Regulations and Curriculum for

Master of Technology (M. Tech.)
in Machine Design

(Deemed to be University under Section 3 of UGC Act, 1956)
(Placed under Category ‘A’ by MHRD, Govt. of India, Accredited with ‘A+’ Grade by NAAC)
University Enclave, Medical Sciences Complex, Deralakatte,
Mangalore – 575 018, Karnataka INDIA
Tel: +91-824-2204300/01/02/03, Fax: 91-824-2204305
Website: www.nitte.edu.in E-mail: info@nitte.edu.in

REGULATIONS GOVERNING
THE DEGREE OF MASTER OF TECHNOLOGY (M.Tech.)

UNDER OUTCOME BASED EDUCATION (OBE)

AND

CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME

OF

NMAM INSTITUTE OF TECHNOLOGY, NITTE

(Effective from academic year 2022 -23)

VISION

To build a humane society through excellence in the education and healthcare

MISSION

To develop
Nitte (Deemed to be University)
As a centre of excellence imparting quality education,
Generating competent, skilled manpower to face the scientific and social challenges with a high degree of credibility, integrity, ethical standards and social concern

NITTE (Deemed to be University) | NMAM INSTITUTE OF TECHNOLOGY

Off-campus Centre, Nitte (Deemed to be University)

NITTE-574110, Karkala Taluk, Udupi District, Karnataka, India

Vision Statement

Pursuing Excellence, Empowering people, Partnering in Community Development

Mission Statement

To develop N.M.A.M. Institute of Technology, Nitte, as Centre of Excellence by imparting Quality Education to generate Competent, Skilled and Humane Manpower to face emerging Scientific, Technological, Managerial and Social Challenges with Credibility, Integrity, Ethics and Social Concern.

M. Tech. Regulations and Curriculum

Batch 2022 – 2024

With Scheme of Teaching & Examination

REGULATIONS: 2022

for

M. Tech. Programs

(Academic year 2022-23)

COMMON TO ALL

M.Tech. DEGREE PROGRAMS

CHOICE BASED CREDIT SYSTEM (CBCS)

Key Information

Program Title	Master of Technology, abbreviated as MTech. (Machine Design)
Short description	Two-year, four semester Choice Based Credit System (CBCS) type of Postgraduate Engineering Degree Program with English as medium of instruction.
Program Code	22ENGR17D2
Revision version	2022.02 These regulations may be modified from time to time as mandated by the policies of the University. Revisions are to be recommended by the Board of Studies for **Mechanical Engineering** and approved by the Academic Council.
Effective from	12-09-2022
Approvals	• Approved in the 50th meeting of Academic Council of NITTE (Deemed to be University), held on 30-05-2022 and vide Notification of NITTE (DU), N(DU)/REG/N-MCE/2022-23/76B dated 19-08-2022. • Notification of Nitte (DU), N(DU)/REG/AC/-SA/2022-23/909 dated 24-04-2023.
Program offered at	NMAM Institute of Technology, Nitte Off Campus Centre, Nitte (Deemed to be University)
Grievance and dispute resolution	All disputes arising from this set of regulations shall be addressed to the Board of Management. The decision of the Board of Management is final and binding on all parties concerned. Further, any legal disputes arising out of this set of regulations shall be limited to jurisdiction of Courts of Mangalore only

Contents

1. INTRODUCTION:

1.1 The general regulations are common to all Degree of Master of Technology Program under Outcome Based Education (OBE) and Choice Based Credit System (CBCS) conducted by Nitte (Deemed to be University), at the NMAM Institute of Technology, Nitte off Campus Centre and shall be called "Nitte (DU) Regulations for M.Tech.- 2022".

1.2 The provisions contained in this set of regulations govern the policies and procedures on the Registration of students, imparting Instructions of course, conducting of the examination and evaluation and certification of students' performance and all amendments there to leading to the said degree program(s)

1.3 This set of Regulations, on approval by the Academic Council and Governing Council, shall supersede all the corresponding earlier sets of regulations of the M.Tech. Degree program (of Nitte (DU)) along with all the amendments thereto, and shall be binding on all students undergoing M.Tech. Degree Program (s) (Choice Based Credit System) conducted at the NMAMIT, Nitte with effect from its date of approval and is applicable for students admitted to 1st year after September 2022. This set of regulations may evolve and get modified or changed through appropriate approvals from the Academic Council / Governing Council from time to time, and shall be binding on all stake holders, (the Students, Faculty, Staff of Departments of NMAMIT, Nitte). The decision of the Academic Council/ Governing Council shall be final and binding.

1.4 In order to guarantee fairness and justice to the parties concerned in view of the periodic evolutionary refinements, any specific issues or matters of concern shall be addressed separately, by the appropriate authorities, as and when found necessary.

1.5 The Academic Council may consider any issues or matters of Concern relating to any or all the academic activities of the NMAMIT courses for appropriate action, irrespective of whether a reference is made here in this set of Regulations or otherwise.

1.6 The course shall be called **Master of Technology** program abbreviated as M.Tech. (subject of specialization) – Choice Based Credit System.

2. DEFINITIONS OF KEYWORDS:

The following are the definitions/descriptions that have been followed for the different terms used in the Regulations of M.Tech. Programs:

2.1 **Program:** Is an educational program in a particular stream/branch of Engineering/branch of specialization leading to award of Degree. It involves events/activities, comprising of lectures/ tutorials/ laboratory work/ field work, outreach activities/ project work/ vocational training/ viva/ seminars/ Internship/ assignments/ presentations/ self-study etc., or a combination of some of these.

2.2 **Branch:** Means Specialization or discipline of M. Tech Degree Program, like Electrical Vehicle Technology, Structural Engineering, Machine Design, etc.

2.3 **Semester:** Refers to one of the two sessions of an academic year (vide: serial number 4), each session being of sixteen weeks duration (with working days greater than or equal to 90). The odd semester may be scheduled from August/September and even semester from February/March of the year.

2.4 **Academic Year:** Refers to the sessions of two consecutive semesters (odd followed by an even) including periods of vacation.

2.5 **Course:** Refers to usually referred to as 'subjects' and is a component of a program. All Courses need not carry the same credit weightage. The Courses should define learning objectives and learning outcomes. A Course may be designed to comprise lectures/ tutorials/ laboratory work/ field work/ outreach activities/ project work/ vocational training/ viva/ seminars/ term papers/ assignments/ presentations/ self-study etc. or a combination of some of these.

2.6 **Credit:** Refers to a unit by which the Course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of lecture or two hours of laboratory/ practical Courses/ tutorials/ fieldwork per week etc.

2.7 **Audit Courses:** Means Knowledge/ Skill enhancing Courses without the benefit of credit for a Course.

2.8 **Choice Based Credit System (CBCS):** Refers to customizing the Course work, through Core, Elective and soft skill Courses, to provide necessary support for the students to achieve their goals.

2.9 **Course Registration:** Refers to formal registration for the Courses of a semester (Credits) by every student under the supervision of a Faculty Advisor (also called Mentor, Counsellor etc.,) in each Semester for the Institution to maintain proper record.

2.10 Course Evaluation: Means Continuous Internal Evaluation (CIE) and Semester End Examinations (SEE) to constitute the major evaluations prescribed for each Course. CIE and SEE to carry 50 % and 50 % respectively, to enable each Course to be evaluated for 100 marks, irrespective of its Credits.

2.11 Continuous Internal Evaluation (CIE): Refers to evaluation of students' achievement in the learning process. CIE shall be by the Course Instructor and includes tests, homework, problem solving, group discussion, quiz, mini-project and seminar throughout the Semester, with weightage for the different components being fixed at the University level.

2.12 Semester End Examinations (SEE): Refers to examination conducted at the University level covering the entire Course Syllabus. For this purpose, Syllabi to be modularized and SEE questions to be set from each module, with a choice confined to the concerned module only. SEE is also termed as university examination.

2.13 Make Up Examination: Refers to examination conducted for the candidates who has a CIE>=35 marks and may have missed to attend the SEE covering the entire course syllabus. The standard of Make Up Examination is same as that of the SEE.

2.14 Supplementary Examination: Refers to the examination conducted to assist slow learners and/or failed students through make up courses for a duration of 8 weeks. This comprises of both the CIE & SEE and will be conducted after the completion of First year M.Tech. even semester.

2.15 Credit Based System (CBS): Refers to quantification of Course work, after a student completes teaching – learning process, followed by passing in both CIE and SEE. Under CBS, the requirement for awarding Degree is prescribed in terms of total number of credits to be earned by the students.

2.16 Credit Representation: Refers to Credit Values for different academic activities considered, as per the Table.1. Credits for seminar, project phases, project viva–voce and internship shall be as specified in the Scheme of Teaching and Examination.

Table 1: Credit Values				
Theory/Lectures (L) (hours/week/Semester)	**Tutorials (T) (hours/week/ Semester)**	**Laboratory /Practical (P) (hours/week/ Semester)**	**Credits (L: T:P)**	**Total Credits**
4	0	0	4:0:0	4
3	0	0	3:0:0	3
2	2	0	2:1:0	3
2	0	2	2:0:1	3
2	2	2	2:1:1	4
0	0	2	0:0:1	1
NOTE: Activities like, practical training, study tour and participation in Guest lectures not to carry any credits.				

2.17 Letter Grade: It is an index of the performance of students in a said Course. Grades are denoted by letters O, A+, A, B+, B, C and F.

2.18 Grading: Grade refers to qualitative measure of achievement of a student in each Course, based on the percentage of marks secured in (CIE+SEE). Grading is done by Absolute Grading. The rubric attached to letter grades are as follows:

Letter Grade	O	A+	A	B+	B	C	F
Academic Level	Outstanding	Excellent	Very Good	Good	Above Average	Average	Fail

2.19 Grade Point (GP): Refers to a numerical weightage allotted to each letter grade on a 10-point scale as under.

Letter Grade and corresponding Grade Points on a typical 10 – Point scale							
Letter Grade	O	A+	A	B+	B	C	F
Grade Point	10	09	08	07	06	05	00

2.20 Passing Standards: Refers to passing a Course only when getting GP greater than or equal to 05 (as per serial number 2.20).

2.21 Credit Point: Is the product of grade point (GP) and number of credits for a Course i.e., Credit points CrP = GP × Credits for the Course.

2.22 Semester Grade Point Average (SGPA): Refers to a measure of academic performance of student/s in a semester. It is the ratio of total credit points secured by a student in various Courses of a semester and the total Course credits taken during that semester.

2.23 Cumulative Grade Point Average (CGPA): Is a measure of overall cumulative performance of a student over all semesters. The CGPA is the ratio of total credit points earned by a student in various Courses in all semesters and the sum of the total credits of all Courses in all the semesters. It is expressed up to two decimal places.

2.24 Grade Card: Refers to a certificate showing the grades earned by a student. A grade card shall be issued to all the registered students after every semester. The grade card will display the program details (Course code, title, number of credits, grades secured) along with SGPA of that semester and CGPA earned till that semester.

