structured, maintainable, and reusable code.
- Equip students with the ability to manipulate arrays, strings, and lists, and apply fundamental searching and sorting algorithms in C and Python..
- Introduce memory management concepts through pointers in C, and provide practical skills in file handling and understanding Python's memory model.

Course Outcomes (COs)
At the completion of the course the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Construct basic programs using variables, operators, and input/output functions in C and Python	Remember
CO2	Execute decision-making and looping structures to solve common computational problems	Apply
CO3	Assemble modular programs by defining reusable functions with appropriate parameter usage and scope control	Analyze.
CO4	Implement basic searching and sorting algorithms to process structured data arrays, strings, and lists	Create
CO5	Demonstrate the use of pointers and dynamic memory in C, and operate file handling and memory reference concepts in C and Python	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	2	3	2	2	1	2	2	1	-	3	2	3
CO2	3	2	2	2	3	2	3	2	2	2	2	2	3	2	3
CO3	3	2	2	2	3	2	3	2	1	1	2	1	3	2	3
CO4	3	2	2	2	3	2	3	2	2	2	2	2	3	2	3
CO5	3	1	1	2	3	2	2	2	2	1	1	-	3	2	3

1 - low, 2 - medium, 3 - high

Unit I: INTRODUCTION TO PROGRAMMING

Introduction to problem solving, algorithms, and flowcharts, Programming structure in C and Python, Data types, variables, constants, Operators and expressions (arithmetic, relational, logical, assignment, Input/output functions: scanf, printf (C); input(), print() (Python) Type conversion and casting

Unit II: CONTROL FLOW AND ITERATIVE STATEMENTS

Decision-making: if, if-else, nested if, switch-case (C); if-elif-else (Python), Looping constructs: while, for, do-while (C); while, for-in (Python), Loop control: break, continue, pass, Problem-solving using loops (e.g., sum of digits, reverse number, pattern printing)

Unit III: FUNCTIONS AND MODULAR PROGRAMMING
Defining and calling functions in C and Python, Function parameters, return types, recursion, Python- specific: default arguments, keyword arguments, lambda functions, Variable scope and storage classes, Modular programming: creating reusable code blocks

Unit IV: ARRAYS, STRINGS, LISTS
Arrays in C: 1D and 2D, basic operations, Strings in C: declaration, input/output, string.h functions, Python lists: indexing, slicing, built-in methods, list comprehensions, Python strings: methods, slicing, immutability, Searching and sorting algorithms (linear, binary search; bubble, selection sort)

Unit V: POINTERS (C) AND FILE HANDLING IN C AND PYTHON
Pointers in C-declaration and initialization- Pointers and arrays-Pointers and functions (call by reference) Pointers and structures, Dynamic memory allocation: malloc(), calloc(), realloc(), free(), File Handling in C-and python, Python memory model Mutable vs immutable objects, Function argument passing (by object reference) using id() to understand memory behavior

PRACTICAL EXERCISES (C and Python):

1. Write a Program to convert Celsius to Fahrenheit and vice versa. (Practice: I/O, arithmetic operators, conditionals)
2. Write a Program to simulate Simple Calculator that Perform addition, subtraction, multiplication, and division based on user input. (Practice: switch-case or if-elif-else.)
3. Write a program to check whether a given number is Odd or Even (Practice: conditionals, modulo operator).
4. Write a program to find Factorial of a Number using both iterative and recursive methods. (Practice: loops, recursion).
5. Write a program to Print Fibonacci series up to n terms. (Practice: loop/recursion logic.)
6. Write a program to find the GCD of two numbers. (Practice: functions, logic)
7. Write a program to check if a number is prime. (Practice: loops, conditionals, modularity.
8 Write a program to reverse a 1D array (C) or list (Python). (Practice: arrays/lists, loops)
9 Write a program to check if a given string is a palindrome. (Practice: string manipulation.)
10 Write a program to sort a list/array using bubble sort or selection sort. (Practice: sorting logic).
11 Write a program to define a structure for storing student data and display it. (Practice: structs, functions).
12 Write a program to implement stack using List (Python) Implement push and pop operations. (Practice: lists, stack logic).
13 Write a program to read from and write to a text file. Practice: file I/O basics.
14 Write a program to read a file and count the number of words. (Practice: string handling, file reading.)

SUGGESTED READINGS

1. Paul Deitel and Harvey Deitel, “C How to Program”, 9th Edition, Pearson Education, 2022
2. John Zelle, “Python Programming: An Introduction to Computer Science”, 3rd Edition, Franklin, Beedle & Associates, 2016. ISBN: 978-1590282755..
3. Mark Lutz, “Learning Python”, 5th Edition, O'Reilly Media, 2013.
4. Eric Matthes, “Python Crash Course”, 2nd Edition, No Starch Press, 2019.
5. Charles Severance, “Python for Everybody: Exploring Data in Python 3”, 2nd Edition, Charles Severance, 2020.

Semester – 2

25MAU208 **ENGINEERING MATHEMATICS -II** **4H – 4C**

Instruction Hours / week: L: 3 T: 1 P: 0

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Define and differentiate the linear partial differential equations of second and higher order with constant coefficients of both homogeneous and non-homogeneous types.
- Identify Fourier and half range Fourier transform techniques used in wide variety of situations.
- Apply the effective mathematical tools for the solutions of partial differential equations that model several physical processes.
- Evaluate Fourier transform techniques for different functions.
- Identify Z-transforms and Elementary properties of several functions

Course Outcomes (COs)
At the completion of the course the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Solve the methods of solving Partial differential equations.	Apply
CO2	Apply the concepts in Fourier series.	Apply
CO3	Apply the Partial derivative one-two dimensional concept in solving the Heat flow equations.	Apply
CO4	Solve the problems under Fourier transforms.	Apply
CO5	Identify and apply Z-transform concepts in Problem solving.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	2	-	-	-	-	-	1	2	1	-
CO2	3	2	1	2	2	-	-	-	-	-	1	2	1	-
CO3	3	3	2	2	2	1	-	-	-	-	1	2	2	1
CO4	3	3	1	2	2	-	-	-	-	-	1	2	1	-
CO5	3	2	1	1	2	-	-	-	-	-	2	1	2	-

1 - low, 2 - medium, 3 - high

Unit I -PARTIAL DIFFERENTIAL EQUATIONS

Formation of partial differential equations. Solutions of standard types of first order partial differential equations – Lagrange's linear equation. Linear partial differential equations of second and higher order with constant coefficients of both homogeneous and non-homogeneous types.

Unit II FOURIER SERIES

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series – Root mean square value – Parseval's identity – Harmonic analysis

Unit III APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS
Classification of PDE – Method of separation of variables – Fourier Series – Solutions of one dimensional wave equation – One dimensional equation of heat conduction – Steady state solution of two dimensional equation of heat conduction (excluding insulated edges).

Unit IV FOURIER TRANSFORMS
Statement of Fourier integral theorem – Fourier transform pair – Fourier sine and cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity.

Unit V- Z TRANSFORMS
Z-transforms – Elementary properties – Convergence of Z-transform – Initial and final value theorem – Inverse Z-transform using partial fraction and residues – Formation of difference equations.

SUGGESTED READINGS

1. Kreyszig, E., 'Advanced Engineering Mathematics', John Wiley and Sons, 10th Edition, New Delhi, 2016.
2. Grewal, B.S., 'Higher Engineering Mathematics', Khanna Publishers, New Delhi, 44th Edition, 2018.
3. Bali, N., Goyal, M., and Watkins, C., 'Advanced Engineering Mathematics', Firewall Media, New Delhi, 7th Edition, 2009.
4. L.C. Andrews and B. Shivamoggi, 'Integral Transforms for Engineers', SPIE Press, 1999.
5. Narayanan, S., Manicavachagom Pillay, T.K., and Ramanaiah, G., 'Advanced Mathematics for Engineering Students', Vol. II & III, S. Viswanathan Publishers Pvt. Ltd, Chennai, 1998

Semester – 2

25CHU221 ENGINEERING CHEMISTRY 5H – 4C

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- To inculcate a sound understanding of water quality parameters and water treatment techniques.
- To impart knowledge on the basic principles and preparatory methods of nanomaterials.
- To introduce the basic concepts and applications of the phase rule and composites.
- To facilitate the understanding of different types of fuels, their preparation, properties, and combustion characteristics.
- To familiarize the students with the operating principles, working processes, and applications of energy conversion and storage devices.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Interpret water quality parameters and treatment methods for domestic and industrial use.	Understand
CO2	Differentiate nanomaterials based on their properties, types, and synthesis techniques.	Analyse
CO3	Analyze phase diagrams and composite material systems with respect to their components and applications.	Apply
CO4	Evaluate fuel types, combustion characteristics, and emission parameters for energy efficiency.	Evaluate
CO5	Compare various energy sources and storage systems based on their principles and applications.	Assess

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	3	1	–	1	–	1	2	1	1	3
CO2	2	3	1	2	2	1	–	–	1	–	2	2	2	1	2
CO3	3	3	2	2	1	1	–	–	1	–	2	3	2	1	3
CO4	3	3	2	2	1	3	1	–	1	–	2	2	3	2	3
CO5	3	2	2	1	1	3	1	–	1	1	3	2	3	2	3

1 - low, 2 - medium, 3 - high

Unit I – WATER AND ITS TREATMENT

Water: Sources and impurities, Water quality parameters: Definition and significance of color, odour, turbidity, pH, hardness, alkalinity, TDS, COD and BOD, fluoride and arsenic. Domestic water treatment: Steps involved - primary treatment and disinfection (UV, Ozonation, breakpoint chlorination). Desalination of brackish water: Electro dialysis- Reverse Osmosis. Boiler troubles: Scale and sludge, Boiler corrosion, Caustic embrittlement, Priming and foaming. Treatment of boiler feed water: Internal treatment (phosphate, colloidal, sodium aluminate, and Calgon conditioning) and External treatment — Ion exchange demineralization process and zeolite process.

Unit II – NANOCHEMISTRY

Basics: Distinction between molecules, nanomaterials and bulk materials; Size-dependent properties (optical, electrical, mechanical and magnetic); Types of nanomaterials: Definition, properties and uses of – nanoparticle, nanocluster, nanorod, nanowire and nanotube-Single walled and Multiwalled Nanotubes- Preparation of nanomaterials: sol-gel, solvothermal, laser ablation, chemical vapour deposition, electrochemical deposition and electro spinning. Applications of nanomaterials in medicine, agriculture, energy, electronics, and catalysis.

Unit III – PHASE RULE AND COMPOSITES

Phase rule: Introduction, definition of terms with examples. One component system – water system; Reduced phase rule; Construction of a simple eutectic phase diagram – Thermal analysis; Two component system: lead-silver system — Pattinson process.

Composites: Introduction: Definition & Need for composites; Constitution: Matrix materials (Polymer matrix, metal matrix, and ceramic matrix) and Reinforcement (fiber, particulates, flakes, and whiskers). Properties and applications of Metal matrix composites (MMC), Ceramic matrix composites (CMC), and Polymer matrix composites (PMC). Hybrid composites – definition and examples.

Unit IV – FUELS AND COMBUSTION

Fuels: Introduction: Classification of fuels; Coal and coke: Analysis of coal (proximate and ultimate), Carbonization, Manufacture of metallurgical coke (Otto Hoffmann method). Petroleum and Diesel: Fractional distillation of Petroleum- Manufacture of synthetic petrol (Fischer–Tropsch and Bergius process), Knocking – octane number, diesel oil – cetane number; Power alcohol and biodiesel. Combustion of fuels: Introduction: Calorific value – higher and lower calorific values, Theoretical calculation of calorific value; Ignition temperature: spontaneous ignition temperature, Explosive range; Flue gas analysis – ORSAT Method. CO_2 emission and carbon footprint.

Unit V – ENERGY SOURCES AND STORAGE DEVICES

Stability of nucleus: mass defect (problems), binding energy; Nuclear energy: light water nuclear power plant, breeder reactor. Solar energy conversion: Principle, working, and applications of solar cells; Recent developments in solar cell materials. Wind energy; Geothermal energy; Batteries: Types of batteries, Primary battery – dry cell, Secondary battery – NICAD battery, lead acid battery, and lithium-ion battery; Electric vehicles – working principles; Fuel cells: H_2-O_2 fuel cell, microbial fuel cell; Super capacitors: Storage principle, types and examples.

SUGGESTED READINGS

1. P. C. Jain and Monica Jain.(2018). Engineering Chemistry, 17th Edition, Dhanpat Rai Publishing Company (P) Ltd, New Delhi.

2. Sivasankar B.(2008). Engineering Chemistry, Tata McGraw-Hill Publishing Company Ltd, New Delhi.

3. S.S. Dara.(2018). A Textbook of Engineering Chemistry, S. Chand Publishing, 12th Edition.

4. Dr. Sayeeda Sultana (2016). Engineering Chemistry, R.K. Publishers, Coimbatore.

5. B. S. Murty, P. Shankar, Baldev Raj, B. B. Rath and James Murday. (2018). Textbook of Nanoscience and Nanotechnology, Universities Press-IIM Series in Metallurgy and Materials Science.

6. Dr. Sayeeda Sultana, (2016). Practical Engineering Chemistry laboratory manual, R.K. Publishers, Coimbatore.

Semester – 2

25ITU222 DATA STRUCTURES 5H – 4C

Instruction Hours / week: L: 3 T: 0 P: 2

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Familiarize the concepts of ADT Linear Data Structure
- Acquaint knowledge in Linear and Non-Linear Data Structures
- Gain knowledge on the fundamentals of Trees
- Describe the various Graph operations on real-world problems
- Apply the Hashing techniques

Course Outcomes (COs)

At the completion of the course, the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Define linear data structures and apply them in real problems	Remember
CO2	Implement linear Data structures like Stack, queue, and deque	Create
CO3	Use appropriate Non-Linear data structure tree to solve a real-world problem	Analyze
CO4	Decide appropriate graph algorithm for graph applications	Evaluate
CO5	Analyze and apply various hashing functions	Analyze

CO-PO Mapping

CO / PO	PO1	PO 2	PO3	PO4	PO5	PO 6	PO7	PO8	PO 9	PO10	PO1 1	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	3	1	–	1	–	1	2	1	1
CO2	2	3	1	2	2	1	–	–	1	–	2	2	2	1
CO3	3	3	2	2	1	1	–	–	1	–	2	3	2	1
CO4	3	3	2	2	1	3	1	–	1	–	2	2	3	2
CO5	3	2	2	1	1	3	1	–	1	1	3	2	3	2

1 - low, 2 - medium, 3 - high Unit

I: LISTS

Basic Terminologies: Elementary Data Organizations, Data Structure Operations: insertion, deletion. traversal, etc.; Abstract Data Types (ADTs) – List ADT – Array-based implementation – Linked list implementation – Singly-linked lists – Circularly linked lists – Doubly-linked lists – Applications of lists – Polynomial ADT – Radix Sort – Multilists

Unit II: STACKS, QUEUES AND DEQUE

Stack ADT – Operations – Applications – Balancing Symbols – Evaluating arithmetic expressions- Infix to Postfix conversion – Function Calls – Queue ADT – Operations – Circular Queue – DeQueue Applications of Queues- Deque ADT – Operations- Applications

Unit III: TREES

Tree ADT – Tree Traversals - Binary Tree ADT – Expression trees – Binary Search Tree ADT – AVL Trees – Red Black Trees- B+ Tree – Priority Queue (Heaps) – Binary Heap.

Unit IV: GRAPHS

Graph Definition – Representation of Graphs – Types of Graphs - Breadth-first traversal – Depth-first traversal – – Bi-connectivity – Euler circuits – Topological Sort – Dijkstra's algorithm – Bellman Ford Algorithm – Minimum Spanning Tree – Prim's algorithm – Kruskal's algorithm

Unit V: HASHING TECHNIQUES

Hashing – Hash Functions – Separate Chaining – Open Addressing – Rehashing – Extendible Hashing- Double Hashing – Load Factor and Rehashing

PRACTICAL EXERCISES:

1. Implementation of Singly Linked List
2. Implementation of Doubly Linked List
3. Implementation of Circular Linked List
4. Array implementation of Stack, Queue and Circular Queue ADTs
5. Linked list implementation of Stack and Linear Queue ADTs
6. Linked List implementation of Deque
7. Implementation of Evaluating Postfix Expressions, Infix to Postfix conversion
8. Implementation of Binary Search Trees
9. Implementation of AVL Trees
10. Implementation of Heaps using Priority Queues
11. Implementation of Dijkstra's Algorithm,
12. Implementation of Prim's and Kruskals
13. Implementation of Open Addressing (Linear Probing and Quadratic Probing)
14. Implementation of intersection of two arrays
15. Implementation of longest subarray with equal number of 0's and 1's in a binary array

SUGGESTED READINGS

1. Michael T. Goodrich, Roberto Tamassia, and Michael H. Goldwasser Data Structures and Algorithms in Python Wiley 2013
2. Liang D Y, Introduction To Python Programming And Data Structures 3/Ed Pearson Education, 2022
3. Shriram K Vasudevan, Abhishek S Nagarajan , Karthick Nanmaran,Data Structures Using Python Oxford university Press 2021
4. Kent D. Lee, Data Structures and Algorithms with Python: With an Introduction to Multiprocessing Springer 2024
5. https://www.w3schools.com/dsa/dsa_intro.php

Semester – 2

25MEU201 **ENGINEERING MECHANICS** **4H – 4C**

Instruction Hours / week: L: 3 T: 1 P: 0

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Learn the use scalar and vector analytical techniques for analysing forces in statically determinate structures.
- Introduce the equilibrium of rigid bodies, vector methods and free body diagram.
- Study and understand the distributed forces, surface, loading on beam and intensity.
- Learn the principles of friction, forces and to determine the apply the concepts of frictional
- forces at the contact surfaces of various engineering systems.
- Develop basic dynamics concepts – force, momentum, work and energy.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Illustrate the vector and scalar representation of forces and moments.	Understand
CO2	Analyze the rigid body in equilibrium.	Analyze
CO3	Evaluate the properties of surfaces and solids.	Evaluate
CO4	Analyze trusses by different methods.	Analyze
CO5	Determine the friction and the effects according to the laws of friction and solve problems based on frictioanl force.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	–	–	–	1	–	1	2	1	1
CO2	3	3	2	2	1	–	–	–	1	–	2	3	2	1
CO3	3	2	2	2	1	–	–	–	1	–	2	2	2	1
CO4	3	3	2	2	1	–	–	1	1	–	2	3	2	1
CO5	3	3	2	2	1	1	–	–	1	–	2	2	3	1

1 - low, 2 - medium, 3 - high

Unit I – BASICS AND STATICS OF PARTICLES

Introduction – Units and Dimensions – Laws of Mechanics – Lami's theorem, Parallelogram and triangular Law of forces – Vectorial representation of forces – Vector operations of forces -additions, subtraction, dot product, cross product – Coplanar Forces – rectangular components – Equilibrium of a particle – Forces in space – Equilibrium of a particle in space – Equivalent systems of forces – Principle of transmissibility.

Unit II – EQUILIBRIUM OF RIGID BODIES

Free body diagram – Types of supports –Action and reaction forces –stable equilibrium – Moments and Couples – Moment of a force about a point and about an axis – Vectorial representation of moments and couples – Scalar components of a moment – Varignon's theorem – Single equivalent force -Equilibrium of Rigid bodies in two dimensions – Equilibrium of Rigid bodies in three dimensions.

Unit III – PROPERTIES OF SURFACES AND SOLIDS PROJECTION OF SOLIDS

Centroids and centre of mass– Centroids of lines and areas - Rectangular, circular, triangular areas by integration – T section, I section, - Angle section, Hollow section by using standard formula –Theorems of Pappus - Area moments of inertia of plane areas – Rectangular, circular, triangular areas by integration – T section, I section, Angle section, Hollow section by using standard formula – Parallel axis theorem and perpendicular axis theorem –Principal moments of inertia of plane areas – Principal axes of inertia-Mass moment of inertia –mass moment of inertia for prismatic, cylindrical and spherical solids from first principle – Relation to area moments of inertia.

Unit IV – TRUSSES
Plane trusses – method of joints – method of sections – tension coefficient method.

Unit V – FRICTION
Friction force – Laws of sliding friction – equilibrium analysis of simple systems with sliding friction – wedge friction- characteristics of dry friction – problems involving dry friction

SUGGESTED READINGS

1. Beer, F.P and Johnston Jr. E.R., "Vector Mechanics for Engineers (In SI Units): Statics and Dynamics", 12th Edition, Tata McGraw-Hill Publishing company, New Delhi (2019).
2. Hibbeller, R.C and Ashok Gupta, "Engineering Mechanics: Statics and Dynamics", 14th Edition,Pearson Education (2015).
3. Vela Murali, "Engineering Mechanics-Statics and Dynamics", Oxford University Press, 2018
4. Irving H. Shames and Krishna Mohana Rao. G., "Engineering Mechanics – Statics and Dynamics", International Edition, Pearson Education (2015).

Semester – 2

25MEU202 ENGINEERING MATERIALS AND METALLURGY 3H –3C

Instruction Hours / week: L: 3 T: 0P: 0

Marks: Internal: **40**External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Be aware of Microstructure, mechanical properties and various methods to quantify their mechanical integrity and failure criteria.
- Acquire knowledge on construction and detailed interpretation of equilibrium phase diagrams.
- Learn the heat treatment, testing and applications of metals and non-metallic materials so as to identify and select suitable materials for various engineering applications.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Build the phase diagram and select appropriate heat treatment methods to tailor the properties of Fe-C alloys.	Apply
CO2	Calibrate and adapt various engineering materials based on their mechanical properties	Apply
CO3	Construct material properties of ferrous and non-ferrous alloys for their uses in engineering field	Apply
CO4	Adapt the different polymer, ceramics and composites and their uses in engineering field.	Understand
CO5	Adapt the various testing procedures and failure mechanism in engineering field.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	1	1	–	–	1	–	2	3	2	1
CO2	3	2	2	2	1	1	–	–	1	–	2	2	3	1
CO3	3	3	2	2	1	1	–	–	1	–	2	3	2	2
CO4	2	2	1	1	1	2	–	–	1	–	2	2	2	1
CO5	2	3	1	3	2	1	–	–	1	–	2	2	3	1

1 - low, 2 - medium, 3 - high

Unit I – ALLOYS AND PHASE DIAGRAMS

Constitution of alloys – Solid solutions, substitutional and interstitial – phase diagrams, Isomorphous, eutectic, eutectoid, peritectic, and peritectoid reactions, Iron – carbon equilibrium diagram. Classification of steel and cast Iron microstructure, properties and application. Mechanism of Crystallization- Nucleation- Homogeneous and Heterogeneous Nucleation- Growth of crystals- Planar growth – dendritic growth.

Unit II – HEAT TREATMENT

Definition – Full annealing, stress relief, recrystallisation and spheroidising – normalising, hardening and Tempering of steel. Isothermal transformation diagrams – cooling curves superimposed on I.T. diagram CCR – Hardenability, Jominy end quench test - Austempering, martempering – case hardening, carburizing, Nitriding, cyaniding, carbonitriding – Flame and Induction hardening – Vacuum and Plasma hardening.

Unit III – FERROUS AND NON-FERROUS METALS

Effect of alloying additions on steel- α and β stabilisers– stainless and tool steels – HSLA, Maraging steels – Cast Iron - Grey, white, malleable, spheroidal – alloy cast irons, Copper and copper alloys – Brass, Bronze and Cupronickel – Aluminium and Al-Cu – precipitation strengthening treatment – Bearing alloys, Mg-alloys, Ni-based super alloys and Titanium alloys.

Unit IV – NON-METALLIC MATERIALS

Polymers – types of polymer, commodity and engineering polymers – Properties and applications of various thermosetting and thermoplastic polymers (PP, PS, PVC, PMMA, PET, PC, PA, ABS, PI, PAI, PPO, PPS, PEEK, PTFE, Polymers – Urea and Phenol formaldehydes)- Engineering Ceramics – Properties and applications of Al2O3, SiC, Si3N4, PSZ and SIALON – Composites-Classifications- Metal Matrix and FRP - Applications of Composites.

Unit V – MECHANICAL PROPERTIES AND DEFORMATION MECHANISMS

Mechanisms of plastic deformation, slip and twinning – Types of fracture – Testing of materials under tension, compression and shear loads – Hardness tests (Brinell, Vickers and Rockwell), hardness tests, Impact test lzod and charpy, fatigue and creep failure mechanisms.

SUGGESTED READINGS

1. Avner S.H "Introduction to Physical Metallurgy",Tata Mcgraw -Hill Company (2008).
2. Williams D.Callister "Material Science and Engineering: An Introduction", Wiley India Pvt. Ltd, Revised Indian Edition (2018).
3. Raghavan V"Materials Science and Engineering", Prentice Hall of India Pvt. Ltd. (2015).
4. Kenneth G. Budinski and Michael K. Budinski "Engineering Materials: Properties and Selection", Pearson India Education, 9thIndian Reprint (2016).

Semester – 2

25IKS001 INTRODUCTION TO INDIAN KNOWLEDGE SYSTEM 2H – 2C

Instruction Hours / week: L: 2 T: 0 P: 0

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

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Course Objectives

- To introduce students to the foundational concepts of the Indian Knowledge System (IKS)
- To explore the relevance and applications of IKS in contemporary times.
- To promote interdisciplinary learning through the integration of traditional Indian knowledge and modern education.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Describe the meaning, scope, and philosophical foundations of IKS	Remembering
CO2	Summarize the features of Indian education, language, and literary contributions	Understanding
CO3	Illustrate traditional Indian scientific and technological advancements	Applying
CO4	Examine the impact of Indian art, aesthetics, and socio-cultural practices	Analyzing
CO5	Evaluate the relevance and application of IKS in contemporary society	Evaluating

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	PO11	PSO1	PSO2	PSO3
CO1	1	1	–	–	–	2	3	–	2	–	2	1	1	–
CO2	1	1	–	1	–	2	3	1	2	–	2	1	1	–
CO3	2	2	1	1	1	2	2	1	2	–	2	1	2	1
CO4	1	2	–	2	–	3	3	1	2	–	2	1	1	–
CO5	2	2	1	2	1	3	3	1	2	1	3	1	2	1

1 - low, 2 - medium, 3 - high

Unit I: FOUNDATIONS OF INDIAN KNOWLEDGE SYSTEM

Meaning and Scope of IKS-Historical evolution and literary sources: Vedas, Upanishads, Puranas-Philosophical foundations: Darshanas (Nyaya, Vaisheshika, Samkhya, Yoga, Mimamsa, Vedanta)-Interdisciplinary nature of IKS.

Unit II: EDUCATION, LANGUAGE, AND LITERATURE

Traditional education systems: Gurukula, Pathashalas-Higher education: Nalanda, Takshashila-Role of Sanskrit and regi1onal languages-Contributions of Panini, Bhartrihari-Epics and classical literature.

Unit III: SCIENCE AND TECHNOLOGY IN IKS

Mathematics: Sulbasutras, Aryabhata, Bhaskara-Astronomy: Surya Siddhanta-Ayurveda: Tridosha, healing systems-Metallurgy, Vastu Shastra, water management.

Unit IV: INDIAN ART, CULTURE, AND SOCIETY

Music, dance, painting, sculpture-Rasa theory, Natya Shastra-Festivals, rituals, socio-cultural life- Dharma, Purusharthas, social organization.

Unit V: CONTEMPORARY RELEVANCE AND APPLICATIONS OF IKS

IKS in modern education and research-Sustainable practices in agriculture, ecology, lifestyle-Yoga and meditation in wellness-Role of IKS in national identity and global relevance.

SUGGESTED READINGS

1. Kapil Kapoor (Ed.) – *Encyclopedia of Hinduism*, Rupa Publications, Comprehensive overview of philosophical and literary foundations of IKS.
2. Michel Danino – *The Indian Mind: A Cultural and Philosophical Perspective*, DK Printworld-Offers insight into Indian civilization's unique philosophical frameworks and relevance today.
3. V. Sivaramakrishnan (Ed.) – *Cultural Heritage of India*, Ramakrishna Mission Institute of Culture- Multi-volume work covering various aspects of Indian science, arts, literature, and education.
4. Subhash Kak, David Frawley & N.S. Rajaram – *In Search of the Cradle of Civilization*, Motilal Banarsidass-Discusses early Indian contributions to science, mathematics, and cosmology.
5. Bharatiya Vidya Bhavan Series – *History and Culture of Indian People*-A classic multi-volume series offering a deep dive into ancient Indian education, society, arts, and sciences.
6. Debroy, Bibek – *The Bhagavad Gita, Upanishads, and the Vedas (Translations)*-For primary source reading and understanding scriptural references in IKS.
7. R. Balasubramanian (Ed.) – *The Bloomsbury Research Handbook of Indian Epistemology and Metaphysics*
8. Yoga Sutras of Patanjali (Various commentaries) – for insights into yoga, wellness, and consciousness studies.

Semester – 2

25MEU211 **DESIGN THINKING AND INNOVATIONS LAB** **3H – 2C**

Instruction Hours / week: L: 1 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Introduce the basic principles and phases of design thinking to solve real-world problems.
- Encourage creativity and innovation through hands-on learning and teamwork.
- Provide foundational skills in plumbing, carpentry, welding, machining, sheet metal, and basic electrical/electronic practices.
- Integrate design thinking with mechanical, electrical, and electronic fabrication techniques to develop simple and functional design solutions.
- Enable students to apply their learning in an innovation project that emphasizes planning, design, development, and presentation...

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Apply design thinking principles to identify and solve real-world problems.	Apply
CO2	Demonstrate basic plumbing and carpentry skills through simple model creation.	Apply
CO3	Develop welding, machining, and sheet metal fabrication skills.	Apply
CO4	Construct basic electrical and electronic circuits for design applications.	Apply
CO5	Execute an innovation project by integrating skills from all units to build and present a working prototype.	Create

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	2	1	2	2	1	2	2	2	1
CO2	2	2	3	1	2	1	2	2	1	1	2	3	1	1
CO3	3	3	3	2	2	1	2	2	1	1	2	3	2	1
CO4	3	2	3	2	3	1	2	2	1	1	2	2	3	2
CO5	3	3	3	3	3	2	2	3	3	2	3	3	3	2

1 - low, 2 - medium, 3 - high

INTRODUCTION TO DESIGN THINKING:

Definition and importance of Design Thinking- Comparison with traditional problem-solving approaches Key principles: Empathy, Experimentation, and Iteration- Problem Reframing techniques to identify innovative opportunities- Discussion and demo on Design Thinking stages and examples- Team activity to understand user needs and define problems

- **PART A: MECHANICAL PRACTICES**

1. Demonstration of pipe joints and wood connections
2. Creation of a simple model using plumbing and carpentry components
3. Arc and gas welding techniques
4. Safety practices in metalworking
5. Basic machining operations (turning, drilling)
6. Sheet metal forming: bending, joining, and component design
7. Fabrication of small metal parts like trays or holders

- **PART B: ELECTRICAL AND ELECTRONICS PRACTICES**

1. Introduction to basic residential wiring: switches, fuses, indicators, and energy meters
2. Wiring of simple lighting circuits (fluorescent, staircase wiring)
3. Study of basic electronic components: resistors, logic gates
4. Introduction to soldering and basic circuit assembly
5. Discussion and demo on simple wiring and soldering
6. Hands-on activity: build a basic electrical/electronic setup for design integration

- **PART C: INNOVATION PROJECT (Integrated Design and Development)**

Application of design thinking in an innovation project - Planning, designing, and building a functional prototype-Integration of mechanical, electrical, and electronic fabrication techniques- Emphasis on creativity, teamwork, and presentation skills

SUGGESTED READINGS

1. Rolf Faste, Design Thinking: Understanding How Designers Think and Work, Springer, 2013.
2. S. K. Hajra Choudhury, A. K. Hajra Choudhury & Nirjhar Roy, Elements of Workshop Technology – Volume 1: Manufacturing Processes, Media Promoters, 2020.
3. K. J. Vinoy & M. Gokhale, Basic Electrical and Electronics Engineering, Wiley India, 2015.
4. Tim Brown, Change by Design: How Design Thinking Creates New Alternatives for Business and Society, Harvard Business Review Press, 2009.
5. Ramesh Babu, Basic Electrical and Electronics Engineering, Scitech Publications, 2021.

Semester – 2

25MAC201 **INDIAN CONSTITUTION AND HUMAN RIGHTS** **2H – 2C**

Instruction Hours / week: L: 2 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives.

- To underline the significance of our Constitution as Fundamental Law of the land and its features.
- To respect human rights, rule of law and democracy.
- To gain In-depth insight into the constitutional, statutory To create the basic philosophical tenets of Indian Constitution and Human Rights.
- and institutional aspects of human rights protection in India.
- To identify the constitutional provisions dealing with human rights and special legislations dealing with protection of vulnerable and marginalized groups.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	**Course Outcomes**	**Blooms Level**
CO1	Demonstrate the provisions under the Constitution of India dealing with human rights	Remember
CO2	Display the nature and scope of special legislations dealing with protection of human rights of marginalized and vulnerable sections.	Understand
CO3	Apply practically human rights law to specific human rights problems in India	Apply
CO4	Analyze complex human rights problems and apply relevant provisions of human rights law in India to a hypothetical situation/case study..	Analyze
CO5	Acquainted with the theoretical knowledge of the underpinnings of the human rights framework in India, its operation and issues associated with its implementation.	Create

CO-PO Mapping

CO / PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	–	–	–	2	3	–	2	–	2	1	–	–
CO2	1	2	1	1	–	3	3	1	2	–	2	1	1	–
CO3	2	3	2	2	1	3	3	1	2	–	2	1	1	1
CO4	2	3	2	3	1	3	3	1	2	1	2	1	2	1
CO5	2	2	1	2	1	3	3	1	2	1	3	1	2	1

1 - low, 2 - medium, 3 - high

Unit I THE CONSTITUTION

Definition and Principles of the Constitution – Socio, Economic and Political Conditions in India at the time of Independence – Contents and Amendments to the Constitution.

Unit II FUNDAMENTAL RIGHTS

Historical Perspectives on Rights in India – Fundamental Rights in India – Provisions in Articles 14 to 32 and its implications on Human Rights – Right against unlawful detention.

Unit III - DUTIES, DIRECTIVE PRINCIPLES AND AFFIRMATIVE ACTIONS

Fundamental Duties of a citizen in India - Directive Principles - Policy and Practices in Reservation – Affirmative Actions: Special Provisions for SCs and STs.

Unit IV- PROTECTION OF WEAKER SECTIONS OF SOCIETY

Constitutional Provisions for the Protection of women and children - Safeguard for the Labours - Minorities – Tribals.

Unit V - ENFORCEMENT MECHANISM AND EVALUATION

Protection of Human Rights Act 1993 – National and State Human Rights Commissions – Role of Judiciary in Human Rights Protection – Critical Appraisal of the Current Status of Human Rights in India – AFSPA.

SUGGESTED READINGS

1. Desai, A.R. (ed.) (1986), Violations of Democratic Rights in India, Bombay: Popular Prakashan.
2. Meghraj Kapurderiya (2013) Indian Philosophical Foundation of Human Rights, New Delhi: R.P. Publications.
3. Mishra, P.K. (2012) Human Rights: Human Rights: Acts, Statues and Constitutional Provisions, Jaipur: Ritu Publications.
4. Satish Chandra (1995) Minorities in National And International Laws, New Delhi: Deep and Deep Publications.

Semester – 3

25MAU301 **NUMERICAL METHODS** **4H – 4C**

Instruction Hours / week: L: 3 T: 1 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Gain knowledge of determining Eigen values and Eigen vectors.
- Aims at providing the necessary basic concepts of a few numerical methods
- Give procedures for solving numerically different kinds of problems occurring in engineering and technology.
- Understand ODE and solve the same.
- Understand boundary value problems.

Course Outcomes (COs)

At the completion of the course the student will be able to

COs	**Course Outcomes**	**Blooms Level**
CO1	Examine the Eigen value problems.	Evaluate
CO2	Identify interpolation and approximations	Analyze
CO3	Design to use numerical differentiation and integrations.	Create
CO4	Adapt the Initial value problem in Differential equations.	.Apply
CO5	Adapt the boundary value problem in Differential equations.	.Apply

CO-PO Mapping

CO / PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**P09**	**P10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	1	2	2	–	–	–	1	–	2	3	2	1
CO2	3	3	1	2	2	–	–	–	1	–	2	2	3	1
CO3	3	3	2	3	3	–	–	–	1	–	2	3	3	2
CO4	3	3	2	2	2	–	–	–	1	–	2	3	2	2
CO5	3	3	2	2	2	–	–	–	1	–	2	3	2	2

1 - low, 2 - medium, 3 - high

Unit I: SOLUTION OF EQUATIONS AND EIGENVALUE PROBLEM

Solution of algebraic and transcendental equations - Fixed point iteration method – Newton Raphson method- Solution of linear system of equations - Gauss elimination method – Pivoting - Gauss Jordan method – Iterative methods of Gauss Jacobi and Gauss Seidel - Matrix Inversion by Gauss Jordan method - Eigen values of a matrix by Power method.

Unit II: INTERPOLATION AND APPROXIMATION

Interpolation with unequal intervals - Lagrange's interpolation – Newton‟s divided difference interpolation – Cubic Splines - Interpolation with equal intervals - Newton‟s forward and backward difference formulae.

Unit III: NUMERICAL DIFFERENTIATION AND INTEGRATION

Approximation of derivatives using interpolation polynomials - Numerical integration using Trapezoidal, Simpson‟s 1/3 rule – Romberg‟s method - Two point and three point Gaussian quadrature formulae – Evaluation of double integrals by Trapezoidal and Simpson‟s 1/3 rules.

Unit IV: INITIAL VALUE PROBLEMS FOR ORDINARY DIFFERENTIAL EQUATIONS

Single Step methods - Taylor"s series method - Euler"s method - Modified Euler"s method - Fourth order Runge-Kutta method for solving first order equations - Multi step methods - Milne"s and Adams- Bash forth predictor corrector methods for solving first order equations.

Unit V: BOUNDARY VALUE PROBLEMS IN ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS

Finite difference methods for solving two-point linear boundary value problems - Finite difference techniques for the solution of two dimensional Laplace"s and Poisson"s equations on rectangular domain – One dimensional heat flow equation by explicit and implicit (Crank Nicholson) methods – One dimensional wave equation by explicit method.

SUGGESTED READINGS

1. Grewal. B.S., and Grewal. J.S., "Numerical methods in Engineering and Science", Khanna Publishers, 9th Edition, New Delhi, 2007.
2. Gerald. C. F., and Wheatley. P. O., "Applied Numerical Analysis", Pearson Education, Asia, 6th Edition, New Delhi, 2006.
3. Chapra. S.C., and Canale.R.P., "Numerical Methods for Engineers, Tata McGraw Hill, 5th Edition, New Delhi, 2007.
4. Brian Bradie. "A friendly introduction to Numerical analysis", Pearson Education, Asia, New Delhi, 2007.
5. Sankara Rao. K., "Numerical methods for Scientists and Engineers", Prentice Hall of India Private, 3rd Edition, New Delhi, 2007.

Semester – 3

25UHV001 **UNIVERSAL HUMAN VALUES AND ETHICS** **2H – 2C**

Instruction Hours / week: L: 2 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Understand the need, basic guidelines, content, and process of value education.
- Develop right understanding and relationship at all levels of living.
- Understand harmony in the human being, family, society, and nature.
- Relate the holistic understanding with professional ethics.
- Apply value-based principles in personal and professional life.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Demonstrate understanding of the holistic development of a human being.	Understand
CO2	Distinguish between physical needs and the needs of the self.	Analyze
CO3	Apply human values in family and societal interactions.	Apply
CO4	Analyze nature and existence in terms of mutual harmony and co-existence.	Analyze
CO5	Integrate ethical human conduct in their professional practice.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	–	–	–	2	3	1	2	–	2	1	1	–
CO2	1	2	–	1	–	2	3	1	2	–	2	1	1	–
CO3	1	2	2	1	–	3	3	2	2	1	2	1	2	1
CO4	1	3	1	2	–	3	3	1	2	–	2	1	2	1
CO5	2	2	2	1	1	3	3	2	2	1	3	1	2	1

1 - low, 2 - medium, 3 - high

Unit I – INTRODUCTION TO VALUE EDUCATION

Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education) Understanding Value Education, Self-exploration as the Process for Value Education, Continuous Happiness and Prosperity – the Basic Human Aspirations, Happiness and Prosperity – Current Scenario, Method to Fulfil the Basic Human Aspirations.

Unit II – HARMONY IN THE HUMAN BEING

Understanding Human being as the Co-existence of the Self and the Body, Distinguishing between the Needs of the Self and the Body, The Body as an Instrument of the Self, Understanding Harmony in the Self, Harmony of the Self with the Body, Programme to ensure self-regulation and Health.

Unit III – HARMONY IN THE FAMILY AND SOCIETY

Harmony in the Family – the Basic Unit of Human Interaction, 'Trust' – the Foundational Value in Relationship, 'Respect' – as the Right Evaluation, Other Feelings, Justice in Human-to-Human Relationship, Understanding Harmony in the Society, Vision for the Universal Human Order.

Unit IV – TREES AND GRAPHS

Understanding Harmony in the Nature, Interconnectedness, self-regulation and Mutual Fulfilment among the Four Orders of Nature, Realizing Existence as Co-existence at All Levels, The Holistic Perception of Harmony in Existence.

Unit V – IMPLICATIONS OF THE HOLISTIC UNDERSTANDING – A LOOK AT PROFESSIONAL ETHICS.

Natural Acceptance of Human Values, Definitiveness of (Ethical) Human Conduct, A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order, Competence in Professional Ethics Holistic Technologies, Production Systems and Management Models-Typical Case Studies, Strategies for Transition towards Value-based Life and Profession.

SUGGESTED READINGS

1. Gaur, R.R., Sangal, R., & Bagaria, G.P., A Foundation Course in Human Values and Professional Ethics, Publisher: Excel Books, New Delhi, 2022.
2. Sharma, S. B., Education for Values, Environment and Human Rights, Publisher: Lotus Press, New Delhi, 2022
3. Pathania, A. , Value Education: Perspectives and Practices, Pearson Education India, 2023
4. The Textbook A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034- 47-1
5. Gaur, R.R., Sangal, R., & Bagaria, G.P., A Foundation Course in Human Values and Professional Ethics, Publisher: Excel Books, New Delhi, 2022.
6. Schumacher, E.F. , Small is Beautiful: A Study of Economics as if People Mattered, Random House UK / Vintage publisher, 2022
7. Dhar, P.L. & Gaur, R.R, Science and Humanism, Publisher: Commonwealth Publishers, New Delhi, 2023
8. Sharma, R.N., Human Values and Professional Ethics, Kalyani Publishers, 2022
9. http://www.mhrd.gov.in – Ministry of Education, Govt. of India.
10. http://www.uhv.org.in – Universal Human Values initiative.
11. https://www.aiu.ac.in – Association of Indian Universities: Value Education resources.