2.25 University: Nitte (Deemed to be University), Mangalore. NMAM Institute of Technology is an off-campus centre of Nitte (DU) and located at Nitte.

3. CLAUSE

CLAUSE	PARTICULARS
22NMT1.0	**DURATION AND CREDITS OF THE PROGRAM OF STUDY** There shall be one category of program: Full-time Program (FT) **Full-time Program:** The Program shall extend over a period of four semesters (2 years). First Semester: i) 16 weeks – Class Work according to the scheme. ii) 4 weeks – Revision holidays and examinations iii) 2 weeks – Vacation **Second Semester:** i) 16 weeks – Class Work according to the scheme ii) 4 weeks – Revision holidays and examinations. **Summer Semester/Vacation** i) 4 weeks — Class work, Examination & Display of Grades **Third Semester: 20 weeks** i) 8 weeks — Industrial Training/Mini Project ii) 12 weeks — Project Part-I

<table>
<tr><td></td><td>— Industrial Training/Mini Project evaluation, Seminar on Special Topic Evaluation & Project Part-I Evaluation
Fourth Semester: 24 weeks
i) 22 weeks — Project Part-II
ii) 2 weeks – Submission, viva -voce
Prescribed Number of Credits for the Program: 80
The number of credits to be completed for the award of Degree shall be 80.</td></tr>
<tr><td>22NMT1.1</td><td>M.Tech Degree Programs are offered in the following specialization and the respective program hosting departments are listed below:
<table>
<tr><th><u>Program</u></th><th><u>Department</u></th></tr>
<tr><td>i) Computer Science & Engineering</td><td>Computer Science & Engineering</td></tr>
<tr><td>ii) Constructional Technology</td><td>Civil Engineering</td></tr>
<tr><td>iii) Structural Engineering</td><td>Civil Engineering</td></tr>
<tr><td>iv) VLSI Design & Embedded Systems</td><td>Electronics and Communication Engineering</td></tr>
<tr><td>v) Machine Design</td><td>Mechanical Engineering</td></tr>
<tr><td>vi) Energy Systems Engineering</td><td>Mechanical Engineering</td></tr>
<tr><td>vii) Cyber security</td><td>Computer Science Engineering</td></tr>
<tr><td>viii) Electric Vehicle Technology</td><td>Electrical and Electronics Engineering</td></tr>
</table>
The provisions of these Regulations shall be applicable to any new specialization that may be introduced from time to time and appended to the above list.</td></tr>
<tr><td>22NMT1.2</td><td>Maximum Duration for Program Completion:
A full-time candidate shall be allowed a maximum duration of 4 years from the I semester of admission to become eligible for the award of master’s degree, failing which he/she may discontinue of register once again as a fresh candidate to I semester of the program.</td></tr>
<tr><td>22NMT2.0</td><td>ELIGIBILITY FOR ADMISSION
(As per the Government orders issued from time to time):
Admission to I year/ I semester Master of Technology Program shall be open to all the candidates who have passed B.E./ B. Tech. Examinations (in relevant field) or any other recognized University/ Institution. AMIE in respective</td></tr>
</table>

	branches shall be equivalent to B.E./ B. Tech. Programs for admission to M.Tech. The decision of the equivalence committee shall be the final in establishing the eligibility of candidates for a particular Program. For the foreign Degrees, Equivalence certificate from the Association of Indian Universities shall be a must.
22NMT2.1	Admission to M.Tech. Program shall be open to the candidates who have passed the prescribed qualifying examination with not less than 50% of the marks in the aggregate of all the years of the Degree examination. Rounding off percentage secured in qualifying examination is not permissible.
22NMT2.2	**For admissions under GATE/ NUCAT qualification** The candidates should be GATE qualified or should have appeared for the NUCAT Entrance Examination conducted by Nitte (Deemed to be University) [Nitte (DU)]
22NMT2.3	**For admissions under Sponsored Quota:** The candidates should be GATE qualified or should have appeared for the NUCAT Entrance Examination conducted by Nitte (DU)
22NMT2.4	The candidates, who are qualified in the GATE Examination for the appropriate branch of engineering, shall be given priority. They are exempted from taking NUCAT Entrance Examination. In case a GATE qualified Candidate appears for entrance examination and become qualified to claim a seat under entrance examination quota, he/she will be considered in the order of merit along with other candidates appeared for the entrance examination.
22NMT2.5	If sufficient number of GATE qualified candidates are not available, the remaining vacant seats shall be filled from amongst the candidates appeared for NUCAT Entrance Examination in the order of merit.
22NMT2.6	Engineering graduates other than the Karnataka candidates shall get their Eligibility verified from Nitte (DU) to seek admission to M.Tech. Program at NMAMIT, Nitte
22NMT2.7	**Admission to vacant seats:** Seats remaining vacant (unfilled), after the completion of admission process through GATE/NUCAT Entrance Exam, the remaining seats shall be filled by Candidates based on merit in the entrance test conducted at the Institution level. An admission Committee, consisting of

<table>
<tr><td></td><td>the Principal, Head of the concerned Department and the subject experts, shall oversee admissions.</td></tr>
<tr><td>22NMT3.0</td><td>REGISTRATION:
Every student after consulting his Faculty-Advisor in parent department is required to register for the approved courses with the Departmental Post Graduate Committee (DPGC) of Parent Department at the commencement of each Semester on the days fixed for such registration and notified in the academic calendar.</td></tr>
<tr><td>22NMT3.1</td><td>Lower and Upper Limits for Course Credits Registered in a Semester.
Course Credit Assignment:
All courses comprise of specific Lecture/ Tutorial/ Practical (L-T-P) schedule. The course credits are fixed based on the following norms.
Lecture/Tutorials/ Practical:
(i) a 1-hour Lecture per week is assigned 1.0 Credit.
(ii) a 2-hour Tutorial session per week is assigned 1.0 Credit.
(iii) a 2-hour Lab. session per week is assigned 1.0 credits
For example, a theory course with L-T-P schedule of 3-2-0 hours will be assigned 4.0 credits.
A laboratory practical course with L-T-P schedule of 0-0-2 hours will be assigned 1.0 credit.
Calculation of Contact Hours / Week – A Typical Example
<table>
<tr><th colspan="5">Typical Academic Load (I & II Semester)</th></tr>
<tr><th>No. of Courses</th><th>LTP</th><th>Credits Per course</th><th>Total Credits</th><th>Contact Hours per Week</th></tr>
<tr><td>2 Lecture Courses</td><td>4-0-0</td><td>04</td><td>08</td><td>08</td></tr>
<tr><td>2 Lab Courses</td><td>0-0-2</td><td>01</td><td>02</td><td>04</td></tr>
<tr><td>1 Research based Course</td><td>0-0-4</td><td>02</td><td>02</td><td>04</td></tr>
<tr><td>3 Elective Courses</td><td>3-0-0</td><td>03</td><td>09</td><td>09</td></tr>
<tr><td>1 Audit Course</td><td>2-0-0</td><td>0</td><td>0</td><td>02</td></tr>
<tr><td>Total: 9 Courses</td><td></td><td></td><td>21</td><td>27</td></tr>
</table>
A student must register, as advised by Faculty Advisor, between a minimum of 16 credits and up to a Maximum of 28 credits. However, the minimum/</td></tr>
</table>

	maximum Credit limit can be relaxed by the Dean (Academic) on the recommendations of the DPGC, only under extremely exceptional circumstances.
22NMT3.2	**Mandatory Pre-Registration for higher semester:** In order to facilitate proper planning of the academic activities of the Semester, it is necessary for the students to declare their intention to register for courses of higher semesters (2nd and above) at least two weeks before the end of the current semester choosing the courses offered by each department in the next higher semester which is displayed on the Departmental Notice Board at least 4 weeks prior to the last working day of the semester. Students who fail to register on or before the specified date will have to pay a late fee. Registration in absentia is allowed only in exceptional cases with the permission of the Dean (Academic). Registration to a higher semester is allowed only if the student fulfills the following conditions- i) Satisfied all the academic requirements to continue with the program of studies without termination. ii) Cleared all institute, hostel and library dues and fines, if any, of the previous semester. iii) Paid all required advance payments of the Institute and the hostel for the current semester. Has not been debarred from registering on any specific grounds by the Institute.
22NMT3.3	**Course Pre-Requisites:** In order for a student to register for some course(s), it may be required either to have completed satisfactorily or to have prior earned credits in some specified course(s). In such instances, the DPGC shall specify clearly, any such course pre-requisites, as part of the curriculum.
22NMT3.4	Students who do not register before the dead line day of registration may be permitted LATE Registration up to the notified day in academic calendar on payment of late fee.
22NMT3.5	REGISTRATION in ABSENTIA will be allowed only in exceptional cases on the recommendation of DPGC through the authorized representative of the student.

22NMT3.6	Medium of Instruction/Evaluation/etc. shall be English.
22NMT4.0	**COURSES:** The curriculum of the Program shall be any combination of following type of courses: i) **Professional Core Courses (PCC)** - relevant to the chosen specialization/ branch [May be split into Hard (no choice) and Soft (with choice), if required]. The core course is to be compulsorily studied by a student and is mandatory to complete the requirements of a program in a said discipline of study. ii) **Professional Electives Courses (PEC)** - relevant to the chosen specialization/ branch: these are the courses, which can be chosen from the pool of papers. It shall be supportive to the discipline/ providing extended scope/enabling an exposure to some other discipline / domain / nurturing student skills. iii) **Research Experience** Through Practice-I and Research Experience Through Practice-II **iv) Project Work** **v) Seminar** **vi) Audit Courses (AC):** a) The Audit course can be any credit course offered by the program to which the candidate is admitted (other than the courses considered for completing the prescribed program credits) or other programs offered in the institution, where the student is studying. b) The students are required to register for one audit course during I and II semesters. Students who have registered to audit the courses, considered on par with students registered to the same course for credit, must satisfy attendance and CIE requirements. However, they need not have to appear for SEE. c) Registration for any audit course shall be completed at the beginning of I and II semesters. The Department should intimate the Controller of Examination about the registration at the beginning of the semester and obtain a formal approval for inclusion of the audit course/s in the Grade card issued to the students

vii) **Internship/ Mini Project:** Preferably at an industry/ R&D organization/IT company/ Government organization of significant repute or at the Research Centre of parent Institution for a specified period mentioned in Scheme of Teaching and Examination.

22NMT4.1

Program Structure:

The number of credits to be registered in a semester is between 16 and 28

Minimum Credit Requirement for the M.Tech. Degree is 80.

The total course package for an M.Tech. Degree Program will typically consist of the following components.