Semester – 3

25MEU301 **MANUFACTURING TECHNOLOGY** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Concepts of casting Technology, Mechanical working of metals
- Theory of metal cutting and cutting tools,
- Gear manufacturing and surface finishing processes, Milling machine and other machine tools

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Familiarize with casting processes, tools and various types.	Remember
CO2	Differentiate various metal forming processes such as Hot and Cold Working, Rolling, Forging, Extrusion and Drawing Processes	Analyze
CO3	Understand and compare the functions and applications of different metal cutting tools.	Understand
CO4	Know different metal removal, finishing and super finishing processes for component production.	Remember
CO5	Demonstrate operation such as Turning, Facing, Threading, Knurling and Grooving on miller, Shaper, Slotter, Plannerand Boring machine.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	1	1	1	1	–	–	1	–	1	2	1	1
CO2	3	3	2	2	1	1	–	–	1	–	2	3	2	1
CO3	3	2	2	1	2	1	–	–	1	–	2	2	3	1
CO4	2	2	1	1	2	1	–	–	1	–	1	2	2	1
CO5	3	3	3	2	3	1	1	1	1	1	2	3	3	2

1 - low, 2 - medium, 3 - high

Unit I – CASTING

Introduction to Casting-Patterns and its types and Materials - Pattern Allowances- Moulding and its types-Moulding sand-Gates and Risers-Numerical problems on pouring time and Caine's rule Cores, Core making-Shell casting, Investment Casting-Die casting, Centrifugal Casting.

Unit II – MECHANICAL WORKING OF METALS

Introduction to Hot and Cold Working-Hot and Cold Rolling-Types of rolling viz. Two, three,four multi and Universal rolling- Open die and Closed die forging, Wire drawing- Hot, Cold Forward, backward and tube extrusion-Shearing, Piercing, Trimming and Stretch forming-Theory of Bending, Bending length and Bending force-calculations- Drawing, Blank size and drawing force calculations-Tube forming, Embossing and coining-Progressive, Compound and Combination dies and defects in forming.

Unit III – THEORY OF METAL CUTTING

Orthogonal and oblique cutting-classification of cutting tools namely single point, and Multipoint-tool signature for single point cutting tool-Mechanics of orthogonal cutting and Force relationship-Merchant Circle and Determination of shear angle- Chip formation. Cutting tool materials Tool wear and Taylor's tool life calculation- machinability and Cutting Fluids-- Biodegradable and eco-friendly cutting fluids: usage and impact.

Unit IV – MACHINE TOOLS

Classification of Milling Machines and its basic construction- Types of cutters in Milling machines- Types of milling operations(up and down, peripheral, face milling)- Simple and differential Indexing methods and its calculations- Shaping and slotting Machine, Its description and Operations- Planers: Double house and open side, Quick return mechanism- Work and tool holding Devices- Boring machine and its Specification, operations, Jig boring machine- Specification of Broaching machine, its types and operations (internal, surface)- Tool nomenclature of broaching tool- Waste reduction and material efficiency in shaping, milling, and gear cutting.

Unit V – GEAR MANUFACTURING & SURFACE FINISHING PROCESS 9Hrs.

Gear Manufacturing viz Extrusion, Stamping and Powder Metallurgy-Gear Machining, Forming, Spur and Helical in milling machine- Gear Generating: Gear shaping, Gear hobbing-Grinding process, Types of Grinding machines viz. Surface,Cylindrical and Centreless Grinding Wheel and its types, Grinding specifications and type of abrasive bonds- Selection of Cutting speed and work speed, dressing and truing- Lapping, Buffing - Honing, and Super finishing- Development and use of sustainable abrasive materials.

SUGGESTED READINGS

1. Hajra Choudhury "Elements of Workshop Technology", Vol.II & Vol.II., Media Promoters.
2. Rao. P.N "Manufacturing Technology - Metal Cutting and Machine Tools",
3. Tata McGraw-Hill, New Delhi (2003).
4. Richerd R Kibbe, John E. Neely, Roland O. Merges and Warren J.White
5. "Machine Tool Practices", Prentice Hall of India (1998).

Semester – 3

25MEU302 **ENGINEERING THERMODYNAMICS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Learn the principles of thermodynamics and its role to analyse the bulk behavior of simple physical systems.
- Acquire knowledge on thermodynamics of state, basic thermodynamic relations, Properties of pure substances.
- Impart the basic concepts of steam formation and its thermodynamic properties.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Apply the zeroth and first law of thermodynamics by formulating temperature scales and calculating the property changes in closed and open engineering systems.	Apply
CO2	Analyze the performance of thermal devices through energy and entropy calculations by applying the second law of thermodynamics.	Analyze
CO3	Evaluate the various properties of steam using steam tables and Mollier chart.	Evaluate
CO4	Compute the macroscopic properties of ideal and real gases using gas laws and appropriate thermodynamic relations.	Apply
CO5	Apply the properties of gas mixtures in calculating the properties of gas mixtures and applying various thermodynamic relations to calculate property changes.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	2	3	2	1
CO2	3	3	2	3	2	2	–	–	1	–	2	3	3	2
CO3	3	2	1	2	2	1	–	–	1	–	2	2	3	1
CO4	3	3	2	2	2	1	–	–	1	–	2	3	2	2
CO5	3	3	2	2	2	1	–	–	1	–	2	3	3	2

1 - low, 2 - medium, 3 - high

Unit I – BASICS, ZEROTH AND FIRST LAW

Review of Basics – Thermodynamic systems, Properties and processes Thermodynamic Equilibrium - Displacement work - P-V diagram. Thermal equilibrium - Zeroth law – Concept of temperature and Temperature Scales. First law – application to closed and open systems – steady and unsteady flow processes.

Unit II – SECOND LAW AND ENTROPY

Heat Engine – Refrigerator - Heat pump, statements of Second Law and their equivalence &Corollaries. Carnot Cycle - Reversed Carnot Cycle - Performance - Clausius inequality. Concept of Entropy - T-S diagram - Tds Equations - Entropy change for a pure substance.

Unit III – AVAILABILITY AND APPLICATIONS OF II LAW

Ideal gases undergoing different processes - principle of increase in entropy. Applications of II Law. High and low grade energy. Availability and Irreversibility for open and closed system processes - I and II law Efficiency.

Unit IV – PROPERTIES OF PURE SUBSTANCES

Steam - formation and its thermodynamic properties - p-v, p-T, T-v, T-s, h-s diagrams. PVT surface. Determination of dryness fraction. Calculation of work done and heat transfer in non-flow and flow processes using Steam Table and Mollier Chart.

Unit V – GAS MIXTURES AND THERMODYNAMIC RELATIONS

Properties of Ideal gas, real gas - comparison. Equations of state for ideal and real gases. Wander Waal's relation - Reduced properties - Compressibility factor - Principle of Corresponding states - Generalized Compressibility Chart. Maxwell relations - Tds Equations - heat capacities relations - Energy equation, Joule-Thomson experiment - Clausius- Clapeyron equation. Vapours power cycle and thermodynamic relations.

SUGGESTED READINGS

1. Nag. P.K. "Engineering Thermodynamics", 6th Edition, Tata McGraw Hill Publishing Co. New Delhi (2017).
2. Rathakrishnan E. "Fundamentals of Engineering Thermodynamics", 2nd Edition, Prentice Hall of India Pvt. Ltd.(2006).
3. Venkatesh. A "Basic Engineering Thermodynamics", Universities Press (India) Limited (2007).
4. Holman.J.P"Thermodynamics", 3rd Edition, Tata McGraw Hill Publishing Co., New Delhi (2007).

Semester – 3

25MEU303 **KINEMATICS OF MACHINERY** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 3 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Impart the basic principles of mechanisms, with respect to the displacement, velocity, and acceleration for specified output motions.
- Familiarize to Acquire the effect of friction in different machine elements.
- Clear insight to apply the concepts of toothed gearing and kinematics of gear trains.
- Impart knowledge to analyze the undesirable effects of unbalances resulting from prescribed motions in mechanism and the effect of dynamics of undesirable vibrations.
- Understand the concepts and importance of balancing and vibration.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Drive any basic mechanisms and its applications in various field of work.	Apply
CO2	Arrange problems on gears and gear trains and Cams.	Apply
CO3	Examine friction in machine elements.	Analyze
CO4	To adapt balancing techniques to rotors with single and multiple masses in various planes, including primary and secondary balancing for reciprocating engines (inline and radial V), using direct and reverse crank methods.	Understand
CO5	Calibrate the balancing masses and their locations of reciprocating and rotating masses.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	1	–	–	1	–	2	3	2	1
CO2	3	3	2	2	2	1	–	–	1	–	2	3	3	1
CO3	3	3	2	2	1	1	–	–	1	–	2	2	3	1
CO4	2	2	1	2	1	1	–	–	1	–	2	2	2	1
CO5	3	3	2	2	2	1	–	–	1	–	2	3	3	2

1 - low, 2 - medium, 3 - high

Unit I – KINEMATICS OF LINKAGE MECHANISMS

Machine Structure – Kinematic link, pair and chain – Degrees of freedom - Slider crank and crank rocker mechanisms – Inversions –Applications – Kinematic analysis of simple mechanisms – Determination of velocity and acceleration. Displacement, velocity and acceleration analysis of simple mechanisms – Graphical method– Velocity and acceleration polygons Energy-efficient linkage design with reduced material usage.

Unit II – FRICTION

Friction in screw and nut – Pivot and collar – Thrust bearing – Plate and disc clutches –Belt (flat and V) and rope drives. Ratio of tensions – Effect of centrifugal and initial tension– Condition for maximum power transmission – Open and crossed belt drive-- Use of biodegradable and eco-friendly lubricants.

Unit III – GEARS, GEAR TRAINS AND CAMS

Gear profile and geometry – Nomenclature of spur and helical gears – Gear trains: Simple, compound gear trains and epicylic gear trains - Determination of speed and torque - Cams – Types of cams – Design of profiles – Knife edged, flat faced and roller ended followers with and without offsets for various types of follower motions-- Waste and energy reduction techniques in gear manufacturing.

Unit IV – BALANCING

Static and dynamic balancing – Single and several masses in different planes –Balancing of reciprocating masses- primary balancing and concepts of secondary balancing – Single and multi-cylinder engines (Inline) – Balancing of radial V engine – direct and reverse crank method- – Energy minimization techniques in balancing operations.

Unit V – VIBRATION

Free, forced and damped vibrations of single degree of freedom systems – Force transmitted to supports – Vibration isolation – Vibration absorption – Torsional vibration of shaft – Single and multi-rotor systems – Geared shafts – Critical speed of shaft- Use of modern tools and sensors for vibration analysis.

SUGGESTED READINGS

1. Rattan.S.S"Theory of Machines", Tata McGraw–Hill Publishing Co., New Delhi (2014).5.
2. Ballany.P.L"Theory of Machines",Khanna Publishers, New Delhi (2018).
3. Cleghorn. W. L., Nikolai Dechev, "Mechanisms of Machines", Oxford University Press, (2015).
4. Sadhu Singh, "Theory of Machines: Kinematics and Dynamics", 5th Edition, Pearson Publication, (2016).

Semester – 3

25MEU321 **MECHANICS OF SOLIDS** **3H – 4C**

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Make the students understand the concepts of stress, strain, principal stresses and principal planes
- Enable them with concept of shearing force and bending moment caused by external loads in determinate beams, and analyzing their impact on stresses.
- Be aware of slopes and deflections in determinate beams by various methods.
- Acquire knowledge on stresses and deformation in circular shafts and helical spring due to torsion.
- Assess the stresses and deformations induced in Columns and Cylinder.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Demonstrate understanding of stress and strain behavior in simple and compound bars, and explain the significance of principal stresses and principal planes in material analysis.	Understand
CO2	Analyze the load transfer mechanism in beams through shear force and bending moment diagrams, and determine stress distribution due to transverse loading.	Analyze
CO3	Calculate slope and deflection in beams using appropriate analytical methods, and apply torsion equations in the design of shafts and helical springs.	Apply
CO4	Conduct standard mechanical tests such as tension, compression, shear, torsion, impact, and hardness tests to evaluate the behavior and properties of engineering materials.	Apply
CO5	Interpret experimental test data to determine material properties like modulus of elasticity, yield strength, and toughness, and apply this knowledge in material selection and design decisions.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	–	–	–	1	–	2	3	2	1
CO2	3	3	2	2	1	–	–	–	1	–	2	3	3	1
CO3	3	3	3	2	2	1	–	–	1	–	2	3	3	2
CO4	3	2	2	3	2	1	1	1	1	–	2	2	3	2
CO5	3	3	2	3	2	1	1	–	1	–	2	3	3	2

1 - low, 2 - medium, 3 - high

Unit I – STRESS, STRAIN AND DEFORMATION OF SOLIDS

Deformation in solids- Hooke's law, stress and strain- tension, compression and shear stresses- elastic constants and their relations- volumetric, linear and shear strains- principal stresses and principal planes- Mohr's circle.

Unit II – TRANSFER OF LOADS AND STRESSES IN BEAMS

Beams and type's transverse loading on beams- shear force and bending moment diagrams-Types of beam supports, simply supported and over-hanging beams, cantilevers. Theory of bending of beams, bending stress distribution and neutral axis, shear stress distribution, point and distributed loads.

Unit III – DEFLECTION OF BEAMS

Moment of inertia about an axis and polar moment of inertia, deflection of a beam using double integration method, computation of slopes and deflection in beams, Maxwell's reciprocal theorems.

Unit IV – TORSION

Torsion, stresses and deformation in circular and hollow shafts, stepped shafts, deflection of shafts fixed at both ends, stresses and deflection of helical springs.

Unit V COLUMS AND CYLINDER

Axial and hoop stresses in cylinders subjected to internal pressure, deformation of thick and thin cylinders, deformation in spherical shells subjected to internal pressure, column and struts, Euler's formula, limitations of Euler's formula.

PRACTICAL EXERCISES

1. Tension test on mild steel rod.
2. Compression test on wood.
3. Double shear test on metal.
4. Torsion test on mild steel rod.
5. Impact test on metal specimen (Izod and Charpy).
6. Hardness test on metals (Rockwell and Brinell Hardness Tests).
7. Deflection test on metal beam.
8. Compression test on helical spring.
9. Deflection test on carriage spring.

SUGGESTED READINGS

1. Rajput R.K "Strength of Materials (Mechanics of Solids)", S.Chand& company Ltd, New Delhi (2018).
2. Egor P Popov, "Engineering Mechanics of Solids", 2nd edition, PHI Learning Pvt. Ltd., New Delhi (2019).
3. Kazimi S.M.A "Solid Mechanics", Tata McGraw-Hill Publishing Co, New Delhi (2018).
4. Singh. D.K., "Strength of Materials", Ane Books Pvt Ltd., New Delhi (2021)

Semester – 3

25MEU311 MANUFACTURING TECHNOLOGY LABORATORY 2H – 2C

Instruction Hours / week: L: 0 T: 0 P:4 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Practice the various operations that can be performed in lathe, shaper, drilling, milling machines etc. and to equip with the practical knowledge required in the core industries.
- Get an idea of the dimensional & form accuracy of products
- Expose students in understanding various metal cutting operations and commonly used machine tools.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Deliver practical knowledge on selection of appropriate machine tools for machining operations.	Understand
CO2	Carry out various basic machining operations in special purpose machines and its applications in real life manufacture of components in the industry	Apply
CO3	Skillfully lathe operations such as turning, taper turning facing, knurling other basic operations	Apply
CO4	Skillfully operations on shapper, slotter, grinder machine and milling	Apply
CO5	Skillfully operation on CNC machines.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	1	2	1	–	–	1	–	2	2	2	1
CO2	3	2	3	2	2	1	1	1	1	–	2	3	2	1
CO3	3	3	3	2	2	1	1	1	1	–	2	3	3	2
CO4	3	3	3	2	2	1	1	1	1	–	2	3	3	2
CO5	3	3	3	2	3	1	1	1	1	1	3	3	3	3

1 - low, 2 - medium, 3 - high

PRACTICAL EXERCISES

1. Exercise on Plain turning and thread cutting, Eccentric Turning.
2. Taper turning and knurling using lathe.
3. Contour milling using vertical milling machine.
4. Spur gear cutting in milling machine.
5. Helical Gear cutting using Hobbing machine.
6. Determination of cutting forces in Milling and drilling using dynamometers.
7. Slotting and key way cutting in vertical slotting machine
8. Shaper Exercise: Making a square from a round rod
9. Exercise on drilling and boring
10. Surface Grinding
11. CNC Part Programming.

SUGGESTED READINGS

1. Geoffrey Boothroyd “Fundamentals of Metal Machining and Machine Tools”, Taylor and Francis, an imprint of CRC Press (2006)
2. Roy. Lindbergh, “Process and Materials of Manufacture”, Fourth Edition, PHI/Pearson Education (2006).

23VA271 **YOGA FOR HUMAN EXCELLENCE** **1H – 0C**

Instruction Hours / week: L: 0 T: 0 P: 1 Course

Objectives

- Articulate and focus on goals and move away from demotivating and corrosive environment.
- Explain the concept and dimensions of wellness which help in pursuing their goals.
- Demonstrate the practices that can promote wellness.
- Plan and follow a daily routine that includes Physical Exercises, Yoga, and Meditation.
- Demonstrate behavior's aligned to universal Human Values

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Articulate and focus on goals and move away from demotivating and corrosive environment.	Understand
CO2	Explain the concept and dimensions of wellness which help in pursuing their goals.	Understand
CO3	Demonstrate the practices that can promote wellness.	Apply
CO4	Plan and follow a daily routine that includes Physical Exercises, Yoga, and Meditation.	Apply
CO5	Demonstrate behaviours aligned to universal Human Values.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	–	–	–	2	3	1	2	–	2	1	1	–
CO2	1	1	–	–	–	3	3	1	2	–	2	1	1	–
CO3	1	1	1	1	–	3	3	2	2	–	2	1	2	1
CO4	1	1	1	1	–	3	3	2	2	1	3	1	2	1
CO5	1	2	1	1	–	3	3	2	2	1	3	1	2	1

1 - low, 2 - medium, 3 - high

Unit I – PHYSICAL HEALTH

Introduction to SKY -Education as a means of Youth Empowerment-Simplified Physical exercises- Yogasanas (Rules- Sun Salutation-Dandasana-Chakrasana-Vrichasana-Trikonasana-Vajrasana- Pranayama-Nadi Suddhi-Clearance Practice).

UNIT II -STRENGTHENING THE LIFE FORCE

Reasons for Diseases-Philosophy of Kaya Kalpa -Maintaining Youthfulness & Postponing Aging – Transformation of Food into seven Body Constituents -Greatness of Seminal Fluid -Limit and Method in Five Factors- Kaya Kalpa Practice

Unit III – WELLNESS OF MIND

Classification of Mind Waves-Agna Meditation- Shanthi Meditation- Thuriya Meditation-Blessing and Benefits-Virtues: Individual Virtues and Societal Virtues -Morals (Importance of Introspection, Six Temperaments and Manoevering, Benefits of Meditation).

Unit IV- PROSPERITY OF MIND- PART I

Philosophy of Life (Purpose of Life, Philosophy of Life, Five Duties-Safeguarding Natural Resources)-Analysis of Thoughts (Ten stages of the Mind-The Five Kosas-Thoughts-Analysis of thoughts and practice)- Moralisation of Desires (Desires- Explanation, Nature, Reasons, Moralisation Practice).

Unit V – PROSPERITY OF MIND-PART II

Neutralisation of Anger (Anger-Reasons, Effects, Peace, Tolerance and Forgiving, Neutralisation) - Eradication of Worries (Reasons, Effects, Corrective measures, Eradication)- Diversity in Men- Love and Compassion

Semester – 4

25MEU421 **THERMAL ENGINEERING** **4H – 4C**

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Gain clear insight to integrate the concepts, laws and methodologies from the first course in thermodynamics into analysis of cyclic processes.
- Facilitate to apply the thermodynamic concepts into various thermal application like IC engines, Steam Turbines, Compressors and Refrigeration and Air conditioning systems.
- Familiarize in analyzing the performance of steam nozzle, calculate critical pressure ratio (Use of standard refrigerant property data book, Steam Tables, Mollier diagram and psychometric chart permitted.
- Impart practical understanding in the concepts of Valve Timing, Port Timing and p-v diagrams and Analyzing the performance characteristics of various engines, Conducting boiler operation and performance test on a boiler and steam turbine.

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Analyze and compare gas power cycles by calculating mean effective pressure and efficiency.	Analyze
CO2	Interpret valve and port timing diagrams, analyze p-V diagrams, and evaluate engine performance through tests.	Evaluate
CO3	Construct velocity diagrams for turbines, analyze steam flow, and study steam generators and turbines	Analyze
CO4	Evaluate compressor performance by calculating efficiencies and analyzing inter-cooling effects.	Evaluate
CO5	Apply refrigeration and air conditioning principles, perform cooling load calculations, and determine fuel flash and fire points.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	2	3	3	2
CO2	3	3	2	3	2	1	–	–	1	–	2	3	3	2
CO3	3	3	2	2	2	1	–	–	1	–	2	3	2	2
CO4	3	3	2	3	2	1	–	–	1	–	2	3	3	2
CO5	3	2	2	2	2	2	1	–	1	–	2	2	3	2

1 - low, 2 - medium, 3 - high

Unit I – GAS POWER CYCLES
Otto, Diesel, Dual, Brayton cycles, Calculation of mean effective pressure, and air standard efficiency - Comparison of cycles.

Unit II – INTERNAL COMBUSTION ENGINES

Classification - Components and their function. Valve timing diagram and port timing diagram - actual and theoretical p-V diagram of four stroke and two stroke engines. Simple and complete Carburettor. MPFI, Diesel pump and injector system. Battery and Magneto Ignition System - Principles of Combustion and knocking in SI and CI Engines. Lubrication and Cooling systems. Performance calculation.

Unit III – STEAM NOZZLES AND TURBINES

Flow of steam through nozzles, shapes of nozzles, effect of friction, critical pressure ratio, supersaturated flow.Impulse and Reaction principles, compounding, velocity diagram for simple and multi-stage turbines, speed regulations –Governors-- Sustainable industrial power generation using efficient turbine systems.

Unit IV AIR COMPRESSOR

Classification and working principle of various types of compressors, work of compression with and without clearance, Volumetric efficiency, Isothermal efficiency and Isentropic efficiency of reciprocating compressors, Multistage air compressor and inter cooling – work of multistage air compressor.

Unit V – REFRIGERATION AND AIR CONDITIONING

Refrigerants - Vapour compression refrigeration cycle- super heat, sub cooling – Performance calculations - working principle of vapour absorption system, Ammonia –Water, Lithium bromide –water systems (Description only) .Air conditioning system - Processes, Types and Working Principles. - Concept of RSHF, GSHF, ESHF- Cooling Load calculations. Cryogenic Engineering- Eco-friendly cooling systems for reducing urban carbon footprint.

PRACTICAL EXERCISES:

1. Valve Timing and Port Timing diagrams.
2. Actual p-v diagrams of IC engines.
3. Performance Test on 4 – stroke Diesel Engine.
4. Heat Balance Test on 4 – stroke Diesel Engine
5. Morse Test on Multi-cylinder Petrol Engine.
6. Retardation Test on a Diesel Engine.
7. Determination of Flash Point and Fire Point of various fuels / lubricants.
8. Study on Steam Generators and Turbines.

SUGGESTED READINGS

1. Rajput. R. K"Thermal Engineering", S.Chand Publishers (2015).
2. Kothandaraman.C.P, Domkundwar. A.V M "A course in Thermal Engineering",5thEdition, Dhanpat Rai & sons (2002).
3. Sarkar, B.K"Thermal Engineering", Tata McGraw-Hill Publishers, New Delhi (2007).
4. Ballaney. P.L "Thermal Engineering", Khanna publishers, 24th Edition (2012).

Semester – 4

25MEU401 **DESIGN OF MACHINE ELEMENTS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Impart knowledge various steps involved in the Design Process.
- Familiarize with designing shafts and couplings for various applications.
- Clear insight on designing temporary and permanent Joints.
- Learn designing connecting rods and crank shafts for various.
- Understand the designing and select sliding and rolling contact bearings.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Evaluate the suitability of machine members under static and variable loads based on design principles.	Evaluate
CO2	Apply design procedures to select appropriate shafts and couplings for mechanical systems.	Apply
CO3	Apply design concepts to assess the performance and suitability of bolted, knuckle, cotter, riveted, and welded joints.	Apply
CO4	Evaluate the functionality of helical springs, leaf springs, and flywheels in mechanical applications.	Evaluate
CO5	Apply standard methods to select suitable sliding and rolling contact bearings for engineering applications.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	3	1	0	0	0	1	1	1	0	3	2	2
CO2	2	2	3	1	0	0	0	1	1	1	0	3	2	2
CO3	2	2	3	1	0	0	0	1	1	1	0	3	2	2
CO4	2	2	3	1	0	0	0	1	1	1	0	3	2	2
CO5	2	2	3	1	0	0	0	1	1	1	0	3	2	2

1 - low, 2 - medium, 3 - high

Unit I – INTRODUCTION TO THE DESIGN PROCESS

Factor influencing machine design, selection of materials based on mechanical properties - Direct, Bending and torsion stress equations - Impact and shock loading - calculation of principle stresses for various load combinations, eccentric loading - Design of curved beams - crane hook and 'C' frame Factor of safety - theories of failure - stress concentration - fatigue strength and the S-N diagram -Soderberg, Goodman and Gerber relationsEco-friendly materials and energy-efficient design practices.

Unit II – DESIGN OF SHAFTS AND COUPLINGS

Design of solid and hollow shafts based on strength, rigidity and critical speed - Design of keys and key ways - Design of rigid and flexible couplings - Introduction to gear and shock absorbing couplings - design of knuckle joints- Material reduction and energy efficiency techniques.

Unit III – DESIGN OF FASTENERS AND WELDED JOINTS

Threaded fasteners - Design of bolted joints including eccentric loading - Design of welded joints for pressure vessels and structures - theory of bonded joints- Recyclable and biodegradable fastener materials.

Unit IV – DESIGN OF ENGINE COMPONENTS

Design of Piston – Connecting rod – Crankshaft – Flywheel. - Design of flywheels involving stresses in rim and arm dimensions- Design of flywheels involving stresses in rim and arm- Lightweight, high-strength engine materials.**Unit V – DESIGN OF BEARINGS AND SPRINGS**

Design of bearings - sliding contact and rolling contact types. - Cubic mean load - Design of journal bearings - McKee's equation - Lubrication in journal bearings - calculation of bearing. Design of helical, leaf, disc and torsion springs under constant loads and varying loads - Concentric torsion springs - Belleville springs - Design of Levers-m Use of composites and shape memory alloy springs.

SUGGESTED READINGS

1. Juvinall R.C. and Marshek K.M."Fundamentals of Machine Component Design",Hoboken, NJ: Wiley, Seventh Edition (2020).
2. Bhandari V.B "Design of Machine Elements", Tata McGraw-Hill Publishers (2017).
3. Norton R.L "Design of Machinery". Tata McGraw-Hill Publishers (2020).
4. Orthwein W"Machine Component Design",Jaico Publishers (2013).

Semester – 4

25MEU422 **FLUID MECHANICS AND MACHINERY** **4H – 4C**

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Introduce the students about properties of the fluids, behaviour of fluids under static conditions.
- Impart basic knowledge of the dynamics of fluids and boundary layer concept.
- Expose to the applications of the conservation laws to a) flow measurements b) flow through
- pipes (both laminar and turbulent) and c) forces on pipe bends.
- Expose the students to basic principles of working of hydraulic machineries and to design Pelton wheel, Francis and Kaplan turbine, centrifugal and reciprocating pumps.
- Exposure to the significance of boundary layer theory and its thicknesses.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Assemble the properties and behaviour in static conditions. Also, to demonstrate the conservation laws applicable to fluids and its application through fluid kinematics and dynamics.	Apply
CO2	Estimate losses in pipelines for both laminar and turbulent conditions and analysis of pipes connected in series and parallel. Also, to demonstrate the concept of boundary layer and its thickness on the flat solid surface.	Evaluate
CO3	Drive the relationship among the parameters involved in the given fluid phenomenon and to predict the performances of prototype by model studies.	Apply
CO4	Assemble the working principles of centrifugal, reciprocating and rotary pumps and design the centrifugal and reciprocating pumps.	Evaluate
CO5	Assemble the working principles of various turbines and design the various types of turbines.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	2	3	2	2
CO2	3	3	2	3	2	1	–	–	1	–	2	3	3	2
CO3	3	3	2	2	2	1	–	–	1	–	2	3	2	2
CO4	3	3	3	2	2	1	–	–	1	–	2	3	3	2
CO5	3	3	3	2	2	2	–	–	1	–	2	3	3	2

1 - low, 2 - medium, 3 - high

Unit I – FLUID PROPERTIES AND FLOW CHARACTERISTICS

Units and dimensions- Properties of fluids- mass density, specific weight, specific volume, specific gravity, viscosity, compressibility, vapor pressure, surface tension and capillarity. Flow characteristics – concept of control volume - application of continuity equation, energy equation and momentum equation. Manometers-Hydrostatic forces- Forces on submerged bodies.

Unit II – FLOW THROUGH CIRCULAR CONDUICT

Hydraulic and energy gradient - Laminar flow through circular conduits and circular annuli-Boundary layer concepts – types of boundary layer thickness – Darcy Weisbach equation –friction factor- Moody diagram- commercial pipes- minor losses – Flow through pipes in series and parallel. Reynold's experiment through circular pipes- Power transmission.

Unit III – DIMENSIONAL ANALYSIS

Need for dimensional analysis – methods of dimensional analysis – Similitude –types of similitude - Dimensionless parameters-application of dimensionless parameters – Model analysis. Buckingham's πtheorem applications- Similarity laws and models.

Unit IV – PUMPS

Impact of jets - Euler"s equation - Theory of roto-dynamic machines – various efficiencies– velocity components at entry and exit of the rotor- velocity triangles - Centrifugal pumps– working principle - work done by the impeller - performance curves - Reciprocating pump- working principle – Rotary pumps –classification. Air vessels- Ideal and Actual Indicator diagram- Estimation of power required- Percentage slip and Efficiency.

Unit V – TURBINES

Classification of turbines – heads and efficiencies – velocity triangles.Axial, radial and mixed flow turbines.Pelton wheel, Francis turbine and Kaplan turbines- working principles - work done by water on the runner – draft tube. Specific speed - unit quantities – performance curves for turbines –governing of turbines.

PRACTICAL EXERCISES:

1. Determination of the Coefficient of discharge of given Orifice meter.
2. Determination of the Coefficient of discharge of given Venturi meter.
3. Calculation of the rate of flow using Rota meter.
4. Determination of friction factor for a given set of pipes.
5. Conducting experiments and drawing the characteristic curves of centrifugal pump/ submergible pump.
6. Conducting experiments and drawing the characteristic curves of reciprocating pump.
7. Conducting experiments and drawing the characteristic curves of Gear pump.
8. Conducting experiments and drawing the characteristic curves of Pelton wheel.
9. Conducting experiments and drawing the characteristics curves of Francis turbine.
10. Conducting experiments and drawing the characteristic curves of Kaplan turbine.

SUGGESTED READINGS

1. Dr.R.K.Bansal "Fluid Mechanics",Laxmi Publications (2018).
2. Modi P.N. and Seth S.M. "Hydraulics and Fluid Mechanics", Standard Book House, New Delhi (2019).
3. Agarwal.S.K."Fluid Mechanics and Machinery", Tata McGraw Hill Publishing Co., New Delhi (2003).
4. Streeter V. L. and Wylie E. B "Fluid Mechanics", Tata McGraw Hill Publishing Co., New Delhi (2010).
5. Kumar K. L. "Engineering Fluid Mechanics", Eurasia Publishing House(p) Ltd., New Delhi (2018).

Semester – 4

25MEU402 **SMART MOBILITY AND NEW GENERATION VEHICLES** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Explain various types of vehicles, power packs and their control.
- Analyze the various types of engines and generation of new generation vehicles.
- Identifying the working parameters of various electrical and electronic devices in a vehicle.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Record the various parts of the automobile and their functions and materials.	Remember
CO2	Examine the engine auxiliary systems and engine emission control.	Analyze
CO3	Differentiate the working of different types of transmission systems.	Understand
CO4	Drive the Steering, Brakes and Suspension Systems.	Apply
CO5	Predict possible alternate sources of energy for IC Engines.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	1	1	1	1	–	–	1	–	1	2	1	1
CO2	3	3	2	2	2	2	–	–	1	–	2	3	3	2
CO3	3	2	2	1	1	1	–	–	1	–	2	2	3	1
CO4	3	3	3	2	2	2	1	–	1	–	2	3	3	2
CO5	3	3	2	2	2	3	1	–	1	–	3	2	3	3

1 - low, 2 - medium, 3 - high

Unit I – INTRODUCTION

Electric and hybrid vehicles, flexible fuel vehicles (FFV), solar powered vehicles, magnetic track vehicles, fuel cells vehicles Clean mobility via EVs, hybrids, and fuel-cell vehicles.

Unit II – POWER SYSTEM AND NEW GENERATION VEHICLES

Hybrid Vehicle engines, Stratified charge engines, learn burn engines, low heat rejection engines, hydrogen engines, HCCI engine, VCR engine, surface ignition engines, VVTI engines. High energy and power density batteries, fuel cells, solar panels, flexible fuel systems- Low-carbon, fuel-efficient engine technologies.

Unit III – VEHICLE OPERATION AND CONTROL

Computer Control for pollution and noise control and for fuel economy – Transducers and actuators - Information technology for receiving proper information and operation of the vehicle like optimum speed and direction- Intelligent control systems for safety and emission reduction.

Unit IV – VEHICLE AUTOMATED TRACKS

Preparation and maintenance of proper road network - National highway network with automated roads and vehicles - Satellite control of vehicle operation for safe and fast travel, GPS Smart transportation systems and safer travel infrastructure.

Unit V – SUSPENSION, BRAKES, AERODYNAMICS AND SAFETY

Air suspension – Closed loop suspension, compensated suspension, anti skid braking system, retarders, regenerative braking, safety gauge air backs- crash resistance. Aerodynamics for modern vehicles, safety systems, materials and standards- Road safety and occupant protection systems.

SUGGESTED READINGS

1. Jain K.K. and Asthana .R.B, "Automobile Engineering" Tata McGraw Hill Publishers, New Delhi (2002).
2. Kirpal Singh, "Automobile Engineering", Vol 1 & 2, Seventh Edition, Standard Publishers, New Delhi, 13th Edition (2014).
3. Ganesan V. "Internal Combustion Engines", Third Edition, Tata McGraw-Hill, (2012).
4. Martin W, Stockel and Martin T Stockle, "Automotive Mechanics Fundamentals," The Good heart - Will Cox Company Inc, USA(1978).
5. Heinz Heisler, "Advanced Engine Technology," SAE International Publications USA, 1998.

Semester – 4

25MEU411 **COMPUTER AIDED MACHINE DRAWING** **3H – 3C**

Instruction Hours / week: L: 1 T: 0 P: 4 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- To familiarize the students with Indian Standards on drawing practices and standard components
- Understand and interpret drawings of machine Components so as to prepare assembly drawings.
- Exposure to 2D Drafting and 3D modeling software systems.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between free sketching and machine drawing.	Understand
CO2	Interpret the features of various machine components.	Analyze
CO3	Compile the standardization of drawings.	Apply
CO4	Create drawings to industrial standardwith appropriate tolerance and fits.	Apply
CO5	Develop manual part drawing for machine components and also using computer aided drafting.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	1	1	–	–	–	1	–	1	2	1	1
CO2	3	3	2	1	1	–	–	–	1	–	2	3	2	1
CO3	3	2	2	1	2	–	–	–	1	–	2	2	3	1
CO4	3	3	3	2	2	1	–	–	1	–	2	3	3	2
CO5	3	3	3	2	3	1	–	1	1	–	3	3	3	2

1 - low, 2 - medium, 3 - high

ENGINEERING DRAWING STANDARDS: FITS AND TOLERANCES

Indian standard code (BIS) of practice for engineering drawing-General principle of presentation, Conventional representation of threaded parts, Springs, Gear and common features, Abbreviations and symbols use in technical drawings.

Tolerance- Types-Symbols used and representation on the drawing - Fit types, Selection for different application- Allowance, Interchangeability. Surface finish- Relation to the manufacturing processes- Types of representation on the drawing- Welding symbols.

MANUAL DRAFTING:

Preparation of part drawing for machine components:

Part Drawing, Assembly Drawing, Detailed Drawing. Dimensioning, Annotations, Symbols, Welding, Surface finish, Threads, Text, Bill of Materials. Exercises: Bolts, Screws, Studs, Nuts, Keys and Key-ways, Engine parts: Connecting rod, spark plug, cross head and gear box, Lathe machine tool parts and accessories.

COMPUTER AIDED DRAFTING:

Orthographic Views, Isometric Views and 2D Sectional Views. Exercises: Sectional view of Gib and Cotter Joint, knuckle joints, Screw Jack, Foot Step Bearing, fuel injection pump for single cylinder engine, Stop valve.

SUGGESTED READINGS

1. Bhatt, N.D. "Machine Drawing" Charotar Publishing House (2000).
2. Narayana.K.L. Machine Drawing, New Age Publisher (2006).
3. Bhatt, N.D. "Machine Drawing" Charotar Publishing House (2000).

Semester – 4

25IKS007 **MATERIAL SCIENCE IN ANCIENT INDIA** **2H – 2C**

Instruction Hours / week: L: 2 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Understand the development of material knowledge in ancient Indian civilizations.
- Explore ancient extraction, processing, and utilization techniques for metals, ceramics, and composites.
- Evaluate the sustainability, functionality, and innovation of ancient Indian materials in architecture, sculpture, and technology.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Recall ancient classifications of materials and their contextual applications.	Remember
CO2	Interpret the techniques of material extraction and processing in historical India.	Understand
CO3	Analyze material usage in architecture, sculpture, and crafts in ancient times.	Analyze
CO4	Compare ancient and modern material technologies and innovations.	Evaluate
CO5	Propose sustainable applications using ancient Indian material knowledge.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	–	–	–	2	2	–	1	–	2	1	1	–
CO2	1	2	–	1	–	2	2	–	1	–	2	1	1	–
CO3	2	3	1	2	1	3	2	1	2	–	2	1	2	1
CO4	2	3	2	2	1	3	2	1	2	–	3	1	2	1
CO5	2	2	2	2	1	3	3	1	2	1	3	1	2	1

1 - low, 2 - medium, 3 - high

UNIT I – INTRODUCTION TO MATERIAL KNOWLEDGE IN ANCIENT INDIA

Historical overview: Vedic, post-Vedic and classical periods- Sources: Vedas, Shilpa Shastra, Rasashastra, Charaka Samhita- Classification: Natural, processed, synthetic, sacred and medicinal materials- Role of environment, tradition, and ritual in material selection.

UNIT II – EXTRACTION & PROCESSING TECHNIQUES

Mining of metals and minerals: gold, iron, copper, zinc- Smelting and alloying: brass, bronze, Panchaloha- Non-metallic materials: stone, clay, lime, terracotta- Organic materials: wood, shellac, plant-based compounds- Ancient furnace and crucible designs

UNIT III – MATERIALS IN ARCHITECTURE, ART AND CRAFTS

Structural materials: stone, brick, wood, mortar- Decorative & sculptural uses: stucco, ivory, precious stones- Tools and weapons: metallic composition and forging methods- Artisans and guild systems; preservation techniques

UNIT IV – MATERIALS IN MEDICINE, COSMETICS AND DAILY LIFE

Rasashastra: mineral-based medicine (mercury, sulfur, mica)- Cosmetic formulations and natural dyes- Pottery, textiles, metallurgy in household utilities- Eco-friendly practices in material usage

UNIT V – MODERN PERSPECTIVES & REVIVAL OF TRADITIONAL MATERIALS

Comparison of ancient vs. modern materials (strength, sustainability, complexity)- Relevance of traditional material science to modern green engineering- Case studies: Delhi Iron Pillar, Jaipur observatory, Ajanta-Ellora- Scope for innovation using traditional knowledge systems

Suggested Readings

1. Aithal, Sreeramana & Ramanathan, P.S., Ancient Indian Material Technology, ResearchGate (2024).
2. Srinivasan, S. (1994). "Wootz crucible steel: A newly discovered production site in South India." Material Issues in Art and Archaeology III.
3. Chattopadhyaya, D.P., Science and Society in Ancient India, Research India Press (2008).

Semester – 4

25MEU491 **EXPLORATORY PROJECT** **2H – 2C**

Instruction Hours / week: L: 0 T:0 P: 4 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Encourage students to explore real-world engineering problems through self-driven learning and innovation.
- Develop the ability to apply fundamental engineering principles to analyze or simulate potential solutions.
- Foster teamwork, technical communication, and project management skills in a collaborative environment.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Identify and define a real-world engineering problem or area of interest through literature survey.	Understand
CO2	Apply fundamental engineering knowledge to propose a feasible approach or model.	Apply
CO3	Develop a prototype, simulation, or conceptual design to explore the identified problem.	Create
CO4	Collaborate effectively within a team and manage tasks related to the exploratory project.	Evaluate
CO5	Present the findings through a technical report and oral presentation.	Analyze

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	2	1	1	1	2	–	2	2	2	1
CO2	3	3	2	2	2	1	1	1	2	1	2	3	2	2
CO3	3	3	3	3	3	2	1	2	2	1	3	3	3	2
CO4	2	2	2	2	2	1	2	3	2	2	2	2	2	1
CO5	2	3	2	2	2	1	1	2	3	1	3	2	2	1

1 - low, 2 - medium, 3 - high

Semester – 5

25MEU521 **DESIGN OF TRANSMISSION SYSTEMS** **4H – 4C**

Instruction Hours / week: L: 3 T: 1 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Designing flexible elements like belt, ropes and chain drives for engineering applications.
- Equip the students to provide knowledge on understanding concepts of spur and helical gear drives for power transmission
- Clear insight for applying principles on bevel and worm drives for power transmission.
- Impart knowledge on designing multi speed gear box for machine tool and automotive applications.
- Familiarize with designing of clutch and brake systems for engineering applications.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different types of flexible elements and select appropriate belts, chains, and ropes for various mechanical applications.	Apply
CO2	Choose suitable spur and helical gears based on material properties, force analysis, and fatigue strength considerations.	Apply
CO3	Assemble and compute the design parameters for bevel and worm gears, ensuring optimal performance in transmission systems	Apply
CO4	Adjust and optimize gearboxes for mechanical and automotive applications by applying principles of speed ratios and torque transmission.	Apply
CO5	Identify and evaluate different clutch and brake systems, applying design principles to improve performance and reliability.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	1	–	–	1	–	2	3	2	1
CO2	3	3	3	2	2	1	–	–	1	–	2	3	3	2
CO3	3	3	3	2	2	1	–	–	1	–	2	3	3	2
CO4	3	3	3	2	2	1	–	1	1	1	2	3	3	2
CO5	3	3	2	2	2	2	1	–	1	1	3	2	3	2

1 - low, 2 - medium, 3 - high

Unit I – DESIGN OF FLEXIBLE ELEMENTS

Motor power capacity for various applications - Design of Flat belts and pulleys - Selection of V belts and sheaves – Selection of wire ropes and pulleys – Design of Transmission Chains and Sprocket.

Unit II – SPUR AND HELICAL GEARS

Gear materials - Design of straight tooth spur & helical gears based on speed ratios, number of teeth, Fatigue strength, Factor of safety, strength and wear considerations. Force analysis –Tooth stresses - Dynamic effects - Helical gears – Module - normal and transverse, Equivalent number of teeth – forces.

Unit III – BEVEL AND WORM GEARS

Straight bevel gear: Gear materials - Tooth terminology, tooth forces and stresses, equivalent number of teeth, estimation of dimensions of straight bevel gears. Worm Gear: Gear materials - Tooth terminology, Thermal capacity, forces and stresses, efficiency, estimation of dimensions of worm gear pair..