Course type	Range %	Suggested Credits
i) Program Core Courses	20 - 25	20
ii) Program Elective Courses	18 - 20	15
iii) Elective Courses (MOOCS)	4	03
iv) Industrial Internship/Research Internship/Mini Project	10	08
v) Project	35	28
vi) Seminar	2.5	02
vii) Research Experience Through Practice	5	04
viii)Audit courses (two courses)	-	-
Total credits		80

The Department Post Graduate Committee (DPGC) will discuss and recommend the exact credits offered for the program for the above components, the semester-wise distribution among them, as well as the syllabi of all postgraduate courses offered by the department from time to time before sending the same to the Board of Studies (BOS).

The BOS will consider the proposals from the departments and make recommendations to the Academic Council for consideration and approval.

Mandatory Learning Courses:

These are courses that must be completed by the student at appropriate time as suggested by the Faculty Adviser or the DPGC. Courses that come under the category are as following:

	Industrial Training: This is a 08-credit course. A full-time student will complete the Industrial Training (or a Mini Project) at appropriate time stipulated by DPGC and register for it in the following Semester and shall also submit a bound copy of training report certified by the authority of Training Organization. The duration and the details, including the assessment scheme, shall be decided by the faculty advisor, with approval from DPGC. **Seminar:** This also carries 2-credits to be completed at appropriate time stipulated by DPGC. The student will make presentations on topics of academic interest, as suggested by DPGC. **Research Experience through Practice-I and Research Experience through Practice-II:** • Research Experience through Practice-I and II are 2-credit courses in the first and second semesters respectively. • The student will work under a faculty supervisor approved by the DPGC and submits a research proposal at the end of the first semester which is evaluated jointly by the faculty supervisor and a co-examiner. • Students shall be offered inputs like how to conduct a literature survey, how to identify a research problem, how to write a research paper, research report, research proposal, and systematic way of conducting research etc. • Department specific/PG Program specific skill sets required for carrying out a research work may be offered to the students like software tools for system/device simulation and analysis, software/ hardware tools for signal acquisition, data processing, control simulation, Testing/measuring equipment used in research and Testing/measuring procedure. • At the end of Research Experience through Practice-I in the first semester, M. Tech. students should be able to identify a research problem, with clear objectives and methodologies backed by extensive literature review. • Two internal examiners will evaluate the Research Experience through Practice-I out of which one will be the guide and the other examiner will a faculty member who is having expertise in the research area of the student

	being evaluated. The research proposal report and the research proposal presentation are evaluated for 100 marks in the first semester. • The student will work on the proposed research in the second semester and submit a research paper at the end of the second semester which is evaluated jointly by the faculty supervisor and a co-examiner. • In the second semester, the students are expected to carry out Mathematical modelling / Design calculations / computer simulations / Preliminary experimentation / testing of the research problems identified during Research Experience through Practice-I carried out in the first semester. At the end of the second semester, students are expected to write a full research paper based on the Mathematical modelling/ Design calculations/computer simulations/Preliminary experimentation/testing carried out during second semester. The research paper submitted by the student and the presentation of the research work carried out is evaluated for 100 marks in the second semester.
22NMT5.0	**INTERNSHIP/MINI PROJECT:** The student shall undergo Internship/Mini Project as per the Scheme of Teaching and Examination. 1. The internship can be carried out in any industry/R&D Organization/Research Institute/Institute of national repute/R&D Centre of Parent Institute. 2. The Department/college shall nominate a faculty to facilitate, guide and supervise students under internship. 3. The students shall report the progress of the internship/Mini Project to the internal guide in regular intervals and seek his/her advice. 4. The Internship shall be completed during the period specified in Scheme of Teaching and Examination. 5. After completion of Internship/mini project, students shall submit a report to the Head of the Department with the approval of both internal and external guides and with the approval of internal guide if the Internship/Mini-Project is carried out in the Institute.

	6. The Internship/Mini Project will be evaluated jointly by two internal examiners appointed by the Head of the Department/Controller of Examination. 7. The Internship/Mini Project report and the presentation by the student will be evaluated for 50 marks each immediately after completion of the Internship/Mini Project. The students are permitted to carry out the internship anywhere in India or Abroad. The Institution will not provide any kind of Financial Assistance to any student for Internship/Mini Project and for the conduct of Viva-Voce on internship.
22NMT5.1	**Failing to undergo Internship/Mini Project:** Securing a pass grade in Internship/Mini Project is mandatory as a partial requirement for the award of Degree. Internship/Mini Project Securing a pass grade in Internship/Mini Project is mandatory. If any student fails to undergo/complete the Internship/Mini Project, he/she shall be considered as fail in that Course.
22NMT6.0	**SEMINAR:** Securing a pass grade in Seminar is mandatory as a partial requirement for the award of Degree. i) Each candidate shall deliver seminar as per the Scheme of Teaching and Examination on the topics chosen from the relevant fields for about 30 minutes. The Head of the Department shall make arrangements for conducting seminars through concerned faculty members of the department. The Panel of Examiners constituted for the purpose by the Head of the Department shall award the CIE marks for the seminar.
22NMT7.0	**PROJECT WORK:** Securing a pass grade in Project Work is mandatory as a partial requirement for the award of Degree. Project work shall be on individual basis.

	Project Part-I and Part-II: **Project Part-I: (In third Semester)** The duration of the Project Part-I is of 12 weeks as notified in the academic calendar. The evaluation of the Project Part-I will be done during the end of third semester. Each department will prepare the Panel of Examiners in advance and also prepare the Project Part-I evaluation schedule indicating the names of the students, their USN, Title of the Project, Name of the Examiners, and time and Venue of the evaluation which will be submitted to the Controller of Examination Office in advance. Project Part-I evaluation will be done by two internal Examiners, one of them will be the Guide and other is preferably one of the experts in the area of PG Project being evaluated. The mark distribution of Project Phase-I evaluation is: 100 marks for report and 100 marks for presentation jointly awarded by the both the examiners. **Project Part-II: (In the fourth Semester)** The total duration of Project Part-II is of 22 weeks as notified in the academic calendar. There will be two Continuous Internal Evaluation of Project Part-II in fourth semester followed by Semester End Evaluation of the Project Phase-II, namely, Project Progress Evaluation-I (PPE-I), Project Progress Evaluation -II(PPE-II) and SEE. The same Panel of Examiners which was formed during Project Part-I evaluation is to be continued for the Project Progress Evaluation in the fourth semester. PPE-I and PPE-II will be scheduled as per the academic calendar and will be evaluated for 100 marks each (50 marks for report and 50 marks for presentation jointly conducted by the two internal examiners). Each department will prepare the Panel of Examiners in advance and also prepare the Project Part-II Project Progress Evaluation Schedule indicating the names of the students, their USN, Title of the Project, Name of the Examiners, and time and Venue of the evaluation as per the format which will be submitted to the Controller of Examination Office in advance.

	For the Off-Campus projects, the Internal Guide should visit the organization in which the M.Tech Student is carrying out his Project at least once during the project term. The candidate shall submit a soft copy of the dissertation work to the Institute. The soft copy of the dissertation should contain the entire Dissertation in monolithic form as a PDF file (not separate chapters). The Guide, after checking the report for completeness shall check the report for Plagiarism content. The allowable plagiarism index is less than or equal to 25%. If the check indicates a plagiarism index greater than 25%, the guide should advice the student to resubmit the dissertation after modifying the report. The report has to be once again checked for the plagiarism content and the signed hard copy of the Plagiarism Report along with the two hard copies of the dissertation is to be submitted to the Head of the Institution through the Head of the Department. The dissertation will be evaluated by two examiners, one of the examiners shall be the Guide of the candidate and the other examiner shall be an external expert in the area of the dissertation being evaluated. The guide shall submit panel of two approved external examiners to the office of the Controller of Examination through the head of the Department. The Controller of Examination will randomly select one of the external examiners and invites him/her formally for the evaluation of the dissertation and Viva-Voce examination giving sufficient time for the external examiner for reading the dissertation.
22NMT7.1	The dissertation will be evaluated by two examiners, one of the examiners shall be the guide of the candidate and the other examiner shall be preferably an external expert in the area of the dissertation being evaluated. The evaluation of the dissertation shall be made independently by each examiner.
22NMT7.2	Examiners shall evaluate the dissertation normally within a period of not more than two weeks from the date of receipt of dissertation through email.
22NMT7.3	The examiners shall independently submit the marks for the dissertation during the viva-voce examination date
22NMT7.4	Sum of the marks awarded by the two examiners shall be the final evaluation marks for the Dissertation.

22NMT7.5	(a) Viva-voce examination of the candidate shall be conducted, if the dissertation work and the reports are accepted by the external examiner. (b) If the external examiner finds that the dissertation work is not up to the expected standard and the minimum passing marks cannot be awarded, the dissertation shall not be accepted for SEE. (c) If the dissertation is rejected during the Project Part II, then the Second Examiner (external) will be appointed by the COE against whom the candidate has to re-present the same dissertation. The decision of the Second Examiner (external) will be final. If the second examiner (external) accepts the dissertation, then the viva-voce examination of the candidate shall be conducted as per the norms. If the second examiner (external) rejects the dissertation, then the student has to take an extension for a minimum period of 3 months and re-work on the project. After the completion of the extension period, viva-voce examination of the candidate shall be conducted as per the norms, if the dissertation work is accepted by the external examiner.
22NMT7.6	The candidate, whose dissertation is rejected, can rework on the same topic or choose another topic of dissertation under the same Guide or new Guide if necessary. In such an event, the report shall be submitted within four years from the date of admission to the Program.
22NMT7.7	Viva-voce examination of the candidate shall be conducted jointly by the external examiner and internal examiner/ guide at a mutually convenient date.
22NMT7.8	The relative weightages for the evaluation of dissertation and the performance at the viva-voce shall be as per the scheme of teaching and examination.
22NMT7.9	The marks awarded by both the Examiners at the viva-voce Examination shall be sent jointly to the office of Controller of Examination immediately after the examination.
22NMT7.10	Examination fee as fixed from time to time by the Institute for evaluation of dissertation report and conduct of viva-voce shall be remitted to the Institute as per the instructions of Dean-Academics, from time to time.
22NMT7.11	The candidates who fail to submit the dissertation work within the stipulated time have to apply for the extension of the Project duration through the Guide

	and the head of the department to the Office of the Controller of Examination. Such candidate is not eligible to be considered for the award of rank.
22NMT8.0	**ATTENDANCE REQUIREMENT:** 1. Each semester is considered as a unit and the candidate has to put in a minimum attendance of 85% in each subject with a provision of condoning 10% of the attendance by Principal for reasons such as medical grounds, participation in University level sports, cultural activities, seminars, workshops and paper presentation etc. 2. The basis for the calculation of the attendance shall be the period of term prescribed by the institution in its calendar of events. For the first semester students, the same is reckoned from the date of admission to the course 3. The students shall be informed about their attendance position in the first week of every month by the College so that the students shall be cautioned to make up the shortage. 4. The head of the department shall notify regularly, the list of such candidates who fall short of attendance. The list of the candidates falling short of attendance shall be sent to the Principal with a copy to Controller of Examinations. 5. A candidate having shortage of attendance (<75%) in any course(s) registered shall not be allowed to appear for SEE of such course(s). Such students will be awarded 'N' grade in these courses. 6. He/she shall have to repeat those course(s) with 'N' grade and shall re-register for the same course(s) core or elective, as the case may be when the particular course is offered next either in a main (odd/even) or summer semester. 7. If a candidate, for any reason, discontinues the course in the middle he/she may be permitted to register to continue the course along with subsequent batch, subject to the condition that he/she shall complete the class work, lab work and seminar including the submission of dissertation within maximum stipulated period. Such candidate is not eligible to be considered for the award of rank.

22NMT9.0	**ADD/ DROP/ AUDIT OPTIONS:** 1. ADD-option: A student has the option to ADD courses for registration till the date specified for late registration. 2. DROP-option: A student has the option to DROP courses from registration until one week after the mid-semester examination. AUDIT-option: A student can register for auditing a course, or a course can even be converted from credit to audit or from audit to credit, with the consent of faculty advisor and course instructor until one week after the mid-semester exam. However, CORE courses shall not be made available for audit. It is not mandatory for the student to go through the regular process of evaluation in an audit course. However, the student has to keep the minimum attendance requirement, as stipulated by the corresponding DPGC for getting the 'U' grade awarded in a course, failing which that course will not be listed in the Grade Card.
22NMT10.0	**ABSENCE DURING THE SEMESTER:** **Leave of Absence** (a) If the period of leave is more than two days and less than three weeks, prior application for leave shall have to be submitted to the Head of the Department concerned, with the recommendation of the Faculty-Advisor stating fully the reasons for the leave request along with supporting documents. It will be the responsibility of the student to intimate the course instructors, Head of the Department and also Chief Warden of the hostel, regarding his absence before availing leave.
22NMT10.1	**Absence during Mid-Semester Examinations:** A student who has been absent from a Mid-Semester Examination (MSE) due to illness and other contingencies may give a request for additional MSE within two working days of such absence to the office of the respective Head of the Department (HOD) with necessary supporting documents and certification from authorized personnel. The HOD may consider such requests depending on the merits of the case, may permit the additional Mid-Semester Examination for the concerned student.

22NMT10.2	**Absence during Semester End Examination:** In case of absence for a Semester End Examination, on medical grounds or other special circumstances the student can apply for 'I' grade in that course with necessary supporting documents and certifications by authorized personnel to the Controller of Examination through Chairman of The Department. The Controller of Examination may consider the request depending on the merits of the case and permit the make-up Semester End Examination for the concerned student. The student may subsequently complete all course requirements within the date stipulated by DPGC (which may be extended till first week of next semester under special circumstances) and 'I' grade will then be converted to an appropriate letter grade. If such an application for the 'I' grade is not made by the student, then a letter grade will be awarded based on his in-semester performance.
22NMT11.0	**WITHDRAWAL FROM THE PROGRAM:** **Temporary Withdrawal:** A student who has been admitted to a Post Graduate Degree program of the College may be permitted to withdraw temporarily, for a period of one semester or more on the grounds of prolonged illness or grave calamity in the family etc. The student should abide by the applicable rules and regulations of the college/University at the time of Temporary Withdrawal.
22NMT11.1	**Permanent Withdrawal:** Any student who withdraws admission before the closing date of admission for the Academic Session is eligible for the refund of the deposits only. Fees once paid will not be refunded on any account. Once the admission for the year is closed, the following conditions govern withdrawal of admissions: a) A student who wants to leave the College for good, will be permitted to do so (and can take Transfer Certificate from the College, if needed), only after remitting the Tuition fees as applicable for all the remaining semesters and clearing all other dues, if any. b) Those students who have received any scholarship, stipend or other forms of assistance from the College shall repay all such amounts in addition to those mentioned in (a) above.

	The decision of the Principal of the Institute regarding withdrawal of a student is final and binding.
22NMT12.0	**EVALUATION SYSTEM:** **Continuous Internal Evaluation (CIE) and Semester End Evaluation (SEE)**
22NMT12.1	For all the theory and laboratory courses, the CIE marks shall be 50. For Research Experience through Practice-I, Research Experience through Practice-II, Seminar, Industrial Training/Mini Project, the CIE marks shall be 100. For Project Phase-I, the CIE Marks shall be 200 For Project Phase-II, the CIE Marks shall be 200 and for SEE 200
22NMT12.2	CIE Marks for courses shall be based on a) Tests MSE-I and MSE-II (for 30 Marks): MSE in a theory course, for 30 marks, shall be based on two tests covering the entire syllabus. Assignments, Quizzes, Simulations, Experimentations, Mini project, oral examinations, field work etc., (for 20 Marks) conducted in respective courses.
22NMT12.3	a) An additional MSE may be conducted for those students absent for valid reasons/ with prior permission. b) For those students who could not score minimum required CIE marks (25 marks), an additional MSE may be conducted, however the maximum CIE marks shall be restricted to 25 out of 50.
22NMT12.4	The candidates shall write the Tests in Blue Book/s. The Blue book/s and other documents relating to award of CIE marks shall be preserved by the Head of the Department for at least six months after the announcement of University results and made available for verification at the directions of the Controller of Examination.
22NMT12.5	Every page of the CIE marks list shall bear the signatures of the concerned Teacher and Head of the Department.
22NMT12.6	The CIE marks list shall be displayed on the Notice Board and corrections, if any, shall be incorporated before submitting to the office of the Controller of Examination (COE).
22NMT12.7	The CIE marks shall be sent to the office of the COE well in advance before the commencement of Semester End Examinations. No corrections of the CIE

	marks shall be entertained after the submission of marks list to the Office of the COE.
22NMT12.8	Candidates obtaining less than 50% of the CIE marks in any course (Theory /Laboratory/ Seminar/ Internship/ Project) shall not be eligible to appear for the Semester end examination in that course/s. In such cases, the Head of the Department shall arrange for the improvement of CIE marks in the course/ Laboratory when offered in the subsequent semester subject to the maximum duration allowed for completion of a M.Tech. program.
22NMT12.9	**Semester End Evaluation:** There shall be a Semester End Examination at the end of each semester.
22NMT12.10	There shall be double valuation of theory papers. The theory Answer booklets shall be valued independently by two examiners appointed by the Controller of Examination.
22NMT12.11	If the difference between the marks awarded by the two examiners is not more than 15 per cent of the maximum marks, the marks awarded to the candidate shall be the average of two evaluations.
22NMT12.12	If the difference between the marks awarded by the two examiners is more than 15 per cent of the maximum marks, the answer booklet shall be evaluated by a third Examiner appointed by the Controller of Examination. The average of the marks of nearest two valuations shall be considered as the marks secured by the candidate. In case, if one of the three marks falls exactly midway between the other two, then the highest two marks shall be taken for averaging.
22NMT12.13	**Summer Semester:** Summer semester is primarily to assist weak and/or students having N/F grade in courses, for a duration of 4 weeks after the completion of regular even SEE. The institute may also offer Add-on/ Audit Courses during this semester.
22NMT12.14	Each candidate shall obtain not less than 50% of the maximum marks (25 marks) prescribed for the CIE of each subject, including seminars. CIE Marks shall be based on assignments, tests, oral examinations and seminar (minimum of two are compulsory) conducted in respective subjects. The candidates obtaining less than 50% of the CIE marks in any subject shall not be eligible to appear for the SEE in that subject(s). Only in such cases, the Controller of Examination may arrange for reregistering the subject(s) in

	subsequent semester or may refer to DPGC for necessary remedial measures. The candidates shall write the Internal Assessment Test in Blue Books, and this shall be maintained by the Head of the Department for at least six months after the announcement of result and is available for verification. The CIE marks sheet shall bear the signature of the concerned Teacher and the Chairman of the Department. The CIE marks list shall be displayed on the Notice Board and corrections, if any, shall be incorporated before sending to the Controller of Examinations.
22NMT12.15	The Academic Performance Evaluation of a student shall be according to a Letter Grading System, based on the Class Performance Distribution. The Letter grades O, A+, A, B+, B, C and F indicate the level of academic achievement, assessed on a decimal (0-10) scale. The Letter grade awarded to a student in a course, for which he has registered shall be based on his performance in quizzes, tutorials, assignments etc., as applicable, in addition to two mid-semester examination and one semester end examination. The distribution of weightage among these components may be as follows: Semester End Examination (SEE) 50% Continuous Internal Evaluation (CIE) (i) Quizzes, Tutorials, Assignments etc., 20% (ii) Mid-semester Examination: 30% Any variation, other than the above distribution, requires the approval of the pertinent DPGC and Academic Council. The letter grade awarded to a student in a 0-0-P (Practical) course, is based on an appropriate continuous evaluation scheme that the course instructor shall evolve, with the approval of the pertinent DPGC. The course Instructor shall announce in the class, and/or display in the display boards or at the website, the details of the Evaluation Scheme, including the distribution of the weightage for each of the components, and method of conversion from the raw scores to the letter-grades; within the first week of the semester in which the course is offered, so that there are no ambiguities in communicating the same to all the students concerned.

22NMT12.16	**The Transitional Grades** 'I', 'W' and 'X' would be awarded in the following cases. These would be converted into one or the other of the letter grades (O-F) after the student completes the course requirements. **Grade "I":** To a student having attendance ≥85% and CIE ≥ 70%, in a course, but remained absent from SEE for valid & convincing reasons acceptable to the College, like: i. Illness or accident, which disabled him/her from attending SEE. ii. A calamity in the family at the time of SEE, which required the student to be away from the College. iii. However, the committee chaired by the Principal is authorized to relax the requirement of CIE ≥ 70% if the student is hospitalized or advised long term rest after discharge from the hospital by the Doctor. iv. Students who remain absent for Semester End Examinations due to valid reasons and those who are absent due to health reasons are required to submit the necessary documents along with their request to the Controller of Examinations to write Make up Examinations within 2 working days of that examination for which he or she is absent, failing which they will not be given permission. • **Grade "W":** To a student having satisfactory attendance at classes but withdrawing from that course before the prescribed date in a semester as per Faculty Advice. • **Grade "X":** To a student having attendance ≥85% and CIE ≥ 70%, in a course but SEE performance could result in a 'F' grade in the course. (No "F" grade awarded in this case, but student's performance record will be maintained separately).
22NMT12.17	**The Make Up Examination** facility would be available to students who may have missed to attend the SEE of one or more courses in a semester for valid reasons and given the 'I' grade. Also, students having the 'X' grade shall also be eligible to take advantage of this facility. The makeup examination would be held as per dates notified in the Academic Calendar. However, it should be made possible to hold a make-up examination at any other time in the semester with the permission of the Academic Council of the College. In all these cases, the standard of SEE would be the same as the normal SEE.