Unit IV – GEAR BOXES

Need - Design of sliding and constant mesh gear boxes: Speed selection - Geometric progression - Standard step ratio - Ray diagram, kinematic layout – Determination of number of teeth. Design of multi speed gear box for machine tool applications, Variable speed gear box, Fluid Couplings, Torque Converters for automotive applications - Continuous variable transmission system.

Unit V – CLUTCHES AND BRAKES

Design of single and multi-plate clutches, cone clutches, internal expanding rim clutches and Electromagnetic clutches. Design of brakes: External shoe brakes - Single and Double Shoe, Internal expanding shoe brakes and Band brakes.

SUGGESTED READINGS

1. Bhandari V, "Design of Machine Elements", 15th reprint, Tata McGraw-Hill Book Co. (2014).
2. Joseph Shigley, Charles Mischke, Richard Budynas and Keith Nisbett "Mechanical Engineering Design", 10th Edition, Tata McGraw- Hill (2014).
3. Sundararajamoorthy T. V, Shanmugam .N, "Machine Design", Anuradha Publications, Chennai (2017).
4. GitinMaitra, L. Prasad "Hand book of Mechanical Design", 2nd Edition, Tata McGraw-Hill (2001).
5. Prabhu. T.J., "Design of Transmission Elements", Mani Offset, Chennai (2018).
6. C.S.Sharma, KamleshPurohit, "Design of Machine Elements", Prentice Hall of India, Pvt. Ltd. (2015).

Semester – 5

25MEU522 **DYNAMICS OF MACHINES** **4H – 4C**

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Provide knowledge on Dynamic force, Inertia force and Torque.
- Understand the motion of linked mechanisms in terms of the displacement, velocity and acceleration at any point in a rigid link.
- Equip the students to design cam systems to generate specified output motion.
- Understand various types, characters and functions of Governors & Gyroscopes.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Measure static and dynamic forces in machines and apply D'Alembert's principle for force analysis.	Apply
CO2	Estimate appropriate balancing techniques to minimize vibrations in rotating and reciprocating systems.	Apply
CO3	Assemble single-degree-of-freedom vibratory models and analyze their responses to different conditions.	Analyze
CO4	Adjust mechanical systems to minimize the effects of forced vibrations and improve vibration isolation.	Apply
CO5	Identify the effects of gyroscopic forces and governing mechanisms in various mechanical applications.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	2	3	2	2
CO2	3	3	2	2	2	1	–	–	1	–	2	3	3	2
CO3	3	3	2	3	2	1	–	–	1	–	2	3	3	2
CO4	3	3	3	2	2	2	–	–	1	–	2	3	3	2
CO5	2	2	1	1	1	1	–	–	1	–	2	2	2	1

1 - low, 2 - medium, 3 - high

Unit I – FORCE ANALYSIS

Dynamic force analysis – Inertia force and Inertia torque– D Alembert's principle –Dynamic Analysis in reciprocating engines – Gas forces – Inertia effect of connecting rod– Bearing loads – Crank shaft torque – Turning moment diagrams –Fly Wheels – Flywheels of punching presses- Dynamics of Cam- follower mechanism.

Unit II – BALANCING

Static and dynamic balancing – Balancing of rotating masses – Balancing a single cylinder engine – Balancing of Multi-cylinder inline, V-engines – Partial balancing in engines – Balancing of linkages – Balancing machines-Field balancing of discs and rotors.

Unit III – FREE VIBRATION

Basic features of vibratory systems – Degrees of freedom – single degree of freedom – Free vibration– Equations of motion – Natural frequency – Types of Damping – Damped vibration– Torsional vibration of shaft – Critical speeds of shafts – Torsional vibration – Two and three rotor torsional systems.

Unit IV – FORCED VIBRATION

Response of one degree freedom systems to periodic forcing – Harmonic disturbances – Disturbance caused by unbalance

– Support motion –transmissibility – Vibration isolation- vibration measurement.

Unit V – GOVERNORS AND GYROSCOPES

Governors – Types – Centrifugal governors – Gravity controlled and spring controlled centrifugal governors – Characteristics – Effect of friction – Controlling force curves. Gyroscopes –Gyroscopic forces and torques – Gyroscopic stabilization – Gyroscopic effects in Automobiles, ships and airplanes.

SUGGESTED READINGS

1. V.Ramamurthi "Mechanics of Machines", Narosa Publishing House (2018).
2. Uicker, J.J., Pennock G.R and Shigley, J.E., “Theory of Machines and Mechanisms”, 4th Edition, Oxford University Press (2018)
3. Leghorn. W. L, “Mechanisms of Machines”, Oxford University Press (2019).
4. Ghosh. A and Mallick, A.K., “Theory of Mechanisms and Machines", 3rd Edition Affiliated East-West Pvt. Ltd., New Delhi (2016).
5. Rattan, S.S, “Theory of Machines”, 4thEdition, Tata McGraw-Hill (2019).
6. Khurmi, R.S.,”Theory of Machines”, 14 Edition, S Chand Publications (2019).
7. Robert L. Norton, "Kinematics and Dynamics of Machinery", Tata McGraw-Hill (2019).

Semester – 5

25MEU523 **METROLOGY AND MEASUREMENTS** **3H – 4C**

Instruction Hours / week: L: 1 T: 2 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

1. Acquire knowledge on various Metrological equipments available to measure the dimension of the components.
2. Get knowledge on the correct procedure to be adopted to measure the dimension of the components.
3. Learn to handle different equipments for the measurement of various linear and angular measurements.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Impart fundamental understanding of metrology concepts, elements, and the importance of accuracy and precision in measurements.	Understand
CO2	Familiarize students with a variety of linear, angular, and form measuring instruments, their applications, and calibration techniques.	Understand
CO3	Introduce modern metrology systems like laser interferometers, Coordinate Measuring Machines (CMM), and machine vision systems.	Remember
CO4	Enable students to perform practical measurements of geometric and physical parameters using conventional and advanced tools.	Apply
CO5	Develop skills in interpreting measurement data, understanding errors, and evaluating the reliability and calibration of systems.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	1	1	–	–	–	1	–	2	2	1	1
CO2	2	2	1	2	2	–	–	–	1	–	2	2	2	1
CO3	2	1	1	1	3	–	–	–	1	–	2	2	3	1
CO4	3	3	2	3	3	1	–	1	1	–	2	3	3	2
CO5	3	3	2	3	2	1	–	–	1	–	3	3	3	2

1 - low, 2 - medium, 3 - high

Unit I – BASICS OF METROLOGY

Introduction to Metrology – Need – Elements – Work piece, Instruments – Persons – Environment – their effect on Precision and Accuracy – Errors – Errors in Measurements – Types – Control – Types of standards.

Unit II – LINEAR AND ANGULAR MEASUREMENTS

Linear Measuring Instruments – Evolution – Types – Classification – Limit gauges – gauge design – terminology – procedure – concepts of interchange ability and selective assembly – Angular measuring instruments – Types – Bevel protractor clinometers angle gauges, spirit levels sine bar – Angle alignment telescope – Autocollimator – Applications.

Unit III – ADVANCES IN METROLOGY

Basic concept of lasers Advantages of lasers – laser Interferometers – types – DC and AC Lasers interferometer – Applications – Straightness – Alignment. Basic concept of CMM – Types of CMM – Constructional features – Probes – Accessories – Software – Applications – Basic concepts of Machine Vision System – Element – Applications.

Unit IV – FORM MEASUREMENT

Principles and Methods of straightness – Flatness measurement – Thread measurement, gear measurement, surface finish measurement, Roundness measurement – Applications.

Unit V – MEASUREMENT OF POWER, FLOW AND TEMPERATURE

Force, torque, power - mechanical, Pneumatic, Hydraulic and Electrical type. Flow measurement: Venturimeter, Orifice meter, rotameter, pitot tube – Temperature: bimetallic strip, thermocouples, electrical resistance thermometer – Reliability and Calibration – Readability and Reliability.

PRACTICAL EXERCISES:

1. Calibration and use of linear measuring instruments – Verniercaliper, micrometer, Vernier height gauge, depth micrometer, bore gauge and Comparators
2. Measurement of angles using bevel protractor, sine bar and autocollimator.
3. Measurement of assembly and transmission elements - screw thread parameters – Two Wire and Three wire method, Toolmaker's microscope.
4. Measurement of gear parameters – Micrometers, Verniercaliper, Gear tester.
5. Measurement of features in a prismatic component using Coordinate Measuring Machine (CMM).
6. Non-contact (Optical) measurement using Measuring microscope / Profile projector.

SUGGESTED READINGS

1. Jain R.K. "Engineering Metrology", Khanna Publishers (2005).
2. Gupta. I.C. "Engineering Metrology", Dhanpatrai Publications (2005).
3. Charles Reginald Shotbolt, "Metrology for Engineers", 5th edition, Cengage Learning MEA (1990).
4. Backwith, Marangoni, Lienhard, "Mechanical Measurements", Pearson Education (2006).

Semester – 5

25MEU581 **INDUSTRY INTERNSHIP I** **2H – 1C**

Instruction Hours / week: L: 0 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Provide early exposure to industrial environments and engineering practices.
- Enable students to observe industry functions and relate theoretical learning to practical applications.
- Enhance professional skills like punctuality, discipline, communication, and technical documentation.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Understand basic industrial operations, safety norms, and workplace ethics.	Understand
CO2	Relate classroom knowledge to actual industry applications and processes.	Apply
CO3	Demonstrate discipline, responsibility, and effective communication during the internship.	Evaluate
CO4	Analyze the differences and challenges between academic and industrial settings.	Analyze
CO5	Document the internship experience in a concise, technically accurate report.	Create

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	–	–	–	2	3	1	2	1	2	1	1	–
CO2	3	2	2	1	2	2	2	1	2	1	2	2	2	1
CO3	1	2	1	1	–	3	3	3	3	2	2	1	1	1
CO4	2	3	1	2	1	2	2	1	2	1	2	2	2	1
CO5	2	2	1	2	2	1	1	1	3	1	3	2	2	1

1 - low, 2 - medium, 3 - high

Semester – 6

25MEU601 CAD/CAM 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- To introduce the principles and applications of CAD, CAM, and CIM in modern product development and manufacturing environments.
- To develop competency in geometric modeling, CNC systems, and part programming using computer-aided tools.
- To impart knowledge of integrated manufacturing systems including GT, FMS, CAQC, and recent trends like lean and reconfigurable manufacturing.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	To introduce the principles and applications of CAD, CAM, and CIM in modern product development and manufacturing environments.	Understand
CO2	To develop competency in geometric modeling, CNC systems, and part programming using computer-aided tools.	Apply
CO3	To impart knowledge of integrated manufacturing systems including GT, FMS, CAQC, and recent trends like lean and reconfigurable manufacturing.	Apply
CO4	To introduce the principles and applications of CAD, CAM, and CIM in modern product development and manufacturing environments.	Analyze
CO5	To develop competency in geometric modeling, CNC systems, and part programming using computer-aided tools.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	1	3	1	–	–	1	1	2	3	3	2
CO2	3	3	3	2	3	1	–	–	1	1	2	3	3	3
CO3	3	3	3	2	3	2	–	1	1	2	3	3	3	3
CO4	3	3	2	2	3	1	–	–	1	1	2	3	3	2
CO5	3	3	3	3	3	1	–	–	1	1	3	3	3	3

1 - low, 2 - medium, 3 - high

Unit I – Overview of CAD/CAM

Product cycle, CAD, CAM and CIM. CAD Tools, CAM Tools, Utilization in an Industrial Environment, Evaluation criteria. CAD standards, CAD data structure, Data base management systems. Computer Graphics: Co-ordinate systems, Graphics package functions, 2D and 3D transformations, homogeneous transformations, clipping, hidden line / surface removal colour, shading.

Unit II – GEOMETRIC MODELING

Geometric Modeling: Representation techniques, Parametric and non parametric representation, various construction methods, wire frame modeling, synthetic curves and their representations, surface modeling, synthetics surfaces and their representations. Solid modelling, solid representation, fundamentals, introduction to boundary representations, constructive solid geometry, analytical solid modeling

Unit III – NUMERICAL CONTROL & CNC PART PROGRAMMING

NC, NC Modes, NC Elements, NC Machine tools and their structure, Machining centre, types and features. Controls in NC, CNC systems, DNC systems. Adaptive control machining systems, types of adaptive control.
Fundamentals, NC word, NC Nodes, canned cycles, cutter radius compensation, length compensation, computed assisted part programming using APT: Geometry statements, motion statements, post process statements, auxiliary statements, macro statement program for simple components.

Unit IV – COMPUTER INTEGRATED MANUFACTURING

Group Technology & FMS: Part Family, Classification and Coding, advantages & limitations, Group technology machine cells, benefits. FMS: Introduction, components of FMS, material handling systems, Computer control systems, advantages.
Computer Aided Quality Control: Terminology in Quality control, Inspection and testing, Contact inspection methods - optical and non-optical, integration of CAQC with CAD and CIM

Unit V – INTEGRATED MANUFACTURING AND PLANNING SYSTEMS

Computer Aided Processes Planning: Retrieval type and Generative type, benefits Machinability data systems, Computer generated time standards. Computer Integrated Production Planning: Capacity planning, shop floor control, MRP-1, MRP-II, CIMS benefits. Trends In Manufacturing Systems: Concepts of Reconfigurable manufacturing, Sustainable manufacturing and lean manufacturing.

SUGGESTED READINGS

1. CAD/CAM, A Zimmers & P.Groover, PE, PHI.
2. CAD/CAM-Principles and applications, P.N. Rao, TMH, 3fidedition, 2010.
3. Automation, Production systems & Computer integrated Manufacturing,Groover, P.E.
4. CAD/CAM/CIM, Radhakrishnan and Subramaniah, New Age, 3Ld edition, 2008.
5. Principles of Computer Aided Design and Manufacturing, FaridAmirouche, Pearson.
6. CAD/CAM Theory and Practice, R. Sivasubramaniam, TMH.
7. Computer Aided Design and Manufacturing, K.LalitNarayan , PHI, 2008.

Semester – 6

25MEU621 **HEAT AND MASS TRANSFER** **4H – 4C**

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Acquire the principle mechanism of heat transfer under steady state and transient conditions.
- Outline the fundamental concept and principles in convective heat transfer.
- Predict the theory of phase change heat transfer and design of heat exchangers. Test the performance of tubes in tube heat exchangers.
- Apply the fundamental concept and principles in radiation heat transfer.
- Analyze the relation between heat and mass transfer and to solve simple mass transfer problems.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Sketch and distinguish between conic curves, cycloids, and involutes, and construct appropriate scales for engineering applications.	Apply
CO2	Identify and apply projection techniques to represent points, lines, and plane surfaces in first angle orthographic views.	Apply
CO3	Assemble and design accurate projections of solid geometries and truncated forms using appropriate methods.	Apply
CO4	Prepare developments and sections of solids with holes and cut-outs, and evaluate the true shape of these sections.	Evaluate
CO5	Create isometric and perspective projections of simple and compound solids, and utilize CAD tools for visualization.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	–	–	–	1	–	2	3	2	1
CO2	3	3	2	1	2	–	–	–	1	–	2	3	2	1
CO3	3	3	3	2	2	–	–	–	1	–	2	3	3	2
CO4	3	3	3	2	2	1	–	–	1	–	2	3	3	2
CO5	3	3	3	2	3	1	–	1	1	–	3	3	3	2

1 - low, 2 - medium, 3 - high

Unit I – CONDUCTION

General Differential equation of Heat Conduction– Cartesian and Polar Coordinates – One Dimensional Steady State Heat Conduction — plane and Composite Systems – Conduction with Internal Heat Generation – Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis –Semi Infinite and Infinite Solids –Use of Heisler‟s charts.

Unit II – CONVECTION

Convection - Hydrodynamic and Thermal Boundary Layer.Free and Forced Convection during external flow over Plates and Cylinders and Internal flow through tubes--Sustainable thermal system design using efficient convection analysis.

**Unit III – PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS **

Nusselt‟s theory of condensation - Regimes of Pool boiling and Flow boiling.Correlations in boiling and condensation. Heat Exchanger Types - Overall Heat Transfer Coefficient – Fouling Factors - Analysis – LMTD method - NTU method- - Industrial innovation through high-efficiency heat exchanger technologies.

Unit IV – RADIATION

Black Body Radiation – Grey body radiation - Shape Factor – Electrical Analogy – Radiation Shields- Radiation through gases- Energy-efficient thermal system design and optimization.

Unit V – MASS TRANSFER

Basic Concepts – Diffusion Mass Transfer – Fick's Law of Diffusion – Steady state Molecular Diffusion – Convective Mass Transfer – Momentum, Heat and Mass Transfer Analogy –Convective Mass Transfer Correlations.

PRACTICAL EXERCISES:

I HEAT TRANSFER LAB:

1. Thermal conductivity measurement using guarded plate apparatus.
2. Thermal conductivity measurement of pipe insulation using lagged pipe apparatus.
3. Determination of heat transfer coefficient under natural convection from a vertical cylinder.
4. Determination of heat transfer coefficient under forced convection from a tube.
5. Determination of Thermal conductivity of composite wall.
6. Determination of Thermal conductivity of insulating powder.
7. Heat transfer from pin-fin apparatus (natural & forced convection modes)
8. Determination of Stefan – Boltzmann constant.
9. Determination of emissivity of a grey surface.
10. Effectiveness of Parallel / counter flow heat exchanger

II REFRIGERATION AND AIR CONDITIONING LAB

1. Determination of COP of a refrigeration system
2. Experiments on Psychrometric processes
3. Performance test on a reciprocating air compressor
4. Performance test in a HC Refrigeration System
5. Performance test in a fluidized Bed Cooling Tower

SUGGESTED READINGS

1. Sachdeva, R.C. "Fundamentals of Engineering Heat & Mass transfer", 5th Edition, New Age International Publishers, (2017).
2. Yunus A. Cengel "Heat Transfer - A Practical Approach" 6thEdition, Tata McGraw Hill, (2017).
3. Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera and David P. Dewitt "Fundamentals of Heat and Mass Transfer", 8th Edition, John Wiley & Sons, (2017).
4. Venkateshan S.P. "Heat Transfer", 3rd Edition, Ane Books, New Delhi (2016).

Semester – 6

25MEU622 **HYDRAULICS AND PNEUMATICS** **4H – 4C**

Instruction Hours / week: L: 3 T: 1 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Providing knowledge on application of fluid power in process, construction and manufacturing Industries.
- Understanding of fluids and components utilized in modern industrial fluid power system.
- Developing a measurable degree of competence in the design, construction and operation of fluid power circuits...

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different fluid power principles and analyze hydraulic pumps' performance.	Analyze
CO2	Identify and select suitable hydraulic actuators and control components for given applications.	Apply
CO3	Assemble and evaluate various industrial hydraulic circuits and systems.	Evaluate
CO4	Execute pneumatic and electro-pneumatic concepts in real-time industrial scenarios.	Apply
CO5	Design and implement troubleshooting strategies for hydraulic and pneumatic applications.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	2	3	2	2
CO2	3	2	3	2	2	1	–	–	1	–	2	3	3	2
CO3	3	3	3	3	2	1	–	1	1	–	2	3	3	2
CO4	3	2	3	2	3	1	–	1	1	–	2	3	3	2
CO5	3	3	3	3	2	2	1	1	1	1	3	3	3	3

1 - low, 2 - medium, 3 - high

Unit I – FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids – Properties of fluids and selection – Basics of Hydraulics – Pascal's Law – Principles of flow – Friction loss – Work, Power and Torque Problems, Sources of Hydraulic power : Pumping Theory – Pump Classification – Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of Linear and Rotary – Fixed and Variable displacementpumps- Problems.- Sustainable industrial automation using efficient fluid power systems.

Unit II – HYDRAULIC ACTUATORS AND CONTROL COMPONENTS

Representation of curves- Hermite curve- Bezier curve- B-spline curves-rational curves-Techniques for surface modeling – surface patch- Coons and bicubic patches- Bezier and B-spline surfaces. Solid modeling techniques- CSG and B-rep Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning – Hydraulic motors – Control Components : Direction Control, Flow control and pressure control valves – Types, Construction and Operation – Servo and Proportional valves – Applications – Accessories: Reservoirs, Pressure Switches – Applications – Fluid Power ANSI Symbols –
Problems- Reliability and precision in hydraulic systems.

Unit III – HYDRAULIC CIRCUITS AND SYSTEMS

Accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double- Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail-Safe, Speed Control, Hydrostatic transmission, Electro hydraulic circuits, Mechanical hydraulic servo systems- Energy-efficient fluid power circuit utilization.

Unit IV – PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS

Properties of air – Perfect Gas Laws – Compressor – Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit – Cascade method – Electro Pneumatic System – Elements – Ladder diagram – Problems, Introduction to fluidics and pneumatic logic circuits..

Unit V – TROUBLE SHOOTING AND APPLICATIONS

Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for Pick and Place applications and tool handling in CNC Machine tools – Low cost Automation – Hydraulic and Pneumatic power packs- Safe, efficient, and sustainable fluid power system operation.

SUGGESTED READINGS

1. Anthony Esposito, "Fluid Power with Applications", Prentice Hall, (2009).
2. Majumdar S.R. "Oil Hydraulics Systems- Principles and Maintenance",Tata McGraw- Hill, New Delhi (2001).
3. Jagadeesha T. "Pneumatics Concepts, Design and Applications", Universities Press (2015).
4. Joshi.P."Pneumatic Control", Wiley India (2018).

Semester – 6

25MEU611 **CAD/CAM LABORATORY** **2H – 2C**

Instruction Hours / week: L: 0 T: 0 P: 4 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Gain proficiency in interpreting and creating detailed machine drawings using CAD software, including the application of GD&T, limits, and fits.
- Develop hands-on skills in CNC programming and machining operations for a variety of processes such as turning, milling, and drilling.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Apply CAD tools to design and assemble mechanical components using GD&T, limits, and fits for product design.	Apply
CO2	Create and assemble detailed drawings for mechanical components like flange couplings, universal couplings, screw jacks, stuffing boxes, and Plummer blocks.	Create
CO3	Demonstrate manual and computer-aided part programming for CNC turning and milling operations, including step, taper, and drilling operations.	Apply
CO4	Generate NC code for various operations such as grooving, thread cutting, drilling, side milling, pocket milling, and tapping.	Apply
CO5	Execute NC code generation for advanced operations such as mirroring and pocket milling in CNC machines.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	1	–	–	1	1	2	3	3	2
CO2	3	3	3	2	3	1	–	1	1	1	2	3	3	2
CO3	3	2	3	2	3	1	–	–	1	1	2	3	3	3
CO4	3	2	3	2	3	1	–	–	1	1	2	3	3	3
CO5	3	3	3	3	3	1	–	–	1	1	3	3	3	3

1 - low, 2 - medium, 3 - high

PRACTICAL EXERCISES:

1. Introduction-Role of CAD in product design process- GD&T, Limits, Fits - Basics
2. Detailing and assembly of flange coupling
3. Detailing and assembly of universal coupling
4. Detailing and assembly of screw jack
5. Detailing and assembly of stuffing box
6. Detailing and assembly of Plummer block
7. Introduction-CAM-Manual part programming- Computer aided part programming basics
8. Manual part programming for step turning operation in CNC turning center
9. Manual part programming for taper turning operation in CNC turning center
10. NC code generation for step turning and facing operation
11. NC code generation for grooving and thread cutting operation

12. Manual part programming for drilling operation
13. NC code generation for drilling operation
14. NC code generation for side milling operation
15. NC code generation for pocket milling, drilling and tapping operation
16. NC code generation for mirroring and pocket milling operation

SUGGESTED READINGS

1. Parthasarathy,N.S.and Vela Murali, "Engineering Drawing", Oxford University Press, 2015.
2. Bhatt N.D. and Panchal V.M., "Engineering Drawing", Charotar Publishing House, 53rd Edition,2014.
3. Gopalakrishna K.R., "Engineering Drawing"m(Vol. I&II combined), Subhas Stores, Bangalore,(2017).
4. Venugopal K. and Prabhu Raja V., "Engineering graphics", New Age International (P) Limited,(2008).
5. Natrajan K.V., "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, (2012).

Semester – 7

25MEU721 **MECHATRONICS AND IOT** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 2 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Acquire knowledge on sensors, actuators, microcontrollers, and their roles in mechatronic systems.
- Gain exposure to interfacing techniques using microprocessors, PLCs, and IoT platforms for automation and control.
- Learn the design approach of mechatronic systems integrated with IoT through case studies and hands-on applications...

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	**Course Outcomes**	**Blooms Level**
CO1	Analyze and apply microprocessor/microcontroller architecture for control and automation tasks.	Analyze
CO2	Interface hardware like ADC, DAC, motors, and sensors using 8255, 8051, and PLC programming.	Apply
CO3	Develop simple IoT-based embedded systems using Arduino/Raspberry Pi for sensing and actuation.	Apply
CO4	Evaluate mechatronic and IoT solutions through real-world applications such as robots and smart systems.	Evaluate
CO5	Analyze and apply microprocessor/microcontroller architecture for control and automation tasks.	Analyze

CO-PO Mapping

CO / PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	2	3	1	–	–	1	1	2	3	3	2
CO2	3	3	3	2	3	1	–	1	1	1	2	3	3	3
CO3	3	2	3	2	3	2	–	1	1	1	3	3	3	3
CO4	3	3	3	3	3	2	1	1	2	1	3	3	3	3
CO5	3	3	2	2	3	1	–	–	1	1	2	3	3	2

1 - low, 2 - medium, 3 - high

UNIT I – INTRODUCTION TO MECHATRONICS AND SENSORS

Introduction to Mechatronics – Systems – Concepts of Mechatronics approach – Need for Mechatronics – Emerging areas of Mechatronics – Classification of Mechatronics. Sensors and Transducers: Static and dynamic characteristics – Potentiometers – LVDT – Capacitance sensors – Strain gauges – Eddy current sensor – Hall effect sensor – Temperature sensors – Light sensors.

UNIT II – 8085 MICROPROCESSOR AND 8051 MICROCONTROLLER

Architecture of 8085 – Pin Configuration – Addressing Modes – Instruction set – Timing diagram of 8085. Concepts of 8051 microcontroller – Block diagram – Architecture basics and control applications.

UNIT III – PROGRAMMABLE PERIPHERAL INTERFACE

Architecture of 8255 – Keyboard interfacing – LED display interfacing – ADC and DAC interface – Applications in Temperature Control, Stepper Motor Control, Traffic Light Control.

UNIT IV – PROGRAMMABLE LOGIC CONTROLLER (PLC)

PLC: Introduction – Basic structure – Input and output processing – Ladder Programming – Mnemonics – Timers, counters, internal relays – Data handling – Selection criteria for PLCs.

UNIT V – ACTUATORS AND MECHATRONIC SYSTEM DESIGN

Types of Stepper and Servo motors – Construction – Working principles – Advantages and Disadvantages.

Design process – Stages of design – Traditional vs. Mechatronics design – Case studies: Pick and place robot, Engine management system, Automatic car park barrier.

SUGGESTED READINGS

1. V Bolton W., "Mechatronics", Pearson Education, 6th Edition, (2015).
2. Ramesh S Gaonkar, "Microprocessor Architecture, Programming, and Applications with the 8085", Penram International Publishing Private Limited, 6th Edition, (2013).
3. Davis G.Alciatore and Michael B.Histand, "Introduction to Mechatronics and Measurement systems", McGraw Hill Education, (2011).
4. Bahga A. and Madisetti V., "Internet of Things – A Hands-On Approach", Universities Press, 1st Edition, (2015).
5. Kamal R., "Internet of Things – Architecture and Design", McGraw-Hill Education, 1st Edition, (2017).

Semester – 7

25MEU711 **GEOMETRIC MODELLING AND SIMULATION LABORATORY** **3H – 4C**

Instruction Hours / week: L: 1 T: 2 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Design 3 Dimensional geometric model of parts, sub-assemblies, assemblies and exporting it to drawing.
- Analyze the force, stress, deflection in mechanical components.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Create and manipulate 3D models of parts and assemblies, and export them into technical drawings	Apply
CO2	Apply and refine advanced surface and feature manipulation techniques to enhance design precision.	Apply
CO3	Assemble and organize components to develop detailed drafting layouts with proper annotations	Apply
CO4	Analyze and evaluate force, stress, deflection, and thermal effects on mechanical components using simulation tools.	Evaluate
CO5	Perform and interpret vibration and dynamic analysis on mechanical systems to assess performance and stability.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	1	–	–	1	1	2	3	3	2
CO2	3	3	3	2	3	1	–	–	1	1	2	3	3	2
CO3	3	2	3	2	3	1	–	1	1	1	2	3	3	2
CO4	3	3	3	3	3	2	–	1	1	1	3	3	3	3
CO5	3	3	2	3	3	2	–	1	1	1	3	3	3	3

1 - low, 2 - medium, 3 - high

PRACTICAL EXERCISES:

A. 3D GEOMETRIC MODELLING

1. CAD Introduction – Sketcher
2. Solid modeling: Extrude, Revolve, Sweep, Varational sweep and Loft.
3. Surface modeling: Extrude, Sweep, Trim, Mesh of curves and Free form.
4. Feature manipulation: Copy, Edit, Pattern, Suppress, History operations.
5. Assembly: Constraints, Exploded Views, Interference check
6. Drafting: Layouts, Standard & Sectional Views, Detailing & Plotting.
7. Exercises in Modeling and drafting of Mechanical Components
8. Assembly using Parametric and Feature based Packages

B. SIMULATION AND ANALYSIS

1. Force and Stress analysis using link elements in Trusses.
2. Stress and deflection analysis in beams with different support conditions.
3. Stress analysis of flat plates.
4. Stress analysis of axis–symmetric components.

5. Thermal stress and heat transfer analysis of plates.
6. Thermal stress analysis of cylindrical shells.
7. Vibration analysis of spring-mass systems.
8. Modal analysis of Beams.
9. Harmonic, transient and spectrum analysis of simple systems.

SUGGESTED READINGS

1. Sham Tickoo, “CATIA V5-6R2020 for Designers”, BPB Publications, 1st Edition, (2020).
2. S. Rajasekaran and G. Sankarasubramanian, “Computational Structural Mechanics”, PHI Learning, 1st Edition, (2001).

Semester – 7

25MEU781 **INDUSTRY INTERNSHIP II** **2H – 1C**

Instruction Hours / week: L: 0 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Provide students with real-time exposure to industrial practices, tools, and technologies.
- Enable students to apply theoretical knowledge to solve practical engineering problems in a professional environment.
- Improve students' soft skills, work ethics, team collaboration, and understanding of industrial workflows.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Observe and understand industry operations, safety practices, and work culture.	Understand
CO2	Apply engineering knowledge in real-time industrial tasks and problem- solving.	Apply
CO3	Demonstrate effective communication, teamwork, and interpersonal skills.	Evaluate
CO4	Analyze gaps between academic knowledge and industry expectations.	Analyze
CO5	Prepare and present a structured internship report highlighting key learnings.	Create

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	–	–	–	2	3	1	2	1	2	1	1	–
CO2	3	3	2	2	2	2	2	1	2	1	2	3	2	2
CO3	1	2	1	1	–	3	3	3	3	2	2	1	1	1
CO4	2	3	1	2	1	2	2	1	2	1	2	2	2	1
CO5	2	2	1	2	2	1	1	1	3	1	3	2	2	1

1 - low, 2 - medium, 3 – high

Semester – 7

25MEU791 **CAPSTONE PROJECT (PHASE-I)** **6H – 6C**

Instruction Hours / week: L: 0 T: 0 P: 12 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

1. Guide students in identifying, formulating, and planning a comprehensive engineering project based on societal or industrial needs.
2. Enable students to perform detailed literature reviews, feasibility studies, and preliminary design or simulation.
3. Enhance documentation, teamwork, and communication skills in preparation for implementation in Phase 2.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Identify and define an engineering problem through need analysis and literature review.	Understand
CO2	Formulate clear objectives, scope, and methodology for project execution.	Apply
CO3	Design a preliminary model or simulation with feasibility analysis.	Create
CO4	Work effectively in a team, planning and assigning roles and responsibilities.	Evaluate
CO5	Prepare a detailed project proposal and communicate ideas effectively.	Analyze

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	2	1	1	1	2	–	2	2	2	1
CO2	3	3	2	2	2	1	1	1	2	1	2	3	2	2
CO3	3	3	3	3	3	2	1	2	2	1	3	3	3	2
CO4	2	2	2	2	2	1	2	3	2	2	2	2	2	1
CO5	2	3	2	2	2	1	1	2	3	1	3	2	2	1

1 - low, 2 - medium, 3 - high

Semester – 8

25MEU891 **CAPSTONE PROJECT (PHASE-II)** **12H – 12C**

Instruction Hours / week: L: 0 T: 0 P: 24 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Enable students to implement the project idea developed in Phase 1 into a tangible working system, prototype, or validated model.
- Provide experience in testing, data collection, result analysis, and optimization.
- Improve professional presentation, technical documentation, and research paper writing skills.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Apply engineering knowledge to implement the design or solution.	Apply
CO2	Conduct experiments, validate results, and refine the project output.	Evaluate
CO3	Demonstrate project management and ethical responsibility throughout execution.	Evaluate
CO4	Communicate technical work through presentations, reports, and publications.	Create
CO5	Reflect on the design process, challenges, and scope for future improvement.	Create

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2	1	1	2	2	2	3	3	2
CO2	3	3	2	3	3	2	1	1	2	1	3	3	3	2
CO3	2	2	2	2	2	2	3	3	2	3	2	2	2	1
CO4	2	2	1	2	2	1	1	2	3	1	3	2	2	1
CO5	2	3	2	2	2	2	2	1	2	1	3	2	2	2

1 - low, 2 - medium, 3 - high

Programme Elective: Design Stream **Semester – 5**

25MEU531A **DESIGN FOR MANUFACTURING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of DFMA principles and material selection criteria for product design.
- Manipulate casting and molding processes by applying suitable design recommendations.
- Assemble machined components with appropriate tolerances and material selections.
- Perform extrusion and stamping processes with proper design considerations.
- Create optimized welded, soldered, and bonded assemblies considering process parameters.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Demonstrate an understanding of DFMA principles and material selection criteria for product design.	Understand
CO2	Manipulate casting and molding processes by applying suitable design recommendations.	Apply
CO3	Assemble machined components with appropriate tolerances and material selections.	Apply
CO4	Perform extrusion and stamping processes with proper design considerations.	Apply
CO5	Create optimized welded, soldered, and bonded assemblies considering process parameters.	Analyze

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	1	–	–	1	–	2	3	2	1
CO2	3	3	3	2	2	1	–	–	1	–	2	3	3	2
CO3	3	3	3	2	2	1	–	–	1	–	2	3	3	2
CO4	3	2	3	2	2	1	–	–	1	–	2	3	3	2
CO5	3	3	3	3	2	2	1	1	1	1	3	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION TO DFMA

History of DFMA, Steps for applying DFMA during product design, Advantages of applying DFMA during product design, Reasons for not implementing DFMA, Introduction to Basic Manufacturing Processes, Classification of engineering materials and material selection criteria for product design, Analysis of Tensile, Compression and Shear properties of materials.

UNIT 2: SAND CASTING

Sand Casting, Die Casting, Injection Moulding, Powder Metal Processing: Introduction, Typical characteristics, Design recommendation, Steps in the processes, Advantages and Disadvantages, Applications, Effect of shrinkage and Suitable materials.

UNIT 3: DESIGN FOR MACHINING

Introduction to machining and Design recommendations, process description, typical characteristics and applications, recommended materials for machinability and tolerances for turning operation, machining round holes, Parts produced by milling, planning, shaping, slotting and broaching.

UNIT 4: METAL EXTRUSION

Nomenclature, Characteristics, Suitable Materials, Design Recommendations and Applications of Extrusion Process, Metal Stamping Process, Fine Blanking process, Impact or Cold Extrusion Process and Forging processes.

UNIT 5: DESIGN FOR WELDING PROCESS

Design for welding, Design for solder and brazed Assembly and Design for adhesively bonded assemblies: Process, Typical characteristics, Suitable materials and detail design recommendations.

SUGGESTED READINGS

1. George E. Dieter and Linda C.Schmidt, "Engineering Design", Fourth edition, McGraw-Hill companies, New York, USA (2009).
2. 2. Geoffrey Boothroyd, Peter Dewhurst and Winston Knight "Product Design for Manufacture and Assembly", Second Edition, CRC press, Taylor & Francis, Florida, USA (2002).
3. 3. D.E. Whitney "Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development", Oxford University Press, New York (2004).
4. 4. Geoffrey Boothroyd "Assembly Automation and Product Design", Second Edition, CRC press, Taylor & Francis, Florida, USA (2005).

   5. P. Dewhurst, W. Knight, G. Boothroyd, "Product Design for Manufacture and Assembly", 3rd edition, CRC Press, (2010).

Programme Elective: Design Stream **Semester – 5**

25MEU532A **PRODUCT DESIGN AND DEVELOPMENT** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of product design principles, integrated product development, and market research.
- Manipulate economic design parameters such as break-even analysis, material selection, and value analysis for product optimization.
- Assemble different product modeling techniques, process chains, and industrial standardization efforts.
- Perform product costing through bill of materials, work measurement, labor, and material cost estimation.
- Create innovative product designs by integrating FEM, PLM, knowledge-based design, and intelligent information systems.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between various principles of creativity, concurrent engineering, product analysis, and life cycle concepts.	Analyze
CO2	Choose optimal materials and processes using economic design concepts such as break-even analysis and value engineering.	Apply
CO3	Assemble and evaluate different product modeling approaches, standardization efforts, and industrial demands.	Evaluate
CO4	Adjust and compute product costs, including labor and material cost estimation in various stages of manufacturing.	Apply
CO5	Identify and integrate modern product design advancements such as FEM, PLM, and intelligent information systems.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	2	1	1	1	1	2	3	2	2
CO2	3	3	3	2	2	2	1	–	1	2	2	3	3	2
CO3	3	3	3	3	2	2	1	1	1	2	3	3	3	3
CO4	3	2	3	2	2	1	1	–	1	3	2	3	3	2
CO5	2	2	2	2	3	1	–	–	1	1	3	2	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: PRODUCT DESIGN AND DEVELOPMENT

Principles of creativity in design- integrated product development and concurrent engineering - Product analysis - Criteria for product design - Market research - Design for customer and design for manufacture - Product life cycle.

UNIT 2: ECONOMICS OF DESIGN

Breaks even point - Selection of optimal materials and processes - Material layout planning - Value analysis - Re- engineering and its impact on product development.

UNIT 3: PRODUCT MODELING

Product modeling - Definition of concept - fundamental issues - Role and basic requirement of process chains and product models -Types of product models - Model standardization efforts - types of process chains - Industrial demands.

UNIT 4: PRODUCT COSTING

Bill of materials - Outline Process charts - Concepts of operational standard time - Work measurement by analytical estimation and synthesis of time - Budgets times - Labor cost and material cost at every stage of manufacture - W.I.P. costing

UNIT 5: RECENT ADVANCES AND CONCEPTS IN PRODUCT DESIGN

Fundamentals of FEM and its significance to product design - Product life cycle management intelligent information system - Concept of Knowledge based product and process design.

SUGGESTED READINGS

1. Jamnia, A., Introduction to Product Design and Development for Engineers, CRC Press, 2018.
2. Paul Trott, "Innovation Management and New Product Development", 6th Edition, Pearson Publication, (2017).
3. Karl T. Ulrich and Stephen D. Eppinger "Product Design and Development", 7th Edition, McGraw- Hill, (2019).
4. Mitsuo Nagamachi, Anitawati Mohd Lokman, "Innovation: Practical Design Applications for Product and Service Development", 1stEdition, CRC Press, (2015).
   Marcus Vinicius Pereira Pessôa, Luis Gonzaga Trabasso, "The Lean Product Design and Development Journey: A Practical View", Springer International Publishing, (2017).

Programme Elective: Design Stream **Semester – 5**

25MEU533A **MODERN CONCEPTS OF ENGINEERING DESIGN** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of the product design process, including design considerations, innovation, and societal impacts.
- Identify opportunities, evaluate resources, and establish target specifications for product planning and specification.
- Develop concepts through structured generation, selection, and testing methodologies.
- Analyze product architecture and integrate industrial design principles for system-level product development.
- Apply Design for Manufacturing (DFM) principles and prototyping techniques to optimize product design and development.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between various stages of the product design process and societal considerations.	Analyze
CO2	Choose appropriate methodologies for product planning and specification.	Apply
CO3	Assemble and evaluate conceptual designs using systematic selection and testing.	Evaluate
CO4	Adjust product architecture and integrate industrial design elements for optimized functionality.	Apply
CO5	Identify cost-effective manufacturing and prototyping strategies for improved product realization.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	1	2	1	1	1	1	2	3	2	2
CO2	3	2	3	2	2	1	1	–	1	2	2	3	3	2
CO3	3	3	3	3	2	2	1	1	1	2	3	3	3	3
CO4	3	2	3	2	2	2	1	1	1	2	2	3	3	2
CO5	2	2	2	2	3	1	–	–	1	1	3	2	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: PRODUCT DESIGN PROCESS

Importance of product design - Design process - Design considerations - Morphology of design Marketing Organisation for design - Computer aided engineering - Codes and standards - Design review - Technological innovation and design process - Product and process cycles -Societal considerations in design.

UNIT 2: PRODUCT PLANNING AND SPECIFICATION

Opportunities identification-Evaluation-Resource allocation - Pre-project planning - Customer need identification - Establishing target specification - Setting the final specification.

UNIT 3: CONCEPT GENERATION, SELECTION AND TESTING

Concept generation- problem clarification- internal and external search- concept exploration- analysis- selection methods (screening and scoring)- concept testing and surveys- product architecture and platform design- system-level design- industrial design and its management- quality assessment.

UNIT 4: PRODUCT ARCHITECTURE, INDUSTRIAL DESIGN

Product architecture - Implications - establishment - platform planning - system level design - Need for industrial design and its impact - The Industrial design process and its management - Assessment of quality

UNIT 5: DESIGN FOR MANUFACTURING AND PROTOTYPING

Overview of Design for Manufacture process - Steps in DFM-Basics principles of prototyping - Prototyping technologies - Planning for prototypes. Case Studies: Identification of economical design and redesign for manufacture.

SUGGESTED READINGS

1. Ulrich KT., and Eppinger S. D "Product Design and Development", McGraw-Hill Book Company (2009).
2. Dieter G. E. "Engineering Design", McGraw-Hill Book Company (2000).
3. Ullman D.G, "The Mechanical Design Process", McGraw-Hill Book Co. (2003).
4. Otto, K.N., and Wood, K.L. "Product Design-Techniques in Reverse Engineering and New product Development", Pearson Education (2004).
   Yousef Haik "Engineering Design Process" Vikas Publishing House (2003).

Programme Elective: Design Stream **Semester – 6**

25MEU631A **DYNAMICS AND CONTROL** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Introduce the principles of dynamics for modeling mechanical systems.
- Provide a foundation in analytical and computational approaches to mechanical vibration and control.
- Develop skills in applying Newtonian and Lagrangian mechanics to model engineering systems.
- Lay groundwork for advanced control and systems engineering.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Formulate mathematical models of mechanical systems using Newtonian and Lagrangian mechanics.	Apply
CO2	Analyze translational and rotational motion of rigid bodies.	Analyze
CO3	Examine dynamic behavior of vibrating systems and interpret mode shapes and natural frequencies.	Analyze
CO4	Develop state-space and transfer function models for linear dynamic systems.	Apply
CO5	Understand basic concepts of control system design and stability analysis.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	2	3	2	2
CO2	3	3	2	2	2	1	–	–	1	–	2	3	3	2
CO3	3	3	2	3	2	1	–	–	1	–	3	3	3	2
CO4	3	3	3	2	3	1	–	–	1	1	3	3	3	3
CO5	2	2	2	2	2	1	–	–	1	1	3	2	2	3

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION TO MECHANICAL SYSTEMS

Modeling mechanical systems – Newton’s laws – Translation and rotation – Energy methods – Free body diagrams – Degrees of freedom – Constraints – Linear and angular momentum – Impulse and momentum – Introduction to system modeling.

UNIT 2: LAGRANGIAN MECHANICS AND LINEAR SYSTEMS

Lagrange’s equations – Generalized coordinates – Application to mechanical systems – Linearization – Equilibrium points – State-space representation – Solution of linear systems.

UNIT 3: DYNAMICS OF PARTICLES AND RIGID BODIES

2D and 3D motion of particles – Rotational dynamics – Moments of inertia – Euler’s equations – Gyroscopic effects – Kinetics of rigid bodies in plane motion – Vibrations of lumped parameter systems.

UNIT 4: INTRODUCTION TO VIBRATIONS

Single and multi-degree of freedom systems – Natural frequencies and mode shapes – Free and forced vibrations – Damping – Modal analysis – Solution techniques for dynamic systems.

UNIT 5: INTRODUCTION TO CONTROL SYSTEMS

Feedback control fundamentals – Transfer functions – Block diagrams – Time and frequency response – Stability concepts – Root locus – PID controllers – Intro to state-space methods.

SUGGESTED READINGS

1. Greenwood, D. T. *Classical Dynamics*. Dover Publications, 2003.
2. Ogata, K. *Modern Control Engineering*, 5th Ed., Pearson, 2010.
3. Franklin, G. F., Powell, J. D., and Emami-Naeini, A. *Feedback Control of Dynamic Systems*, 6th Ed., Pearson, 2010.
4. Hibbeler, R. C. *Engineering Mechanics: Dynamics*, Pearson, 14th Ed., 2015.
5. Rao, S. S. *Mechanical Vibrations*, Pearson, 6th Ed., 2017.

Programme Elective: Design Stream **Semester – 6**

25MEU632A **MECHANICAL VIBRATIONS AND NOISE CONTROL** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate fundamental concepts of vibration, classify types of vibration, and analyze single and two-degree-of- freedom systems.
- Manipulate noise measurement techniques and analyze noise parameters such as amplitude, frequency, and sound pressure levels.
- Assemble the sources of automotive noise and analyze noise characteristics from various components like engines, transmissions, and aerodynamics.
- Perform vibration isolation and control techniques, including tuned absorbers, viscous dampers, and damping treatments.
- Create solutions for noise reduction using predictive analysis, palliative treatments, enclosures, and sound energy absorption techniques.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different types of vibration and analyze single and two- degree-of-freedom systems.	Analyze
CO2	Choose appropriate noise measurement techniques and analyze environmental noise data.	Analyze
CO3	Identify sources of automotive noise and evaluate their impact on vehicle performance.	Evaluate
CO4	Apply various vibration control methods and assess their effectiveness.	Apply
CO5	Design noise reduction techniques for automotive applications and evaluate their performance.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	2	3	3	2
CO2	3	3	1	3	2	2	–	–	1	–	2	2	3	2
CO3	3	3	2	2	2	3	1	–	1	–	2	3	3	2
CO4	3	2	3	2	2	2	–	–	1	–	2	3	3	2
CO5	3	3	3	3	2	3	1	–	1	1	3	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: BASICS OF VIBRATION

Introduction, classification of vibration: Free and forced vibration, Undammed and damped vibration and linear and non linear vibration, Response of damped and undammed systems Under harmonic force, analysis of single degree and two degree of freedom systems, Torsion vibration, determination of natural frequencies.

UNIT 2: BASICS OF NOISE

Introduction, Amplitude, Frequency, Wavelength sound pressure level, addition, subtraction and averaging decibel levels, noise dose level, legislation, measurement and analysis of noise, Measurement environment, Equipment, Frequency analysis Tracking analysis Sound quality analysis.

UNIT 3: AUTOMOTIVE NOISE SOURCES

Noise Characteristics of Engines, engine overall noise levels, Assessment of combustion noise, Assessment of mechanical noise, Engine radiated noise, Intake and exhaust noise, Engine accessory contributed noise, Transmission noise, Aerodynamic noise, Tyre noise, Brake noise.

UNIT 4: CONTROL TECHNIQUES

Vibration isolation, Tuned absorbers, Unturned viscous dampers, Damping treatments, Application dynamic forces generated by IC engines, engine isolation, Crank shaft damping, Modal analysis of the mass elastic model shock absorbers.

UNIT 5: SOURCE OF NOISE AND CONTROL

Methods for control of engine noise, Combustion noise, Mechanical noise Predictive analysis, palliative treatments and enclosures, automotive noise control principles, Sound in enclosures, Sound energy absorption, Sound transmission through barriers.

SUGGESTED READINGS

1. W T Thomson, Chapman & Hall "Theory of Vibration with Applications", Fourth Edition, Digital Printing (2018).
2. SingiresuS.Rao "Mechanical Vibrations in SI Units" Pearson Education, 6th Edition (2017).
3. Grover. G.K., Nigam. S. P., "Mechanical Vibrations", Nem Chand and Bros., (2014).
4. Pang, Jian, "Noise and vibration control in automotive bodies", Wiley Publications, (2019). Julian Happian-Smith "An Introduction to Modern Vehicle Design", Butterworth-Heinemann, (2004).

Programme Elective: Design Stream **Semester – 6**

25MEU633A **APPLIED FINITE ELEMENT ANALYSIS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate the fundamental concepts of finite element methods and mathematical modeling of engineering problems.
- Manipulate one-dimensional finite element problems related to solid mechanics and heat transfer.
- Assemble and solve two-dimensional scalar variable problems using finite element formulation.
- Perform finite element analysis for vector variable problems in elasticity, including plane stress, plane strain, and axisymmetric conditions.
- Create isoparametric formulation techniques and apply numerical integration methods in solving engineering problems.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between various mathematical modeling techniques and their applications in engineering problems.	Analyze
CO2	Choose appropriate finite element discretization techniques for one- dimensional problems and analyze their structural behavior.	Apply
CO3	Assemble and apply finite element methods to solve two-dimensional scalar field problems in engineering applications.	Apply
CO4	Adjust and optimize stress analysis techniques in two-dimensional elasticity problems using finite element approaches.	Analyze
CO5	Identify and solve dynamic problems using isoparametric formulation and computational tools.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	2	3	2	2
CO2	3	3	3	2	3	1	–	–	1	–	2	3	3	2
CO3	3	3	3	3	3	1	–	–	1	–	3	3	3	3
CO4	3	3	3	3	3	1	–	–	1	–	3	3	3	3
CO5	3	3	2	3	3	1	–	–	1	1	3	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION

Historical Background – Mathematical Modeling of field problems in Engineering – Governing Equations – Discrete and continuous models – Boundary, Initial and Eigen Value problems– Weighted Residual Methods – Variational Formulation of Boundary Value Problems – Ritz Technique – Basic concepts of the Finite Element Method.

UNIT 2: ONE-DIMENSIONAL PROBLEMS

One Dimensional Second Order Equations – Discretization – Element types- Linear and Higher order Elements – Derivation of Shape functions and Stiffness matrices and force vectors- Assembly of Matrices - Solution of problems from solid mechanics and heat transfer. Longitudinal vibration frequencies and mode shapes. Fourth Order Beam Equation –Transverse deflections and Natural frequencies of beams.

UNIT 3: TWO DIMENSIONAL SCALAR VARIABLE PROBLEMS

Second Order 2D Equations involving Scalar Variable Functions – Variational formulation –Finite Element formulation – Triangular elements – Shape functions and element matrices and vectors. Application to Field Problems - Thermal problems – Torsion of Non circular shafts –Quadrilateral elements – Higher Order Elements.

UNIT 4: TWO DIMENSIONAL VECTOR VARIABLE PROBLEMS

Equations of elasticity – Plane stress, plane strain and axisymmetric problems – Body forces and temperature effects – Stress calculations - Plate and shell elements.

UNIT 5: ISOPARAMETRIC FORMULATION

Natural co-ordinate systems – Isoparametric elements – Shape functions for iso parametric elements – One and two dimensions – Serendipity elements – Numerical integration and application to plane stress problems - Matrix solution techniques – Solutions Techniques to Dynamic problems – Introduction to Analysis Software.

SUGGESTED READINGS

1. 1. Reddy. J.N "An Introduction to the Finite Element Method", 3rd Edition, Tata McGraw-Hill Publishers (2018).
2. 2. Seshu, P "Text Book of Finite Element Analysis", Prentice-Hall of India Pvt. Ltd., New Delhi (2017).
3. 3. Bhatti Asghar M, "Fundamental Finite Element Analysis and Applications", John Wiley & Sons (2018).
4. 4. Chandrupatla&Belagundu, "Introduction to Finite Elements in Engineering", 3rd Edition, Prentice Hall College Div. (2019).

5. Logan D L "A first course in Finite Element Method", Thomson Asia Pvt. Ltd. (2016).

Programme Elective: Design Stream **Semester – 7**

25MEU731A **DESIGN OF JIGS, FIXTURES AND PRESS TOOLS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of locating and clamping principles used in tool design, including jigs and fixtures.
- Manipulate various types of jigs and fixtures for machining and assembly operations.
- Assemble and design cutting dies by applying press working terminologies and principles.
- Perform bending and drawing die operations while considering press capacity and material behavior.
- Create advanced forming techniques and evaluate modern trends in tool design

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different locating and clamping methods used in jigs and fixtures.	Analyze
CO2	Choose appropriate jigs and fixtures for machining and assembly operations.	Apply
CO3	Assemble and design various elements of cutting dies for different press working operations.	Apply
CO4	Adjust bending and drawing dies while analyzing factors affecting metal flow.	Analyze
CO5	Identify and apply modern forming techniques and evaluate their efficiency	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	1	1	1	1	1	2	3	2	1
CO2	3	2	3	1	2	1	1	1	1	1	2	3	2	1
CO3	3	2	3	2	2	1	1	1	1	1	2	3	3	2
CO4	2	3	2	2	2	1	1	1	1	1	2	2	3	2
CO5	2	3	2	3	2	2	1	1	1	1	2	2	3	2

1 - low, 2 - medium, 3 - high

UNIT I: LOCATING AND CLAMPING PRINCIPLES

Objectives of tool design- Function and advantages of Jigs and fixtures – Basic elements – principles of location – Locating methods and devices – Redundant Location – Principles of clamping – Mechanical actuation – pneumatic and hydraulic actuation Standard parts – Drill bushes and Jig buttons – Tolerances and materials used.

UNIT II: JIGS AND FIXTURES

Design and development of jigs and fixtures for given component- Types of Jigs – Post, Turnover, Channel, latch, box, pot, angular post jigs – Indexing jigs – General principles of milling, Lathe, boring, broaching and grinding fixtures – Assembly, Inspection and Welding fixtures – Modular fixturing systems- Quick change fixtures.

UNIT III: PRESS WORKING TERMINOLOGIES AND ELEMENTS OF CUTTING DIES

Press Working Terminologies - operations – Types of presses – press accessories – Computation of press capacity – Strip layout – Material Utilization – Shearing action – Clearances – Press Work Materials – Center of pressure- Design of various elements of dies – Die Block – Punch holder, Die set, guide

plates – Stops – Strippers – Pilots – Selection of Standard parts – Design and preparation of four standard views of simple blanking, piercing, compound and progressive dies.

UNIT IV: BENDING AND DRAWING DIES

Difference between bending and drawing – Blank development for above operations – Types of Bending dies – Press capacity – Spring back – knockouts – direct and indirect – pressure pads – Ejectors – Variables affecting Metal flow in drawing operations – draw die inserts – draw beads- ironing – Design and development of bending, forming, drawing, reverse redrawing and combination dies – Blank development for ax symmetric, rectangular and elliptic parts – Single and double action dies.

UNIT V: FORMING TECHNIQUES AND EVALUATION

Bulging, Swaging, Embossing, coining, curling, hole flanging, shaving and sizing, assembly, fine Blanking dies – recent trends in tool design- computer Aids for sheet metal forming Analysis – basic introduction - tooling for numerically controlled machines- setup reduction for work holding – Single minute exchange of dies – Poka Yoke.

SUGGESTED READINGS

- C.Elanchezhian,T.Sunderselvan, Vijayaramnath B "Design of Jigs, Fixtures and Press tools", Eswar Press (2005).
- Akgoroshkin "Jigs and Fixture Handbook", Mix Publishers, Moscow, (2016).
- ASTME Handbook of Fixture design,(2009).
- Design Data, PSG Tech, Coimbatore, (2003).
- Fundamentals of tool Design ASTME, (2010).

Note: (Use of P S G Design Data Book is permitted in the University examination)

Programme Elective: Design Stream **Semester – 7**

25MEU732A **TRIBOLOGY IN DESIGN** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 2 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate knowledge of surface interaction, friction, and surface properties for various engineering materials.
- Manipulate different types of wear mechanisms and surface treatment techniques for improving tribological performance.
- Assemble knowledge of lubricants, lubrication regimes, and standards to optimize friction and wear in machine components.
- Perform calculations related to hydrodynamic and hydrostatic lubrication theories for bearing applications.
- Create solutions for high-pressure contact problems using elasto-hydrodynamic lubrication principles.

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Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	**Course Outcomes**	**Blooms Level**
CO1	Distinguish between different types of surface interactions, friction properties, and thermal effects in sliding contacts.	Analyze
CO2	Choose suitable wear-resistant surface treatments and coatings based on wear mechanisms.	Apply
CO3	Assemble knowledge of lubricants, their properties, and lubrication regimes in mechanical systems.	Understand
CO4	Adjust lubrication parameters for hydrostatic and hydrodynamic bearings to optimize performance.	Apply
CO5	Identify contact stresses and elasto-hydrodynamic lubrication effects in rolling elements and traction drives.	Understand

CO-PO Mapping

CO / PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	2	2	1	1	1	1	1	2	3	2	1
CO2	3	2	3	2	2	2	1	1	1	1	2	3	3	2
CO3	3	2	2	1	2	1	1	1	1	1	2	2	3	1
CO4	3	2	3	2	3	2	1	1	1	1	2	3	3	2
CO5	3	3	2	2	2	1	1	1	1	1	2	3	2	2

1 - low, 2 - medium, 3 - high

UNIT 1: SURFACE INTERACTION AND FRICTION

Topography of Surfaces – Surface features-Properties and measurement – Surface interaction – Adhesive Theory of Sliding Friction –Rolling Friction-Friction properties of metallic and non-metallic materials – friction in extreme conditions –Thermal considerations in sliding contact.

UNIT 2: WEAR AND SURFACE TREATMENT

Types of wear – Mechanism of various types of wear – Laws of wear –Theoretical wear models-Wear of Metals and Non metals – Surface treatments – Surface modifications – surface coatings methods- Surface Topography measurements –Laser methods – instrumentation - International standards in friction and wear measurements.

UNIT 3: LUBRICANTS AND LUBRICATION REGIMES

Lubricants and their physical properties- Viscosity and other properties of oils –Additives-and selection of Lubricants- Lubricants standards ISO,SAE,AGMA, BIS standards – Lubrication Regimes –Solid Lubrication-Dry and marginally lubricated contacts- Boundary Lubrication- Hydrodynamic lubrication — Elasto and plasto hydrodynamic - Magneto hydrodynamic lubrication – Hydro static lubrication – Gas lubrication.

UNIT 4: THEORY OF HYDRODYNAMIC AND HYDROSTATIC LUBRICATION 9 hrs

Reynolds Equation,-Assumptions and limitations-One and two dimensional Reynolds Equation-Reynolds and Sommerfeld boundary conditions- Pressure wave, flow, load capacity and friction calculations in Hydrodynamic bearings-Long and short bearings-Pad bearings and Journal bearings-Squeeze film effects-Thermal considerations-Hydrostatic lubrication of Pad bearing- Pressure , flow , load and friction calculations-Stiffness considerations- Various types of flow restrictors in hydrostatic bearings.

UNIT 5: HIGH PRESSURE CONTACTS AND ELASTO HYDRODYNAMIC LUBRICATION

Rolling contacts of Elastic solids- contact stresses – Hertzian stress equation-Spherical and cylindrical contacts-Contact Fatigue life- Oil film effects- Elasto Hydrodynamic lubrication Theory-Soft and hard EHL-Reynolds equation for elasto hydrodynamic lubrication- - Film shape within and outside contact zones-Film thickness and friction calculation- Rolling bearings- Stresses and deflections-Traction drives.

SUGGESTED READINGS

1. Rabinowicz.E “Friction and Wear of materials”, John Willey &Sons,UK (995).
2. Cameron A “Basic Lubrication Theory”, Ellis Herward Ltd., UK (1981).
3. Halling, J. “Principles of Tribology”, Macmillian (1984).
4. Williams J.A “Engineering Tribology”, Oxford Univ. Press (1994).
5. S.K. Basu, S.N.Sengupta & B.B.Ahuja “Fundamentals of Tribology”, Prentice Hall of India Pvt Ltd, New Delhi (2005).

Programme Elective: Design Stream **Semester – 7**

25MEU733A **DESIGN OF HEAT EXCHANGERS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 2 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate knowledge of different classifications of heat exchangers and their applications.
- Manipulate the fundamental principles of heat transfer to design heat exchangers.
- Assemble mechanical design aspects of shell and tube heat exchangers based on industrial standards.
- Perform an analysis of compact and plate heat exchangers for optimal performance.
- Create designs for condensers and cooling towers based on their performance characteristics.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different classifications of heat exchangers and their suitability for various applications.	Analyze
CO2	Apply heat transfer principles to process design and sizing of heat exchangers.	Apply
CO3	Design mechanical components of shell and tube heat exchangers using industrial standards.	Apply
CO4	Analyze the performance characteristics of compact and plate heat exchangers.	Analyze
CO5	Evaluate the efficiency and design parameters of condensers and cooling towers.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	2	1	1	1	1	1	2	3	2	1
CO2	3	2	3	2	2	2	1	1	1	1	2	3	3	2
CO3	3	2	3	2	3	2	1	1	1	1	2	3	3	2
CO4	3	3	2	2	2	1	1	1	1	1	2	2	3	2
CO5	3	3	2	3	2	2	1	1	1	1	2	3	3	2

1 - low, 2 - medium, 3 - high

UNIT I: DIFFERENT CLASSIFICATION OF HEAT EXCHANGERS

Parallel flow, counter flow and cross flow; shell and tube and plate type; single pass and multipass; once through steam generators etc.

UNIT II: PROCESS DESIGN OF HEAT EXCHANGERS

Heat transfer correlations, Overall heat transfer coefficient, LMTD, sizing of finned tube heat exchangers, U tube heat exchangers, fouling factors, pressure drop calculations.

UNIT III: MECHANICAL DESIGN OF SHELL AND TUBE TYPE

Thickness calculation, Tube sheet design using TEMA formula, concept of equivalent plate for analysing perforated analysis, flow induced vibration risks including acoustic issues and remedies, tube to tubesheet joint design, buckling of tubes, thermal stresses.

UNIT IV: COMPACT AND PLATE HEAT EXCHANGER

Types, Merits and Demerits, Design of compact heat exchangers, plate heat exchangers, performance influencing parameters, limitations.

UNIT V: CONDENSORS AND COOLING TOWERS

Design of surface and evaporative condensers, cooling tower, performance characteristics.

SUGGESTED READINGS

1. Manfred Nitsche, Raji Olayiwola Gbadamosi, "Heat Exchanger Design Guide: A Practical Guide for Planning, Selecting and Designing of Shell and Tube Exchangers", 1st Edition, Butterworth-Heinemann Publishers, (2015).
2. W. M. Kays& A. L. London, "Compact Heat Exchangers", 3rd Edition, MEDTECH Publishers, (2018).
3. Wilfried Roetzel Xing Luo Dezhen Chen, "Design and Operation of Heat Exchangers and their Networks", Elsevier,Academic Press, (2019).
4. J.E. Hesselgreaves, Richard Law, David Reay, "Compact Heat Exchangers. Selection, Design and Operation", Butterworth-Heinemann Publishers, (2016).
   C. Ranganayakulu, Kankanhalli N. Seetharamu, "Compact Heat Exchangers: Analysis, Design and Optimization using FEM and CFD Approach", Wiley-ASME Press Series, (2018).

Programme Elective: Design Stream **Semester – 7**

25MEU734A COMPUTATIONAL TECHNIQUES FOR FLUID DYNAMICS 3H – 3C

Instruction Hours / week: L: 3 T: 0 2 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of governing equations and boundary conditions for computational fluid dynamics (CFD).
- Manipulate finite difference and finite volume methods for solving diffusion problems.
- Assemble numerical schemes for convection-diffusion equations and analyze their properties.
- Perform flow field analysis using finite volume methods and pressure correction algorithms. Create turbulence models and generate computational grids for CFD simulations.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different types of governing equations and boundary conditions in CFD.	Analyze
CO2	Solve diffusion problems using finite difference and finite volume methods.	Apply
CO3	Analyze convection-diffusion problems and apply suitable discretization schemes.	Analyze
CO4	Implement flow field analysis techniques using pressure correction algorithms.	Apply
CO5	Design computational grids and apply turbulence models for CFD applications.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	1	1	1	1	2	3	2	2
CO2	3	2	3	3	3	1	1	1	1	1	2	3	3	2
CO3	3	3	2	3	3	1	1	1	1	1	2	3	3	2
CO4	3	2	3	3	3	2	1	1	1	1	2	3	3	3
CO5	3	2	3	3	3	2	1	1	1	1	3	3	3	3

1 - low, 2 - medium, 3 - high

UNIT: I GOVERNING EQUATIONS AND BOUNDARY CONDITIONS

Basics of computational fluid dynamics – Governing equations of fluid dynamics – Continuity, Momentum and Energy equations – Chemical species transport – Physical boundary conditions – Time-averaged equations for Turbulent Flow – Turbulent–Kinetic Energy Equations – Mathematical behaviour of PDEs on CFD - Elliptic, Parabolic and Hyperbolic equations.

UNIT: II FINITE DIFFERENCE AND FINITE VOLUME METHODS FOR DIFFUSION

Derivation of finite difference equations – Simple Methods – General Methods for first and second order accuracy – Finite volume formulation for steady state One, Two and Three -dimensional diffusion problems –Parabolic equations – Explicit and Implicit schemes – Example problems on elliptic and parabolic equations – Use of Finite Difference and Finite Volume methods.

UNIT: III FINITE VOLUME METHOD FOR CONVECTION DIFFUSION

Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Hybrid, Power-law,
QUICK Schemes.

UNIT: IV FLOW FIELD ANALYSIS

Finite volume methods -Representation of the pressure gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and Velocity corrections – Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms.

UNIT: V TURBULENCE MODELS AND MESH GENERATION

Turbulence models, mixing length model, Two equation (k-Є) models – High and low Reynolds number models – Structured Grid generation – Unstructured Grid generation – Mesh refinement – Adaptive mesh – Software tools.

SUGGESTED READINGS

1. Ghoshdastidar, P.S. "Computer Simulation of flow and heat transfer", Tata McGraw Hill Publishing Company Ltd. (2017).
2. Versteeg, H.K. and Malalasekera, W. "An Introduction to Computational Fluid Dynamics: The finite volume Method", Pearson Education Ltd. Second Edition (2008).
3. Anil W. Date "Introduction to Computational Fluid Dynamics" Cambridge University Press (2012).
4. Chung, T.J. "Computational Fluid Dynamics", Cambridge University, Press, (2010).
   Ghoshdastidar P.S. "Heat Transfer", Oxford University Press (2012).

Programme Elective: Design Stream **Semester – 7**

25MEU735A **PIPING ENGINEERING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate understanding of plant layout, P&ID interpretation, and pipe routing fundamentals used in process industries.
- Manipulate various piping components and materials by selecting appropriate ratings, welding methods, and corrosion allowances for industrial applications.
- Assemble isometric drawings, piping symbols, and Bill of Materials (BOM) by applying industrial codes and standards such as ASME, ASTM, and API.
- Perform pipe support selection and flexibility analysis considering thermal expansion and system stress constraints.
- Create proper fabrication, testing, and safety procedures for piping installation and operational integrity in process plants.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Identify and sketch piping layouts and P&ID elements used in process plant construction.	Understand
CO2	Select and organize piping components/materials based on fluid properties, pressure-temperature conditions, and fabrication needs.	Apply
CO3	Prepare basic piping drawings and apply relevant codes/standards for thickness calculation and documentation.	Apply
CO4	Operate and adjust pipe support systems with appropriate flexibility considerations for stress minimization.	Analyze
CO5	Inspect, evaluate, and execute safe piping fabrication, testing, and quality control practices at industrial sites.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	1	1	1	1	1	2	2	2	1
CO2	3	2	3	2	3	2	1	1	1	1	2	3	3	2
CO3	3	2	3	2	3	2	1	1	2	1	2	3	3	2
CO4	3	3	2	3	2	2	1	1	1	1	2	3	2	2
CO5	3	3	2	3	2	3	2	1	2	1	2	3	3	2

1 - low, 2 - medium, 3 - high

UNIT I : Introduction to Piping Engineering

Overview of piping engineering and plant layout – Types of industries using process piping – Project execution cycle – P&ID (Piping & Instrumentation Diagram) – Equipment layout and piping design considerations – Pipe routing fundamentals.

UNIT 2: Piping Components and Materials

Pipes, fittings, flanges, gaskets, valves – Pressure ratings and schedules – Material selection based on fluid properties, temperature, and pressure – Corrosion allowance – Welding and fabrication methods.

UNIT 3: Codes, Standards, and Drafting
International codes and standards: ASME B31.3, B31.1, ASTM, API – Pipe thickness calculation – Isometric drawings – Bill of Materials (BOM) – Piping symbols – Introduction to 3D modeling and drafting software tools (Overview).

UNIT 4: Pipe Supports and Flexibility Analysis
Types of supports – Support selection and placement – Flexibility requirements – Thermal expansion and stresses – Expansion loops and joints – Basics of stress analysis – Introduction to Caesar II (Conceptual overview).

UNIT 5: Piping Fabrication, Inspection and Safety Fabrication procedures and tolerances – Site installation – Hydrostatic and pneumatic testing – NDT methods – Quality control
– Safety standards in piping system design and operation – Hazard management in process plants.

SUGGESTED READINGS

1. Mohinder L. Nayyar, Piping Handbook, 8th Edition, McGraw-Hill, 2021.
2. Partho Sarathi De, Piping Engineering – Principles, Design and Practice, 2nd Edition, McGraw-Hill, 2023.
3. R. K. Rajput, A Textbook of Piping Engineering, S. Chand Publishing, 2022.
4. Karan Sotoodeh, Piping and Pipeline Engineering: Design, Construction, Maintenance & Integrity, Elsevier, 2024.
5. ASME B31.1 / B31.3 – Process and Power Piping Codes, ASME International, Latest Revisions (2023/2024)
6. David A. Simpson, Pipe Stress Engineering, 3rd Edition, McGraw-Hill, 2022.
7. Karan Sotoodeh, Practical Piping Engineering and Pipeline Integrity, Wiley, 2021.

Programme Elective: Production and Industrial Engineering Stream **Semester – 5**

25MEU531B **3D PRINTING AND DESIGN** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Introduce the fundamental principles and process chains in 3D printing.
- Illustrate the working principles of extrusion, inkjet, and laser-based 3D printing methods.
- Equip students with skills in designing, slicing, and preparing models for additive manufacturing.
- Expose students to material selection and industrial applications of additive manufacturing technologies.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Describe the digital workflow in 3D printing including modelling, scanning, slicing, and file format selection, and demonstrate understanding of model preparation and build setup.	Understand
CO2	Explain and differentiate among extrusion, lamination, and photopolymerization-based 3D printing processes, and evaluate suitable materials and selection criteria.	Evaluate
CO3	Demonstrate the principles and working mechanisms of inkjet-based 3D printing systems and evaluate their actuation methods, material jetting techniques, and material formulation aspects.	Evaluate
CO4	Explain the construction and function of laser-based 3D printing systems including light sources, powder fusion techniques, and machine configuration.	Understand
CO5	Identify and assess various industrial applications and emerging trends in 3D printing, including sustainable practices, bioprinting, and Industry 4.0 integration.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	3	1	1	1	1	1	2	3	2	2
CO2	3	3	2	2	3	2	1	1	1	1	2	3	3	2
CO3	3	3	2	3	3	2	1	1	1	1	2	3	3	3
CO4	3	2	2	2	3	1	1	1	1	1	2	3	2	3
CO5	3	3	3	2	3	3	2	1	2	1	3	3	3	3

1 - low, 2 - medium, 3 - high

UNIT I – Introduction to 3D Printing

Digital workflow – Modelling – Scanning – Slicing – File formats – STL – OBJ – AMF – Model preparation – Support generation – Orientation – Platform selection

UNIT II – 3D Printing Principles

Extrusion-based printing – Wire materials – Granular materials – Lamination-based printing – Sheet bonding – Paper usage – Polymer usage – Photopolymerization techniques – SLA – DLP – UV-curing – Material types – Plastics – Metals – Ceramics – Paper – Bio-materials – Graphene – Material selection criteria – Strength – Compatibility – Cost – Resolution

UNIT III – Inkjet-Based 3D Printing
Inkjet printing systems – Continuous Inkjet (CIJ) – Drop-on-Demand – Actuation mechanisms – Thermal systems – Piezoelectric systems – Material jetting methods – Liquid jet printing – Powder jet printing – Color jet printing – Material formulation – Rheology – Viscosity control – Binding agents

UNIT IV – Laser-Based 3D Printing
Light sources and optics – Lasers – Mirrors – Scanning systems – Powder bed fusion processes – SLS – DMLS – SLM – Stereolithography – Laser curing – Resin materials – Machine configuration – Build platform – Motion system – Support strategies

UNIT V – Applications and Emerging Trends

Industrial applications – Electronics – Healthcare – Food – Biotechnology – Packaging – Displays – Advanced technologies – Bioprinting – 4D printing – Multi-material printing – Sustainability trends – Recyclable materials – Energy-efficient systems – Research and future outlook – Industry 4.0 – Customized manufacturing

SUGGESTED READINGS

1. C. Barnatt, "3D Printing: The Next Industrial Revolution", CreateSpace Independent Publishing, USA, (2013).
2. I.M. Hutchings, G.D. Martin, "Inkjet Technology for Digital Fabrication", Wiley, UK, (2013).
3. Chua C.K., Leong K.F., Lim C.S., "Rapid Prototyping: Principles and Applications", World Scientific Publishing, Singapore, (2010).
4. Joan Horvath, "Mastering 3D Printing", APress, USA, (2014).
   C. Barnatt, "3D Printing: The Next Industrial Revolution", CreateSpace Independent Publishing, USA, (2013).

Programme Elective: Production and Industrial Engineering Stream **Semester – 5**

25MEU532B **MICRO AND NANO MACHINING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Understand the fundamentals of micro- and nano-manufacturing processes and their significance.
- Explore various techniques and equipment used in micro- and nano-fabrication.
- Analyze the physical, chemical, thermal, and mechanical mechanisms behind micro and nano material removal.
- Gain insights into metrology, inspection, and quality control techniques at micro and nano scales.
- Explore recent advances and future trends in micro- and nano-manufacturing.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Differentiate micro and nano-manufacturing processes from conventional ones and understand their underlying principles.	Understand
CO2	Select suitable physical and mechanical micro/nano manufacturing techniques for precise applications.	Apply
CO3	Apply chemical and thermal processes in micro/nano patterning with controlled accuracy.	Apply
CO4	Operate and analyze electrical and electrochemical micromachining methods for material removal.	Analyze
CO5	Evaluate metrology tools and explore emerging technologies in the field of micro and nano manufacturing.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	1	1	1	1	1	2	3	2	2
CO2	3	2	3	2	3	1	1	1	1	1	2	3	3	2
CO3	3	2	3	3	3	2	1	1	1	1	2	3	3	3
CO4	3	3	2	3	3	1	1	1	1	1	2	3	3	3
CO5	3	3	2	3	3	2	1	1	1	1	3	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION TO MICRO AND NANO MANUFACTURING

Introduction – Differences between macro, micro, and nano-manufacturing – Need and advantages – Scaling laws – Challenges in micro and nano-manufacturing – Applications in electronics, biomedical, aerospace, automotive, and other sectors.

UNIT 2: PHYSICAL AND MECHANICAL PROCESSES

Mechanical micromachining (micro turning, micro milling, micro drilling) – Ultra-precision machining – Ion beam machining – Focused ion beam machining – Nano indentation – Mechanical properties at micro/nano scale.

UNIT 3: CHEMICAL AND THERMAL PROCESSES
Chemical etching – Photolithography – Electron beam lithography – X-ray lithography – Nanoimprint lithography – Thermal processing (e.g., laser-based heating, annealing) – Principles, equipment, parameters, and applications.

UNIT 4: ELECTRICAL AND ELECTROCHEMICAL PROCESSES
Electrochemical machining (ECM) – Micro-ECM – Electric discharge machining (EDM) – Micro EDM – Laser beam micromachining – Electron beam micromachining – Equipment, process parameters, MRR, and surface finish.

UNIT 5: METROLOGY, INSPECTION, AND EMERGING TRENDS
Metrology tools for micro/nano features – AFM, SEM, STM – Surface roughness measurement – Quality control at micro/nano level – Emerging materials – Hybrid processes – 3D nanofabrication – Future of micro and nano manufacturing.

SUGGESTED READINGS

1. Mark J. Jackson, "Microfabrication and Nanomanufacturing", CRC Press, 2005.
2. Yi Qin, "Micromanufacturing Engineering and Technology", William Andrew Publishing, 2010.
3. Mark Hadfield, "Precision Manufacturing", Springer, 2013.
4. Irene Fassi and David Shipley, "Micro-Manufacturing Technologies and Their Applications", Springer, 2017.
5. Kapil Gupta (Ed.), "Advanced Manufacturing Technologies: Modern Machining Methods", Springer, 2017.

Programme Elective: Production and Industrial Engineering Stream **Semester – 5**
25MEU533B **UNCONVENTIONAL MACHINING TECHNIQUES** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

1. Demonstrate knowledge of unconventional machining processes, their classification, advantages, and limitations.
2. Manipulate thermal and electrical energy-based machining processes by understanding their principles, equipment, and process parameters.
3. Assemble and analyze chemical and electrochemical machining processes by examining process parameters and surface finish.
4. Perform advanced nano-finishing processes to achieve high-precision machining.
5. Create innovative solutions by exploring recent trends in non-traditional machining processes.

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between various unconventional machining processes and analyze their working principles.	Analyze
CO2	Choose appropriate thermal and electrical energy-based machining techniques for different industrial applications.	Apply
CO3	Identify and apply chemical and electrochemical machining processes to achieve high-precision machining.	Apply
CO4	Adjust and optimize process parameters in advanced nano-finishing processes for enhanced performance.	Analyze
CO5	Evaluate and compare recent trends in non-traditional machining processes to enhance manufacturing efficiency.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	1	1	1	1	2	3	2	2
CO2	3	2	3	2	3	1	1	1	1	1	2	3	3	2
CO3	3	2	3	3	3	2	1	1	1	1	2	3	3	3
CO4	3	3	2	3	3	2	1	1	1	1	2	3	3	3
CO5	3	3	3	3	3	2	1	1	1	1	3	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION AND MECHANICAL ENERGY BASED PROCESSES

Unconventional machining Process – Need – classification – merits, demerits and applications. Abrasive Jet Machining – Water Jet Machining – Abrasive Water Jet Machining - Ultrasonic Machining. (AJM, WJM, AWJM and USM). Working Principles – equipment used – Process parameters – MRR- Applications.

UNIT 2: THERMAL AND ELECTRICAL ENERGY BASED PROCESSES

Electric Discharge Machining (EDM) – Wire cut EDM – Working Principle-equipments-Process Parameters-Surface Finish and MRR- electrode / Tool – Power and control Circuits-Tool Wear – Dielectric – Flushing — Applications. Laser Beam machining and drilling, (LBM), plasma, Arc machining (PAM) and Electron Beam Machining (EBM). Principles – Equipment –Types - Beam control techniques –

Applications.

UNIT 3: CHEMICAL AND ELECTRO-CHEMICAL ENERGY BASED PROCESSES

Chemical machining and Electro-Chemical machining (CHM and ECM)- Etchants – Maskant - techniques of applying maskants - Process Parameters – Surface finish and MRR-Applications. Principles of ECM- equipments-Surface Roughness and MRR Electrical circuit-Process Parameters- ECG and ECH - Applications.

UNIT 4: ADVANCED NANO FINISHING PROCESSES

Abrasive flow machining, chemo-mechanical polishing, magnetic abrasive finishing, magneto rheological finishing, magneto rheological abrasive flow finishing their working principles, equipments, effect of process parameters, applications, advantages and limitations.

UNIT 5 **HYBRID NON-TRADITIONAL MACHINING TECHNIQUES**

Hybrid Non-Traditional Machining Processes: principles, equipment, process parameters, applications, advantages, limitations, and process selection & comparison.

SUGGESTED READINGS

1. Vijay.K.Jain, "Advanced Machining Processes", Allied Publishers Pvt. Ltd,New Delhi, (2013).
2. Pandey P.C. and Shan H.S. "Modern Machining Processes", Tata McGraw-Hill, New Delhi, (2008).
3. Golam Kibria, Bhattacharyya B. and Paulo Davim J., "Non-traditional Micromachining Processes: Fundamentals and Applications", Springer International Publishing., Switzerland, (2017).
4. Jagadeesha T, "Non-Traditional Machining Processes", I.K. International Publishing House Pvt. Ltd., New Delhi, India, (2017).

   Kapil Gupta, Neelesh K. Jain and Laubscher R.F., "Hybrid Machining Processes: Perspectives on Machining and Finishing", 1st edition, Springer International Publishing., Switzerland, (2016).

Programme Elective: Production and Industrial Engineering Stream **Semester – 6**

25MEU631B **NON-DESTRUCTIVE EVALUATION OF MATERIALS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

1. Demonstrate an understanding of various Non-Destructive Testing (NDT) methods and their applications in material characterization and defect detection.
2. Manipulate different surface NDT methods such as Liquid Penetrant Testing and Magnetic Particle Testing for defect identification.
3. Assemble and operate Thermography and Eddy Current Testing equipment for flaw detection and material evaluation.
4. Perform Ultrasonic and Acoustic Emission Testing to evaluate internal defects and material integrity.
5. Create radiographic test setups, analyze radiographic images, and interpret results for effective material evaluation.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between various NDT methods and their suitability for different materials and defects.	Analyze
CO2	Choose appropriate surface NDE methods and apply them for defect detection in engineering components.	Apply
CO3	Assemble and operate thermographic and eddy current testing instruments for non-destructive evaluation.	Apply
CO4	Adjust ultrasonic and acoustic emission testing parameters to optimize defect detection.	Apply
CO5	Identify radiographic techniques and interpret radiographic images for quality assessment in materials and structures.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	1	-	-	-	1	-	1	2	2	1
CO2	2	3	2	2	3	-	-	1	1	-	1	3	2	1
CO3	2	2	2	2	3	-	-	1	1	1	1	3	3	2
CO4	2	3	2	3	3	-	-	-	1	1	1	3	3	2
CO5	3	3	1	3	2	1	1	-	2	-	1	2	2	1

1 - low, 2 - medium, 3 - high

UNIT 1: OVERVIEW OF NDT

NDT Versus Mechanical testing, Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterisation. Relative merits and limitations, various physical characteristics of materials and their applications in NDT. Visual inspection – Unaided and aided.

UNIT 2: SURFACE NDE METHODS

Liquid Penetrant Testing - Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, inspection materials Magnetisation methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.

UNIT 3:THERMOGRAPHYAND EDDY CURRENT TESTING

Thermography- Principles, Contact and non contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation - infrared radiation and infrared detectors, Instrumentations and methods, applications. Eddy Current Testing-Generation of eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation,Types of arrangement, Applications, advantages, Limitations, Interpretation / Evaluation.

UNIT 4: ULTRASONIC TESTING ANDACOUSTIC EMISSION

Ultrasonic Testing-Principle, Transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique – Principle, AE parameters, Applications**.**

UNIT 5: RADIOGRAPHY

Principle, interaction of X-Ray with matter, imaging, film and film less techniques, types and use of filters and screens, geometric factors, Inverse square, law, characteristics of films- graininiess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy- Xero-Radiography, Computed Radiography, Computed Tomography.

SUGGESTED READINGS

1. Baldev Raj, T. Jayakumar, M. Thavasimuthu."Practical Non-Destructive Testing", NarosaPublishing House, (2014).
2. Ravi Prakash, "Non-Destructive Testing Techniques", 1st revised edition, New Age International Publishers, (2010).
3. ASM Metals Handbook, "Non-Destructive Evaluation and Quality Control", American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
4. ASNT, American Society for Non Destructive Testing, Columbus, NDT Handbook,Vol. 1, Leak Testing, Vol.2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing.
5. Charles, J. Hellier, "Handbook of Nondestructive evaluation", McGraw Hill, New York (2001).
6. Paul E Mix, "Introduction to Non-destructive testing: a training guide", Wiley, 2nd Edition New Jersey, (2005).

Programme Elective: Production and Industrial Engineering Stream **Semester – 6**

25MEU632B **CASTING AND WELDING PROCESSES** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate knowledge of casting processes, materials, and molding techniques.
- Manipulate different types of melting furnaces and metal mold casting techniques.
- Assemble casting components considering solidification and non-ferrous foundry practices.
- Perform various welding techniques and evaluate their applications.
- Create defect-free welding joints using advanced welding and inspection techniques.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different casting techniques and their applications.	Analyze
CO2	Choose appropriate melting and metal mold casting methods for manufacturing.	Apply
CO3	Identify solidification variables and propose methods to enhance casting quality.	Understand
CO4	Adjust welding parameters to optimize performance and joint quality.	Apply
CO5	Evaluate soldering, brazing, and welding defects and apply appropriate inspection methods.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	1	–	–	–	1	–	1	2	2	1
CO2	3	3	3	2	3	1	–	1	1	–	1	3	3	2
CO3	3	2	2	3	2	1	–	–	1	–	1	3	2	1
CO4	2	3	2	2	3	1	–	1	1	1	1	3	3	2
CO5	3	3	2	3	3	2	1	1	2	1	1	3	3	2

UNIT 1: INTRODUCTION

Classification, factors that determine the selection of a casting alloy. Introduction to casting process & steps involved. Patterns: Definition, classification, materials, allowances and their importance. Sand molding: Types of base sand, requirement of base sand. Binder, Additives definition, need and types. Molding machines- Jolt type, squeeze type and Sand slinger.Study of important molding process: Green sand, core sand, dry sand, sweep mold, CO_2mold, shell mold, investment mold, plaster mold, cement bonded mold. Cores: need, types. Method of making cores, concept of gating (top, bottom, parting line, horngate) and risering (open, blind) Functions and types.

UNIT 2: MELTING & METAL MOLD CASTING METHODS

Melting furnaces- Classification of furnaces, Gas fired pit furnace, Resistance furnace, Coreless induction furnace,electric arc furnace, constructional features & working principle of cupola furnace. Casting using metal molds. Gravity die casting, pressure die casting, centrifugal casting, squeeze casting, slush casting,thixocasting, and continuous casting processes.