22NMT12.18	All the 'W' grades awarded to the students would be eligible for conversion to the appropriate letter grades only after the concerned students re-register for these courses in a main/summer semester and fulfil the passing standards for their CIE and (CIE+SEE).
22NMT12.19	The suggested passing standards are CIE to have >=50% and CIE+SEE to have a grade better or at least equal to C. For maintaining high standards, the students scoring less than 50% in CIE are advised to withdraw and to reregister for the course when offered next. The letter grade 'W' to be entered in the grade card against the subject and not to be taken into account while calculating SGPA & CGPA
22NMT12.20	**Rules for grace marks** Grace marks up to 1% of the maximum total marks of the courses for which he/she is eligible and have registered (non-credit courses excluded) in the examination or 10 marks whichever is less shall be awarded to the failed course(s), (with a restriction of a maximum of 5 marks per course) provided on the award of such grace marks the candidate passes in that course(s)
22NMT13.0	**LETTER GRADES AND GRADE POINTS:** The Institute adopts absolute grading system wherein the marks are converted to grades, and every semester result will be declared with semester grade point average (SGPA) and Cumulative Grade Point Average (CGPA). The CGPA will be calculated for every semester, except for the first semester. The grading system with the letter grades and the assigned range of marks under absolute grading system are as given below:

Letter Grade	**Grade- Points**	**Raw Scores %**	**Level of Academic Achievement**
O	10	≥90	Out standing
A+	09	80-89	Excellent
A	08	70-79	Very Good

B+	07	60-69	Good
B	06	55-59	Above average
C	05	50-54	Average
F	00	<50	Fail
U			Audited

A student obtaining Grade F in a Course shall be considered fail and is required to reappear in subsequent SEE. Whatever the letter grade secured by the student during his /her reappearance shall be retained. However, the number of attempts taken to clear a Course shall be indicated in the grade cards/ transcripts.

Earned Credits:

This refers to the credits assigned to the course in which a student has obtained any one of the letter grades O, A+ A, B+, B and C

22NMT14.0 **PROMOTION AND ELIGIBILITY:**

22NMT14.1 **Promotion:**

a) All students are promoted to their next semester or year of their program, irrespective of the academic performance.

However, for submission for M.Tech. Major Project report in 4th semester, student should have completed all the courses up to 3rd semester

22NMT14.2 **The mandatory non-credit courses,** if any, shall not be considered for the award of class, calculation of SGPA and CGPA. However, a pass grade (PP) in the above courses is mandatory for the award of Degree.

22NMT15.0 **ELIGIBILITY FOR PASSING AND AWARD OF DEGREE:**

22NMT15.1

1. A student who obtains any grade O to C shall be considered as passed and if a student secures F grade in any of the head of passing, he/she has to reappear in that head for SEE
2. A student shall be declared successful at the end of the program for the award of Degree only on obtaining CGPA≥5.00, with none of the courses remaining with F grade.

In case, the CGPA falls below 5.00, the student shall be permitted to appear again for SEE for required number of courses (other than seminar and practical) and times, subject to the provision of University, to make up CGPA≥5.0. The student should reject the SEE results of previous attempt and obtain written permission form the Controller of Examinations to reappear to the subsequent

	SEE.
22NMT15.2	For a pass in a theory course, the student shall secure a minimum of 40% of the maximum marks prescribed in the Semester End Examination and 50% of marks in CIE and 50% in the aggregate of CIE and SEE marks. The minimum passing grade in a course is C.
22NMT15.3	For a pass in Internship/ Practical/ Project/ Dissertation/ Viva-voce examination, a student shall secure a minimum of 50% of the maximum marks prescribed for the SEE in Internship/ Practical/ Project/ Dissertation/ Viva-voce. The minimum passing grade in a course is C.
22NMT15.4	For a pass, a candidate shall obtain a minimum of 50% of maximum marks in Seminar.
22NMT15.5	IV Semester full time candidates having backlog courses are permitted to upload the dissertation report and to appear for SEE. The IV semester grade card shall be released only when the candidate completes all the backlog courses and become eligible for the award of Degree.
22NMT15.6	**Eligibility for Award of Degree:** A student shall be declared to have completed the Degree of Master of Technology, provided the student has undergone the stipulated course work as per the regulations and has earned the prescribed credits, as per the scheme of teaching and examination of the program
22NMT16.0	**EVALUATION OF PERFORMANCE:** **Computation of SGPA and CGPA** SGPA and CGPA: The credit index can be used further for calculating the Semester Grade Point Average (SGPA) and the Cumulative Grade Point Average (CGPA), both being important academic performance indices of the student. While SGPA is equal to the credit index for a semester divided by the total number of credits registered by the student in that semester, CGPA gives the sum total of credit indices of all the previous semesters divided by the total number of credits registered in all these semesters. Both the equations together facilitate the declaration of academic performance of a student, at the end of a semester and at the end of successive semesters respectively SGPA is computed as follows:

	$$SGPA = \frac{\sum[(Course\ Credits) \times (Grade\ Point)]}{\sum[Course\ Credits]}$$ (for all courses with letter grades including F grades in that semester) (for all courses with letter grades including F grades in that semester) CGPA is computed as follows: $$CGPA = \frac{\sum[(Course\ Credits) \times (Grade\ Point)]}{\sum[Course\ Credits]}$$ (for all courses excluding those with F grades until that semester) (for all courses excluding those with F grades until that semester)
22NMT16.1	**Communication of Grades:** • The SGPA and CGPA respectively, facilitate the declaration of academic performance of a student at the end of a semester and at the end of successive semesters. Both of them would be normally calculated to the second decimal position, so that the CGPA, in particular, can be made use of in rank ordering the students' performance in the Institute. If two students get the same CGPA, the tie could be resolved by considering the number of times a student has obtained higher SGPA, But, if it is still not resolved, the number of times a student has obtained higher grades like O, A, B etc. could be taken into account.
22NMT16.2	**Challenge evaluation** If a student is not satisfied with the marks allotted to him/her in the semester end examinations, he/she could apply for challenge evaluation within the prescribed time specified. In such cases the answer papers will be valued by the DPGC committee and marks secured by the students in the challenge evaluation will be final.
22NMT16.3	**Grade Card:** Based on the secured letter grades, grade points, SGPA and CGPA, a grade card for each semester shall be issued. On specific request on paying prescribed fee, a transcript indicating the performance in all semesters may be issued.

22NMT16.4	**Conversions of Grades into Percentage and Class Equivalence** Conversion formula for the conversion of CGPA into percentage is given below: Percentage of marks secured, P = CGPA Earned × 10 **Illustration: for CGPA of 8.18**: P = CGPA Earned 8.18 × 10 = 81.8 %
22NMT17.0	**DEGREE REQUIREMENTS:** The Degree requirements of a student for the M.Tech Degree program are as follows: 1. College Requirements: i) Minimum Earned Credit Requirement for M.Tech. Degree is 80 ii) Satisfactory completion of all Mandatory Learning courses 2. Program Requirements: i) Minimum Earned Credit Requirements on all core courses, ii) Elective Courses and major project as specified by the DPGC. The maximum duration for a student for complying to the Degree requirements is 8 semesters from the date of first registration for his first semester.
22NMT18.0	**TERMINATION FROM THE PROGRAM/READMISSION:** A student shall be required to leave the College without the award of the Degree, under the following circumstances: ii) Failing to complete the degree requirements in double the duration of the program Based on disciplinary action suggested by the Academic Council/Governing Council.
22NMT19.0	**GRADUATION REQUIREMENTS AND CONVOCATION:** 1. A student shall be declared to be eligible for the award of the Degree if he has a) Fulfilled Degree Requirements b) No Dues to the College, Departments, Hostels, Library Central Computer Centre and any other center c) No disciplinary action pending against him. 2. The award of the Degree must be recommended by the Academic council and approved by Governing Council of Nitte (DU)

<table>
<tr><td></td><td>Convocation: Degree will be awarded in person for the students who have graduated during the preceding academic year. Degrees will be awarded in absentia to such students who are unable to attend the Convocation. Students are required to apply for the Convocation along with the prescribed fees, after having satisfactorily completed all the Degree requirements within the specified date in order to arrange for the award of the Degree during convocation.</td></tr>
<tr><td>22NMT20.0</td><td>AWARD OF CLASS, PRIZES, MEDALS & RANKS:

Award of Class: Sometimes, it would be necessary to provide equivalence of SGPA and CGPA with the percentages and/or Class awarded as in the conventional system of declaring the results of University examinations. This can be done by prescribing certain specific thresholds in these averages for Distinction, First Class and Second Class as described below.

Percentage Equivalence of Grade Points (For a 10-Point Scale)
<table>
<tr><th>GPA</th><th>Percentage of Marks*</th><th>Class</th></tr>
<tr><td>≥ 7.00</td><td>≥ 70%</td><td>Distinction</td></tr>
<tr><td>≥ 6.00</td><td>≥ 60%</td><td>First Class</td></tr>
<tr><td>5.0 ≥ GPA <6.00</td><td>50≥ Percentage < 60%</td><td>Second Class</td></tr>
</table>
Percentage * = (GPA) x 10

For the award of Prizes, Medals and ranks: The conditions stipulated by the Donor may be considered as per the statutes framed by the Universityfor such awards.
An attempt means the appearance/registration of a candidate for an examination in one or more courses either in part or failing a particular examination.
A candidate who fails/remaining absent (after submitting exam application) in the main examination and passes one or more subjects/courses or all subjects/courses in the supplementary/Make-up examination such candidates shall be considered as taken more than an attempt.
Merit Certificates and University Medals/ will be awarded on the basis of overall CGPA, governed by the specific selection criteria that may be formulated by the University for such Medals / Awards
</td></tr>
</table>

	○ Only those candidates who have completed the Program and fulfilled all the requirements in the minimum number of years prescribed (i.e., 2 years) and who have passed each semester in the first attempt are eligible for the award of Merit Certificates and /or Ranks and University Medals. Candidates with W, N, I, X & F grades and who passes the courses in the subsequent/supplementary/make up examinations are not eligible for the award of Gold Medal or Merit Certificate.
22NMT21.0	**CONDUCT AND DISCIPLINE:** 1. Students shall conduct themselves within and outside the premises of the Institute, in a manner befitting the students of an Institution of National Importance 2. **As per the order of Honorable Supreme Court of India, ragging in any form is considered as a criminal offence and is banned, any form of ragging will be severely dealt with**. 3. The following acts of omission/ or commission shall constitute gross Violation of the code of conduct and are liable to invoke disciplinary measures: a) Ragging b) Lack of courtesy and decorum; indecent behavior anywhere within or outside the campus. c) Willful damage or stealthy removal of any property /belongings of the Institute /Hostel or of fellow students/ citizens d) Possession, consumption or distribution of alcoholic drinks or any kind of hallucinogenic drugs. e) Mutilation or unauthorized possession of Library books. f) Noisy and unseemly behavior, disturbing studies of fellow Students. g) Hacking in computer systems (such as entering into other Person's area without prior permission, manipulation and/or Damage of computer hardware and software or any other Cybercrime etc.,). h) Plagiarism of any nature. i) Any other act of gross indiscipline as decided by the University from time to time. j) Smoking in College Campus and supari chewing.

	k) Unauthorized fund raising and promoting sales 4. Commensurate with the gravity of offense, the punishment may be: reprimand, expulsion from the hostel, debarment from an examination, disallowing the use of certain facilities of the College, rustication for a specified period or even outright expulsion from the College, or even handing over the case to appropriate law enforcement authorities or the judiciary, as required by the circumstances. i) For an offence committed in a) A hostel b) A department or in a classroom c) Elsewhere, the Chief Warden, the Head of the Department and the Dean (Students Welfare), respectively, shall have the authority to reprimand or impose fine. ii) All cases involving punishment shall be reported to the Principal. 5. Cases of adoption of unfair means and/or any malpractice in an examination shall be reported to the Controller of Examination. ○ **Note:** Students are required to be inside the examination hall 20 minutes before the commencement of examination. This is applicable for all examinations (Semester end/Supplementary/makeup) henceforth. Students will not be allowed inside the examination hall after the commencement, under any circumstances.