UNIT 3: SOLIDIFICATION & NON FERROUS FOUNDRY PRACTICE

Solidification: Definition, Nucleation, solidification variables, Directional solidification-need and methods. Degasification in liquid metals-Sources of gas, degasification methods. Fettling and cleaning of castings, Basic steps involved. Sand Casting defects- causes, features and remedies. Advantages& limitations of casting process nonferrous foundry practice, Aluminium castings - Advantages, limitations, melting of aluminium using lift-out type crucible furnace. Hardeners used, drossing, gas absorption, fluxing and flushing, grain refining, pouring temperature. Stir casting set up, procedure, uses, advantages and limitations.

UNIT 4: WELDING PROCESS

Welding process, Definition, Principles, Classification, Application, Advantages & limitations of welding. Arc welding:Principle, Metal arc welding (MAW), Flux Shielded Metal Arc Welding (FSMAW), Inert Gas Welding (TIG & MIG)Submerged Arc Welding (SAW) and Atomic Hydrogen Welding (AHW). Special type of welding: Resistance welding principles, Seam welding, Butt welding, Spot welding and Projectionwelding. Friction welding, Explosive welding, Thermit welding, Laser welding and electron beam welding.

UNIT-5 SOLDERING, BRAZING AND METALLURGICAL ASPECTS IN WELDING

Structure of welds, Formation of different zones during welding, Heat Affected Zone (HAZ), Parameters affecting HAZ.Effect of carbon content on structure and properties of steel, Shrinkage in welds& Residual stresses, Concept ofelectrodes, filler rod and fluxes. Welding defects- Detection, causes & remedy. Soldering, brazing, gas welding:Principle, oxy-Acetylene welding, oxy-hydrogenwelding, air-acetylene welding, Gas cutting, powder cutting.Inspection methods: Methods used for inspection of casting and welding. Visual, magnetic particle, fluorescent particle,ultrasonic.Radiography, eddy current, holography methods of inspection.

SUGGESTED READINGS

1. P.N.Rao, “Manufacturing Technology”, Tata McGraw Hill, 2008.
2. Heine, Loper and Rosenthal, “Principles of Metal Casting”, Tata McGraw Hill, 2001.
3. A.K.Chakrabarti, “Casting Technology and Cast Alloys”, Prentice –Hall Of India Ltd, 2005.
4. T.V.Rama Rao, “Metal casting Principles and Practice”, New Age International, 2010.
   R.S Parmar, “Welding Engineering and Technology”, Khanna Publishers, 2002.

Programme Elective: Production and Industrial Engineering Stream **Semester – 6**

25MEU633B **PROCESS PLANNING AND COST ESTIMATION** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate knowledge of process planning methodologies, drawing interpretation, and material evaluation.
- Manipulate process parameters and select appropriate tools, jigs, fixtures, and quality assurance methods.
- Assemble cost estimation components, including material, labor, and overhead allocation.
- Perform production cost estimation for different manufacturing jobs.
- Create machining time calculations for various machining operations.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Identify and explain various process planning methods, material evaluation techniques, and tooling selection.	Understand
CO2	Choose appropriate process parameters, jigs, fixtures, and quality assurance methods for efficient manufacturing.	Apply
CO3	Compute cost estimates, including labor, material, overhead, and depreciation costs.	Apply
CO4	Analyze and evaluate production cost estimation for forging, welding, and foundry processes.	Analyze
CO5	Compute machining time for lathe, milling, shaping, drilling, boring, grinding, and planning operations.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	–	–	–	1	–	1	2	2	1
CO2	3	3	3	2	3	1	–	1	1	1	1	3	3	2
CO3	3	3	2	2	2	1	–	–	1	3	1	3	2	2
CO4	3	3	2	3	2	1	–	–	1	2	1	3	2	2
CO5	3	3	2	2	3	–	–	–	1	2	1	3	3	2

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION TO PROCESS PLANNING

Introduction- methods of process planning-Drawing interpretation-Material evaluation – steps in process selection-.Production equipment and tooling selection.

UNIT 2: PROCESS PLANNING ACTIVITIES

Process parameters calculation for various production processes-Selection jigs and fixtures election of quality assurance methods - Set of documents for process planning-Economics of process planning- case studies. Process Planning Integration based on modelling and simulation. Cost Estimation system for product manufacturing using Expert System.

UNIT 3: INTRODUCTION TO COST ESTIMATION

Importance of costing and estimation –methods of costing-elements of cost estimation –Types of estimates – Estimating procedure- Estimation labor cost, material cost- allocation of over head charges- Calculation of depreciation cost. Software systems for more accurate & improved process planning followed by improving profit margins, strong relations, automated cost estimation and pricing

UNIT 4: PRODUCTION COST ESTIMATION

Estimation of job costs in various shops- Forging Shop, Welding Shop, Foundry Shop.

UNIT 5: MACHINING TIME CALCULATION

Estimation of Machining Time - Importance of Machine Time Calculation- Calculation of Machining Time for Different Lathe Operations ,Drilling and Boring - Machining Time Calculation for Milling, Shaping and Planning -Machining Time Calculation for Grinding.

SUGGESTED READINGS

1. Peter scalon."Process planning, Design/Manufacture Interface", Elsevier science technology Books, Dec (2002).
2. Ostwalal P.F. and Munez J."Manufacturing Processes and systems", 9th Edition, John Wiley, (1998).
3. Russell R.S and Tailor B.W. "Operations Management", 4th Edition, PHI, (2003).
4. Chitale A.V. and Gupta R.C. "Product Design and Manufacturing", 2nd Edition, PHI, (2002).

Programme Elective: Production and Industrial Engineering Stream **Semester – 6**

25MEU634B **MANAGEMENT & ORGANIZATIONAL BEHAVIOUR** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of management principles and organizational behavior by organizing the roles and responsibilities of managers in business environments.
- Identify and classify individual behavioral attributes at the workplace by observing personality, perception, and motivation factors.
- Perform effective time and stress management techniques by applying planning tools and coping mechanisms in simulated work situations.
- Assemble and coordinate group activities by practicing teamwork, collaboration, and group decision-making methods.
- Create conflict resolution and leadership approaches by applying negotiation skills and communication strategies in organizational scenarios.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Differentiate and demonstrate managerial roles and ethical practices required for effective business operations.	Apply
CO2	Identify and evaluate the impact of personality, perception, attitudes, and motivation on employee behavior.	Analyze
CO3	Apply and control time management tools and stress-reduction techniques to improve individual performance.	Apply
CO4	Coordinate teamwork and group decision-making processes for enhancing group efficiency and cohesiveness.	Analyze
CO5	Design and execute appropriate leadership and conflict management strategies to resolve workplace issues effectively.	Create

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	2	2	1	1	2	3	2	2	2	1	1	1	1
CO2	1	3	1	2	1	2	2	2	2	1	1	1	1	1
CO3	–	2	1	1	2	2	2	2	2	2	3	–	1	1
CO4	–	3	2	2	1	2	2	3	2	2	1	–	1	1
CO5	–	3	3	2	2	3	3	3	3	2	2	–	1	1

1 - low, 2 - medium, 3 - high

UNIT 1: Principles of Management and Organizational Behaviour 9

Nature, scope, and functions of management – Managerial roles and skills – Levels of management – Organizational behavior: meaning and scope – Social responsibilities and ethics in business – Holistic approach to business.

UNIT 2: Individual Behaviour at Work 9

Personality determinants and theories – Perception process and perceptual errors – Attitudes, values, and workplace behavior – Motivation theories (Maslow, Herzberg, McGregor) – Employee behavior modification.

UNIT 3: Time and Stress Management 9

Importance of time management – Planning and scheduling tools (ABC analysis, Pareto principle, Time logs) – Definition of stress – Sources and types of stress – Stress consequences and coping strategies – Employee wellness and relaxation techniques.

UNIT 4: Group Behaviour and Team Dynamics 9

Group formation and development stages – Types of groups – Group norms, roles, and cohesiveness – Teamwork and collaboration – Group decision-making techniques – Managing group performance and barriers.

UNIT 5: Conflict Management and Leadership 9

Concept and nature of conflict – Sources, types, and stages of conflict – Negotiation and conflict resolution strategies – Preventive and corrective approaches – Leadership theories and styles – Communication process and barriers to effective communication.

SUGGESTED READINGS

1. Stephen P. Robbins, Timothy A. Judge & Neharika Vohra Organizational Behavior, 19th Edition, Pearson, 2023.
2. Ricky W. Griffin, Principles of Management, 10th Edition, Cengage Learning, 2022.
3. Harold Koontz & Heinz Weihrich, Essentials of Management: An International, Innovation, and Leadership Perspective, 11th Edition, Tata McGraw-Hill, 2021.
4. P. Subba Rao, Management and Organizational Behaviour, Himalaya Publishing House, Revised Edition, 2024.
5. John R. Schermerhorn Jr., Daniel G. Bachrach & Barry Wright Organizational Behavior, 15th Edition, Wiley, 2023.
6. Fred Luthans, Brett C. Luthans & Kyle W. Luthans Organizational Behavior: An Evidence-Based Approach, 14th Edition, McGraw-Hill, 2021.
7. M. S. Ramaiah & S. Jayashree Principles of Management, Universities Press, 2020.

Programme Elective: Production and Industrial Engineering Stream **Semester – 7**
25MEU731B **COMPUTER INTEGRATED MANUFACTURING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Demonstrate the fundamentals of CAD/CAM, manufacturing planning, control, and automation techniques.
- Manipulate production planning and control methodologies, including material requirement and inventory control.
- Assemble and analyze part families using Group Technology (GT) and Cellular Manufacturing principles.
- Perform quantitative analysis in Flexible Manufacturing Systems (FMS) and Automated Guided Vehicle Systems (AGVS).
- Create and integrate robotic systems for industrial applications, ensuring accuracy and repeatability.

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different types of production systems, automation levels, and CIM concepts.	Analyze
CO2	Choose appropriate production planning and control strategies to optimize manufacturing processes.	Apply
CO3	Assemble part families and apply classification coding using Group Technology (GT).	Apply
CO4	Adjust and evaluate the performance of FMS and AGVS for improved manufacturing efficiency.	Analyze
CO5	Identify and utilize industrial robotics for automation in manufacturing environments.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	2	1	–	–	1	–	1	2	2	1
CO2	3	3	3	2	3	1	–	1	1	2	1	3	3	2
CO3	2	2	2	2	3	–	–	1	1	1	1	3	3	2
CO4	3	3	2	3	3	1	–	1	1	2	1	3	3	2
CO5	2	2	2	2	3	1	–	1	1	1	1	3	3	2

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION

Brief introduction to CAD and CAM – Manufacturing Planning, Manufacturing control- Introduction to CAD/CAM – Concurrent Engineering-CIM concepts – Computerised elements of CIM system –Types of production - Manufacturing models and Metrics – Mathematical models of Production Performance – Simple problems – Manufacturing Control – Simple Problems – Basic Elements of an Automated system – Levels of

Automation – Lean Production and Just-In-Time Production.

UNIT 2: PRODUCTION PLANNING AND CONTROL AND COMPUTERISED PROCESS PLANNING

Process planning – Computer Aided Process Planning (CAPP) – Logical steps in Computer Aided Process Planning – Aggregate Production Planning and the Master Production Schedule – Material Requirement planning – Capacity Planning- Control Systems-Shop Floor Control-Inventory Control – Brief on Manufacturing Resource Planning-II (MRP-II) & Enterprise Resource Planning (ERP) - Simple Problems.

UNIT 3: CELLULAR MANUFACTURING

Group Technology(GT), Part Families – Parts Classification and coding – Simple Problems in Opitz Part Coding system – Production flow Analysis – Cellular Manufacturing – Composite part concept – Machine cell design and layout – Quantitative analysis in Cellular Manufacturing – Rank Order Clustering Method
- Arranging Machines in a GT cell – Hollier Method – Simple Problems.

UNIT 4: FLEXIBLE MANUFACTURING SYSTEM (FMS) AND AUTOMATED GUIDED VEHICLE SYSTEM (AGVS)

Types of Flexibility - FMS – FMS Components – FMS Application & Benefits – FMS Planning and Control – Quantitative analysis in FMS – Simple Problems. Automated Guided Vehicle System (AGVS) – AGVS Application – Vehicle Guidance technology – Vehicle Management & Safety.

UNIT 5: INDUSTRIAL ROBOTICS

Robot Anatomy and Related Attributes – Classification of Robots- Robot Control systems – End Effectors – Sensors in Robotics – Robot Accuracy and Repeatability - Industrial Robot Applications – Robot Part Programming – Robot Accuracy and Repeatability – Simple Problems.

SUGGESTED READINGS

1. Jamnia, A., Introduction to Product Design and Development for Engineers, CRC Press, 2018.
2. Paul Trott, "Innovation Management and New Product Development", 6th Edition, Pearson Publication, (2017).
3. Karl T. Ulrich and Stephen D. Eppinger "Product Design and Development", 7th Edition, McGraw- Hill, (2019).
4. Mitsuo Nagamachi, Anitawati Mohd Lokman, "Innovation: Practical Design Applications for Product and Service Development", 1stEdition, CRC Press, (2015).
   Marcus Vinicius Pereira Pessôa, Luis Gonzaga Trabasso, "The Lean Product Design and Development Journey: A Practical View", Springer International Publishing, (2017).

Programme Elective: Production and Industrial Engineering Stream **Semester – 7**

25MEU732B **MAINTENANCE ENGINEERING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate the need, objectives, and challenges of maintenance management.
- Manipulate different maintenance models, policies, and optimal scheduling methods.
- Assemble maintenance logistics, including planning, scheduling, and spare parts control.
- Perform maintenance quality assessment using FMECA, RCA, and RCM.
- Create an effective Total Productive Maintenance (TPM) strategy.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between various maintenance concepts and their applications.	Analyze
CO2	Choose appropriate maintenance models for different industrial scenarios.	Apply
CO3	Assemble and manage maintenance logistics effectively.	Apply
CO4	Adjust maintenance quality strategies for improved reliability and maintainability.	Analyze
CO5	Identify key aspects of Total Productive Maintenance (TPM) and its implementation	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	1	1	–	–	1	–	1	2	2	1
CO2	3	3	3	2	2	1	–	1	1	1	1	3	3	2
CO3	2	2	2	2	3	1	–	2	1	2	1	3	3	2
CO4	3	3	2	3	2	2	–	1	1	2	1	3	3	2
CO5	2	2	1	2	2	2	1	1	1	1	1	2	2	1

1 - low, 2 - medium, 3 - high

UNIT 1: MAINTENANCE CONCEPT

Need for maintenance – Maintenance definition – Maintenance objectives – Challenges of Maintenance management – Tero technology – Scope of maintenance department – Maintenance costs.

UNIT 2: MAINTENANCE MODELS

Proactive/Reactive maintenance – Imperfect maintenance – Maintenance policies – PM versus break down maintenance – Optimal PM schedule and product characteristics – Optimal Inspection frequency: Maximizing profit– Minimizing downtime – Replacement models.

UNIT 3: MAINTENANCE LOGISTICS

Human factors – Crew size decisions: Learning curves – Simulation – Maintenance resource requirements: Optimal size of service facility – Optimal repair effort – Maintenance planning – Maintenance scheduling – Spare parts control – Capital spare.

UNIT 4: MAINTENANCE QUALITY

Maintenance excellence –Five Zero concept –FMECA –Root cause analysis – System effectiveness – Design for maintainability – Maintainability allocation – CMMS – Reliability Centred Maintenance.

UNIT 5: TOTAL PRODUCTIVE MAINTENANCE

TPM features – Chronic and sporadic losses – Equipment defects – Six major losses – Overall Equipment Effectiveness – TPM pillars –TPM implementation – Autonomous maintenance.

SUGGESTED READINGS

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1. Andrew K.S.Jardine & Albert H.C.Tsang, "Maintenance, Replacement and Reliability",Taylor and Francis, 2nd edition, 2013.
2. Bikas Badhury & S.K.Basu, "Tero Technology: Reliability Engineering and Maintenance Management", Asian Books, 2003.
3. Seichi Nakajima, "Total Productive Maintenance", Productivity Press, 1993

Programme Elective: Production and Industrial Engineering Stream **Semester – 7**

25MEU733B **PRODUCTION PLANNING AND CONTROL** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

1. Demonstrate knowledge of production planning and control, including its objectives, functions, and types of production systems.
2. Analyze various work study techniques, including method study and work measurement, to improve productivity.
3. Develop effective product planning and process planning strategies, ensuring efficiency and optimization.
4. Perform production scheduling using different control systems, scheduling rules, and sequencing techniques.
5. Implement inventory control techniques and apply modern trends in production planning and control, such as MRP and ERP systems.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different types of production systems and analyze their suitability for various manufacturing scenarios.	Analyze
CO2	Apply work study techniques to optimize production processes and improve efficiency.	Apply
CO3	Plan and design process planning strategies to enhance manufacturing effectiveness and resource utilization.	Apply
CO4	Utilize scheduling techniques to manage production timelines and ensure timely completion of manufacturing tasks.	Apply
CO5	Implement inventory control systems and integrate modern production planning methods for effective resource management.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	1	1	–	–	1	–	1	2	2	1
CO2	3	3	2	2	3	1	–	1	1	1	1	3	3	2
CO3	3	3	3	2	3	1	–	1	1	2	1	3	3	2
CO4	2	3	2	2	3	1	–	1	1	3	1	3	3	2
CO5	3	3	3	2	3	2	–	1	1	3	1	3	3	2

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION

Objectives and benefits of planning and control-Functions of production control-Types of production-job- batch and continuous-Product development and design-Marketing aspect - Functional aspects- Operational aspect-Durability and dependability aspect-aesthetic aspect. Profit consideration - Standardization, Simplification &specialization – Break Even Analysis-Economics of a new design.

UNIT 2: WORKSTUDY

Method study, basic procedure –Selection –Recording of process-Critical analysis, Development -Implementation –Micro motion and memo motion study – Work measurement-Techniques of work measurement- Time study- Production study - Work sampling- Synthesis from standard data– Pre- determined motion time standards.

UNIT 3: PRODUCT PLANNING AND PROCESS PLANNING

Product planning-Extending the original product information-Value analysis-Problems in lack of product planning-Process planning and routing- Pre requisite information needed for process planning-Steps in process planning-Quantity determination in batch production-Machine capacity, balancing-Analysis of process capabilities in a multi product system.

UNIT 4: PRODUCTION SCHEDULING

Production Control Systems-Loading and scheduling –Master Scheduling –Scheduling rules- Gantt charts-Perpetual loading-Basics scheduling problems - Line of balance –Flow production scheduling- Batch production scheduling-Product sequencing - Production Control systems- Periodic batch control- Material requirement planning - Kanban–Dispatching-Progress reporting and expediting-Manufacturing lead time-Techniques for aligning completion times and due dates.

UNIT 5: INVENTORY CONTROL AND RECENT TRENDS IN PPC

Inventory control-Purpose of holding stock-Effect of demand on inventories-Ordering procedures. Two bin system-Ordering cycle system-Determination of Economic order quantity and economic lot size-ABC analysis-Recorder procedure-Introduction to Computer Integrated Production Planning systems – elements of Just In Time Systems-Fundamentals of MRPII and ERP.

SUGGESTED READINGS

1. Martand Telsang "Industrial Engineering and Production Management" S. Chand and Company, 2nd edition (2002).
2. Samson Eilon"Elements of Production Planning and Control", Universal Book Corpn. (1984).
3. Elwood S.Buffa and Rakesh K. Sarin"Modern Production/Operations Management",8th Ed. John Wiley and Sons (2000).
4. Jain K.C &Aggarwal L.N "Production Planning Control and Industrial Management", Khanna Publishers, 6th Edition (2008).
5. Nair N.G "Production and Operations Management", Tata McGraw-Hill Publisher, New Delhi (2004).

Programme Elective: Production and Industrial Engineering Stream **Semester – 7**

25MEU734B **SAFETY IN PROCESS INDUSTRIES** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate knowledge of safety considerations in process design and pressure system design, including safety standards and risk assessment.
- Manipulate commissioning and inspection procedures to ensure the safe operation and maintenance of process plants.
- Assemble and execute plant operations while adhering to safety protocols and hazard management techniques.
- Perform plant maintenance and modifications effectively, ensuring compliance with safety regulations and emergency preparedness.
- Create storage safety protocols and evaluate storage hazard assessments for various industrial chemicals.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different safety mechanisms in process design and pressure systems.	Analyze
CO2	Choose appropriate commissioning and inspection techniques for ensuring plant safety and performance.	Apply
CO3	Assemble operational procedures to enhance safety and minimize risks in plant operations.	Apply
CO4	Adjust maintenance and modification plans to comply with safety regulations and emergency protocols.	Analyze
CO5	Identify storage hazards and design safety measures for industrial chemical storage facilities.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	2	2	–	1	–	1	2	2	1
CO2	3	3	3	2	3	2	2	1	1	1	1	3	3	2
CO3	2	3	3	2	2	3	2	2	1	2	1	3	3	2
CO4	3	3	2	3	2	3	2	1	1	2	1	3	3	2
CO5	2	2	3	2	2	3	2	1	1	1	1	2	2	1

1 - low, 2 - medium, 3 - high

UNIT 1: SAFETY IN PROCESS DESIGN AND PRESSURE SYSTEM DESIGN

Design process, conceptual design and detail design, assessment, inherently safer design chemical reactor, types, batch reactors, reaction hazard evaluation, assessment, reactor safety, operating conditions, unit operations and equipments, utilities. Pressure system, pressure vessel design, standards and codes- pipe works and valves heat exchangers- process machinery- over pressure protection, pressure relief devices and design, fire relief, vacuum and thermal relief, special situations, disposal- flare and vent systems- failures in pressure system.

UNIT 2: PLANT COMMISSIONING AND INSPECTION

Commissioning phases and organization, pre-commissioning documents, process commissioning, commissioning problems, post commissioning documentation Plant inspection, pressure vessel, pressure piping system, nondestructive testing, pressure testing, leak testing and monitoring- plant monitoring, performance monitoring, condition, vibration, corrosion, acoustic emission-pipe line inspection.

UNIT 3: PLANT OPERATIONS

Operating discipline, operating procedure and inspection, format, emergency procedures hand over and permit system- start up and shut down operation, refinery units- operation of fired heaters, driers, storage- operating activities and hazards- trip systems- exposure of personnel-colour coding of pipes and cylinders – Corrosion prevention for underground pipes.

UNIT 4: PLANT MAINTENANCE, MODIFICATION AND EMERGENCY PLANNING

Management of maintenance, hazards- preparation for maintenance, isolation, purging, cleaning, confined spaces, permit system- maintenance equipment- hot works- tank cleaning, repair and demolition- online repairsmaintenance of protective devices modification of plant, problems- controls of modifications. Emergency planning, disaster planning, onsite emergency- offsite emergency.

UNIT 5: STORAGES

General consideration, petroleum product storages, storage tanks and vessel- storages layout-segregation, separating distance, secondary containment- venting and relief, atmospheric vent, pressure, vacuum valves, flame arrestors, fire relief- fire prevention and protection- LPG storages, pressure storages, layout, instrumentation, vapourizer, refrigerated storages- LNG storages, hydrogen storages, toxic storages, chlorine storages, ammonia storages, other chemical storages- underground storages- loading and unloading facilities-drum and cylinder storage- ware house, storage hazard assessment of LPG and LNG.

SUGGESTED READINGS

1. Lees, F.P., “Loss Prevention in Process Industries” Butterworth publications, London, 3rd edition, 2005.
2. Sanoy Banerjee, “Industrial hazards and plant safety”, Taylor & Francis, London, 2003.
3. Fawcett, H. and Wood, “Safety and Accident Prevention in Chemical Operations” Wiley inters, 2nd Edition, 1984.
4. McElroy, Frank E., “Accident Prevention Manual for Industrial Operations”, NSC, Chicago, 1988. Green, A.E., “High Risk Safety Technology”, John Wiley and Sons, 1984

Programme Elective: Production and Industrial Engineering Stream **Semester – 7**

25MEU735B **QUALITY AND RELIABILITY ENGINEERING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of quality concepts, Statistical Quality Control (SQC), and process capability.
- Manipulate control charts for attributes and analyze process variations.
- Assemble different sampling techniques and apply them to acceptance sampling.
- Perform reliability analysis and life testing for engineering applications.
- Create quality improvement strategies using reliability optimization techniques.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different quality concepts, SQC techniques, and process capability analysis.	Analyze
CO2	Choose appropriate control charts to monitor process variations.	Apply
CO3	Assemble and apply acceptance sampling techniques for decision-making in quality control.	Apply
CO4	Adjust system reliability and perform life testing to enhance product dependability.	Analyze
CO5	Identify and implement reliability improvement strategies in product design and development.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	2	1	–	–	1	–	1	2	2	1
CO2	3	3	2	2	3	1	–	1	1	1	1	3	3	2
CO3	3	3	2	2	3	1	–	1	1	1	1	3	3	2
CO4	3	3	2	3	3	2	–	1	1	1	1	3	3	2
CO5	2	2	3	2	2	2	1	1	1	1	1	2	2	1

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION AND PROCESS CONTROL FOR VARIABLES

Introduction, definition of quality, basic concept of quality, definition of SQC, benefits and limitation of SQC, Quality assurance, Quality cost-Variation in process- factors - process capability- process capability studies and simple problems - Theory of control chart- uses of control chart -Control chart for variables - X chart, R chart.

UNIT 2: PROCESS CONTROL FOR ATTRIBUTES

Control chart for attributes -control chart for proportion or fraction defectives - p chart and np chart control chart for defects - C and U charts, State of control and process out of control identification in charts.

UNIT 3: ACCEPTANCE SAMPLING

Lot by lot sampling - types - probability of acceptance in single, double, multiple sampling techniques - O.C. curves - producer's Risk and Consumer's Risk. AQL, LTPD, AOQL concepts- standard sampling plans for AQL and LTPD- uses of standard sampling plans.

UNIT 4: LIFE TESTING – RELIABILITY

Life testing - Objective - failure data analysis, Mean failure rate, mean time to failure, mean time between failure, hazard rate, system reliability, series, parallel and mixed configuration - simple problems. Maintainability and availability - simple problems. Acceptance sampling based on reliability test - O.C Curves.

UNIT 5: QUALITY AND RELIABLITY

Reliability improvements - techniques- use of Pareto analysis - design for reliability - redundancy unit and standby redundancy - Optimization in reliability - Product design - Product analysis - Product development - Product life cycles.

SUGGESTED READINGS

1. Grant, Eugene .L."Statistical Quality Control", McGraw-Hill, 7th Edition (2006).
2. L .S.Srinath."Reliability Engineering", Affiliated East west press, 4th Edition, (2009).
3. Monohar Mahajan."Statistical Quality Control", DhanpatRai& Sons, (2001).
4. R. C. Gupta. "Statistical Quality control", Khanna Publishers, 6thEdition, (2003).
   Besterfield D.H. "Quality Control", Prentice Hall, (1993).

Programme Elective: Production and Industrial Engineering Stream **Semester – 7**

25MEU736B **PRECISION MANUFACTURING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

1. Demonstrate an understanding of precision, accuracy, and smoothness in machining processes.
2. Manipulate various precision machine elements, including guideways, bearings, and drive systems.
3. Analyze different sources of errors in precision machining and apply error control techniques.
4. Perform precision manufacturing techniques such as micro-machining, micro-engraving, and energy-assisted processes.
5. Create MEMS-based systems for applications in various engineering fields

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between precision, accuracy, and smoothness in machining processes.	Analyze
CO2	Choose appropriate precision machine elements for specific engineering applications.	Apply
CO3	Identify and mitigate sources of errors in precision machining.	Analyze
CO4	Apply precision manufacturing techniques in various industrial applications.	Apply
CO5	Design and develop MEMS-based components for automotive, healthcare, and aerospace industries.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	2	–	–	–	1	–	1	2	2	1
CO2	3	3	3	2	3	1	–	1	1	1	1	3	3	2
CO3	3	3	2	3	2	–	–	–	1	–	1	3	2	1
CO4	3	3	2	2	3	1	–	1	1	1	1	3	3	2
CO5	3	3	3	2	3	2	1	1	2	1	1	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: PRECISION ENGINEERING

Introduction – Precision, Accuracy & Smoothness – Need – Development of overall machining precision- Classes of achievable machining Accuracy-Precision machining-High precision Machining-Ultra precision Machining-application of precision machining- Materials for tools and machine elements – carbides – ceramic, CBN & diamond-Tool and work material compatibility.

UNIT 2: PRECISION MACHINE ELEMENT

Introduction – Guide ways – Drive systems – Spindle drive – preferred numbers - Rolling elements – hydrodynamic & hydrostatic bearings –Hybrid fluid bearings- Aero static and aero dynamic bearings- Hybrid gas bearings-materials for bearings.

UNIT 3: ERROR CONTROL

Error – Sources – Static stiffness – Variation of the cutting force – total compliance – Different machining methods – Thermal effects – heat source – heat dissipation – Stabilization – decreasing thermal effects – forced vibration on accuracy – clamping & setting errors – Control – errors due to locations – principle of constant location surfaces.

UNIT 4: PRECISION MANUFACTURING
Micro machining processes-diamond machining - micro engraving - Micro replication techniques-forming- casting-injection moulding - micro embossing - Energy assisted processes 80 - LBM, EBM, FIB, Micro electro discharge machining-photolithography-LIGA process- Silicon micro machining-Wet and dry etching-thin film deposition.

UNIT 5: MEMS
Introduction – MEMS –characteristics- principle – Design – Application: automobile, defence, health care, Industrial, aerospace etc.

SUGGESTED READINGS

1. Venkatesh V.C. and Izman S.“Precision Engineering”, Tata McGraw Hill, (2007).
2. Murthy R.L.“Precision Engineering”, New Age International, (2009).
3. Nakazawa H.“Principles of Precision Engineering”, Oxford University Press, (1994).

Programme Elective: Production and Industrial Engineering Stream **Semester – 7**
25MEU737B **LEAN SIX SIGMA** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of Lean and Six Sigma principles, their origins, and their significance in quality management.
- Manipulate the integration of Lean and Six Sigma methodologies to enhance process efficiency and effectiveness.
- Assemble high-performance project teams and select projects based on structured methodologies.
- Perform process improvement using the DMAIC framework and associated tools.
- Create strategies for institutionalizing Lean Six Sigma in organizations and apply Design for Lean Six Sigma concepts.

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between Lean and Six Sigma principles and their impact on process efficiency.	Analyze
CO2	Choose and integrate Lean and Six Sigma methodologies to optimize processes.	Apply
CO3	Assemble and train project teams for effective implementation of Lean Six Sigma projects.	Apply
CO4	Apply the DMAIC process and related tools for continuous process improvement.	Apply
CO5	Create strategies for sustaining Lean Six Sigma initiatives in organizations and develop solutions using Design for Lean Six Sigma concepts.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	2	1	2	–	–	1	–	1	2	2	1
CO2	2	3	3	2	3	2	–	1	1	2	1	3	3	2
CO3	1	2	2	1	2	2	1	3	2	2	1	2	2	1
CO4	2	3	2	3	3	2	–	2	2	2	1	3	3	2
CO5	2	3	3	3	3	3	1	3	2	3	2	3	3	2

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION TO LEAN AND SIX SIGMA

Introduction to Lean- Definition, Purpose, Features of Lean ; Top seven wastes, Need for Lean management, The philosophy of lean management, Creating a lean enterprise, Elements of Lean, Lean principles, the lean metric, Hidden time traps. Introduction to quality, Definition of six sigma, origin of six sigma, Six sigma concept and Critical success factors for six sigma.

UNIT 2: INTEGRATION OF LEAN AND SIX SIGMA

Evolution of lean six sigma, the synergy of Lean and six sigma, Definition of lean six sigma, the principles of lean six sigma, Scope for lean six sigma, Features of lean six sigma. The laws of lean six sigma, Key elements of LSS, the LSS model and the benefits of lean six sigma. Initiation - Top management commitment – Infrastructure and deployment planning, Process focus, organizational structures, Measures – Rewards and recognition, Infrastructure tools, structure of transforming event and Launch preparation.

UNIT 3: PROJECT SELECTION AND TEAM BUILDING

Resource and project selection, Selection of Black belts, Training of Black belts and Champions, Identification of potential projects, top down (Balanced score card) and Bottom up approach – Methods of selecting projects – Benefit/Effort graph, Process mapping, value stream mapping, Predicting and improving team performance, Nine team roles and Team leadership.

UNIT 4: THE DMAIC PROCESS AND TOOLS

The DMAIC process – Toll gate reviews; The DMAIC tools; Define tools – Project definition form, SIPOC diagram; Measure tools – Process mapping, Lead time/cycle time, Cause and Effect matrix, Idea – generating and organizing tools – Brainstorming, Nominal group technique and Multi-voting; Data collection and accuracy tools- Check sheet, Gauge R&R; Understanding and eliminating variation- run charts; Analyze tools - Scatter plots, ANOVA, Regression analysis, Time trap analysis; Improve tools – Mistake proofing, Set up time reduction (SMED) and the pull system; Control tools – statistical process control.

UNIT 5: INSTITUTIONALIZING AND DESIGN FOR LSS

Institutionalizing lean six sigma – improving design velocity, creating cycle time base line, valuing projects, gating the projects, reducing product line complexity, Design for lean six sigma, QFD, Theory of Inventive Problem solving (TRIZ), Robust design; Case study presentations.

SUGGESTED READINGS

1. Michael L. George “Lean Six Sigma”, McGraw-Hill., (2002).
2. James P. Womack, Daniel T. Jones “Lean Thinking”, Free press business,(2003).
3. RonaldG.Askin and Jeffrey B.Goldberg “Design and Analysis of Lean Production Systems”, John Wiley &Sons, (2003).
4. Salman Taghizadegan “Essentials of Lean Six Sigma”, Elsevier,(2010).

Michael L. George “Lean Six Sigma”, McGraw-Hill., (2002).

Programme Elective: Production and Industrial Engineering Stream **Semester – 7**

25MEU738B **ENTERPRISE RESOURCE PLANNING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of enterprise systems, their evolution, risks, and benefits in planning and implementation.
- Analyze different ERP software solutions and their functional units in various business processes.
- Assemble the knowledge of ERP implementation, including selection, methodology, training, and data migration.
- Evaluate post-implementation challenges, including maintenance, organizational impact, and success/failure factors.
- Assess emerging trends in ERP, including cloud computing, business analytics, CRM, and SCM.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the fundamental concepts, benefits, and risks associated with enterprise systems.	Understand
CO2	Differentiate between various ERP software solutions and their functional units in business process management.	Analyze
CO3	Apply ERP implementation methodologies and evaluate the effectiveness of different implementation strategies.	Apply
CO4	Analyze post-implementation challenges and assess success and failure factors in ERP deployment.	Analyze
CO5	Identify and explore emerging ERP trends, including cloud-based ERP, CRM, and SCM applications.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	2	1	1	2	2	1	–	1	–	1	1	1	1
CO2	1	3	2	2	2	2	–	1	1	1	1	1	2	1
CO3	1	3	3	2	3	2	–	2	1	3	1	2	3	2
CO4	1	3	2	3	2	2	1	1	1	2	1	2	2	1
CO5	1	2	2	2	3	3	1	1	1	1	2	1	2	1

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION

Overview of enterprise systems – Evolution - Risks and benefits - Fundamental technology - Issues to be consider in planning design and implementation of cross functional integrated ERP systems.

UNIT 2: ERP SOLUTIONS AND FUNCTIONAL UNITS

Overview of ERP software solutions- Small, medium and large enterprise vendor solutions, BPR, and best business practices - Business process Management, Functional UNITs.

UNIT 3: ERP IMPLEMENTATION

Planning Evaluation and selection of ERP systems - Implementation life cycle - ERP implementation, Methodology and Frame work- Training – Data Migration. People Organization in implementation-Consultants, Vendors and Employees.

UNIT 4: POST IMPLEMENTATION

Maintenance of ERP- Organizational and Industrial impact; Success and Failure factors of ERP Implementation.

UNIT 5: EMERGING TRENDS ON ERP

Extended ERP systems and ERP add-ons -CRM, SCM, Business analytics - Future trends in ERP systems-web enabled, Wireless technologies, cloud computing.

SUGGESTED READINGS

1. Alexis Leon "ERP demystified", second Edition Tata McGraw-Hill (2008).
2. 2. Alexis Leon "Enterprise Resource Planning", second edition, Tata McGraw-Hill (2008).
3. 3. Jagan Nathan Vaman "ERP in Practice", Tata McGraw-Hill, (2008).
4. 4. Sinha P. Magal and Jeffery Word "Essentials of Business Process and Information System", Wiley India (2012).

   5. Summer "ERP", Pearson Education (2008).

Programme Elective: Thermal Engineering Stream **Semester – 5**
25MEU531C **REFRIGERATION AND AIR CONDITIONING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Demonstrate the fundamental concepts of refrigeration, ideal cycles, and refrigerants.
- Manipulate the vapour compression refrigeration system parameters for improved efficiency.
- Assemble and operate various alternative refrigeration systems.
- Perform psychrometric property calculations and air-conditioning process analysis.
- Create an air-conditioning system layout and perform load estimation.

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different refrigeration cycles, their efficiencies, and refrigerant properties.	Analyze
CO2	Choose appropriate components and analyze the performance of vapour compression refrigeration systems.	Apply
CO3	Assemble and operate non-conventional refrigeration systems, understanding their working principles.	Apply
CO4	Adjust psychrometric properties to optimize air-conditioning processes.	Apply
CO5	Identify, compute, and evaluate air-conditioning loads and control systems.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	2	1	–	–	1	–	1	2	2	1
CO2	3	3	3	2	3	2	–	1	1	1	1	3	3	2
CO3	2	2	2	2	3	2	–	1	1	1	1	3	3	2
CO4	3	3	2	2	3	2	–	1	1	1	1	3	3	2
CO5	3	3	3	3	3	2	–	1	1	2	1	3	3	2

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION

Introduction to Refrigeration - Unit of Refrigeration and C.O.P.– Ideal cycles- Refrigerants Desirable properties – Classification - Nomenclature - ODP & GWP.

UNIT 2: VAPOUR COMPRESSION REFRIGERATION SYSTEM

Vapor compression cycle: p-h and T-s diagrams - deviations from theoretical cycle – subcooling and super heating- effects of condenser and evaporator pressure on COP- multipressure system - low temperature refrigeration - Cascade systems – problems. Equipments: Type of Compressors, Condensers, Expansion devices, Evaporators.

UNIT 3: OTHER REFRIGERATION SYSTEMS

Working principles of Vapour absorption systems and adsorption cooling systems — Steam jet refrigeration- Ejector refrigeration systems- Thermoelectric refrigeration- Air refrigeration - Magnetic - Vortex and Pulse tube refrigeration systems.

UNIT 4: PSYCHROMETRIC PROPERTIES AND PROCESSES

Properties of moist Air-Gibbs Dalton law, Specific humidity, Dew point temperature, Degree of saturation, Relative humidity, Enthalpy, Humid specific heat, Wet bulb temperature Thermodynamic wet bulb temperature, Psychrometric chart; Psychrometric of air-conditioning processes, mixing of air streams.

UNIT 5: AIR CONDITIONING SYSTEMS AND LOAD ESTIMATION

Air conditioning loads: Outside and inside design conditions; Heat transfer through structure, Solar radiation, Electrical appliances, Infiltration and ventilation, internal heat load; Apparatus selection; fresh air load, human comfort & IAQ principles, effective temperature & chart, calculation of summer & winter air conditioning load; Classifications, Layout of plants; Air distribution system; Filters; Air Conditioning Systems with Controls: Temperature, Pressure and Humidity sensors, Actuators & Safety controls.

SUGGESTED READINGS

1. Arora, C.P "Refrigeration and Air conditioning", 3rd edition, McGraw Hill, New Delhi(2010).
2. ASHRAE Hand book, Fundamentals (2010).
3. Jones W.P "Air conditioning engineering", 5th edition, Elsevier Butterworth-Heinemann (2007).
4. Roy J. Dossat "Principles of Refrigeration", 4th edition, Pearson Education Asia(2009). Stoecker, W.F. and Jones J. W "Refrigeration and Air Conditioning", McGraw Hill, New Delhi (2014).

Programme Elective: Thermal Engineering Stream **Semester – 5**

25MEU532C **TURBO MACHINERY** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Identify and compare different types of turbomachines, their classifications, and performance parameters.
- Demonstrate the general analysis of radial and axial flow turbomachines, including velocity triangles and energy transfer.
- Analyze the working principles and efficiency of impulse and reaction steam turbines.
- Evaluate the performance characteristics of hydraulic turbines, including Pelton, Francis, and Kaplan turbines.
- Design and assess the operational characteristics of centrifugal pumps and compressors, including cavitation and priming.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different types of turbomachines and evaluate their efficiencies based on thermodynamic principles.	Analyze
CO2	Analyze velocity triangles, degree of reaction, and performance characteristics of radial and axial flow turbomachines	Analyze
CO3	Evaluate the design and performance of steam turbines, including impulse and reaction turbines.	Evaluate
CO4	Compare and assess the operational characteristics of hydraulic turbines such as Pelton, Francis, and Kaplan turbines.	Evaluate
CO5	Apply theoretical and practical knowledge to determine the efficiencies, cavitation conditions, and operational parameters of centrifugal pumps and compressors.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	1	3	3	2
CO2	3	3	2	3	3	–	–	–	1	–	1	3	3	2
CO3	3	3	3	3	2	1	–	–	1	1	1	3	3	2
CO4	3	3	2	2	2	2	–	–	1	1	1	3	3	2
CO5	3	3	2	3	3	2	–	1	1	1	1	3	3	2

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION

Definition of turbomachine, parts of turbomachines,Comparison with positive displacement machines, Classification, Dimensionless parameters and their significance, Effect of Reynold's number, Unit and specific quantities, model studies. Application of first and second law's of thermodynamics to turbomachines, Efficiencies of turbomachines.

UNIT 2: GENERAL ANALYSIS OF TURBO MACHINES

Radial flow compressors and pumps – general analysis, Expression for degree of reaction, velocity triangles, Effect of blade discharge angle on energy transfer and degree of reaction, Effect of blade discharge angle on performance, Theoretical head – capacity relationship, General analysis of axial flow pumps and compressors, degree of reaction, velocity triangles.

UNIT 3: STEAM TURBINES

Classification, Single stage impulse turbine, condition for maximum blade efficiency, stage efficiency, Need and methods of compounding, Multi-stage impulse turbine, expression for maximum utilization factor, Reaction turbine – Parsons's turbine, condition for maximum utilization factor, reaction staging.

UNIT 4: HYDRAULIC TURBINES

Classification, Different efficiencies, Pelton turbine –velocity triangles, design parameters, Maximum efficiency. Francis turbine - velocity triangles, design parameters, runner shapes for different blade speeds. Draft tubes- Types and functions. Kaplan and Propeller turbines - velocity triangles, design parameters.

UNIT 5: CENTRIFUGAL PUMPS AND COMPRESSORS

Classification and parts of centrifugal pump, different heads and efficiencies of centrifugal pump, Minimum speed for starting the flow, Maximum suction lift, Net positive suction head, Cavitation, Need for priming, Pumps in series and parallel. Problems. Centrifugal Compressors: Stage velocity triangles, slip factor, power input factor, Stage work, Pressure developed, stage efficiency and surging. Axial flow Compressors: Expression for pressure ratio developed in a stage, work done factor, efficiencies and stalling.

SUGGESTED READINGS

1. Fox, R.W., Pritchard, P.J. and McDonald, A. T.,"Introduction to Fluid Mechanics", 7th edition, Wiley India, 2015.
2. 2. White, F., M., "Fluid Mechanics", 4th edition, McGraw-Hill, (2014).
3. 3. Som, S.K., Biswas, G. and Chakraborty, S., "Fluid Mechanics and Fluid Machines", 3rd edition, McGraw-Hill, (2012).
4. 4. Dixon, S.L., "Fluid Mechanics and Thermodynamics of Turbomachines", 4th edition, Butterworh Hinemann, (2014).

   5. Kadambi, V. and Manohar Prasad, "An Introduction to Energy Conversion Vol.III: Turbomachinery", Wiley Eastern, (2015).

Programme Elective: Thermal Engineering Stream **Semester – 5**

25MEU533C **ADVANCED INTERNAL COMBUSTION ENGINEERING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate the working principles of fuel injection systems and analyze combustion characteristics.
- Manipulate the parameters influencing combustion and knocking in diesel engines.
- Identify the sources of engine emissions and apply control technologies.
- Evaluate the properties and suitability of alternative fuels for engine applications.
- Create innovative turbocharging and hybrid vehicle solutions for enhanced performance and emission control.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different types of fuel injection systems and analyze their combustion characteristics.	Analyze
CO2	Identify and solve issues related to combustion knocking and fuel spray behavior in diesel engines.	Apply
CO3	Evaluate the formation of pollutants and apply emission control technologies effectively.	Evaluate
CO4	Compare and assess the properties, advantages, and challenges of alternative fuels.	Evaluate
CO5	Design and optimize turbochargers and hybrid powertrains for improved engine performance and emissions	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	1	3	3	2
CO2	3	3	2	3	3	1	–	–	1	–	1	3	3	2
CO3	3	3	2	3	3	3	1	1	1	1	1	3	3	2
CO4	3	3	3	2	2	3	1	–	1	1	1	3	3	2
CO5	3	3	3	3	3	3	1	1	1	2	1	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION

Mixture requirements – Fuel injection systems – Monopoint, Multipoint & Direct injection – Stages of combustion – Normal and Abnormal combustion – Knock – Factors affecting knock – Combustion chambers.

UNIT 2: ENGINE SYSTEM

Diesel Fuel Injection Systems – Stages of combustion – Knocking – Factors affecting knock – Direct and Indirect injection systems – Combustion chambers – Fuel Spray behaviour – Spray structure and spray penetration – Air motion – Introduction to Turbocharging.

UNIT 3: POLLUTION

Pollutant – Sources – Formation of Carbon Monoxide, Unburnt hydrocarbon, Oxides of Nitrogen, Smoke and Particulate matter – Methods of controlling Emissions – Catalytic converters, Selective Catalytic Reduction and Particulate Traps – Methods of measurement – Emission norms and Driving cycles.

UNIT 4: ALTERNATE FUELS

Alcohol, Hydrogen, Compressed Natural Gas, Liquefied Petroleum Gas and Bio Diesel – Properties, Suitability, Merits and Demerits – Engine Modifications.

UNIT 5: TURBOCHARGERS

Air assisted Combustion, Homogeneous charge compression ignition engines – Variable Geometry turbochargers – Common Rail Direct Injection Systems – Hybrid Electric Vehicles – NOxAdsorbers – Onboard Diagnostics.

SUGGESTED READINGS

1. V. Ganesan, "Internal Combustion Engines", V Edition, Tata McGraw Hill, (2012).
2. B.P. Pundir, "IC Engines Combustion & Emission", Narosa Publishing House, (2014).
3. Mathur. R.B. and R.P. Sharma "Internal Combustion Engines", Dhanpat Rai & Sons (2007).
4. K.K. Ramalingam, "Internal Combustion Engine Fundamentals", SciTech Publications, (2011).

Programme Elective: Thermal Engineering Stream **Semester – 6**

25MEU631C **BIOFUELS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- To characterize different biomass feedstock's based on its constituents and properties & understand the analytical techniques to characterize biomass.
- To Understand and evaluate various biomass pre-treatment and processing techniques in terms of their applicability for different biomass types.
- To provide students with the basic principles of biofuels and bioenergy systems design.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Understand the principles and processes of extracting energy from various biomass types for sustainable bioenergy production.	Understand
CO2	Evaluate the environmental and economic advantages of biomass energy sources over traditional fossil fuels.	Evaluate
CO3	Analyze different pre-treatment and conversion technologies for efficient biofuel production.	Analyze
CO4	Explore advanced biofuel innovations and their applications, including algae and microbial biofuels.	Understand
CO5	Assess the environmental, economic, and social impacts of biofuel utilization in comparison to conventional energy sources.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	1	1	3	–	–	1	–	1	2	2	1
CO2	2	3	2	2	1	3	1	–	1	1	1	2	2	1
CO3	3	3	2	3	2	2	–	1	1	1	1	3	3	2
CO4	2	2	2	2	2	3	–	1	1	1	2	2	3	2
CO5	2	3	3	2	1	3	1	1	1	2	2	2	3	2

1 - low, 2 - medium, 3 - high

Unit: 1 BIOENERGY AND BIOMASS RESOURCES

Importance of bioenergy and biofuels in solving energy crisis and global warming. Introduction to various biomass types – constituents, characterization. Biogas & bio-electricity, Bio-heat; Clean sustainable bioenergy, bio-electricity and biogas production from Dairy manure and Food Waste streams.

Unit: 2 BIOMASS PRE-TREATMENT AND PELLETIZATION

Biomass pre-treatment: Acid/alkali treatment, steam explosion, ammonia fibre expansion, enzymatic, ball milling, other non-conventional techniques, choice of pre-treatment based on biomass types. Pellets made from wood or grass biomass are commercially available at stores for heating homes, schools, businesses.

Unit: 3 BIOFUEL PRODUCTION AND ADVANCED FUELS

Seed-based biodiesel, bioethanol, conversion of waste oil to biodiesel, advanced biofuels including algae-biofuel, microbial biofuel, Conversion of waste vegetable oil into biodiesel, and advanced innovations in enzymatic conversion of non-food feed-stocks. Fuel properties, engine applications.

Unit: 4 THERMOCHEMICAL BIOMASS CONVERSION

Biomass conversion technologies for biofuel. Thermochemical processes: Combustion, gasification, pyrolysis, hydrothermal liquefaction, hydropyrolysis, torrefaction, choice of thermal process based on biomass type and product requirement.

Unit: 5 BIOFUEL IMPACTS: ENVIRONMENTAL, ECONOMIC AND SOCIAL

Biofuels/energy related environmental, economics, & social issues. The source, processing, and social impacts of biofuel utilization.

SUGGESTED READINGS

1. Filemon A. Uriarte Jr., Biofuels from plant oils, National Academy of Science and Technology, 2010.
2. Anju Dahiya, Bioenergy: Biomass to Biofuels, Eslevier, 2015
3. Sunggyu Lee and Y.T. Shah, Biofuels and Bio-energy Processes and Technology, CRC Press, Taylor and Francis Group, 2013.
4. Pandey, A., Larroche, C., Ricke, S.C., Dussap, C.-G., Gnansounou, E., Biofuels: Alternative feedstocks and conversion processes, Academic Press, U.S.A., 2011.
5. Brown, R.C. (Ed.) Thermochemical processing of biomass into fuels, chemicals and power, Wiley, 2011.
6. Clark, J., Deswarte, F. (Ed.) Introduction to chemicals from biomass, John Wiley and Sons, U.K., 2008.
7. Understanding clean energy and fuels from biomass, H. S. Mukunda, 2011.

Programme Elective: Thermal Engineering Stream **Semester – 6**

25MEU632C ENERGY EFFICIENT MECHANICAL SYSTEMS FOR BUILDINGS 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

1. Demonstrate knowledge of energy sources, energy auditing, and conservation techniques in buildings.
2. Manipulate the principles of refrigeration and air conditioning to evaluate different HVAC systems.
3. Assemble and analyze advanced HVAC technologies for energy-efficient solutions.
4. Perform energy conservation techniques in various buildings using emerging trends.
5. Create fire safety management strategies integrating energy conservation methods.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different energy sources and analyze energy utilization trends.	Analyze
CO2	Choose suitable refrigeration and air conditioning techniques for different applications.	Apply
CO3	Assemble and evaluate recent HVAC technologies for energy efficiency.	Evaluate
CO4	Identify and apply emerging energy conservation trends in buildings.	Apply
CO5	Solve fire safety challenges while incorporating energy-efficient firefighting equipment.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	1	2	–	–	1	–	1	2	2	1
CO2	3	3	3	2	3	2	–	1	1	1	1	3	3	2
CO3	3	3	2	3	3	3	–	1	1	1	1	3	3	2
CO4	3	3	3	2	2	3	1	1	1	1	1	3	3	2
CO5	3	3	3	3	3	3	2	2	1	2	1	3	3	2

1 - low, 2 - medium, 3 - high

UNIT 1: HISTORY AND GROWTH OF ENERGY UTILISATION

Sources of energy, Energy demand and supply, Load curves of residential and commercial buildings, Energy auditing in buildings, Identifying avenues for Energy conservation, Conservation through periodic maintenance. High performance insulation, Day lighting and harnessing solar energy. Economic analysis.

UNIT 2: BASIC PRINCIPLES OF REFRIGERATION AND AIR CONDITIONING

Reversed Carnot cycle, refrigerants and Eco friendly refrigerants, tonne of refrigeration, COP, vapor compression and vapor absorption refrigeration cycles, Geothermal air conditioning, Maisotsenko cycle, Kalina cycle. Psychrometric processes, Infiltration and indoor air quality.

UNIT 3: RECENT ADVANCES IN HVAC SYSTEMS

Air conditioning systems for various types of buildings: Window air conditioning, Split air conditioning, unitary air conditioning, Packed air conditioning, Centralized systems: single zone and multi zone systems. Economizer cycle, and Heat pumps. HVAC systems: Predictive and Preventive maintenance. Energy conservation through periodic maintenance of HVAC systems.

UNIT 4: EMERGING TRENDS IN ENERGY CONSERVATION AND MANAGEMENT

Thermal modelling, Star ratings - Energy efficient refrigerators and air conditioners, Energy efficient ventilation of large enclosures, Energy efficiency in domestic buildings, school and college environments, Hospital buildings, auditoriums theatres and malls.

UNIT 5: FIRE SAFETY AND CASE STUDIES

Fire triangle, fire classification and extinguishers, Cause of fire in buildings, Fire, smoke and heat Detectors – fire alarm Systems –Manual and Automatic Sprinklers - Fire Drills - Dry and Wet Risers, Fire protection of single and Multi-store Building. Methods of handling the physically challenged and the elderly people during emergency. Energy conservation methods in firefighting equipment.

SUGGESTED READINGS

1. Tom Dontigny "An Introduction to Building Mechanical Systems", Author house publications(2006).
2. Khurmi and Gupta "Refrigeration and air conditioning" S. Chand publisher(2015).
3. P.N. Ananthanarayanan "Basic refrigeration and air conditioning", TMH(2013).
4. ASHRAE Hand book – HVAC Systems& Equipment, HVAC Applications(2015).
5. Grandzik"Air conditioning System Design Manual", Elsevier Publications, Second edition(2011).
6. Albert Thumann and Scott Dunning "Plant Engineers & Managers Guide to Energy Conservation", The Fairmont Press, 10th Edition (2011).
7. Dale R. Patrick, Stephen W. Fardo, Ray E. Richardson "Energy Conservation Guidebook", Fairmont Press; 2nd Edition(2007).
8. Joel Levitt "Handbook of Maintenance Management", Industrial Press Inc.,U.S.; 2nd edition, (2009).

Programme Elective: Thermal Engineering Stream **Semester – 6**

25MEU633C **GAS DYNAMICS FOR SPACE PROPULSION** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of energy and momentum equations in compressible fluid flows and analyze the effects of Mach number on compressibility.
- Manipulate the variations in flow properties in Rayleigh and Fanno flows through constant area ducts.
- Assemble and apply governing equations to analyze normal and oblique shocks, including Prandtl-Meyer relations.
- Perform cycle analysis and evaluate the efficiency of various jet propulsion systems, including turbojet, turbofan, and turbo prop engines.
- Create models for rocket propulsion systems and evaluate their performance based on staging and velocity parameters.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between compressible and incompressible flow and analyze Mach waves, stagnation states, and isentropic flows.	Analyze
CO2	Identify the effects of heat transfer and friction in Rayleigh and Fanno flows and analyze the variations in flow parameters.	Analyze
CO3	Solve problems related to normal and oblique shocks, applying governing equations and Prandtl-Meyer relations.	Apply
CO4	Assess the performance of various jet propulsion systems based on thrust, propulsive efficiency, and stagnation state conditions.	Evaluate
CO5	Design and evaluate rocket propulsion systems considering propellant characteristics, ignition, combustion, and space flight applications.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	1	3	3	2
CO2	3	3	2	3	2	1	–	–	1	–	1	3	3	2
CO3	3	3	2	3	3	–	–	–	1	–	1	3	3	2
CO4	3	3	3	3	3	2	–	1	1	1	1	3	3	3
CO5	3	3	3	3	3	2	1	1	1	2	1	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: BASIC CONCEPTS AND ISENTROPIC FLOWS

Energy and momentum equations of compressible fluid flows – Stagnation states, Mach waves and Mach cone – Effect of Mach number on compressibility – Isentropic flow through variable ducts – Nozzle and Diffusers.

UNIT 2: FLOW THROUGH DUCTS

Flows through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) – variation of flow properties.

UNIT 3: NORMAL AND OBLIQUE SHOCKS

Governing equations – Variation of flow parameters across the normal and oblique shocks – Prandtl – Meyer relations – Applications.

UNIT 4: JET PROPULSION

Theory of jet propulsion – Thrust equation – Thrust power and propulsive efficiency – Operating principle, cycle analysis and use of stagnation state performance of ram jet, turbojet, turbofan and turbo prop engines.

UNIT 5: SPACE PROPULSION

Types of rocket engines – Propellants-feeding systems – Ignition and combustion – Theory of rocket propulsion – Performance study – Staging – Terminal and characteristic velocity – Applications – space flights.

SUGGESTED READINGS

1. Anderson, J.D. "Modern Compressible flow", 3rd Edition, McGraw Hill (2012).
2. Yahya, S.M. "Fundamentals of Compressible Flow", New Age International (P) Limited, New Delhi (2018).
3. Cohen. H. G.E.C. Rogers and Saravanamutto, "Gas Turbine Theory", Longman Group Ltd. (1980).
4. Ganesan. V."Gas Turbines", Tata McGraw Hill Publishing Co., New Delhi (2010).
5. Sutton. G.P."Rocket Propulsion Elements", John wiley, New York (2010).
6. Zucrow. N.J. "Principles of Jet Propulsion and Gas Turbines", John Wiley, New York (2010).

Programme Elective: Thermal Engineering Stream **Semester – 7**

25MEU731C SOLAR ENERGY TECHNOLOGY 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of solar radiation properties and its impact on energy generation. Manipulate semiconductor physics concepts to enhance solar cell efficiency.
- Assemble and analyze solar cell systems for various applications.
- Perform thermodynamic analysis of solar thermal systems and their applications.
- Create hybrid solar systems integrating thermal and photovoltaic technologies.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different solar radiation properties and calculate solar irradiance at surfaces.	Analyze
CO2	Choose appropriate solar cell technologies and apply efficiency enhancement methods.	Apply
CO3	Assemble and simulate solar cell systems using computational tools.	Apply
CO4	Adjust and optimize solar thermal systems for various applications.	Apply
CO5	Identify and evaluate hybrid solar systems for large-scale deployment.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	2	–	–	1	–	1	3	3	2
CO2	3	3	3	2	3	2	–	1	1	1	1	3	3	2
CO3	2	2	2	3	3	2	–	1	1	1	1	3	3	2
CO4	3	3	3	2	3	3	–	1	1	1	1	3	3	2
CO5	3	3	3	3	3	3	1	1	1	2	1	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: SOLAR RADIATION

Properties of sunlight. Absorption by the atmosphere. Calculation of solar irradiance at surfaces.

UNIT 2: SOLAR CELLS AND UNITS

The function of solar cells from semiconductor physics. Different solar cell technologies and fabrication methods. Concepts for increasing efficiency based on loss analysis. Wavelength sensitivity. Series connection of solar cells to units. Unit function and characteristics. Shading of cells and units.

UNIT 3: SOLAR CELL SYSTEMS

System components and their functions. Calculating output and dimensioning of solar cell systems. Analysis and computer simulation of a solar cell system. Concentrated sunlight and solar power (CSP). Properties of optical concentration systems. Solar cells in concentrated sunlight. Overview of the different components in a CSP system and their functions. Examples of CSP-systems globally.

UNIT 4: SOLAR THERMAL

Thermodynamic description of solar collectors. Optical properties of solar collectors and technologies for fabrication. Solar thermal systems for different applications in Sweden and abroad. Storage of solar generated heat.

UNIT 5: HYBRID SYSTEMS

Combinations of solar thermal and solar cell systems. Overview of different applications. District heating with solar thermal components. Grid aspects of large scale deployment of solar cells as well as environmental and socioeconomic aspects.

SUGGESTED READINGS

- Nelson."The Physics of Solar Cells" Imperial College Press, (2015).
- Rai,G.D."Solar Energy Utilization", Khanna Publishers, N. Delhi, (2017).
- Stuart R. Wenham, Martin A. Green, Muriel E. Watt, Richard Corkish (Editors), "Applied Photo voltaics", Earthscan, (2018).
- Duffie, J.A., and Beckman, W.A. "Solar Energy Thermal Process", John Wiley and Sons, New York, (2016).

Programme Elective: Thermal Engineering Stream **Semester – 7**

25MEU732C MARINE PROPELLERS AND PROPULSION 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of various propulsion systems and propeller geometries used in marine applications.
- Analyze the environmental and performance characteristics influencing propeller efficiency and functionality.
- Apply propeller theories to assess cavitation, noise, and hydrodynamic interactions.
- Evaluate ship resistance, propulsion mechanisms, and propeller-ship interactions for improved performance.
- Develop strategies for service performance enhancement, tolerance assessment, and propeller maintenance.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different propulsion systems and propeller geometries used in marine applications.	Analyze
CO2	Assess the impact of environmental conditions on propeller performance and efficiency.	Analyze
CO3	Apply theoretical and computational methods to analyze cavitation, noise, and performance characteristics of propellers.	Evaluate
CO4	Evaluate ship resistance, propulsion, and hydrodynamic interactions for effective design improvements.	Apply
CO5	Develop maintenance strategies and service performance monitoring techniques for propellers.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	1	3	3	2
CO2	3	3	2	2	2	2	–	–	1	–	1	3	3	2
CO3	3	3	2	3	3	1	–	–	1	–	1	3	3	2
CO4	3	3	3	3	3	2	–	1	1	1	1	3	3	3
CO5	2	3	2	3	2	2	1	1	1	2	1	3	3	2

1 - low, 2 - medium, 3 - high

UNIT 1: PROPULSION SYSTEMS AND PROPELLER GEOMETRY

Propeller types (fixed pitch, ducted, podded, contra-rotating, overlapping, tandem, controllable pitch, cycloidal), marine propulsors (azimuthing, waterjet, paddle wheel, MHD, superconducting motors), reference frames and lines, pitch–rake–skew geometry, blade outlines and area, propeller drawing and section geometry, blade thickness distribution and fractions, CPP interference limits and off-design geometry, and conventional propeller geometry terminology.

UNIT 2: PROPELLER ENVIRONMENT & PERFORMANCE CHARACTERISTICS

Density of water, Salinity, Water temperature, Viscosity, Vapour pressure, Dissolved gases in sea water, Surface tension, Weather, Silt and marine organisms.

UNIT 3: PROPELLER THEORY, CAVITATION & NOISE

Momentum theory (Rankine, R.E. Froude), blade element theory (W. Froude), propeller development methods (Burrill, Lerbs, Eckhardt–Morgan), lifting-line and lifting-surface models, hybrid and vortex lattice methods, boundary element and CFD approaches, specialist propulsor design methods, cavitation physics, types, inception and damage, propeller testing, and analysis of pressure data from cavitating propellers. Propeller - rudder interaction. Physics of underwater sound, Propeller noise characteristics, scaling laws, prediction and control methods, and radiated noise measurement.

UNIT4: PROPELLER-SHIP INTERACTION, SHIP RESISTANCE AND PROPULSION

Bearing forces, Hydrodynamic interaction, Froude's analysis procedure, Components of calm water resistance, Methods of resistance evaluation, propulsive coefficients, the influence of rough water, restricted water effects, High-speed hull form resistance, Air resistance.

UNIT 5: SERVICE PERFORMANCE, TOLERANCE AND MAINTENANCE 9

Effects of weather, Hull roughness and fouling, Hull drag reduction, Propeller roughness and fouling, Generalized equations for the roughness-induced power penalties in ship operation, Monitoring of ship performance. Propeller tolerances, Propeller inspection, Causes of propeller damage, Propeller repair, Welding and the extent of weld repairs, stress relief.

SUGGESTED READINGS

1. VJohn Carlton, “Marine Propellers and Propulsion”, (2nd Edition) published by Elservier limited (2007).
2. Woud, Hans Klein, and Douwe Stapersma “Design of Propulsion and Electric Power Generation Systems”. London, UK: IMarEST, Institute of Marine Engineering, Science and Technology, (2002).
3. Lewis, Edward V. "Resistance and Propulsion", Principles of Naval Architecture. Vol. II. Jersey City, NJ:
4. Society of Naval Architects and Marine Engineers, (2009).
5.John Carlton, “Marine Propellers and Propulsion”, (4th Edition) published by Elservier limited (2018).

Programme Elective: Thermal Engineering Stream **Semester – 7**

25MEU733C **NANOTECHNOLOGY FOR ENERGY SYSTEMS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of solar energy technologies, including photovoltaic devices and hydrogen production.
- Manipulate nanotechnology concepts in renewable energy systems to enhance energy conversion and storage.
- Assemble energy sector products using nanomaterials for various applications like batteries, capacitors, and LEDs.
- Perform analysis and integration of fuel cell technology for micro-power generation.
- Create and evaluate hydrogen storage techniques for efficient energy utilization.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different generations of solar cell technologies and their applications.	Analyze
CO2	Choose and apply nanotechnology techniques in renewable energy systems for enhanced performance.	Apply
CO3	Assemble and test energy sector products that utilize nanomaterials for improved efficiency.	Apply
CO4	Adjust and optimize fuel cell designs to enhance performance and integration in micro-systems.	Apply
CO5	Identify and evaluate hydrogen storage materials and methods for various energy applications	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	1	3	3	2
CO2	3	3	2	2	2	2	–	–	1	–	1	3	3	2
CO3	3	3	2	3	3	1	–	–	1	–	1	3	3	2
CO4	3	3	3	3	3	2	–	1	1	1	1	3	3	3
CO5	2	3	2	3	2	2	1	1	1	2	1	3	3	2

1 - low, 2 - medium, 3 - high

UNIT 1: SOLAR ENERGY TECHNOLOGY

Electromagnetic spectrum – Availability of solar radiation – Photovoltaic devices – Dye sensitized solar cells – Silicon technology for solar cells – First generation, second generation and third generation solar cells – Photoelectrochemical cells for hydrogen production.

UNIT 2: NANOTECHNOLOGY IN RENEWABLE ENERGY SYSTEMS

Energy challenges – Development and implementation of renewable energy technologies – Nanotechnology enabled renewable energy technologies – Energy transport, conversion and storage – Nano, micro and meso scale phenomena and devices.

UNIT 3: ENERGY SECTOR PRODUCTS USING NANOMATERIALS

Light emitting diodes – Batteries – Catalytic reactors – Capacitors – Super capacitors – Microfluidic systems – Nano engines – Biogas – Biodiesel.

UNIT 4: FUEL CELL TECHNOLOGY

Fuel cell technologies – Integration and performance for micro – Fuel cell systems – Thin film and microfabrication methods – Design methodologies – Micro-fuel cell power sources.

UNIT 5: HYDROGEN STORAGE TECHNOLOGY

Hydrogen storage methods – Metal hydrides – Hydrogen storage capacity – Hydrogen reaction kinetics – Carbon-free cycle – Gravimetric and volumetric storage capacities – Hydriding/dehydriding kinetics – High enthalpy of formation – Thermal management during the hydriding reaction – Distinctive chemical and physical properties – Multiple catalytic effects – Degradation of the sorption properties – Hydride storage materials for automotive applications.

SUGGESTED READINGS

1. Parasuraman Swaminathan, "Semiconductor Materials, Devices and Fabrication", Wiley India, (2017).
2. Peter Van Zant "Microchip Fabrication: A Practical Guide to Semiconductor Processing", 6th Edition, McGraw-Hill, (2013).
3. Lynn J. Frewer, WillehmNorde, R. H. Fischer and W. H. Kampers, "Nanotechnology in the Agri-food sector", Wiley-VCH Verlag, (2011).
4. Quan Li "Nanomaterials for sustainable energy", Springer, (2016)
5. Kathy Lu "Materials in energy conversion, harvesting and storage", Wiley, (2017)
6. Alfred Rufer "Energy storage systems and components", CRC Press, (2015)
7. S.A. Sherif "Handbook of Hydrogen energy", CRC Press, (2016)

Programme Elective: Thermal Engineering Stream **Semester – 7**
25MEU734C **WASTE TO ENERGY CONVERSION** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of different types of solid waste, their properties, and their impact on the environment.
- Manipulate waste treatment and disposal methods such as landfills, leachate control, and environmental monitoring systems.
- Assemble techniques for energy recovery from waste using thermo-chemical conversion processes.
- Perform biochemical waste conversion techniques including biogas and landfill gas generation.
- Create effective waste management strategies, focusing on hazardous waste, e-waste legislation, and recycling.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between various solid waste sources, their physical and chemical properties, and their environmental impacts.	Analyze
CO2	Choose appropriate waste treatment and disposal methods, including landfill classification and design.	Apply
CO3	Assemble waste-to-energy conversion systems utilizing thermo-chemical techniques such as gasification and briquetting.	Apply
CO4	Adjust and optimize biochemical waste conversion techniques like anaerobic digestion and biogas production.	Apply
CO5	Identify and evaluate waste management policies, e-waste legislation, and global trade in hazardous waste.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	1	3	–	–	1	–	1	2	2	1
CO2	3	3	3	2	3	3	1	1	1	1	1	3	3	2
CO3	3	3	3	2	3	3	–	1	1	1	1	3	3	2
CO4	3	3	2	3	2	3	–	1	1	1	1	3	3	2
CO5	2	3	3	2	2	3	2	1	1	2	1	2	3	2

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION TO WASTE & WASTE PROCESSING

Solid Waste Sources Solid Waste Sources, types, composition, Properties, Global warming, Municipal Solid Waste: Physical, chemical and biological properties , Waste Collection and, Transfer stations, Waste minimization and recycling of municipal waste, Segregation of waste, Size Reduction , Managing Waste. Status of technologies for generation of Energy from Waste Treatment and Disposal Aerobic composting, incineration, Furnace type and design, Medical waste /Pharmaceutical waste treatment Technologies, incineration, Environmental impacts, Measures to mitigate environmental effects due to incineration.

UNIT 2: WASTE TREATMENT AND DISPOSAL

Land Fill method of Solid waste disposal Land fill classification, Types, methods and Sitting consideration, Layout and preliminary design of landfills: Composition, characteristics, generation, Movement and control of landfill leach ate and gases, Environmental monitoring system for land fill gases.

UNIT 3: ENERGY FROM WASTE-THERMO CHEMICAL CONVERSION

Energy Generation from Waste Bio-chemical Conversion: Sources of energy generation, anaerobic digestion of sewage and municipal wastes, direct combustion of MSW-refuse derived solid fuel, Industrial waste, agro residues, Anaerobic Digestion.

UNIT 4: ENERGY FROM WASTE-BIO-CHEMICAL CONVERSION

Biogas production, Land fill gas generation and utilization, Thermo-chemical conversion: Sources of energy generation, Gasification of waste using Gasifiers, Briquetting, Utilization and advantages of briquetting, Environmental benefits of Bio-chemical and Thermo- chemical conversion.

UNIT 5: WASTE MANAGEMENT

Hydrogen storage methods – Metal hydrides – Hydrogen storage capacity – E-waste: e-waste in the global context – Growth of Electrical and Electronics Industry in India – Environmental concerns and health hazards – Recycling e-waste: a thriving economy of the unorganized sector – Global trade in hazardous waste – impact of hazardous e-waste in India. Management of e-waste: e-waste legislation, Government regulations on e-waste management – International experience – need for stringent health safeguards and environmental protection laws of India.

SUGGESTED READINGS

1. Nicholas P. Cheremisinoff. "Handbook of Solid Waste Management and Waste Minimization Technologies". An Imprint of Elsevier, New Delhi (2003).
2. Rogoff, M.J. and Screve, F., "Waste-to-Energy: Technologies and Project Implementation", Elsevier Store, (2016).
3. Young G.C., "Municipal Solid Waste to Energy Conversion processes", John Wiley and Sons, (2015).
4. Harker, J.H. and Backhusrt, J.R., "Fuel and Energy", Academic Press Inc, (2015).
5. EL-Halwagi, M.M., "Biogas Technology- Transfer and Diffusion", Elsevier Applied Science, (2017).
6. Hall, D.O. and Overeed, R.P.," Biomass - Renewable Energy", John Willy and Sons. (2016).
7. Mondal, P. and Dalai, A.K. eds.Sustainable Utilization of Natural Resources. CRC Press (2017).

Programme Elective: Thermal Engineering Stream **Semester – 7**

25MEU735C **CRYOGENIC ENGINEERING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- To builds a solid foundation in the fundamentals of cryogenics.
- To encourage a "hand's – on" approach to solving cryogenic problems.
- To provide update cryogenic information..

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Understand the principles of achieving cryogenic temperatures through adiabatic expansion and liquefaction cycles.	Understand
CO2	Analyze and apply classical thermodynamics to cryogenic technologies, including gas separation and purification.	Apply
CO3	Evaluate the performance of different cryogenic cycles such as Linde- Hampson, Claude, and Stirling cycles.	Evaluate
CO4	Explore the material properties and behavior of fluids at cryogenic temperatures for various applications.	Understand
CO5	Design and assess cryogenic systems, including Dewar flasks, transfer lines, and insulation techniques.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	1	–	–	1	–	1	2	2	1
CO2	3	3	2	2	3	1	–	–	1	–	1	3	3	2
CO3	3	3	2	3	3	1	–	–	1	1	1	3	3	2
CO4	3	2	2	2	2	1	–	–	1	–	1	2	3	2
CO5	3	3	3	2	3	2	1	1	1	1	1	3	3	3

1 - low, 2 - medium, 3 - high

UNIT: 1 BASICS AND APPLICATIONS OF CRYOGENIC

Insight on Cryogenics, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures. Applications of Cryogenics - Space Programs, Superconductivity, Cryo Metallurgy, Medical applications.

UNIT: 2 CRYOGENIC LIQUEFACTION SYSTEMS

Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles. Inversion Curve-Joule Thomson Effect. Linde Hampson Cycle, Precooled Linde Hampson Cycle, Claude Cycle Dual Pressure Cycle, Ortho-Para hydrogen conversion, Critical Components in Liquefaction Systems.

UNIT: 3 SEPARATION AND PURIFICATION METHODS

Binary Mixtures, T-C and H-C Diagrams , Principle of Rectification, Rectification Column Analysis - McCabe Thiele Method , Adsorption Systems for purification.

UNIT: 4 CRYOCOOLERS AND REFRIGERATION TECHNIQUES

J.T.Cryocoolers, Stirling Cycle Refrigerators, G.M. Cryocoolers, Pulse Tube Refrigerators Regenerators used in Cryogenic Refrigerators, Magnetic Refrigerators.

UNIT: 5 CRYOGENIC EQUIPMENT AND INSTRUMENTATION

Cryogenic Dewar Design, Cryogenic Transfer Lines. Insulations in Cryogenic Systems, Different Types of Vacuum Pumps, Instruments to measure Flow, Level and Temperature.

SUGGESTED READINGS

1. Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985.
2. Scott R.B., Cryogenic Engineering, Van Nostrand and Co., 1988.
3. Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press New York, 1989.
4. Herald Weinstock, Cryogenic Technology, 1969. bert W. Vance, Cryogenic Technology, John Wiley & Sons, Inc., New York, London, 1969.

Programme Elective: Thermal Engineering Stream **Semester – 7**

25MEU736C **ENERGY CONSERVATION IN INDUSTRIES** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

1. Demonstrate the key battery parameters, performance characteristics, and comparison of advanced battery technologies used in EVs.
2. Manipulate various fuel cell components to understand their working principles, hydrogen storage, safety, and recent technological enhancements.
3. Assemble different EV battery charging systems by applying charger architecture, power factor correction, and power semiconductor requirements.
4. Operate battery management and energy management systems to ensure optimal performance and safety in hybrid and electric vehicles.
5. Construct a suitable EV charging station layout through selection, sizing, and placement of charging infrastructure with a practical case study..

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Identify and distinguish various EV battery types, SOC/SOH concepts, and interpret battery discharge/aging curves.	Understand
CO2	Explain and assess fuel cell types, components, limitations, and safety issues with respect to EV applications.	Analyze
CO3	Apply and execute proper charging techniques, standards, and power factor correction circuits in EV chargers.	Apply
CO4	Analyze and utilize BMS/EMS strategies to optimize energy storage and vehicle performance.	Analyze
CO5	Plan, design, and evaluate a complete EV charging station configuration for real-world deployment.	Create

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	2	–	–	1	–	1	3	3	2
CO2	3	3	2	2	2	2	1	–	1	–	1	3	3	2
CO3	3	3	3	2	3	2	–	1	1	2	1	3	3	2
CO4	3	3	2	3	3	2	–	1	1	2	1	3	3	3
CO5	3	3	3	3	3	3	1	2	2	3	2	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: FUNDAMENTALS

Introduction to Electrochemical battery, battery capacity, Battery Parameters and Comparisons, Battery Pack Discharge Curves and Aging, Battery Models, SOC, SOD, SOH, DOD, Battery technologies used in recent EVs, Lead acid battery, Nickle based battery, Lithium battery, Graphene battery and comparison of Battery types**.**

UNIT 2: FUEL CELLS

Overview of key Fuel cell technologies, fuel cell types, electrode materials, electrolytes and other components, working principles, Hydrogen generation and storage, limitations, recent progress in Fuel cell technologies, safety issues vs cost aspects, life cycle analysis.

UNIT 3: BATTERY CHARGING

Basic Requirements for Charging System, Charger Architectures, Grid Voltages, Frequencies, and Wiring, Charger Functions, Real Power, Apparent Power, and Power Factor, Charging Standards and Technologies, Wireless Charging, Boost Converter for Power Factor Correction: The Boost PFC Power Stage, Sizing the Boost Inductor, Average Currents in the Rectifier, Switch and Diode Average Currents, Switch, Diode, and Capacitor RMS Currents, Power Semiconductors for Charging, Examples.

UNIT 4: BATTERY AND ENERGY MANAGEMENT SYSTEMS

Battery Management Systems: Background of Battery Management Systems, Typical Structure of BMSs, Key Points of BMSs in Future Generation. Energy management strategies, Optimization techniques used in Hybrid and Electric vehicles for Energy storages, classification of Energy Management strategies, comparison and implementation issues of Energy management strategies.

UNIT 5: BATTERY CHARGING STATION

Types of charging stations, selection and sizing of charging station, components of charging station, single line diagram of charging station, charging station placement for Electric vehicles, Case study of any Indian city for installation and commissioning of a battery charging station.

SUGGESTED READINGS

1. Husain, I. & Ehsani, M. (2021). Electric and Hybrid Vehicles: Design Fundamentals (3rd ed.). CRC Press.
2. Sabrina, D., & Khaligh, A. (2022). Energy Storage Systems for Transportation: Batteries, Fuel Cells and Supercapacitors. Wiley.
3. Broussely, M., & Pistoia, G. (2020). Industrial Applications of Batteries: From Electric Vehicles to Smart Grid Storage. Elsevier
4. Mourad, A. & Omar, N. (2023). Advanced Battery Management Technologies for Electric Vehicles. Springer.
5. Pistoia, G. & Liaw, B. (2021). Lithium-Ion Batteries: Advances and Applications (2nd ed.). Elsevier.
6. Shrimali, H. (2024). EV Charging Systems and Infrastructure Design. McGraw-Hill Education.
7. Kandhasamy, N. & Rajendran, S. (2022). Hydrogen and Fuel Cells: A Sustainable Power Option. CRC Press.

Programme Elective: Thermal Engineering Stream **Semester – 7**

25MEU737C ENERGY STORAGE SYSTEMS FOR ELECTRIC VEHICLES 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

6. Demonstrate an understanding of energy consumption patterns and auditing techniques for effective energy management.
7. Manipulate electrical system components such as transformers, motors, and capacitors to optimize energy efficiency.
8. Assemble energy-efficient transformers and assess the factors affecting their performance.
9. Perform energy assessments on compressed air systems and identify efficiency improvement opportunities.
10. Create strategies for energy conservation in fans, blowers, and lighting systems by utilizing advanced control mechanisms.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different energy consumption patterns and auditing methodologies.	Analyze
CO2	Choose appropriate electrical system components to enhance energy efficiency.	Apply
CO3	Assemble and evaluate the performance of transformers for energy optimization.	Evaluate
CO4	Adjust and enhance compressed air system operations to improve efficiency.	Apply
CO5	Identify and implement energy-saving strategies in fans, blowers, and lighting systems.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	3	–	–	1	–	1	2	2	1
CO2	3	3	3	2	3	3	–	1	1	1	1	3	3	2
CO3	3	3	2	3	3	2	–	1	1	1	1	3	3	2
CO4	3	3	3	2	2	3	–	1	1	1	1	3	3	2
CO5	3	3	3	2	3	3	1	1	1	2	1	3	3	2

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION

Energy – Power – Past & Present scenario of World; National Energy consumption Data – Environmental aspects associated with energy utilization –Energy Auditing: Need, Types, Methodology and Barriers. Role of Energy Managers. Instruments for energy auditing.

UNIT 2: ELECTRICAL SYSTEMS

Components of EB billing – HT and LT supply, Transformers, Cable Sizing, Concept of Capacitors, Power Factor Improvement, Harmonics, Electric Motors – Motor Efficiency Computation, Energy Efficient Motors, Illumination – Lux, Lumens, Types of lighting, Efficacy, LED Lighting and scope of Encon in Illumination.

Power Factor- improvement and its benefit, selection and location of capacitors, Electric Motors- Types, losses in induction motors, motor efficiency, factor affecting motor performance, energy saving opportunities in motors.

UNIT 3: TRANSFORMERS AND ELECTRIC DISTRIBUTION

Types of transformers, transformer losses, energy efficient transformers, factor affecting the performance of transformers and energy conservation opportunities, cables, switch gears, distribution losses, and energy conservation opportunities in-house electrical distribution system.

UNIT 4: COMPRESSED AIR SYSTEMS

Types of air compressors, compressor efficiency, efficient compressor operation, compressed air systems components, capacity assessment, leakage test, factors affecting the performance and energy savings opportunities. Sixth Assignment Part Pumps and Pumping System: types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities.

UNIT 5: FANS & BLOWERS

Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities Seventh Assignment Part Lighting System: Light source, choice of lighting, energy efficient lighting controls Luminance requirements and energy conservation avenues.Energy Conservation through- Variable Speed Drives, Occupancy Sensors, Energy Savers, Day Lighting Case studies.

SUGGESTED READINGS

1. GA Mansoori, N Enayati, LB Agyarko "Energy: Sources, Utilization, Legislation, Sustainability", Illinois as Model State, World Sci. Pub. Co., (2016).
2. Gary Steffy, "Architectural Lighting Design", John Wiley and Sons (2015).
3. R.Chattopadhyay "Green Tribology, Green Surface Engineering and Global Warming". ASM International,USA, (2014).
4. Zehner, Ozzie "Green Illusions". Lincoln and London: University of Nebraska Press, (2012).
5. B.R. Gupta, "Generation Of Electrical Energy", Eurasia Publishing House (PVT.) LTD. Ram Nagar, (2015).

Programme Elective: Engineering Materials Stream **Semester – 5**

25MEU531D **POLYMER SCIENCE AND ENGINEERING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate the fundamental concepts of polymerization, including different polymerization techniques and their kinetics.
- Manipulate molecular weight determination techniques and analyze molecular weight distribution in polymers.
- Assemble an understanding of phase transitions, crystallinity, and structure-property relationships in polymers.
- Perform experiments to evaluate polymer solution properties, rheology, and flow behavior.
- Create an understanding of polymer processing techniques, including molding, extrusion, and fiber spinning.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish different polymerization methods and analyze polymerization kinetics.	Analyze
CO2	Choose appropriate molecular weight determination techniques and evaluate molecular weight distribution.	Evaluate
CO3	Identify phase transitions, crystallinity, and their effects on polymer properties.	Understand
CO4	Apply knowledge of polymer solution properties and rheology to processing applications.	Apply
CO5	Demonstrate proficiency in polymer processing techniques, including molding and extrusion.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	1	3	3	2
CO2	3	3	2	3	3	1	–	–	1	–	1	3	3	2
CO3	3	2	2	2	2	2	–	–	1	–	1	2	3	2
CO4	3	3	3	2	3	2	–	1	1	1	1	3	3	2
CO5	3	3	3	3	3	2	1	1	1	2	1	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: POLYMERIZATION

Fundamentals of polymers – monomers – functionality - Classification – characterization –. Types of Polymerization: cationic polymerization – anionic polymerization – coordination polymerization – free radical polymerization. Copolymerization concepts - Simple condensation reactions – Extension of condensation reactions to polymer synthesis – functional group reactivity. Poly condensation – kinetics of poly condensation - Carother's equation – Linear polymers by poly condensation – Interfacial polymerization – cross linked polymers by condensation – gel point.

UNIT 2: MOLECULAR WEIGHTS OF POLYMERS

Number average and weight average molecular weights – Degree of polymerization – molecular weight distribution – Polydispersity – Molecular weight determination- Different methods – Gel Permeation Chromatography.

UNIT 3: TRANSITIONS IN POLYMERS

First and second order transitions – Glass transition, Tg – multiple transitions in polymers – experimental study – significance of transition temperatures. Crystallinity in polymers – effect of crystallization – factors affecting crystallization, crystal nucleation and growth – Relationship between Tg and Tm – Structure– Property relationship.

UNIT 4: SOLUTION PROPERTIES OF POLYMERS

Size and shape of the macromolecules – Solubility parameter – polymer/solvent interaction parameter – temperature – size and molecular weight, Solution properties of polymers. Importance of Rheology – Newtonian and Non-Newtonian flow behaviour – Polymer melts Rheology.

UNIT 5: POLYMER PROCESSING

Overview of Features of Single screw extruder –Tubular blown film process - Coextrusion.- Injection Moulding systems – Compression & Transfer Moulding - Blow Moulding – Rotational Moulding – Thermoforming – Vacuum forming -Calendering process – Fiber Spinning process –Structural Foam Moulding – Sandwich Moulding. Processing for Thermosets- Reaction Injection Moulding& Reinforced Reaction Injection Moulding.