NITTE
(Deemed to be University)

University Enclave, Medical Sciences Complex,
Deralakatte, Mangaluru – 575 018, Karnataka India
Tel: +91-824-2204300 | E-mail: info@nitte.edu.in

Scheme & Syllabus for
M. Tech. (Machine Design)

DEPARTMENT OF MECHANICAL ENGINEERING

2022-24

Institution Vision

Pursuing Excellence, Empowering people, Partnering in Community Development.

Institution Mission

To develop NMAM Institute of Technology, Nitte, as Center of Excellence by imparting Quality Education to generate Competent, Skilled and Humane Manpower to face emerging Scientific, Technological, Managerial and Social Challenges with Credibility, Integrity, Ethics and Social Concern.

Department Vision

To produce Mechanical engineers of the highest quality who are professionally competent and highly qualified to suit the needs of industries and organizations by promoting excellence in teaching, learning and research.

Department Mission

The Dept. of Mechanical Engineering is committed to

- Provide high quality education to the students, to fulfill the requirements of a 'Global Engineer'
- Constantly strive to improve the teaching-learning methods, in order to deliver good academic programs
- Respond to the fast evolving scientific and technological challenges in a highly competitive world
- Inculcate, ethics, integrity, honesty, credibility, social and environmental consciousness

Program Educational Objectives (PEO)

1. PEO-1: To prepare students to pursue a career in design in academic, R & D and industrial organizations at national and international level.
2. PEO-2: To prepare students to pursue higher studies and research and generate necessary knowledge to enrich the domain and involve in a process of lifelong learning.
3. PEO-3: To contribute to the society by solving domain and societal problems through the knowledge and skills acquired professionally, ethically with concern for the society and environment and fulfilling sustainable development goals.

Program Outcomes (PO)

At the end of M.Tech in Machine Design Program Students will have

1. PO1: An ability to independently carry out research /investigation and development work to solve practical problems
2. PO2: An ability to write and present a substantial technical report/document
3. PO3: Students should be able to demonstrate a degree of mastery over machine design.

Note: Program may add up to three additional POs.

4. PO4: An ability to use the in depth knowledge of machine design to address and solve complex engineering problems in the real world through proper design of experiments, analysis and interpretation of data and synthesis of information.
5. PO5: An ability to effectively use modern IT tools including prediction and modelling of complex engineering problems and understanding their limitations.
6. PO6: An ability to understand the impact of the solutions suggested to different problems on the society and environment and adopt practices which are relevant and professional.

Program Specific Outcomes (PSO)

1. PSO-1: Design Mechanical systems using interrelationship among force, stress, vibration and failure analysis
2. PSO-2: Develop advanced analysis tools for evaluating performance of mechanical systems to enhance the capability of the designer

3. PSO-3 The students will have good research skills with fair synthesis and analysis of data which makes them lifelong learner

Sl. No	Name of Faculty	Qualification	Designation
1.	Dr. Srinivasa Pai P	PhD	Professor & Head
2.	Dr. Muralidhara	PhD	Professor
3.	Dr. Kumar H S	PhD	Associate Professor
4.	Dr. Nithin Kumar	PhD	Associate Professor
5.	Dr. Veeresh R K	PhD	Associate Professor
6.	Dr. Dilip Kumar K	M Tech	Assistant Professor
7.	Mr. Ravikiran Kamath	M Tech	Assistant Professor
8.	Mr. Divijesh P	M Tech	Assistant Professor
9.	Mr. Melwyn Rajesh Castelino	M Tech	Assistant Professor

M. Tech. in Machine Design

CREDIT DISTRIBUTION

No.	Course Category	Suggested Credits
1.	Professional Courses (PCC) – core	16
2.	Professional Courses (PEC) – elective	18
3.	Research Methodology & IPR/RETP	04
4.	Labs	04
5.	Project Work (UCC) (Phase 1 & 2)	08+20
6.	Audit Courses (2 Nos)	00
7.	Seminar on Current Topic (UCC)	02
8.	Internship (UCC)	08
	Total Credits to be earned:	**80**

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Off-Campus Centre, Nitte - 574 110, Karkala

M.Tech. (MMD): Scheme of Teaching and Examinations 2022-24

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

(Effective from the academic year 2022 - 23)

1st Year Scheme

I SEMESTER

Sl. No	Course Type	Course Code	Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Lecture	Tutorial	Practical/ Drawin	Duration in hours	CIEMarks	SEEMarks	Total Marks	
					L	T	P					
1	PCC	22MMD101	Computational Methods In Engineering	Mech	4	0	0	3	50	50	100	4
2	PCC	22MMD102	Finite Element Methods and its Applications	Mech	4	0	0	3	50	50	100	4
3	RETP	22MMD103	Research Experience Through Practice -I	Mech	Four contact hours /week for carrying out Research and Interaction between the faculty and students			-	100	0	100	2
4	PCC	22MMD104	Modeling and Analysis Lab	Mech	0	0	2	3	50	50	100	1
5	PCC	22MMD105	Hydraulics and Pneumatics Lab	Mech	0	0	2	3	50	50	100	1
6	PEC	22MMD11X	Elective – I	Mech	3	0	0	3	50	50	100	3
7	PEC	22MMD12X	Elective - II	Mech	3	0	0	3	50	50	100	3
8	PEC	22MMD13X	Elective - III	Mech	3	0	0	3	50	50	100	3
9	AUDIT	22MMDAU1X	Audit Course-I	Mech	2	0	0	0	0	0	0	U
				Total	**19**	**0**	**4**	**21**	**450**	**350**	**800**	**21**

II SEMESTER

Sl. No	Course Type	Course Code	Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Lecture	Tutorial	Practical/ Drawin	Duration in hours	CIEMarks	SEEMarks	Total Marks	
					L	T	P					
1	PCC	22MMD201	Theory of Vibrations	Mech	4	0	0	3	50	50	100	4
2	PCC	22MMD202	Fatigue of Materials	Mech	4	0	0	3	50	50	100	4
3	RETP	22MMD203	Research Experience Through Practice -II	Mech	Four contact hours /week for carrying out Research and Interaction between the faculty and students			-	100	0	100	2
4	PCC	22MMD204	Design Engineering Lab	Mech	0	0	2	3	50	50	100	1
5	PCC	22MMD205	Programming Lab	Mech	0	0	2	3	50	50	100	1
6	PEC	22MMD21X	Elective – IV	Mech	3	0	0	3	50	50	100	3
7	PEC	22MMD22X	Elective – V	Mech	3	0	0	3	50	50	100	3
8	PEC	22MMD23X	Elective - VI	Mech	3	0	0	3	50	50	100	3
9	AUDIT	22MMDAU2X	Audit Course-II	Mech	2	0	0	0	0	0	0	U

				Total	**19**	**0**	**4**	**21**	**450**	**350**	**800**	**21**

Note: PCC: Professional Core Course, PEC: Professional Elective Course, AUDIT (AU): Non-credit Audit course, RETP: Research Experience Through Practice.
L –Lecture, T – Tutorial, P- Practical/ Drawing, CIE: Continuous Internal Evaluation, SEE: Semester End Examination.

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M.Tech. (MMD): Scheme of Teaching and Examinations 2022-24

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

(Effective from the academic year 2022 - 23)

2nd Year Scheme

III SEMESTER

Sl. No	Course Type	Course Code	Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawin	Duration in hours	CIEMarks	SEEMarks	Total Marks	
					L	T	P					
1	UCC	22MMD301	Industry Internship/ Research Internship/Mini Project	Mech	8 Weeks Full Time [32Hrs/week]			3	100	0	100	8
2	UCC	22MMD302	Seminar on Special Topic	Mech	0	0	2	3	100	0	100	2
3	UCC	22MMD303	Project Part -1	Mech	12 Weeks Full Time [min 30 Hrs/week]			3	200	0	200	8
				Total	**0**	**0**	**2**	**9**	**400**	**0**	**400**	**18**

Note: L –Lecture, T – Tutorial, P- Practical/ Drawing, S – Self Study Component, CIE: Continuous Internal Evaluation, SEE: Semester End Examination.

Internship: CIE Evaluation is for 100 Marks where 50 Marks is for Report and 50 Marks for the Presentation

Project Part-1: CIE Evaluation is for 200 Marks where 100 Marks is for Report and 100 Marks for the Presentation

IV SEMESTER

Sl. No	Course Type	Course Code	Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawin	Duration in hours	CIEMarks	SEEMarks	Total Marks	
					L	T	P					
1	UCC	22MMD401	Project Part -2	Mech	22 Weeks Full Time [min 36 Hrs/week]			3	200	200	400	20
				Total	**0**	**0**	**0**	**3**	**200**	**200**	**400**	**20**

Note: L –Lecture, T – Tutorial, P- Practical/ Drawing, S – Self Study Component, CIE: Continuous Internal Evaluation, SEE: Semester End Examination.

Project Part-2: CIE Evaluation is for 200 Marks having Project Progress Evaluation (PPE)-1 and PPE-2 each for 100 Marks.

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M.Tech. (MMD): Scheme of Teaching and Examinations 2022-24

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

(Effective from the academic year 2022 - 23)

List of Domain Specific Skill Development Audit Course (AUDIT)	
Course Code	**Course Title**
22MMDAU1-1	Automotive Safety
22MMDAU2-1	Design Optimization

List of Electives [PEC]			
Elective - I		**Elective - II**	
Code	**Course Title**	**Code**	**Course Title**
22MMD111	Design of Hydraulic & Pneumatic Systems	22MMD121	Continuum Mechanics
22MMD112	Industrial process equipment design	22MMD122	Computer Graphics
22MMD113	Mechanism design	22MMD123	Computer Applications in Design
Elective - III		**Elective - IV**	
Code	**Course Title**	**Code**	**Course Title**
22MMD131	Automobile System Design	22MMD211	Biomechanics
22MMD132	Creative Engineering	22MMD212	Experimental Stress Analysis
22MMD133	Mechatronics System Design	22MMD213	Smart Materials & Structures
Elective - V		**Elective – VI**	
Code	**Course Title**	**Code**	**Course Title**
22MMD221	Design and Control of Robotic Manipulator	22MMD231	Composite Materials Technology
22MMD222	Design for Manufacturing	22MMD232	Design of wheeled mobile robots
22MMD223	Fracture Mechanics	22MMD233	Digital Manufacturing
		22MMD234**	Aircraft Design

** Elective course 22MMD234 may be registered under NPTEL

Professional Core Courses

COMPUTATIONAL METHODS IN ENGINEERING

Course Code:	**22MMD101**	**Course Type**	**PCC**
Teaching Hours/Week (L: T: P)	**4:0:0**	**Credits**	**04**
Total Teaching Hours	**50+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	To prepare students to understand rank and determinant of matrices, linear equations, Eigenvalues and eigenvectors.
2.	To prepare students to learn various numerical methods to solve system of linear equations.
3.	To prepare students to develop the mathematical models of machine design using ODE's and PDE's.
4.	To prepare students to analyze and solve separation of variables related to heat and wave equations.
5.	To prepare students to understand statistical and probabilistic concepts required to test the hypothesis and designing the experiments using RBD.

UNIT-I

Matrix Algebra	**10 Hours**
Algebra of matrices, rank and determinant of matrices, solution of systems of linear algebraic equations using Gauss elimination and Gauss-Seidel methods. Eigenvalues and eigenvectors.	

UNIT-II

Differential Equations and its Applications	**10 Hours**
Linear ordinary differential equations (ODEs), variation of parameters, Sturm-Liouville problem. Partial differential equations (PDEs) - Classification of second order PDEs, General solution of higher order PDEs with constant coefficients. Method of separation of variables for Laplace, Heat and Wave equations	

UNIT-III

Transformation techniques	**10 Hours**
Laplace transformation, Fourier transforms, z - transformation to solve differential and difference equations.	

UNIT-IV

Numerical Methods	**10 Hours**
Numerical solution of algebraic and transcendental equations- iteration method and Newton - Raphson method, Numerical solutions of ODEs and PDEs. Numerical differentiation and integration	

UNIT-V

Sampling theory	**10 Hours**
Testing of hypothesis: Chi square test and F-test. Analysis of Variance (ANOVA): one way classification, Design of experiments, RBD	

Course Outcomes: At the end of the course student will be able to

1.	Determine rank and determinant of matrices, linear equations, Eigenvalues and eigenvectors.
2.	Apply various numerical methods to solve system of linear equations.
3.	Develop the mathematical models of machine design using ODE's and PDE's.
4.	Analyze and solve separation of variables related to heat and wave equations.

5.	Apply statistical and probabilistic concepts required to test the hypothesis and designing the experiments using RBD.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	**PSO↓** 1	2	3
22MMD101.1	**1**	**1**	**2**	**2**	**3**	**2**	**2**	**2**	**3**
22MMD101.2	**1**	**1**	**2**	**3**	**3**	**2**	**2**	**2**	**3**
22MMD101.3	**1**	**1**	**3**	**3**	**2**	**2**	**2**	**2**	**3**
22MMD101.4	**1**	**1**	**3**	**2**	**1**	**2**	**2**	**2**	**3**
22MMD101.5	**3**	**3**	**3**	**2**	**3**	**3**	**2**	**2**	**3**

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	Numerical methods for Scientific and Engg computation M K Jain, S.R.K Iyengar, R K. Jain New Age International 2003
2.	Theory of ordinary differential equations, Coddington E., Levinson N., McGraw-Hill publishing Company, TMH Edition, 9th Reprint, 1987.
3.	'Differential Equations and Calculus of Variations', Elsgolts L, MIR Publications, 3rd Edition, 1977
4.	Higher Engineering Mathematics B.S. Grewal Khanna Publishers 2017
5.	Probability and Statistics for Engineers and Scientists R.E, Walpole, R.H.Myres, S.L.Myres and Keying Ye Pearson 2012
6.	Probability and Statistics in Engineering William W.H., Douglas C.M., David M.G.and Connie M.B Wiley 2008
7.	Advanced Engineering Mathematics C. Ray Wylie and Louis C Barrett McGraw-Hill 1995

FINITE ELEMENT METHODS AND ITS APPLICATIONS

Course Code:	**22MMD102**	**Course Type**	**PCC**
Teaching Hours/Week (L: T: P)	**4:0:0**	**Credits**	**04**
Total Teaching Hours	**50+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Formulate and perform one dimensional structural analysis using line elements and truss elements.
2.	Formulate and perform two dimensional structural analysis using triangular elements and quadrilateral elements. Students should be able to formulate and perform two dimensional structural analyses for axisymmetric bodies using axisymmetric triangular and quadrilateral ring elements.
3.	Perform three dimensional analyses of mechanical systems using standard software.
4.	Students should be able to formulate and perform one dimensional structural analyses using beam element.
5.	Formulate and perform one dimensional and two dimensional heat transfer analysis. Students should be able to formulate and perform one dimensional modal analysis using consistent mass matrix and lumped mass matrix and different forms of solution.

UNIT-I

10 Hours

Background of Various Stress analysis methods, comparison of FEM with classical methods. Advantages and limitations of FEM, Steps involved in FEM, Applications of FEM and FEM Packages. Discretization: Element shapes and behavior – Choice of element types – size and number of elements – Element shape and distortion – Location of nodes – Mesh Quality Parameters, Principle of minimum PE.

UNIT-II

10 Hours

Interpolation Models and FE Analysis of 2D Problems Interpolation polynomials- Linear, quadratic and cubic. Simplex complex and multiplex elements, Convergence Criteria -2D PASCAL's triangle. 2-D Problems: CST and quadrilateral elements-Shape functions in NCS, Strain displacement matrix and Jacobian for triangular element. (no derivation), Iso parametric, Sub parametric and Super parametric elements. Numerical integration.

UNIT-III

Two-Dimensional Elements-Analysis of Plane Elasticity Problems — **6 Hours**

Three-Noded Triangular Element (TRIA 3), Four-Noded Quadrilateral Element (QUAD4),Shape functions for Higher Order Elements (TRIA 6, QUAD8)

Axi-symmetric Solid Elements-Analysis of Bodies of Revolution under axi-symmetric loading — **4 Hours**

Axisymmetric Triangular and Quadrilateral Ring Elements. Shape functions for Higher Order Elements.

UNIT-IV

Three-Dimensional Elements-Applications to Solid Mechanics Problems — **5 Hours**

Basic Equations and Potential Energy Functional, Four-Noded Tetrahedral Element (TET4), Eight-Noded Hexahedral Element (HEXA8), Tetrahedral elements, Hexahedral elements: Serendipity family, Hexahedral elements: Lagrange family. Shape functions for Higher Order Elements

Beam Elements- Analysis of Beams and Frames — **5 Hours**

1-D Beam Element, 2-D Beam Element, Problems.

UNIT-V

FEM in Heat Transfer and Fluid Mechanics problems — **5 Hours**

Finite element solution for one dimensional heat conduction with convective boundaries. Formulation of element characteristics and simple numerical problems. Formulation for 2-D and 3-D heat conduction problems with convective boundaries. Introduction to thermo-elastic contact problems. Finite element applications in potential flows; Formulation based on Potential function and stream function

Algorithmic Approach for problem solving	**5 Hours**

Algorithmic approach for Finite element formulation of element characteristics, Assembly and incorporation of boundary conditions. Guidelines for code development.

Course Outcomes: At the end of the course student will be able to

1.	**Explain** the basic steps and convergence criteria in the finite element method; apply the direct stiffness, Rayleigh-Ritz, Galerkin method to **solve** static structural problems.
2.	**Analyze** bar and truss elements by applying suitable boundary conditions to **compute** displacements, stresses and support reactions.
3.	**Derive** basic equations of two dimensional elements and axi-symmetric element.
4.	**Derive** basic equations of Four-Noded Tetrahedral Element (TET4) and Eight-Noded Hexahedral Element (HEXA8). **Compute** deflection and slope in beams subjected to Point load and UDL, **determine** slope and deflection of beam element.
5.	**Derive** basic equations of heat transfer and **Estimate** the temperature distribution in composite wall and pin fin using finite element formulation for 1D steady state heat transfer problems; **Develop** finite element formulations for fluid flow problems.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	**PSO↓** 1	2	3
22MMD102.1	**1**	**1**	**3**	**1**	**1**	**1**	**2**	**2**	**3**
22MMD102.2	**1**	**1**	**3**	**1**	**1**	**1**	**2**	**2**	**3**
22MMD102.3	**2**	**1**	**3**	**1**	**1**	**1**	**2**	**2**	**3**
22MMD102.4	**2**	**1**	**3**	**1**	**1**	**1**	**2**	**2**	**3**
22MMD102.5	**2**	**1**	**3**	**1**	**1**	**1**	**2**	**2**	**3**

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	Singiresu S.Rao, Finite element Method in Engineering, 5ed, Elsevier, 2012.
2.	Chandrupatla T.R.“**Finite Elements in engineering”-**2nd Edition, PHI,2007.
3.	Lakshminarayana H.V. “**Finite Elements Analysis”**-Procedures in Engineering, Universities Press, 2004

REFERENCE BOOKS:

1.	Rao S.S.“Finite Elements Method in Engineering”-4thEdition, Elsevier,2006
2.	Seshu P, Textbook of Finite Element Analysis, PHI. 2004 2. Reddy, J.N.,
3.	Finite Element Method in Engineering, Tata McGraw Hill, 2017 3. Zeincowicz,
4.	The Finite Element Method 4 Vol set, 4th Edition, Elsevier 2007

E Books / MOOCs/ NPTEL

1.	http://nptel.ac.in/courses/112104116/
2.	http://nptel.ac.in/keyword_search_result.php?word=finite+element%20method
3.	http://nptel.ac.in/keyword_search_result.php?word=Finite+Element%20analysis

MODELING AND ANALYSIS LAB

Course Code:	**22MMD103**	**Course Type:**	**PCC Lab**
Teaching Hours/Week (L: T: P)	**0:0:2**	**Credits:**	**01**
Total Teaching Hours:	**0+0+26**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	To acquire basic understanding of Modeling and Analysis software and develop program for FEA using MATLab
2.	To understand the different kinds of analysis and apply the basic principles to find out the stress and other related parameters of bars, plates, beams loaded with different loading conditions.

List of Experiments

Tool: MATLAB/ANSYS/Creo.