SUGGESTED READINGS

1. Marc A. Dubé, Tizazu Mekonnen, “Renewable Polymers: Processing and Chemical Modifications”, MDPI (2020).
2. Donald G. Baird, Dimitris I. Collias, “Polymer Processing: Principles and Design”, 2 Edition, Wiley, (2014).
3. Subramanian, Muralisrinivasan., “Basics of polymers : fabrication and processing technology”, Momentum Press(2015).
4. Rodriguez, F., Cohen.C., Oberic.K and Arches, L.A., “Principles of Polymer Systems”, 5th edition, Taylor and Francis, (2003).
5. Pramendra K. Bajpai, Inderdeep Singh, “Reinforced Polymer Composites: Processing, Characterization and Post Life Cycle Assessment”,Wiley-VCH, (2019).

Programme Elective: Engineering Materials Stream **Semester – 5**

25MEU532D **CHARACTERIZATION OF MATERIALS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate the principles and applications of metallographic techniques, including specimen preparation and quantitative metallography.
- Manipulate X-ray diffraction techniques to analyze material structures and diffraction patterns.
- Assemble and interpret X-ray diffraction data to determine crystal structures, residual stress, and phase quantification.
- Perform electron microscopy techniques, including transmission and scanning electron microscopy, to investigate microstructural characteristics.
- Create a comprehensive understanding of surface analysis methods for material characterization using spectroscopy and diffraction techniques.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different metallographic techniques and apply them to analyze material microstructures.	Analyze
CO2	Choose appropriate X-ray diffraction methods to investigate and interpret crystalline structures.	Apply
CO3	Assemble and evaluate X-ray diffraction data for precise material characterization.	Evaluate
CO4	Adjust electron microscopy parameters to obtain high-resolution images and diffraction patterns for material analysis.	Apply
CO5	Identify suitable surface analysis techniques to assess the chemical composition and structural properties of materials.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	1	3	3	2
CO2	3	3	2	3	3	1	–	–	1	–	1	3	3	2
CO3	3	3	2	3	3	1	–	–	1	–	1	3	3	2
CO4	3	3	2	3	3	1	–	1	1	1	1	3	3	2
CO5	3	2	2	2	2	2	–	1	1	1	1	3	3	2

UNIT 1: METALLOGRAPHIC TECHNIQUES

Macro examination - applications, metallurgical microscope - principle, construction and working, metallographic specimen preparation, optic properties - magnification, numerical aperture, resolving power, depth of focus, depth of field, different light sources lenses aberrations and their remedial measures, various illumination techniques-bright field , dark field, phase-contrast polarized light illuminations, interference microscopy, high temperature microscopy; quantitative metallography – Image analysis.

UNIT 2: X-RAY DIFFRACTION TECHNIQUES

Crystallography basics, reciprocal lattice, X-ray generation, absorption edges, characteristic spectrum, Bragg’s law, Diffraction methods – Laue, rotating crystal and powder methods. Stereographic projection. Intensity of diffracted beams –structure factor calculations and other factors. Diffractometer- brief description only, Cameras - General feature and optics, proportional, Scintillating and Geiger counters.

UNIT 3: ANALYSIS OF X-RAY DIFFRACTION

Line broadening, particle size, crystallite size, Precise parameter measurement, Phase identification, phase quantification, Phase diagram determination X-ray diffraction applicationin the determination of crystal structure, lattice parameter, residual stress – quantitative phase estimation, ASTM catalogue of Materials identification.

UNIT 4: ELECTRON MICROSCOPY

Construction and operation of Transmission electron microscope — Diffraction effects and image formation, specimen preparation techniques, Selected Area Electron Diffraction, electron- specimen interactions, Construction, modes of operation and application of Scanning electron microscope, Electron probe micro analysis, basics of Field ion microscopy (FIB), Scanning Tunneling Microscope (STM) and Atomic Force Microscope(AFM).

UNIT 5: SURFACE ANALYSIS

Surface chemical composition- Mass spectroscopy and X-ray emission spectroscopy (Principle and limitations) - Energy Dispersive Spectroscopy- Wave Dispersive Spectroscopy- Quadrapole mass spectrometer. Electron spectroscopy for chemical analysis (ESCA), Ultraviolet Photo Electron Spectroscopy (UPS), X ray Photoelectron Spectroscopy (XPS),Auger Electron Spectroscopy (AES), Electron Energy Analysers, Secondary ion mass spectrometry - Applications. Unit meshes of five types of surface nets - diffraction from diperiodic structures using electron, Low Energy Electron Diffraction (LEED), Reflection High Energy Electron Diffraction (RHEED).

SUGGESTED READINGS

1. Cullity, B. D “Elements of X-ray diffraction”, Addison-Wesley Company Inc., New York, 3rd Edition (2000).
2. Phillips V A “Modern Metallographic Techniques and their Applications”, Wiley Eastern (1971).
3. Brandon D. G “Modern Techniques in Metallography”, Von Nostrand Inc. NJ, USA (1986).
4. Thomas G “Transmission electron microscopy of metals”, John Wiley (1996).
5. Weinberg, F “Tools and Techniques in Physical Metallurgy”, Volume I & II, Marcel and Decker (1970).
6. Haines, P.J “Principles of Thermal Analysis and Calorimetry”, Royal Society of Chemistry (RSC), Cambridge (2002).D. A. Skoog, F. James Leary and T. A. Nieman “Principles of Instrumental Analysis”, Fifth Edition, Saunders Publishing Co (1998).

Programme Elective: Engineering Materials Stream **Semester – 5**

25MEU533D **POWDER METALLURGY** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of the historical evolution, characteristics, and applications of Powder Metallurgy.
- Manipulate different methods of powder production and assess their effectiveness.
- Assemble various techniques for powder characterization and compaction.
- Perform powder forming techniques such as rolling, forging, extrusion, and explosive forming.
- Create sintered components using different hydrogen storage methods and sintering processes.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different powder characteristics, such as size, shape, density, and friction conditions.	Analyze
CO2	Choose suitable powder production methods based on material and application requirements.	Apply
CO3	Assemble powder compaction tools and analyze density distribution in green compacts.	Analyze
CO4	Adjust powder forming techniques to achieve desired mechanical and structural properties.	Apply
CO5	Identify appropriate sintering techniques and evaluate their effects on the properties of final components.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	1	3	3	2
CO2	3	3	3	2	3	1	–	–	1	–	1	3	3	2
CO3	3	3	2	3	3	1	–	1	1	1	1	3	3	2
CO4	3	3	3	2	3	2	–	1	1	1	1	3	3	2
CO5	3	3	3	3	3	2	1	1	1	2	1	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION AND CHARACTERISTICS OF METAL POWDER

Historical and modern developments in P/M. Advantages limitations and applications of P/M. Particle size, shape and size distribution, Characteristics of powder mass such as apparent density, tap density, flow rate, friction conditions. Properties of green compacts and sintered compacts.

UNIT 2: METHODS OF POWDER PRODUCTION

Machining, milling, atomization, electro deposition, reduction from oxide, carbonyl process, production of alloy powders, New development.

UNIT 3: POWDER CHARACTERIZATION

Powder conditioning, fundamentals of powder compaction, density distribution in green compacts, types of compaction presses, compaction tooling and role of lubricants, Single and double die compaction, iso static pressing, hot pressing.

UNIT 4: POWDER FORMING

Powder rolling, powder forging, powder extrusion and explosive forming technique.

UNIT 5: HYDROGEN STORAGE METHODS

Definition, stages, effect of variables, sintering atmospheres and furnaces, Mechanism, liquid-phase sintering, infiltration process. Study of sintered bearings, cutting tools, and metallic filters, Study of friction and antifriction parts and electrical contact materials.

SUGGESTED READINGS

1. P.C.Angelo and R.Subramanian., “Powder Metallurgy: Science, Technology and Application” Prentice Hall, (2008).
2. B. K. Datta, “Powder Metallurgy: An Advanced Technique Of Processing Engineering Materials”, PHI Learning, (2011).
3. R. M. German, "Powder Metallurgy and Particulate Materials Processing," Metal Powder Industries Federation, Princeton, New Jersey, (2015).
4. F. Thummler and R.Oberacker "An Introduction to Powder Metallurgy" The Institute of Materials, London (2012)
5. G. S. Upadhyaya, "Sintered Metallic and Ceramic Materials" John Wiley and Sons, West Sussex, England, (2016)

Programme Elective: Engineering Materials Stream **Semester – 6**

25MEU631D **COMPOSITE MATERIALS AND MECHANICS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

1. Demonstrate an understanding of composite materials, their characteristics, and manufacturing processes.
2. Manipulate laminate constitutive equations to analyze stress and strain in composite laminates.
3. Assemble failure theories to evaluate lamina strength and predict failure in composites.
4. Perform thermal analysis of composite laminates, considering coefficient of thermal expansion effects.
5. Create analytical models for static bending, buckling, and free vibration analysis of laminated flat plates.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different types of fibers, matrices, and their applications in composite materials.	Analyze
CO2	Choose appropriate laminate constitutive equations to analyze and compute stress-strain relations in composite structures.	Apply
CO3	Identify failure criteria and apply them to evaluate the strength of composite laminates.	Apply
CO4	Adjust composite laminate equations to incorporate thermal effects in structural analysis.	Apply
CO5	Analyze laminated flat plates for static bending, buckling, and free vibration characteristics.	Analyze

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	2	–	–	1	–	1	3	3	2
CO2	3	3	3	2	3	1	–	–	1	–	1	3	3	2
CO3	3	3	3	3	3	1	–	–	1	–	1	3	3	2
CO4	3	3	3	2	3	2	–	1	1	1	1	3	3	2
CO5	3	3	3	3	3	2	–	1	1	1	1	3	3	3

UNIT 1: INTRODUCTION, LAMINA CONSTITUTIVE EQUATIONS & MANUFACTURING

Definition –Need – General Characteristics, Applications. Fibers – Glass, Carbon, Ceramic and Aramid fibers. Matrices – Polymer, Graphite, Ceramic and Metal Matrices – Characteristics of fibers and matrices. Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Typical Commercial material properties, Rule of Mixtures. Generally Orthotropic Lamina – Transformation Matrix, Transformed Stiffness. Manufacturing: Bag Moulding Compression Moulding – Pultrusion – Filament Winding – Other Manufacturing Processes.

UNIT 2: FLAT PLATE LAMINATE CONSTITUTE EQUATIONS

Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric

Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.

UNIT 3: LAMINA STRENGTH ANALYSIS

Introduction - Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure.

UNIT 4: THERMAL ANALYSIS

Assumption of Constant C.T.E's. Modification of Hooke's Law. Modification of Laminate Constitutive Equations. Orthotropic Lamina C.T.E's. C.T.E's for special Laminate Configurations – Unidirectional, Off- axis, Symmetric Balanced Laminates, Zero C.T.E laminates, Thermally Quasi-Isotropic Laminates.

UNIT 5: ANALYSIS OF LAMINATED FLAT PLATES

Equilibrium Equations of Motion. Energy Formulations. Static Bending Analysis. Buckling Analysis. Free Vibrations – Natural Frequencies.

SUGGESTED READINGS

1. Gibson, R.F., "Principles of Composite Material Mechanics", Tata McGraw Hill, (2013).
2. P.K.Mallicak, "Fiber-reinforced composites", MonalDeklar Inc., New York, (2013).
3. F.L.Matthews &R.D.Rawlings, :Composite Materials", Engg and Sci, Chapman & hall, London, (2015).
4. Micaelhyer, "Stress Analysis of Fiber - Reinforced Composite Materials", Tata McGraw Hill, (2014).
5. Ronald Gibson, "Principles of Composite Material Mechanics", Tata McGraw Hill, (2016).
6. Sanjay.K.Majumdar, "Composites Manufacturing", Kindle edition, CRC press, (2017).

Programme Elective: Engineering Materials Stream **Semester – 6**

25MEU632D **MECHANICAL METALLURGY** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of elastic and plastic behavior in materials, including dislocation theory and slip mechanisms.
- Manipulate various strengthening mechanisms such as cold working, grain boundary strengthening, and precipitation strengthening.
- Analyze fracture mechanics concepts, including ductile and brittle fracture, Griffith’s theory, and fracture toughness.
- Perform fatigue testing and evaluate fatigue behavior under different stress conditions.
- Create deformation mechanism maps and assess mechanical properties like creep behavior in materials.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between elastic and plastic behavior in materials and describe the role of dislocations in deformation.	Analyze
CO2	Identify different strengthening mechanisms and their applications in ferrous and non-ferrous materials.	Understand
CO3	Analyze different fracture mechanisms, impact tests, and apply fracture mechanics concepts to material failure.	Analyze
CO4	Evaluate fatigue behavior, assess fatigue life prediction, and understand residual life estimation.	Evaluate
CO5	Apply knowledge of mechanical properties and deformation mechanisms to high-temperature material performance.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	1	3	3	2
CO2	3	2	2	2	2	1	–	–	1	–	1	3	3	2
CO3	3	3	2	3	3	1	–	–	1	–	1	3	3	2
CO4	3	3	2	3	3	1	–	1	1	1	1	3	3	2
CO5	3	3	3	2	3	2	–	1	1	1	1	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: ELASTIC AND PLASTIC BEHAVIOUR

Elastic behaviour of materials - Hooke’s law, plastic behaviour: dislocation theory - Burger’s vectors and dislocation loops, dislocations in the FCC, HCP and BCC lattice, stress fields and energies of dislocations, forces on and between dislocations, dislocation climb, intersections of dislocations, Jogs, dislocation sources, multiplication of dislocations, dislocation pile-ups, Slip and twinning.

UNIT 2: STRENGTHENING MECHANISMS

Elementary discussion of cold working, grain boundary strengthening. Solid solution strengthening, Martensitic strengthening, Precipitation strengthening, Particulate Strengthening, Dispersion strengthening, Fiber strengthening, Examples of above strengthening mechanisms from ferrous and non- ferrous systems, Yield point phenomenon, strain aging and dynamic strain aging.

UNIT 3: FRACTURE AND FRACTURE MECHANICS

Types of fracture, Basic mechanisms of ductile and brittle fracture, Griffith's theory of brittle fracture, Orowan's modification .Izod and Charpy Impacts tests, Ductile to Brittle Transition Temperature (DBTT), Factors affecting DBTT, Determination of DBTT .Fracture mechanics-Introduction, Modes of fracture, Stress intensity factor, Strain energy release rate, Fracture toughness and Determination of KIC, Introduction to COD, J integral

UNIT 4: FATIGUE BEHAVIOUR AND TESTING

Fatigue: Stress cycles, S-N curves, Effect of mean stress, Factors affecting Fatigue, Structural changes accompanying fatigue, Cumulative damage, HCF / LCF, thermo mechanical fatigue, application of fracture mechanics to fatigue crack propagation, fatigue testing machines- Pari's Equation, Residual life prediction under Fatigue.

UNIT 5: MECHANICAL PROPERTIES AND DEFORMATION MECHANISMS

Creep curve, Stages in creep curve and explanation, Structural changes during creep, Creep mechanisms, Metallurgical factors affecting creep, High temperature alloys, Stress rupture testing, Creep testing machines, Parametric methods of extrapolation. Deformation Mechanism Maps according to Frost/Ashby

SUGGESTED READINGS

1. Dieter, G. E "Mechanical Metallurgy", McGraw-Hill Education, New Delhi (2013).
2. Courtney, T. H "Mechanical Behaviour of Materials", McGraw-Hill (2013).
3. Robert W Cahn, Hael Mughrab "Plastic deformation and fracture of materials", Weinheim: Wiley- VCH (2005).
4. Suryanarayana, A. V. K "Testing of Metallic Materials", BS Publications, New Delhi (2007)
5. Prashant Kumar "Elements of Fracture Mechanics", McGraw-Hill (2009).

Programme Elective: Engineering Materials Stream **Semester – 6**

25MEU633D SMART MATERIALS: APPLICATION OF NANOMATERIAL FOR BATTERIES, SOLAR AND FUEL CELLS

3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of renewable energy technologies and their role in addressing energy challenges.
- Manipulate solar photovoltaic materials and technologies for efficient energy conversion.
- Assemble and evaluate micro-battery components for energy storage applications.
- Perform analysis and integration of fuel cell technologies in various energy systems.
- Create and optimize hydrogen storage methods for sustainable energy applications.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different renewable energy technologies and their applications.	Analyze
CO2	Choose appropriate solar photovoltaic materials and fabrication techniques for energy conversion.	Apply
CO3	Assemble and assess the performance of micro-batteries and their industrial applications.	Evaluate
CO4	Adjust and integrate fuel cell systems for dynamic and stationary applications.	Apply
CO5	Identify and evaluate hydrogen storage methods for energy sustainability.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	3	–	–	1	–	1	3	3	2
CO2	3	3	3	2	3	3	–	1	1	1	1	3	3	2
CO3	3	3	2	3	3	3	–	1	1	1	1	3	3	2
CO4	3	3	3	2	3	3	–	1	1	1	1	3	3	3
CO5	3	3	3	3	3	3	1	1	1	2	1	3	3	3

UNIT 1: RENEWABLE ENERGY

Energy challenges and crisis - development and implementation of renewable energy technologies - current status of solar, wind, tidal and biomass -Energy production, transport, conversion and storage of nanotechnology enabled renewable energy technologies.

UNIT 2: SOLAR PHOTOVOLTAICS

Solar radiation, evolution of solar cells, amorphous and crystalline silicon, Thin films, Cadmium telluride solar cell, Copper indium gallium selenide solar cell, Gallium arsenide multi-junction solar cell, Dye- sensitized solar cell, Quantum Dot Solar Cells (QDSCs), Organic/polymer solar cells, hybrid photovoltaic system.

UNIT 3: MICRO BATTERIES

Super ionic solids - Nano-ionic materials - thin film battery- electrolyte thin films- capacity of a cell - power and energy density of a cell - polymer electrolytes - super capacitors. Primary lithium batteries - Secondary lithium batteries - Li-ion electrode materials - Applications of Lithium batteries in electronic devices and industries.

UNIT 4: FUEL CELL TECHNOLOGY

Types of fuel cells and their characteristics, physical and chemical phenomena in fuel cells, - integration and performance for micro-fuel cell systems - design methodologies - micro-fuel cell power sources, fuel cells for stationary and dynamic applications.

UNIT 5: HYDROGEN STORAGE METHODS

Metal hydrides - hydrogen storage capacity - hydrogen reaction kinetics - carbon-free cycle - gravimetric and volumetric storage capacities - hydriding / dehydriding kinetics - thermal management during the hydriding reaction - size effects - distinctive chemical and physical properties - multiple catalytic effects

SUGGESTED READINGS

1. Kothari D P, Singal K C and Rakesh Ranjan “Renewable Energy Sources and Emerging Technologies”, PHI Learning, New Delhi (2013).
2. Leon Freris and David Infield “Renewable Energy in Power Systems”, John Wiley & Sons, London (2009).
3. Chetan Singh Solanki “Solar Photovoltaics: Fundamentals, Technologies and Applications”, PHI Learning, New Delhi (2009).
4. Kiehne H A “Battery Technology Handbook”, Marcel Dekkar, New York (2003).
5. Viswanathan B and Aulice Scibioh M “Fuel Cells: Principles and Applications”, Universities Press, Hyderabad (2009).

Programme Elective: Engineering Materials Stream **Semester – 7**

25MEU731D **HEAT TREATMENT OF METALS AND ALLOYS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of phase transformations in steels and their impact on mechanical properties.
- Manipulate heat treatment processes such as annealing, normalizing, and quenching to achieve desired material properties.
- Assemble case hardening processes, including carburizing and nitriding, to enhance surface characteristics.
- Perform operations in different heat treatment furnaces and analyze process control systems.
- Create optimized heat treatment procedures for specific alloys and troubleshoot defects in heat-treated components.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different phase transformations and their effects on microstructure using TTT and CCT diagrams.	Analyze
CO2	Choose appropriate heat treatment processes and evaluate their influence on material properties.	Evaluate
CO3	Assemble and apply different case hardening techniques based on specific industrial applications.	Apply
CO4	Adjust and control heat treatment processes through the use of different furnaces and quenching media.	Apply
CO5	Identify heat treatment procedures for different alloys and propose solutions for defects in heat-treated parts.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	1	3	3	2
CO2	3	3	3	2	3	1	–	–	1	–	1	3	3	2
CO3	3	3	3	2	3	1	–	1	1	1	1	3	3	2
CO4	3	3	3	2	3	2	–	1	1	1	1	3	3	2
CO5	3	3	3	3	3	2	1	1	1	2	1	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: TRANSFORMATIONS IN STEELS

Allotropic changes in Iron, Iron-Iron carbide equilibrium diagram – transformations on heating and cooling - influence of alloying elements – general principles of heat treatment of steels – isothermal and continuous cooling transformations in steels – Time-Temperature-Transformation curves (TTT-diagrams), continuous cooling transformations – CCT-diagrams– effect of alloying additions on TTT diagrams, mechanism and kinetics of pearlitic, bainitic and martensitic transformations.

UNIT 2: HEAT TREATMENT PROCESSES

Annealing- Types, Normalising, Hardening & Quenching –Mechanisms- hardenability studies– Jominy end-quench test, Tempering – tempered brittleness – effects of alloying elements on tempering, austempering and martempering, precipitation hardening, thermomechanical treatment, intercriticalheat treatment, polymer quenching.

UNIT 3: CASE HARDENING

Introduction, carburisation – principle – carbon potential – mechanism – application of Fick's law– depth of carburisation and its control – methods of carburising – heat treatment after carburizing – structure, properties and defects in carburising, nitriding – mechanism – retained austenite –Remedy- effect of microstructure – nitriding methods, ion-nitriding and nitro-carburising, induction and flame hardening, – principles – methods – operating variables, measurement of case depth.

UNIT 4: FURNACES, ATMOSPHERE AND PROCESS CONTROL

Various heating atmosphere used for heat treatment, Temperature Measurement Control devices – quenching media and their characteristics, Stages of Quenching, Various Heat Treatment furnaces- Roller and Mesh type continuous furnaces- fluidised bed furnaces, cryo-chamber, cryo-treatment of steels, plasma equipment- Elements of Process control systems-PLC ,PID controllers and continuous monitoring systems.

UNIT 5: HEAT TREATMENT OF SPECIFIC ALLOYS

Heat treatment of special purpose steels – tool steels, high speed steels, maraging steels, HSLA steels and die steels, heat treatment of cast irons – gray cast irons, white cast irons and S.G. irons, austempering of S.G. Iron, heat treatment of non-ferrous alloys – aluminium alloys, copper alloys, nickel alloys and titanium alloys, defects in heat treated parts – causes and remedies.

SUGGESTED READINGS

1. Rajan, T. V., Sharma, C. P., Ashok Sharma "Heat Treatment Principles and Techniques" Prentice- Hall of India Pvt. Ltd., New Delhi (2012).
2. Kenneth G Budinski "Engineering Materials",Pearson India Education, New Delhi (2016).
3. Vijendra Singh "Heat Treatment of Metals", Second edition, Standard Publishers Distributors New Delhi (2007).
4. Williams D. Callister "Material Science and Engineering: An Introduction", Wiley India Pvt. Ltd, Revised Indian Edition (2018).
5. Prabhudev. K. H. "Handbook of Heat Treatment of Steels", Tata McGraw-Hill Publishing Co., New Delhi (2011).

Programme Elective: Engineering Materials Stream **Semester – 7**

25MEU732D **CREEP AND FATIGUE BEHAVIOR OF MATERIALS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of lattice resistance, dislocation movement, and deformation mechanisms in crystalline solids.
- Analyze the high-temperature deformation response of materials, including creep and superplasticity.
- Examine fatigue failure mechanisms and estimate fatigue life for notched components.
- Investigate fatigue crack propagation, fracture modes, and the influence of microstructure on crack growth.
- Conduct failure analysis through metallographic and fractographic examination of engineering components.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different deformation mechanisms in crystalline solids.	Analyze
CO2	Analyze the creep behavior of solids and extrapolate creep rupture data.	Analyze
CO3	Evaluate fatigue failure mechanisms and estimate fatigue life for engineering applications.	Evaluate
CO4	Assess fatigue crack propagation characteristics and their correlation with fracture modes.	Evaluate
CO5	Conduct engineering failure analysis using metallographic and fractographic techniques.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	1	3	3	2
CO2	3	3	2	3	2	1	–	–	1	–	1	3	3	2
CO3	3	3	2	3	3	1	–	–	1	–	1	3	3	2
CO4	3	3	2	3	3	1	–	1	1	1	1	3	3	2
CO5	3	3	3	3	3	2	1	1	1	2	1	3	3	3

UNIT 1: INTRODUCTION

Strength of perfect crystal - Lattice resistance to dislocation movement – Elastic properties of dislocation – Dislocation multiplication – Slip and twinning in crystalline solid.

UNIT 2: HIGH – TEMPERATURE DEFORMATION RESPONSE

Creep of Solids – Temperature stress – Strain rate relation- Deformation mechanism –Super plasticity deformation mechanism maps – Extrapolation procedure for creep rupture data – materials for elevated temperature rules.

UNIT 3: CYCLIC STRES AND STRAIN FATIGUE

Macro fractrography fatigue failures - cyclic stress and strain controlled fatigue - Fatigue life estimation for notched components – Crack initiation mechanisms.

UNIT 4: FATIGUE CRACK PROPAGATION

Stress and crack lengths correlations with FCP – Fracture modes in Fatigue – Microscopic fracture mechanisms – Crack growth behavior at Δk extremes – Influences – Micro structural aspects of FCP in metal alloys.

UNIT 5: ANALYSIS OF ENGINERING FAILURES

Typical defects – Microscopic surface examination – metallographic and fractographic examination – Component failure analysis – Fracture surface preservation – Cleaning and replication techniques and image interpretation.

SUGGESTED READINGS

1. Richard. W. Hertzberg "Deformation and Fracture Mechanism of Engineering Materials", John Willey and Sons, 6th edition (2020).
2. Anderson, T. L "Fracture Mechanics: Fundamentals and Applications", CRC Press, 4th edition (2017).
3. Courtney, T. H "Mechanical Behaviour of Materials", McGraw-Hill (2013).
4. Hull & Bacon "Introduction to Dislocations", 4th ed., Jordan Hill: Elsevier Science (2014).
5. Suresh. S "Fatigue of Materials", Cambridge University Press, 2nd edition (2006).
6. Ashok Saxena "Nonlinear Fracture Mechanics for Engineers", CRC Press (2010).

Programme Elective: Engineering Materials Stream **Semester – 7**

25MEU733D **FRACTURE MECHANICS AND FAILURE ANALYSIS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate the selection of materials and design principles considering mechanical properties and environmental factors.
- Analyze fracture mechanics concepts including ductile and brittle fractures, stress intensity, and crack propagation.
- Evaluate elastic-plastic fracture mechanics parameters such as CTOD and J-integral under various loading conditions.
- Examine different types of wear, failure mechanisms, and experimental techniques for fracture toughness evaluation.
- Apply failure analysis tools and reliability concepts for life prediction and system performance improvement.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Identify material selection criteria and design considerations for different engineering applications.	Understand
CO2	Assess fracture mechanics principles to analyze and predict material failure	Evaluate
CO3	Compute elastic-plastic fracture parameters and interpret their significance.	Apply
CO4	Analyze wear mechanisms and evaluate failure modes under different conditions.	Analyze
CO5	Utilize failure analysis tools to enhance reliability and safety in engineering design.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	2	–	–	1	1	1	3	3	2
CO2	3	3	2	3	2	1	–	–	1	–	1	3	3	2
CO3	3	3	2	3	3	1	–	–	1	–	1	3	3	2
CO4	3	3	2	3	3	2	–	1	1	1	1	3	3	2
CO5	3	3	3	3	3	2	1	1	1	2	1	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: MATERIALS AND DESIGN

Factors affecting the behavior of materials in components, effect of component geometry and shape factors, designing with high strength and low toughness materials, designing for hostile environments, the design process, materials selection in design, processes and their influence on design, systematic process selection. Material life cycle assessment and energy – selecting materials for eco design.

UNIT 2: FRACTURE MECHANICS

Ductile fracture, brittle fracture, cleavage-fractography, ductile-brittle transition, fracture mechanics approach to design-energy criterion, stress intensity approach, time dependent crack growth and damage. Griffith theory, energy release rate, Instability and R-curve, stress analysis of cracks stress intensity factor, K-threshold, Crack growth instability analysis, crack tip stress analysis.

UNIT 3: ELASTIC PLASTIC FRACTURE MECHANICS

Crack tip opening displacement (CTOD), J-integral, relationship between J and CTOD. Dynamic fracture, rapid loading of a stationary crack, rapid crack propagation, dynamic contour integral, creep crack growth- C Integral, visco elastic fracture mechanics, visco elastic integral.

UNIT 4: WEAR FAILURES AND FRACTURE TOUGHNESS VALUES

Types of wear, different methods of wear measurement, analysis wear failures, wear at elevated temperatures, wear on different materials, role of friction on wear, stick slip friction, creep, stress rupture, elevated temperature fatigue, metallurgical instabilities, environmental induced failure. Experimental determination of plane strain fracture toughness, K-R curve testing, J measurement, CTOD testing, Effect of temperature, Strain rate on fracture toughness.

UNIT 5: FAILURE ANALYSIS TOOLS

Reliability concept and hazard function, life prediction, life extension, application of poisson, exponential and Weibull distribution for reliability, bath tub curve, parallel and series system, MTBF,MTTR, FMEA definition-Design FMEA, process FMEA, analysis causes of failure, modes, ranks of failure modes, fault tree analysis, microscopic failure analysis, industrial case studies / Projects on FMEA.

SUGGESTED READINGS

1. Anderson T L, “Fracture Mechanics: Fundamentals and Applications”, Taylor and Francis (2019).
2. ASM Metals Handbook, "Failure Analysis and Prevention", ASM Metals Park, Ohio, USA, Vol. 10 (2010).
3. Michael F Ashby, “Materials Selection in Mechanical Design”, Butterworth – Heinemann (2018).
4. Michael F Ashby, Hugh Shercliff and David Cebon, “Materials – Engineering, Science, Processing and Design”, Butterworth – Heinemann (2019).
5. Shigley and Mische, "Mechanical Engineering Design", McGraw Hill (2018).

Programme Elective: Intelligent Systems Stream **Semester – 5**

25MEU531E MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE FOR MECHANICAL ENGINEERS USING PYTHON

3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

1. Demonstrate an understanding of the fundamentals of Machine Learning (ML) and Artificial Intelligence (AI), including normal distribution, business moments, and their applications.
2. Manipulate supervised learning techniques such as linear regression, logistic regression, decision trees, and gradient descent methods.
3. Assemble models using Random Forest, Support Vector Machines (SVM), and classifier evaluation techniques.
4. Perform clustering techniques such as K-Nearest Neighbors (KNN), K-means clustering, hierarchical clustering, and evaluate their effectiveness.
5. Create and apply feature selection techniques, Principal Component Analysis (PCA), and Artificial Neural Networks (ANN) for deep learning applications
6.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between various Machine Learning and Artificial Intelligence concepts and statistical distributions.	Analyze
CO2	Choose appropriate supervised learning models and implement regression and classification techniques.	Apply
CO3	Assemble and evaluate classification models such as Random Forest and Support Vector Machines.	Evaluate
CO4	Identify and apply clustering algorithms, including KNN, K-means, and hierarchical clustering.	Apply
CO5	Utilize feature selection techniques, PCA, and deep learning methodologies for advanced ML applications.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	–	–	1	–	1	3	2	2
CO2	3	3	3	2	3	1	–	–	1	–	1	3	3	2
CO3	3	3	3	3	3	1	–	1	1	1	1	3	3	2
CO4	3	3	2	3	3	1	–	1	1	1	1	3	3	2
CO5	3	3	3	3	3	2	1	1	1	2	1	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION TO ML &AI

Basics of ML & AI- Introduction to normal distribution & standard normal distribution- Introduction tobusiness moments- Artificial Intelligence.

UNIT 2: SUPERVISED LEARNING

Introduction to supervised learning- linear regression- One hot encoding- Cost function and gradient descent- Introduction to classification problems- logistic regression -Cost function and gradient descent- Decision tree- Entropy- Information gain.

UNIT 3: RANDOM FOREST & MODEL EVALUATION

Random Forest- Bootstrapping and majority rule- Evaluation of classifiers- Support Vector Machines - Mathematical intuition behind SVM.

UNIT 4: KNN & CLUSTERING

K-Nearest Neighbour- Lazy Algorithm- Single layer Neural Network – clustering- Significance of clustering-Kmeans and elbow curve -Hierarchical Clustering- Dendrogram- Evaluation of clusteringalgorithms.

UNIT 5: FEATURE SELECTION TECHNIQUES

Feature Selection- Principal Component Analysis- Mathematical intuition behind PCA- Artificial NeuralNetwork - Deep learning.

SUGGESTED READINGS

1. Stewart Russell and Peter Norvig. " Artificial Intelligence-A Modern Approach ", 2nd Edition, Pearson Education/ Prentice Hall of India, 2004 References.
2. Nils J. Nilsson, “Artificial Intelligence: A new Synthesis”, Harcourt Asia Pvt. Ltd., 2000.
3. Elaine Rich and Kevin Knight, “Artificial Intelligence”, 2nd Edition, Tata McGraw-Hill, 2003.
4. George F. Luger, “Artificial Intelligence-Structures and Strategies For Complex Problem Solving”, Pearson Education / PHI, 2002.

Programme Elective: Intelligent Systems Stream **Semester – 5**

25MEU532E **IOT & SMART MANUFACTURING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Demonstrate an understanding of IoT architecture, design principles, and prototyping techniques.
- Manipulate embedded code to optimize memory management, performance, and real-time processing in IoT applications.
- Assemble secure and reliable IoT systems considering privacy, governance, and security aspects.
- Perform smart manufacturing processes with data-driven, real-time resource management.
- Create smart design and fabrication solutions utilizing digital tools, automation, and robotics.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between various IoT design principles and prototyping techniques.	Analyze
CO2	Choose appropriate embedded system components and optimize real-time reactions.	Apply
CO3	Identify security, privacy, and governance challenges in IoT applications.	Understand
CO4	Apply smart manufacturing processes and sustainable resource management.	Apply
CO5	Design and integrate smart perception and automation tools for fabrication.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	2	–	–	1	–	1	3	2	2
CO2	3	3	3	2	3	2	–	–	1	1	1	3	3	2
CO3	3	2	2	2	2	3	3	–	1	–	1	3	2	2
CO4	3	3	3	2	3	3	–	1	1	1	1	3	3	3
CO5	3	3	3	3	3	3	1	1	1	2	1	3	3	3

UNIT 1: THE INTERNET OF THINGS

An overview; Design Principles for Connected Devices; Internet Principles.Thinking about Prototyping – Costs versus ease of prototyping, prototyping and Production, open source versus Closed Source. Prototyping Embedded devices – Electronics, Embedded Computing Basics, Arduino/ Raspberry Pi/ BeagleBone Black/ etc., Electric Imp and other notable platforms Prototyping of Physical Design. Prototyping online Components – Getting Started with an API, Writing a New API.

UNIT2: REAL TIME REACTIONS, OTHER PROTOCOLS

Techniques for Writing Embedded Code – Memory Management, Performance and Battary Life, Libraries and debugging.Automatic Storage Management in a Cloud World – Introduction to Cloud, Relational

Databases in the Cloud, Automatic Storage Management in the Cloud. Smart Connected System Design Case Study

UNIT 3: INTERNET OF THINGS PRIVACY, SECURITY AND GOVERNANCE

Introduction, Overview of Governance, Privacy and Security Issues, Contribution from FP7 Projects, Security, Privacy and Trust in IoT-Data-Platforms for Smart Cities, First Steps Towards a Secure Platform, Smartie Approach. Data Aggregation for the IoT in Smart Cities, Security

UNIT 4: INTRODUCTION TO SMART MANUFACTURING

Smart manufacturing- how does it differ from conventional/legacy manufacturing-Smart Manufacturing Processes- Three Dimensions: (1) Demand Driven and Integrated Supply Chains;(2) Dynamically Optimized Manufacturing Enterprises (plant + enterprise operations);(3) Real Time, Sustainable ResourceManagement (intelligent energy demand management, production energy optimization and reduction of GHG)

UNIT 5: SMART DESIGN/FABRICATION

Smart Design/Fabrication - Digital Tools, Product Representation and Exchange Technologies and Standards, Agile (Additive) Manufacturing Systems and Standards.Mass Customization, Smart Machine Tools, Robotics and Automation (perception, manipulation, mobility, autonomy), Smart Perception – Sensor networks and Devices.

SUGGESTED READINGS

1. McEwen and H. Cassimally, “Designing the Internet of Things”, 1st edition, Wiley, 2013, ISBN- 10: 111843062X.
2. N. Vengurlekar and P. Bagal, “Database Cloud Storage: The Essential Guide to Oracle Automatic Storage Management”, 1st edition, McGraw-Hill Education, 2013, ISBN-10: 0071790152.
3. M. Kuniavsky, “Smart Things: Ubiquitous Computing User Experience Design”, 1st edition, Morgan Kaufmann, 2010, ISBN-10: 0123748992.

Programme Elective: Intelligent Systems Stream **Semester – 5**

25MEU533E **INDUSTRIAL PROCESS AUTOMATION** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

1. Demonstrate an understanding of automation principles, strategies, and identification methods.
2. Manipulate various material handling and storage systems used in industrial automation.
3. Assemble automated manufacturing systems, including Group Technology (GT) and Flexible Manufacturing Systems (FMS).
4. Perform metrology and inspection techniques using automated inspection technologies.
5. Create control systems using SCADA, RTU, and digital I/O modules for process automation.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between different levels and functions of automation in production systems.	Analyze
CO2	Choose appropriate material handling and identification technologies for automated systems.	Apply
CO3	Assemble and operate manufacturing systems using GT and FMS principles.	Apply
CO4	Adjust inspection technologies for accurate metrology and quality control.	Apply
CO5	Identify and implement industrial control systems for automation applications.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	2	–	–	1	–	1	3	3	2
CO2	3	3	3	2	3	2	–	–	1	1	1	3	3	2
CO3	3	3	3	3	3	2	–	1	1	1	1	3	3	2
CO4	3	3	2	3	3	2	–	1	1	1	1	3	3	2
CO5	3	3	3	2	3	2	1	1	1	2	1	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION & AUTOMATIC DATA CAPTURE

Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations. Overview of Automatic Identification Methods, Barcode Technologies, and other ADC Technologies.

UNIT 2: MATERIAL HANDLING AND IDENTIFICATION TECHNOLOGIES

Overview of Material Handling Systems, Principles and Design Consideration, Industrial Trucks, Automated Guided Vehicles, Conveyor Systems, Storage Systems Performance, Automated Storage Systems Carousel Storage Systems.

UNIT 3: AUTOMATED MANUFACTURING SYSTEMS

Components, Classification and Overview of Manufacturing Systems, GT and Cellular Manufacturing – Part Families, Parts Classification and Coding, Production Flow Analysis, Cellular Manufacturing, Application Consideration in GT, FMS – FMS Components, FMS Application and Benefits FMS Planning and Implementation issues.

UNIT 4: INSPECTION TECHNOLOGIES FOR AUTOMATION

Inspection Metrology, Contact vs. Non-contact inspection Technologies, Coordinate Measuring Machines Technologies, Machine Vision, Optical Inspection Techniques and Non-contact Non-optical Inspection Technologies.

UNIT 5: CONTROL TECHNOLOGIES IN AUTOMATION

Industrial Control Systems, Process Industries Verses Discrete Manufacturing Industries, Continuous Verses Discrete Control, Computer Process Control and its Forms. Introduction & Automatic Process Control, Building Blocks of Automation Systems: LAN, Analog & Digital I/O Modules, SCADA Systems & RTU.

SUGGESTED READINGS

1. M.P. Groover "Automation, Production Systems and Computer Integrated Manufacturing", Pearson Education (2008).
2. Krishna Kant "Computer Based Industrial Control", Prentice Hall India Pvt. Limited (2004).
3. Amber G.H & P. S. Amber "Anatomy of Automation", Prentice Hall India Pvt. Limited (1962).
4. S.K. Vajpayee "Principles of Computer Integrated Manufacturing", Prentice Hall India Pvt. Limited (1995).
5. N. Viswanadham & Y. Narahari "Performance Modeling of Automated Manufacturing Systems", Prentice Hall India Pvt. Limited (1992).

Programme Elective: Intelligent Systems Stream **Semester – 6**

25MEU631E **MEMS AND MICROSYSTEMS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

1. Demonstrate an understanding of Micro and Nano scale systems and their applications in MEMS and NEMS.
2. Manipulate various MEMS fabrication technologies, including lithography, deposition, etching, and micromachining.
3. Assemble different types of MEMS sensors and analyze their working principles.
4. Perform actuation mechanisms using different MEMS actuation techniques.
5. Create nanosystems and apply quantum mechanics concepts in MEMS design

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Distinguish between various micro and nano electromechanical systems and materials used in MEMS.	Analyze
CO2	Choose appropriate MEMS fabrication technologies for different applications.	Apply
CO3	Assemble and analyze MEMS sensors based on different sensing principles.	Analyze
CO4	Adjust MEMS actuators and evaluate their performance in real-world applications.	Apply
CO5	Identify and apply quantum mechanics principles in the design of nanosystems.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	2	–	–	1	–	1	3	3	2
CO2	3	3	3	2	3	2	–	–	1	1	1	3	3	2
CO3	3	3	2	3	3	2	–	1	1	1	1	3	3	2
CO4	3	3	3	3	3	2	–	1	1	1	1	3	3	3
CO5	3	3	2	2	2	2	1	–	1	–	1	3	3	2

1 - low, 2 - medium, 3 - high

UNIT 1: OVERVIEW AND INTRODUCTION

New trends in Engineering and Science: Micro and Nano scale systems Introduction to Design of MEMS and NEMS, Overview of Nano and Micro electromechanical Systems, Applications of Micro and Nano electro mechanical systems, Micro electromechanical systems, devices and structures Definitions, Materials for MEMS: Silicon, silicon compounds, polymers, metals.

UNIT 2: MEMS FABRICATION TECHNOLOGIES

Microsystem fabrication processes: Photolithography, Ion Implantation, Diffusion, and Oxidation. Thin film depositions: LPCVD, Sputtering, Evaporation, Electroplating; Etching techniques: Dry and wet etching, electrochemical etching; Micromachining: Bulk Micromachining, Surface Micromachining, High Aspect-Ratio

(LIGA and LIGA-like) Technology; Packaging: Microsystems packaging, Essential packaging technologies, Selection of packaging materials.

UNIT 3: MICRO SENSORS

MEMS Sensors: Design of Acoustic wave sensors, resonant sensor, Vibratory gyroscope, Capacitive and Piezo Resistive Pressure sensors- engineering mechanics behind these Micro sensors. Case study: Piezo-resistive pressure sensor.

UNIT 4: MICRO ACTUATORS

Design of Actuators: Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals, Actuation using Electrostatic forces (Parallel plate, Torsion bar, Comb drive actuators), Micromechanical Motors and pumps. Case study: Comb drive actuators.

UNIT 5: NANOSYSTEMS AND QUANTUM MECHANICS

Atomic Structures and Quantum Mechanics, Molecular and Nanostructure Dynamics: Shrodinger Equation and Wave function Theory, Density Functional Theory, Nanostructures and Molecular Dynamics, Electromagnetic Fields and their quantization, Molecular Wires and Molecular Circuits.

SUGGESTED READINGS

1. Marc Madou “Fundamentals of Micro fabrication”, CRC press (2004).
2. Stephen D. Senturia “Micro system Design”, Kluwer Academic Publishers (2011).
3. Tai Ran Hsu “MEMS and Microsystems Design and Manufacture”, Tata McGraw Hill (2014).
4. Chang Liu “Foundations of MEMS”, Pearson Education India Limited (2016).

Programme Elective: Intelligent Systems Stream **Semester – 6**

25MEU632E **VIRTUAL REALITY AND AUGMENTED REALITY** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

1. Provide an overview of VR/AR systems architectures and requirements for the development of VR/AR applications.
2. Acquire knowledge on hardware and software aspects of virtual reality and augmented reality for modeling, analysis and design of engineering systems.
3. Impart exercises aiming to design and develop simple prototype AR/VR applications using state-of- the-art tools.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Understand the overview of AR/VR systems and realize the differences in AR/VR concepts.	Understand
CO2	Comprehend the functions and select the appropriate hardware for VR/AR applications.	Apply
CO3	Cognize Geometric modeling and dynamics of 3D models for VR simulation	Understand
CO4	Develop and prototype effective AR/VR applications	Apply
CO5	Interpret and match VR/AR technology to human needs and use with human factors.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	2	–	–	1	–	1	3	2	2
CO2	3	3	3	2	3	2	–	–	1	1	1	3	3	2
CO3	3	3	2	2	3	1	–	–	1	–	1	3	3	2
CO4	3	3	3	3	3	2	–	1	1	1	1	3	3	3
CO5	3	3	3	2	2	3	2	1	2	1	1	3	3	3

1 - low, 2 - medium, 3 - high

UNIT 1: INTRODUCTION TO VIRTUAL REALITY AND AUGMENTED REALITY

Introduction to Virtual Reality and Augmented Reality, Virtual reality, Augmented reality and Mixed Reality concepts – Virtual world space and real world – Interface to virtual world (inputs and outputs) – Types of interactions – Requirements for VR/AR systems – Benefits and Applications of VR and AR.

UNIT 2: VR/AR HARDWARE TECHNOLOGIES

Input devices - filtering & tracking, Output devices-Visual Displays, Auditory Displays, Haptic Displays and Augmenting displays. Augmented Reality (AR) hardware, spatial audio, computing architectures for VR - Haptic assembly architecture - Haptic Interface. Human Factors in Virtual Reality, Perceptual training, best practices, VR sickness, experimental methods involving human subjects.

UNIT 3: GEOMETRIC MODELING AND DYNAMICS

Geometric modeling, transforming rigid bodies, yaw, pitch, roll, axis-angle representation, quaternions, 3D rotation inverses and conversions, homogeneous transforms, transforms to displays, look-at and eye transforms, canonical view and viewport transforms. Motion in Virtual world - simulation, collision detection, avatar motion and vection. Touch, haptics and robotic interfaces, telepresence and Brain- machine interfaces.

UNIT 4: VISUAL PERCEPTION AND RENDERING

Implications of perception on VR -Depth perception, motion perception and color perception. Graphical rendering, ray tracing, shading, BRDFs, rasterization, barycentric coordinates, VR rendering problems, anti-aliasing, distortion shading, image warping (time warp), panoramic rendering. Traditional and emerging VR/AR applications in Engineering, Architecture, Education, Medicine, Entertainment, Science, and Training Implementation

UNIT 5: TRACKING AND INTERACTION

Tracking systems – sensors for tracking position, orientation and motion, estimating rotation, IMU integration, drift errors, tilt and yaw correction. Devices for navigation and interaction -sensor fusion, eye tracking and map building.Remapping, locomotion, manipulation, specialized interaction mechanisms.Sound propagation and auditory perception.

SUGGESTED READINGS

1. GrigoreBurdea, Philippe Coiffet, Virtual Reality Technology (2006), 2nd edition. Wiley India.
2. Steve Aukstakalnis, Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR (Usability)(2017), ISBN-13: 978-0134094236.
3. John vince, Virtual Reality Systems (2007), Pearson Education. MatjazMihelj, Jonezpodobnik, Haptics for virtual reality and tele operation (2012), Springer.
4. Sean Morey and John Tinnell, Augmented Reality: Innovative Perspectives across Art, Industry, and Academia (2016), ISBN-13: 978-1602355569.

Programme Elective: Intelligent Systems Stream **Semester – 6**

25MEU633E **INTELLIGENT MANUFACTURING SYSTEMS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

To know the concepts of Artificial Intelligence.

To Practice the methods of solving problems using Artificial Intelligence.

To build components of intelligent decision support system for Manufacturing

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Understand the fundamentals of AI and its components in manufacturing systems.	Understand
CO2	Apply AI languages such as LISP and PROLOG to develop simple intelligent programs.	Apply
CO3	Develop knowledge-based systems using logic, fuzzy reasoning, and semantic networks.	Apply
CO4	Analyze and design intelligent decision-making systems for various manufacturing tasks.	Analyze
CO5	Evaluate the role of AI in smart factories and propose solutions for planning and scheduling.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	2	–	–	1	–	1	3	2	2
CO2	3	3	3	2	3	1	–	–	1	1	1	3	3	2
CO3	3	3	3	3	3	1	–	1	1	1	1	3	3	2
CO4	3	3	3	3	3	2	–	1	1	1	1	3	3	3
CO5	3	3	3	3	3	3	1	1	1	2	1	3	3	3

UNIT I INTRODUCTION

Components of manufacturing – Soft and Hard Automation – Flexible Manufacturing Cell – Flexible handling methods -Basic concepts of Artificial intelligence and expert systems – Intelligent System Components - System architecture and Data flow – System Operations.

UNIT 2 ARTIFICIAL INTELLIGENCE LANGUAGES

Heuristic search-logic programming and reasoning-automatic programming-scope of AI-in manufacturing components of intelligent manufacturing Aspects of intelligence and AI Requirements of AI languages, LISP & PROLOG – Simple programs.

UNIT3 BUILDING OF KNOWLEDGE BASED SYSTEMS

Knowledge engineering-protocol analysis -fuzzy logic -Semantic networks, Learning systems Knowledge Engineering Knowledge representation – Knowledge acquisition and optimization - Knowledge based approaches to design mechanical parts and mechanisms and design for automated assembly.

UNIT 4 INTELLIGENT SYSTEMS

Knowledge based system for material selection – Intelligent process planning system. Intelligent system for equipment selection -Intelligent system for project management & factory monitoring. Inference engine Vision programmes-factory vision systems -machine learning.

UNIT 5 FACTORIES OF FUTURE

The role of Artificial Intelligence in the factory of the future Features of Experts systems -applications in manufacturing planning and control – Intelligent systems. Scheduling in manufacturing – scheduling the shop floor – Diagnosis & trouble shooting.

SUGGESTED READINGS

Andrew Kussiak, "Intelligent Manufacturing Systems", Prentice Hall, 1990.
2. Kenneth R.Baker, "Introduction to sequencing and scheduling", John Wiley & Sons, New York, 2000.
3. Richard W. Conway, William Maxwell and Louis W. Miller, "Theory of Scheduling", Dover Publications, 2003.
4. Rich,E., "Artificial Intelligence", McGraw Hill, 1986. 5. Simons, G.L, "Introducing Artificial Intelligence", NCC Pub, 1990.

Programme Elective: Intelligent Systems Stream **Semester – 7**

25MEU731E **ROBOT DYNAMICS AND APPLICATIONS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- To introduce the basic components, classifications, and degrees of freedom (DOF) of industrial robots and manipulators.
- To provide a detailed understanding of forward and inverse kinematics, including the Denavit-Hartenberg representation for robot manipulators.
- To analyze the velocity kinematics of robots, including velocity propagation, transformation, and singularity analysis.
- To develop an understanding of robot dynamics using Euler-Lagrange and Newton-Euler formulations for motion analysis.
- To explore various industrial applications of robots, including welding, material handling, mobile robots, and specialized robots like underwater and surgical robots.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Describe the components, classifications, and DOF of serial and parallel robot manipulators, and understand singularity and dexterity in robot work envelopes.	Understand
CO2	Perform forward and inverse kinematic analysis using homogeneous matrices and Denavit-Hartenberg representation, applying these to robots like the Puma 500 and SCARA.	Apply
CO3	Analyze velocity transformations, derive the Jacobian matrix, and conduct static force analysis for robot manipulators.	Analyze
CO4	Apply Euler-Lagrange and Newton-Euler formulations to solve forward and inverse dynamics problems for robotic systems.	Apply
CO5	Identify and explain the industrial applications of robots, including mobile, underwater, space, and service robots, in various sectors.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	1	1	-	-	-	-	-	1	2	1	-
CO2	3	3	2	2	2	-	-	-	-	-	1	3	2	1
CO3	3	3	2	2	2	-	-	-	-	-	1	3	2	1
CO4	3	3	3	2	2	-	-	-	-	-	1	3	2	1
CO5	2	2	1	1	1	1	1	1	2	1	2	2	1	1

UNIT 1: INTRODUCTION TO ROBOT MANIPULATOR

Components of Industrial robot – Basic classifications – DOF of serial and parallel manipulator – Specifications of industrial robots – Singularity in robot work envelop – Dexterity – Introduction to redundant manipulator.

UNIT 2: ROBOT KINAMATICS

Representing Position and orientation – Homogeneous matrices - Forward kinematics – Inverse Kinematics – Denavit hartenberg representation – case study: Puma 500, standford arm and SCARA robot.

UNIT 3: VELOCITY KINEMATICS

Velocity propagation – Velocity transformation – angular and linear velocity - Static force analysis – Derivation of Jacobian – inverse velocities and acceleration – wrist and arm singularity.

UNIT 4: ROBOT DYNAMICS

Euler-Lagrange Equations – equation of motion – forward and inverse dynamics – properties of robot dynamics equations – Newton-Euler formulation.

UNIT 5: INDUSTRIAL APPLICATION

Welding – Assembly – Material handling –Loading and Unloading – Pressing – fettling –
Paining- Mobile robot – types of wheeled mobile robot – Underwater robot – space robot - service robot– surgical robot- Mobile robot – types of wheeled mobile robot – Underwater robot – space robot - service robot– surgical robot.

SUGGESTED READINGS

1. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar 'Robot Dynamics and Control' John
2. Wiley & Sons, 04-Aug-2008
3. S. R. Deb, Sankha Deb , (2009)Robotics Technology And Flexible Automation, McGraw Hill Edition.
4. Fu, K.S., Gonzalez, R.C. and Lee, C.S.G., "Robotics: Sensing, Vision and Intelligence", Tata McGraw-Hill, New Delhi, 2008.
5. Craig, John. J., "Introduction to Robotics: Mechanics and Control", Second Edition, Pearson Education, New Delhi, 2002.
6. Niku, Saeed.B "Introduction to Robotics: Analysis, Systems, Applications", New Delhi: Prentice Hall of India Pvt Ltd , 2005

Programme Elective: Intelligent Systems Stream **Semester – 7**

25MEU732E PYTHON PROGRAMMING FOR MECHANICAL ENGINEERS 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

Understand the fundamentals of Python programming relevant to mechanical engineering.

- Apply Python to solve numerical and simulation-based engineering problems.
- Utilize Python libraries for data analysis, visualization, and design automation.
- Integrate Python with CAD, FEA, and thermal-fluid applications.
- Develop simple intelligent systems and automation routines using Python tools.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the basic syntax, data structures, and control flows of Python.	Understand
CO2	Apply Python to solve basic mechanical engineering problems numerically.	Apply
CO3	Use Python libraries (NumPy, Matplotlib) for numerical computation and data visualization.	Apply
CO4	Analyze and simulate thermal, structural, or kinematic problems using Python tools.	Analyze
CO5	Design and implement simple Python-based automation or simulation systems for mechanical applications.	Create

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	1	1	-	-	-	-	-	1	2	1	-
CO2	3	3	2	2	2	-	-	-	-	-	1	3	2	1
CO3	3	3	2	2	2	-	-	-	-	-	1	3	2	1
CO4	3	3	3	2	2	-	-	-	-	-	1	3	2	1
CO5	2	2	1	1	1	1	1	1	2	1	2	2	1	1

UNIT 1: INTRODUCTION TO PYTHON PROGRAMMING

Python IDEs, Syntax, Variables, Data types, Control statements, Loops, Functions

UNIT 2: DATA HANDLING AND VISUALIZATION

Lists, Tuples, Dictionaries, File I/O, Introduction to NumPy, Matplotlib for plots and graphs

UNIT 3: NUMERICAL METHODS IN PYTHON

Solving algebraic & differential equations, Interpolation, numerical integration using SciPy

UNIT 4: PYTHON FOR MECHANICAL ENGINEERING

Applications in thermodynamics, heat transfer, and fluid mechanics, Basic simulations and design automation

UNIT 5: PYTHON IN CAD/FEA & AUTOMATION

Scripting in FreeCAD and Python for FEA (e.g., Pycalculix), Automation using PySerial, basic vision systems with OpenCV

SUGGESTED READINGS

1. Jaan Kiusalaas, Numerical Methods in Engineering with Python 3, Cambridge University Press, 3rd Edition, 2013.
2. Hans Petter Langtangen, A Primer on Scientific Programming with Python, Springer, 5th Edition, 2016.
3. Allen B. Downey, Think Python: How to Think Like a Computer Scientist, O'Reilly Media, 2nd Edition, 2015.

Open Elective
25MEU041 **APPLIED ERGONOMICS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Explore the history, interdisciplinary nature, and principles of ergonomics, including biostatic and biodynamic mechanics.
- Study factors influencing human performance, including information processing, response mechanisms, errors, and signal detection theory.
- Understand energy expenditure, physical work capacity, fatigue, and develop work and rest schedules for optimal performance.
- Apply anthropometry, posture analysis, and workstation layout to design ergonomic workspaces, displays, controls, and hand tools.
- Identify hazards, implement safety management practices, and understand the impact of environmental factors in compliance with regulations.

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Understand the history, interdisciplinary nature, and principles of human factors engineering, including biostatic and biodynamic mechanics.	Understand
CO2	Learn factors influencing performance, information processing, human errors, and theories like Signal Detection and Information Theory.	Understand
CO3	Understand metabolism, energy expenditure, physical work capacity, fatigue, and work-rest schedules.	Understand
CO4	Understand metabolism, energy expenditure, physical work capacity, fatigue, and work-rest schedules.	Understand
CO5	Apply ergonomic principles to design workspaces, tools, and controls, considering body size,	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	1	1	-	-	-	-	-	-	1	1	-	-
CO2	2	2	1	1	-	-	-	-	-	-	1	1	-	-
CO3	2	1	1	1	-	-	-	-	-	-	1	1	-	-
CO4	2	1	1	1	-	-	-	-	-	-	1	1	-	-
CO5	3	2	3	2	2	3	2	2	2	1	2	2	1	1

UNIT 1: INTRODUCTION
Brief history of human factors Engineering/Ergonomics – Interdisciplinary nature- Principles of Human factors Engineering- Biostatic and Biodynamic Mechanics.

UNIT 2: HUMAN PERFORMANCE
Factors Influencing performance – Information receiving and processing – Information theory and its application – Human response and errors – Signal detection theory.

UNIT 3: PHYSIOLOGICAL ASPECTS OF HUMAN AT WORK

Metabolism – Physiological factors involved in muscular activity – Measurement of energy expenditure – Quantitative work load analysis – Physical work capacity and its evaluation – Physiological fatigue – Work and rest schedules – Physical fitness tests.

UNIT 4: WORK PLACE DESIGN9Hrs.

Problems of body size, Anthropometry measures, Work posture – Work space layout and work station design – Design of displays, controls and VDT work stations – Hand tool design, illumination.

UNIT 5: OCCUPATIONAL HEALTH AND SAFETY

Industrial accidents, Personnel Protective devices, Safety Management practices – Effect of Environment – heat, cold & noise – NIOSH regulations and Factories Act.

SUGGESTED READINGS

1. Bridger, R.S., “Introduction to Ergonomics”, McGraw Hill, 1995.
2. Martin Helander, “A guide to Ergonomics of Manufacturing”, TMH, 2006.
3. John Grimaldi, “Safety Management”, A.I.B.S., 5th Edition, Hazard Control Technology 2003.
4. Philips, Chandler A, “Human Factors Engineering”, John Wiley and Sons, Inc. 2000.
5. Mecormik, T.J., “Human Factors Engineering”, TMH, 1990.

Open Elective
25MEU042 **STRUCTURE AND PROPERTIES OF MATERIALS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Understand crystal structures, defects, and crystallization mechanisms.
- Learn to interpret phase diagrams and related reactions.
- Study properties and applications of ferrous and non-ferrous alloys.
- Explore types, properties, and applications of ceramics and composites.
- Understand polymer classification, polymerization, and their engineering applications.

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Identify and analyze crystal structures and defects.	Analyze
CO2	Interpret phase diagrams and apply related concepts.	Apply
CO3	Classify and understand ferrous and non-ferrous alloys.	Understand
CO4	Analyse the behavior of ceramics and composites.	Analyze
CO5	Implement the knowledge on developing polymers, elastomers and the applications.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	1	-	-	-	-	-	1	2	1	-
CO2	3	3	2	2	1	-	-	-	-	-	1	2	1	-
CO3	2	2	1	1	-	-	-	-	-	-	1	2	1	-
CO4	3	3	2	2	1	-	-	-	-	-	1	3	2	1
CO5	3	2	3	2	2	1	-	-	1	-	2	3	2	1

1 - low, 2 - medium, 3 - high

UNIT 1: STRUCTURE OF SOLIDS

Overview of Crystal Structure – Solid Solutions-Hume Rothery Rules-Crystal Imperfections- Point Defects-Line Defects-Surface Defects-Bulk Defects-Critical nucleus size and Critical Free energy- Mechanism of Crystallisation- Nucleation-Homogeneous and Heterogenous Nucleation- Growth - Single crystal -Polycrystalline Materials - Basic principles of solidification of metals and alloys.

Growth of crystals- Planar growth – dendritic growth – Solidification time - Cooling curves - Non-crystalline solids- Glass Transition Temperature.

UNIT 2: PHASE DIAGRAMS

Phase Rule –Unary System- Binary Phase diagrams- Isomorphous systems-Congruent phase diagrams - Free energy Composition curves- Construction -Microstructural changes during cooling- Tie Line- Lever Rule- Eutectic , Peritectic, Eutectoid and Peritectoid reactions- Typical Phase diagrams – Cu-Zn System – Pb-Sn system- Ag-Pt system-Iron-Iron carbide Equilibrium Diagram.

UNIT 3: FERROUS AND NON FERROUS MATERIALS

Classification of steels and cast iron –Microstructure– Effect of alloying elements on steel- Ferrous alloys and their applications - Factors affecting conductivity of a metal – Electrical Resistivity in alloys – Thermal conductivity of metals and alloys - High Resistivity alloys –Some important Titanium alloys, Nickel alloys, Copper alloys, Magnesium alloys and Aluminium alloys.

UNIT 4: CERAMIC AND COMPOSITE MATERIALS

Types - Crystal Structures - Silicate Ceramics - Glasses – Glass Ceramics – Advanced ceramics- Functional properties and applications of ceramic materials – Super hard materials - Tungsten carbide and Boron nitrides – Graphene. Classification of Composites - Fibre reinforced materials – Law of mixtures – Continuous fibres – Discontinuous fibres – Particle-reinforced composites – Cermets – Dispersion strengthened materials – Structural composites- Laminar – Sandwich panel-Application of composites in various fields of technology-Smart Composites.

UNIT 5: POLYMERS AND ELASTOMERS

Classification of polymer – Mechanisms of polymerisation – Copolymers – Examples- Defects in polymers- Thermoplastics - Thermosets – Engineering plastics - Advanced Polymeric materials -Liquid crystal polymers - Conductive polymers – High Performance fibres– Photonic polymers -Elastomers- Applications.

SUGGESTED READINGS

1. William D. Callister, Jr. "Materials Science and Engineering an Introduction", 2/e Edition, John Wiley & Sons, Inc (2007).
2. V. Raghavan "Materials Science and Engineering", Prentice –Hall of India Pvt. Ltd (2007).
3. W. Bolton "Engineering Materials Technology", 3rd Edition, Butterworth & Heinemann
4. (2001).
5. Donald R. Askeland, Pradeep P Phule, "The Science and Engineering of Materials",
6. 5thEdition, Thomson Learning, First Indian Reprint (2007).
7. Sidney H. Avner "Introduction to Physical Metallurgy", Tata Mc-Graw-Hill Inc, 2/e (1997).

Open Elective 25MEU043

INTERNATIONAL SUPPLY CHAIN MANAGEMENT **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- To introduce students to the principles and practices of global supply chain management.
- To understand the complexities, challenges, and strategies involved in managing international supply chains.
- To develop analytical skills for designing and optimizing global logistics and distribution networks.
- To familiarize students with trade regulations, customs, and documentation in international business.
- To explore technological trends and sustainability practices in global supply chain operations.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Understand the structure, drivers, and scope of global supply chains.	Understand
CO2	Analyze the strategies for sourcing, production, and distribution in international networks.	Analyze
CO3	Apply concepts of trade regulations, documentation, and risk management in global logistics.	Apply
CO4	Evaluate the performance of international supply chains using key performance indicators (KPIs).	Evaluate
CO5	Understand the impact of digitization, automation, and sustainability in international supply chains.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	1	-	-	1	-	-	-	-	1	1	-	-
CO2	2	3	2	2	1	1	-	-	-	-	1	2	1	-
CO3	2	2	2	2	2	2	1	1	1	1	1	2	1	1
CO4	2	3	2	3	2	2	-	1	1	1	1	2	1	1
CO5	2	2	2	1	2	3	2	1	1	1	2	2	1	1

UNIT 1 – Fundamentals of International Supply Chain

Overview of supply chain management in global context- Key drivers of global supply chains – cost, quality, time, flexibility- Structure and models of international supply chains- Importance of coordination and integration across borders

UNIT 2 – Global Sourcing and Procurement

Strategic sourcing in global markets- Supplier selection and evaluation in international trade Outsourcing vs offshoring – benefits and risks- Legal and ethical issues in global sourcing

UNIT 3 – International Logistics and Transportation

Modes of global transportation – air, ocean, intermodal- Freight forwarding, customs clearance, and INCOTERMS- Cross-border logistics challenges and risk mitigation- Trade documents – Bill of Lading, Certificate of Origin, Invoice, Packing List

UNIT 4 – Global Supply Chain Network Design

Location decisions for warehouses, plants, and distribution centers- Network optimization models- Demand forecasting in international environments- Performance metrics and supply chain KPIs

UNIT 5 – Technology, Risk and Sustainability

Use of ERP, TMS, WMS, and blockchain in global SCM- Supply chain visibility and traceability Managing risks – political, economic, environmental, operational- Sustainable and resilient supply chains – green logistics, circular supply chains

SUGGESTED READINGS

1. Chopra, S., and Meindl, P., Supply Chain Management: Strategy, Planning, and Operation, Pearson Education
2. Dornier, P., Ernst, R., Fender, M., and Kouvelis, P., Global Operations and Logistics, Wiley
3. Bowersox, D. J., Closs, D. J., and Cooper, M. B., Supply Chain Logistics Management, McGraw- Hill
4. Christopher, M., Logistics and Supply Chain Management, Pearson Education
5. International Trade Centre (ITC) Manuals and World Trade Organization (WTO) Guidelines

Open Elective

25MEU044 **INTELLECTUAL PROPERTY RIGHTS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Give an idea about IPR, registration process for patents, copyrights and trademarks.
- Understand types and need for intellectual property international treaties and national IPR legislation.
- Explore IP laws related to digital products and cyber law.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain key IPR types (Patents, Copyrights, Trademarks, etc.) and their importance in protecting inventions and creativity	Understand
CO2	Learn the registration processes for IPRs in India and globally.	Understand
CO3	Understand international treaties (TRIPS, PCT) and relevant Indian IPR laws (Patent Act, Trademark Act, etc.).	Understand
CO4	Analyze the protection of digital innovations and the relationship between IP laws and cyber law.,	Analyze
CO5	Identify IPR infringements and understand enforcement mechanisms and emerging issues.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	-	-	-	2	2	-	-	-	1	-	-	-
CO2	1	1	-	-	-	2	2	-	-	-	1	-	-	-
CO3	1	2	-	1	-	2	3	-	-	-	1	-	-	-
CO4	1	3	1	2	1	2	3	1	1	-	1	1	-	-
CO5	1	2	1	1	-	2	3	1	2	-	2	1	-	-

UNIT 1: INTRODUCTION

Introduction to IPRs, Basic concepts and need for Intellectual Property–Patents, Copyrights, Geographical Indications, IPR in India and Abroad – Genesis and Development – the way from WTO to WIPO –TRIPS, Nature of Intellectual Property, Industrial Property, technological Research, Inventions and Innovations–Important examples of IPR.

UNIT 2: REGISTRATION OF IPRs

Meaning and practical aspects of registration of Copy Rights, Trademarks, Patents, Geographical Indications, Trade Secrets and Industrial Design registration in India and Abroad.

UNIT 3: AGREEMENTS AND LEGISLATIONS

International Treaties and Conventions on IPRs, TRIPS Agreement, PCT Agreement, Patent Act of India, Patent Amendment Act, Design Act, Trademark Act, Geographical Indication Act.

UNIT 4: DIGITAL PRODUCTS AND LAW

Digital Innovations and Developments as Knowledge Assets – IP Laws, Cyber Law and Digital Content Protection – Unfair Competition – Meaning and Relationship between Unfair Competition and IP Laws – Case Studies.

UNIT 5: ENFORCEMENT OF IPRs
Infringement of IPRs, Enforcement Measures, Emerging issues – Case Studies.

SUGGESTED READINGS

- Derek Bosworth and Elizabeth Webster,"The Management of Intellectual Property", Edward Elgar Publishing Ltd.,2013.
- Deborah E.Bouchoux, "Intellectual Property: The Law of Trademarks", Copyrights, Patents and Trade Secrets,Cengage Learning,Third Edition,2012.
- V. Scople Vinod, "Managing Intellectual Property",Prentice Hall of India pvt Ltd,2012.
- Prabuddha Ganguli, "Intellectual Propert y Rights: Unleashing the Knowledge Economy",McGraw Hill Education,2011.
- S.V.Satakar, "Intellectual Property Rights and Copy Rights", EssEss Publications, NewDelhi,2002.

Open Elective 25MEU045

ENERGY SYSTEMS **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

• Introduce the national and global energy scenario, energy conservation policies, and energy efficient systems.

• Present various renewable energy sources—solar, wind, biomass, hydro, hydrogen—and their working principles.
• Explain energy storage mechanisms including batteries, fuel cells, and hydrogen systems.
• Develop skills in techno-economic performance evaluation of energy systems (efficiency, storage, cost).

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Describe energy scenarios (Indian and global), energy reforms, conservation policies, and green building standards.	Understand
CO2	Explain working principles of renewable energy systems (solar thermal, PV, wind, biomass, hydro) and their applications.	Understand
CO3	Calculate performance metrics such as efficiency of fuel cells, solar collectors, batteries, and hydrogen systems.	Apply
CO4	Analyze storage technologies including batteries, fuel cells, hydrogen, and determine appropriate selection criteria.	Analyze
CO5	Evaluate techno-economic and environmental aspects of energy systems, including hybrid systems and energy-efficient buildings.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	–	–	–	3	–	–	2	–	2	–	–	–
CO2	3	2	1	–	2	3	–	–	1	–	1	–	–	–
CO3	3	3	1	–	3	–	–	–	–	–	–	–	–	–
CO4	2	3	3	2	3	3	–	–	–	1	1	–	–	–
CO5	2	3	3	3	2	3	1	1	2	3	3	–	–	–

1 - low, 2 - medium, 3 - high

UNIT 1: ENERGY SCENARIO & POLICY FRAMEWORK

Indian and world energy scenarios - Indian energy sector reforms, energy and environment concerns, energy security - Energy Conservation Act- Energy efficient systems, green building standards, lamp technologies and efficiencies

UNIT 2: RENEWABLE ENERGY SOURCES

Solar thermal systems: working principles and block diagrams- Solar photovoltaic systems: fundamentals- Wind energy systems: aerodynamics and power extraction Biomass, tidal, wave, geothermal systems

UNIT 3: ENERGY STORAGE & FUEL CELLS

Battery technologies and batteries' working principles- Hydrogen production (electrolysis, thermo-chemical), storage and utilization- Fuel cells: types, efficiency calculation, losses and applications

UNIT 4: PERFORMANCE EVALUATION & HYBRID SYSTEMS

Efficiency calculations for fuel cells and renewable sources- Design and analysis of hybrid energy systems (solar–wind–biomass combos)- Modeling and simulation (e.g. F-chart, utilizability methods)

UNIT 5: ENERGY EFFICIENT BUILDINGS & GREEN SYSTEMS

Energy efficiency in buildings, lighting design, daylighting, sensor & control systems- Green building rating systems: ECBC, LEED, GRIHA- Economic analysis: lifecycle cost, payback period

SUGGESTED READINGS

1. Bureau of Energy Efficiency: Guide Books for Energy Managers and Auditors (Book 2 and 4)
2. D. Y. Goswami, F. Kreith, and J. F. Kreider, Principles of Solar Engineering, Taylor & Francis, 2000
3. Mathew Sathyajith, Wind Energy: Fundamentals, Resource Analysis and Economics, Springer, 2006
4. G. L. Johnson, Wind Energy Systems, Prentice Hall, 1985

Open Elective

25MEU046 ENGINEERING ETHICS & SUSTAINABLE DEVELOPMENT 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Analyze the ethical responsibilities of engineers in addressing global challenges.
- Apply ethical decision-making frameworks in engineering contexts related to the SDGs.
- Evaluate the environmental, social, and economic impact of engineering solutions.
- Identify ethical dilemmas in engineering projects and propose sustainable solutions.
- Engage in critical discussions on the role of technology and innovation in promoting sustainability..

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Identify ethical issues in the development and implementation of emerging technologies.	Understand
CO2	Analyze the impact of technological innovations on sustainability and ethics	Analyze
CO3	Propose solutions to address ethical dilemmas in the development of new technologies..	Create
CO4	Identify ethical dilemmas in engineering projects and propose sustainable solutions.	Analyze
CO5	Engage in critical discussions on the role of technology and innovation in promoting sustainability.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	–	–	–	2	3	–	1	–	1	–	–	–
CO2	1	3	1	2	1	3	3	–	2	–	1	–	–	–
CO3	–	2	3	2	1	3	3	2	2	–	1	–	–	–
CO4	1	3	2	2	1	3	3	1	2	1	1	–	–	–
CO5	–	2	2	2	1	3	3	2	3	1	2	–	–	–

1 - low, 2 - medium, 3 - high

UNIT 1: Foundations of Engineering Ethics

Introduction to ethics: key concepts and definitions. – Ethical theories: Utilitarianism, Deontology, Virtue Ethics – Professional engineering codes of ethics (NSPE, IEEE, etc.) –The role of ethics in the engineering profession.

UNIT 2: Sustainable Development and the SDGs

Introduction to sustainable development and global challenges –Overview of the UN Sustainable Development Goals –The engineer's role in advancing sustainability –Ethical implications of engineering for sustainable development.

UNIT 3: Environmental Ethics and Sustainable Engineering

Environmental ethics: principles and theories –Engineering solutions to environmental problems –Climate Action and the role of engineers in mitigating climate change. –Ethical dilemmas in balancing technological advancement with environmental preservation.

UNIT 4: Social Responsibility and Corporate Ethics

Corporate social responsibility (CSR) in engineering.–Ethical decision-making in engineering companies.–Sustainableproduction practices and ethical supply chains.–Responsible Consumption and Production and its relevance to engineering.

UNIT 5: Emerging Technologies and Ethical Challenges

Ethical challenges in emerging technologies (AI, robotics, biotechnology) –Balancing innovation with ethical considerations. –Industry, Innovation, and Infrastructure and ethical innovation in engineering. – The future of ethical engineering: sustainable technology and its societal impact.

SUGGESTED READINGS

1. Charles E. Harris Jr., Michael S. Pritchard, and Michael J. Rabins "Engineering Ethics: Concepts and Cases"Cengage Learning, 6th Edition (2023)
2. David T. Allen and David R. Shonnard "Sustainable Engineering: Principles and Practice"2nd Edition (2020)
3. Caroline Whitbeck, "Ethics in Engineering Practice and Research"2nd Edition (2011)
4. Mike W. Martin and Roland Schinzinger "Ethics in Engineering", McGraw-Hill Education, 2017 (6th Edition)
5. F. Douglas Muschett, "Principles of Sustainable Development",CRC Press, 2016.

Open Elective

25MEU047 **BIO MECHANICAL ENGINEERING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

To introduce fundamental principles of biomechanics and their relevance to biological systems.

- To develop an understanding of mechanical behavior of biological tissues under various loading conditions.
- To analyze the biomechanics of the musculoskeletal system and prosthetic device design.
- To apply engineering principles to solve real-world biomedical and clinical problems.
- To explore recent advances in bio-mechanical technologies including implants, wearable systems, and rehabilitation devices.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	**Course Outcomes**	**Blooms Level**
CO1	Explain fundamental biomechanics concepts and relate mechanical engineering principles to biological systems.	Understand
CO2	Analyze the mechanical properties of biological tissues such as bone, cartilage, and muscle.	Analyze
CO3	Apply mechanical models to evaluate joint mechanics and locomotion in humans.	Apply
CO4	Design prosthetic and orthotic devices considering anatomical and physiological constraints.	Apply
CO5	Evaluate performance and safety of bio-mechanical systems using engineering standards and clinical guidelines.	Evaluate

CO-PO Mapping

CO / PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	–	–	1	2	–	–	1	–	1	–	–	–
CO2	3	3	1	2	1	2	–	–	–	–	1	–	–	–
CO3	3	3	3	2	2	2	–	–	–	–	1	–	–	–
CO4	2	2	3	2	2	2	–	2	–	–	1	–	–	–
CO5	2	3	2	3	1	3	2	–	2	–	1	–	–	–

UNIT 1 – INTRODUCTION TO BIOMECHANICS

Overview of biomechanics and its importance in engineering and medicine- Introduction to anatomy and physiology relevant to biomechanics- Mechanical properties of biological materials: stress, strain, elasticity, viscoelasticity.

UNIT 2 – BIOLOGICAL TISSUE MECHANICS

Structure and mechanical behavior of bone, cartilage, tendons, and ligaments- Experimental methods for biological tissue testing- Modeling of tissue mechanics using continuum mechanics principles.

UNIT 3 – JOINT MECHANICS AND LOCOMOTION

Kinematics and kinetics of human motion- Biomechanics of joints: hip, knee, shoulder, and spine- Gait analysis and interpretation using force plates and motion capture.

UNIT 4 – PROSTHETICS AND ORTHOTICS

Design principles of prosthetic limbs and orthotic devices- Material selection and biomechanical compatibility- Case studies on artificial limbs, knee braces, and exoskeletons.

UNIT 5 – EMERGING TRENDS IN BIO-MECHANICAL ENGINEERING

Wearable bio-mechanical systems for rehabilitation- • Implant biomechanics and surgical planning- Advanced technologies: tissue engineering, bioMEMS, and robotic surgery.

SUGGESTED READINGS

1. Nihat Özkaya, Margareta Nordin, David Goldsheyder, Dawn Leger, 'Fundamentals of Biomechanics', Springer.
2. Susan J. Hall, 'Basic Biomechanics', McGraw-Hill Education.
3. Robert M. Alexander, 'Principles of Animal Locomotion', Princeton University Press.
4. Donald R. Peterson, Joseph D. Bronzino, 'Biomechanics: Principles and Applications', CRC Press.
1. M. N. Narayanamurthy, 'Biomedical Engineering', Prentice Hall India.

Open Elective 25MEU048

FLEET MANAGEMENT 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- To introduce the fundamentals of fleet management and its importance in transportation and logistics.
- To understand strategies for vehicle acquisition, operation, maintenance, and disposal.
- To develop knowledge in cost control, fuel management, and driver performance monitoring.
- To familiarize students with regulatory compliance, safety protocols, and sustainability in fleet operations.
- To explore digital tools and emerging technologies in smart fleet management systems..

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Understand the concepts, scope, and importance of fleet management in modern logistics.	Understand
CO2	Analyze strategies for vehicle selection, acquisition, operation, and lifecycle management.	Analyze
CO3	Apply cost control methods and fuel efficiency techniques in managing fleet operations.	Apply
CO4	Evaluate fleet maintenance programs, driver management, and regulatory compliance systems.	Evaluate
CO5	Explore the use of digital platforms, GPS, telematics, and automation in smart fleet systems.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	–	–	1	2	–	–	2	–	1	–	–	–
CO2	3	3	2	2	2	2	–	–	1	2	1	–	–	–
CO3	2	3	2	1	3	2	–	–	–	3	1	–	–	–
CO4	1	3	2	3	2	3	2	2	2	2	1	–	–	–
CO5	2	2	1	1	3	3	–	1	2	1	3	–	–	–

1 - low, 2 - medium, 3 - high

UNIT 1 – INTRODUCTION TO FLEET MANAGEMENT

Definition, scope and objectives of fleet management- Types of fleets – commercial, government, rental- Role of fleet managers and performance indicators

UNIT 2 – VEHICLE SELECTION AND ACQUISITION

Vehicle types, selection criteria, procurement strategies- Leasing vs owning vehicles – cost-benefit analysis- Lifecycle costing and replacement policies

UNIT 3 – OPERATION AND COST MANAGEMENT

Fleet budgeting and cost control- Fuel management systems and optimization techniques- Insurance, taxes, and financial planning

UNIT 4 – MAINTENANCE AND COMPLIANCE

Preventive and predictive maintenance strategies- Driver training, behavior monitoring, and safety programs- Legal regulations and environmental compliance

UNIT 5 – TECHNOLOGY IN FLEET MANAGEMENT

Telematics and GPS tracking systems- Fleet management software and automation tools- Trends in electric vehicles, IoT, and sustainable fleets

SUGGESTED READINGS

1. John Dolce, Fleet Management, McGraw-Hill Professional
2. G. M. Verrall, Fleet Management: A Practical Guide to Managing Vehicle Operations, Kogan Page
3. Donald B. Bunn, Fleet Management and Logistics, Springer
4. Tom Denton, Automobile Mechanical and Electrical Systems, Routledge
5. White Papers and Industry Reports on Fleet Technology and Sustainability (e.g., Geotab, Samsara, etc.)

Open Elective

25MEU049 **DRONE DESIGN AND DEVELOPMENT** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

To introduce the fundamental principles of unmanned aerial vehicle (UAV) design and operation.

- To understand the aerodynamic, structural, and control system requirements of drones.
- To develop skills in drone component selection, system integration, and fabrication techniques.
- To apply theoretical and practical knowledge in the development and testing of drone prototypes.
- To explore regulations, safety, and emerging technologies in drone applications across industries.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Understand the classifications, components, and working principles of UAVs.	Understand
CO2	Analyze aerodynamic characteristics and structural design of multirotor drones.	Analyze
CO3	Apply principles of electronics and embedded systems in the integration of drone subsystems.	Apply
CO4	Design, assemble, and test a basic drone prototype considering system requirements.	Apply
CO5	Evaluate drone performance, safety standards, and regulatory compliance.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	–	–	1	2	–	–	1	–	1	–	–	–
CO2	3	3	2	2	1	2	–	–	1	–	1	–	–	–
CO3	3	2	2	2	3	2	–	–	–	–	1	–	–	–
CO4	2	3	3	2	3	2	–	2	–	1	1	–	–	–
CO5	2	3	2	3	2	3	2	–	2	–	1	–	–	–

1 - low, 2 - medium, 3 - high

UNIT 1 – INTRODUCTION TO UAV SYSTEMS

History and evolution of drones- Types and classifications of UAVs (fixed-wing, rotary-wing, hybrid)- Applications in agriculture, defense, delivery, surveillance, and mapping

UNIT 2 – AERODYNAMICS AND PROPULSION

Principles of flight – lift, drag, thrust, weight- Multirotor configurations – quadcopter, hexacopter, octocopter - Propeller and motor selection – thrust calculation, efficiency

UNIT 3 – STRUCTURE AND SUBSYSTEMS

Frame materials and structural design considerations- Electronic Speed Controllers (ESC), flight controllers, GPS, IMU- Battery selection, power distribution, safety considerations

UNIT 4 – DESIGN AND PROTOTYPING

CAD modeling of drone components- Drone fabrication techniques – assembly of motors, arms, electronics- Flight controller programming – PID tuning, fail-safe, and telemetry setup

UNIT 5 – TESTING, REGULATION AND EMERGING TRENDS

Flight testing – stability, maneuverability, endurance- DGCA/UAS regulatory norms, safety standards, and airspace classification- Trends in autonomous navigation, swarming, and AI-based drone systems

SUGGESTED READINGS

1. Kimon P. Valavanis and George J. Vachtsevanos, Handbook of Unmanned Aerial Vehicles, Springer
2. Andreas Birk, Introduction to UAV Systems, Wiley
3. Paul G. Fahlstrom and Thomas J. Gleason, Introduction to UAV Systems, Wiley
4. Austin R., Unmanned Aircraft Systems: UAVS Design, Development and Deployment, Wiley
5. DGCA India Guidelines and UAS Rulebook (latest edition)

Open Elective

25MEU050 **ENGINEERING INNOVATION FOR SDG IMPACT** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Explore how engineering innovation can be harnessed to address global challenges and advance the United Nations Sustainable Development Goals.
- Apply creative problem-solving techniques, engineering design thinking, and interdisciplinary collaboration to develop sustainable solutions.
- Know the importance of key SDGs such as clean water and sanitation, affordable and clean energy and climate action among others.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Understand the key challenges and opportunities related to providing affordable and clean energy.	Understand
CO2	Analyze different clean energy technologies and their applications.	Analyze
CO3	Apply engineering design principles to develop innovative clean energy solutions.	Apply
CO4	Evaluate the sustainability, economic feasibility, and scalability of various energy systems.	Evaluate
CO5	Explore emerging technologies in renewable energy and energy storage.	Analyze

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	–	–	–	3	–	–	1	–	2	–	–	–
CO2	3	3	1	2	2	3	–	–	2	–	1	–	–	–
CO3	3	3	3	2	3	3	–	–	1	1	2	–	–	–
CO4	2	3	3	3	2	3	–	–	2	2	1	–	–	–
CO5	2	3	1	2	2	3	–	–	1	–	2	–	–	–

1 - low, 2 - medium, 3 - high

UNIT 1: Foundations of Engineering and SDGs

Overview of the 17 SDGs – The engineer's role in global development– Understanding the environmental, social, and economic aspects of sustainability.

UNIT 2: Innovation Processes in Engineering

Engineering design thinking– Interdisciplinary innovation and collaboration–Tools for sustainable product development.

UNIT 3: Engineering Solutions for Key SDGs

Application of engineering innovation to address specific SDGs– Water and sanitation systems–Renewable energy solutions–Climate resilience strategies–Sustainable infrastructure and smart cities.

UNIT 4: Emerging Technologies and Social Innovation

AI, IoT, and their role in sustainability–Innovations for global health and well–being (SDG 3) –Social innovation for equality.

UNIT 5: Engineering Solutions for Affordable and Clean Energy

Addressing the global need for reliable, sustainable, and modern energy systems– Innovations that are advancing clean energy technologies\ energy storage systems– Case studies and engage in hands-on activities –Design and evaluate energy solutions that meet the needs of diverse populations reducing environmental impact.

SUGGESTED READINGS

1. George S. Yip & Colin B. J. O'Reilly "Engineering and Sustainable Development: Theory, Practice, and Application" Cambridge University Press, 2015
2. Arthur T. M. Duiguid, Engineering Solutions for Sustainable Development", Wiley Publisher, 2017.