	UNIT – I	**13 Hours**
1.	Introduction to Pro/E and working with features like Extrude & Revolve in sketch mode	
2.	Model solids with features like Hole, Round, Chamfer and Rib	
3.	Model solids with features like Pattern, Copy, Rotate, Move and Mirror	
4.	Advanced modeling tools (Sweep, Blend, Variable section Sweep etc)	
5.	Assembly modelling in Pro/E, Generating, editing and modifying drawings in Pro/E	
6.	Introduction to developing program for finite element analysis in MATLAB	
	UNIT – II	**13 Hours**
1.	Introduction to FEA software, ANSYS	
2.	Solution of problems of Trusses using ANSYS	
3.	Solution of problems of Beams and Frames using ANSYS	
4.	Solution of problems involving triangular element etc. using ANSYS	
5.	Nonlinear plastic Deformation and buckling Analysis	
6.	Analysis of Composite materials	
7.	Analysis of pressure vessels	
8.	Solution of 3D analysis problems using ANSYS	

Course Outcomes: At the end of the course student will be able to

1.	Develop programs for modeling the synthetic curves and surfaces. Develop finite element code to solve problems involving Trusses, Beams and Frames.
2.	Solve structural problems using finite element software and Execute mini project involving both modeling and analysis.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	**PSO↓**		
↓ Course Outcomes							1	2	3
22MDE103.1	2	1	2	1	3	1	1	2	3
22MDE103.2	2	1	2	1	3	1	1	2	3

1: Low 2: Medium 3: High

REFERENCE BOOKS:	
1.	Huei-Huang Lee, Finite Element Simulations with ANSYS® Workbench 2020
2.	Xiaolin Chen, Yijun Liu, Finite Element Modeling and Simulation with ANSYS® Workbench
3.	Mary Kathryn Thompson (Author), John M. Thompson (Author), ANSYS® Mechanical APDL for Finite Element Analysis
4.	Saeed Moaveni, Finite Element Analysis: Theory and Application with ANSYS
5.	William Palm III, A Concise Introduction to Matlab, McGraw-Hill, 2008
6.	Roger Toogood Ph.D. Creo Parametric 3.0 Advanced Tutorial, 2015

HYDRAULICS AND PNEUMATICS LAB

Course Code:	**22MMD104**	**Course Type:**	**PCC Lab**
Teaching Hours/Week (L: T: P:)	**0:0:2**	**Credits:**	**01**
Total Teaching Hours:	**0+0+26**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	To study the design of basic hydraulic, electro-hydraulic and PLC Controlled hydraulic circuits
2.	To study the design of basic pneumatics, electro- pneumatics and PLC Controlled pneumatics circuits

List of Experiments

	UNIT – I	**13Hours**
1.	Design a hydraulic circuit for a lifting device to lift heavy loads, which is equipped with two hydraulic cylinders. To perform this operation correctly, both cylinders should advance at the same speed even when the device is subjected with one sided load. The circuit must contain a flow divider and two non-return valves to	
2.	Design a hydraulic circuit for plastic injection moulding machine which is initially filled using a low working pressure (low force). The plastic is then moulded at high pressure (higher force). The working pressure is switched over a roller lever actuated 2/2-way valve after the piston has travelled a certain distance. The necessary pressures are set on two pressure relief valves.	
3.	Design an electro-hydraulic circuit for a bending device equipped with a double acting cylinder which is used to produce U shaped sheet metal workpieces. The start signal for this operation is provided to a single solenoid valve by a push button. A second push button is pressed to initiate the return stroke of the cylinder. The advanced return stroke must be at slow speed.	
4.	Design an electro-hydraulic circuit to push cartoons from one conveyor to another using a double acting cylinder. The cartoon boxes are fed continuously using a start button by to and fro motion of the double acting cylinder. The motion can be stopped by a separate stop push button. The speed of forward and reverse motion can be adjustable. Cylinder position is monitored by limit switches.	
5.	Design a PLC hydraulic circuit for a sorting device used to sort heavy steel workpieces by the press of a push button. The piston rod of a double acting cylinder pushes theworkpieces to the adjacent conveyor belt. The piston rod retracts to the home position when the push button is released.	
6.	Design a PLC hydraulic circuit for a lifting table. The four crates arriving on a conveyor belt must be raised to the height of packing conveyor by means of a lifting table. The raising and lowering of the lifting table are controlled by a cylinder. The advanced stroke is controlled by pressing of any one of two push buttons. The speed of advanced stroke is adjustable.	
	UNIT – II	**13Hours**
1.	Design pneumatic circuit to a sorting device for metal stampings. Through operation of the push button on the actuating valve, metal stampings lying in random positions are sorted out and transferred to a second conveyor belt. The forward motion of the piston rod of a single acting cylinder (1A) takes t = 0.4 seconds. When the push button is released, the piston rod travels to the retracted end position. A pressure gauge is fitted before and after the one-way flow control valve.	
2.	Design a pneumatic circuit to a welding machine for thermoplastics. Two double-acting cylinders (1A) and (2A) press together two electrically heated bars and, in doing so, join	

	two thermoplastic sheets by welding. The thickness of the sheets varies between 1.5 mm and 4 mm. The seams may be of any length. The piston force of both cylinders is limited via a pressure regulator. Value set p = 4 bar (=400 kPa). By actuating a push button, two double-acting cylinders are made to advance in parallel with their exhaust air restricted. To assist regulation, pressure gauges have been fitted between the cylinders and the oneway flow control valves. The end positions of the cylinders are interrogated. After a time of t = 1.5 seconds, the bar moves back to the initial position. The return stroke may be instantly initiated by means of a second push button.
3.	Design an electro-pneumatic circuit for opening and closing device. Using a special device, the valve in a pipeline is to be opened and closed. The valve is opened by pressing the pushbutton switch. When the pushbutton is released, the valve is closed.
4.	Design an electro-pneumatic circuit for clamping device. Parts are to be clamped using a clamping device. By pressing a pushbutton switch the moveable clamping jaw is pushed forward and the part is clamped. By pressing another pushbutton switch the clamping jaw is returned to its start position.
5.	Design a PLC pneumatic circuit for a stamping device. Parts are to be stamped with a stamping device. By pressing two pushbutton switches the die is pushed down and the part is stamped. When the stamping pressure has been achieved, the die is returned to its start position.
6.	Design a PLC pneumatic circuit for heat sealing device. Using a hot-pressing die, packing material is to be sealed by application of heat and pressure. By pressing a pushbutton switch the heating rail is advanced and the packaging material is heated along the adhesive strip. After the adhesion pressure has been reached, the heating rail is returned to its start position.

Course Outcomes: At the end of the course student will be able to

1.	Design the basic hydraulic, electro-hydraulic and PLC Controlled hydraulic circuits for different real word applications.
2.	Design the basic pneumatics, electro- pneumatics and PLC Controlled pneumatics circuits for different real word applications

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	**PSO↓**		
↓ Course Outcomes							1	2	3
22MMD104.1	**1**	**1**	**3**		1		**1**	**1**	**1**
22MMD104.2	**1**	**2**	**3**		1		**1**	**1**	**1**

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	Festo-Didactic Hydraulics workbook basic level
2.	Festo-Didactic Electro-Hydraulics workbook basic level
3.	Festo-Didactic Pneumatics workbook basic level
4.	Festo-Didactic Electro-Pneumatics workbook basic level

REFERENCE BOOKS:

1.	Festo-Didactic Programmable logic controllers Basic level TP301 – Textbook

RESEARCH EXPERIENCE THROUGH PRACTICE -1

Course Code:	**22MMD105**	**Course Type**	**RETP**
Teaching Hours/Week (L: T: P)	**0:0:4**	**Credits**	**2**
Total Teaching Hours	**0+0+52**	**CIE**	**100**

Teaching Department: Any

Course Objectives: The research purposes are

1. To foresee future problems through pursuit of truth as a "global centre of excellence for intellectual creativity".
2. To respond to current social demands, and to contribute to the creation and development of scientific technologies with the aim of realizing an affluent society and natural environment for humanity.
3. At the same time, the course aims to create excellent educational resources and an excellent educational environment through frontline researches
4. To Understand professional writing and communication contexts and genres, analyzing quantifiable data discovered by researching, and constructing finished professional workplace documents.

Individual PG Students are to be allotted to the individual faculty members based on student's area of research interest, specialization of faculty members in the beginning of the first semester.

MODULE -1

Defining the research problem – Selecting the problem – Necessity of defining the problem - Techniques involved in defining the problem – Importance of literature review in defining a problem – Survey of literature – Primary and secondary sources – Reviews, treatise, monographs patents – web as a source – searching the web – Identifying gap areas from literature review – Development of working hypothesis, systematic way of conducting research, write a review / research paper, research proposal, preparation of research report.

MODULE-2

- Introduction various simulation tools related to Machine Design
- Use of software tools (MATLAB)
- Introduction to typesetting tool (Latex).
- At the end of the course students should submit a research proposal and should present the idea.

The Research proposal report prepared based on the work carried out by the PG Student is evaluated for 50 marks and 20 minutes presentation on the research work carried out will be evaluated for 50 marks jointly by the examiners.

Course Outcomes: At the end of the course student will be able to

1.	Identify and define the problem statement based on the literature reviewed.
2.	Formulate the objectives specific to the defined problem statement.
3.	Develop the methodology for achieving the objectives.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	**PSO↓** 1	2	3
22MMD105.1	3	3	1		1	1	1	1	1
22MMD105.2	3	3	1		1	1	1	1	1
22MMD105.3	3	3	1		1	1	1	1	1

1: Low 2: Medium 3: High

REFERENCE BOOKS:	
1.	The Undergraduate Research Hand book. Gina Wisker · 2018
E Books / MOOCs/ NPTEL	
1.	https://elearn.nptel.ac.in/shop/nptel/introduction-to-research/
2.	https://onlinecourses.nptel.ac.in/noc22_ge08/preview

THEORY OF VIBRATIONS

Course Code:	**22MMD201**	**Course Type**	**PCC**
Teaching Hours/Week (L: T: P)	**4:0:0**	**Credits**	**04**
Total Teaching Hours	**50+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Recall the basic theory and concepts of mechanical vibrations with regard to single degree of freedom systems considering free, damped and forced vibrations and analyze two degree of freedom systems and use these concepts to solve problems.
2.	Learn the significance of transient vibrations and apply mathematical concepts to solve problems related to it and get familiarized with vibration control and know about the different methods of achieving the same.
3.	Know about the concepts of nonlinear vibrations and its applications and how vibration measurements are important and solve problems related to the same.
4.	Apply mathematical techniques to analyze random vibrations and appreciate the use of modal analysis and condition monitoring in vibration signal analysis.
5.	Learn the mathematical techniques to determine the equations of motion and natural frequencies of continuous systems and study their free/ forced vibration behavior and know how to solve Eigen value problems in vibrations.

UNIT-I

Review of Mechanical Vibrations	**10 Hours**

Basic concepts, free vibration of single dof systems with and without damping, forced vibration of single dof systems, Force and motion isolation, Two dof systems – natural frequency determination and mode shapes.

UNIT-II

Transient vibrations of single degree-of freedom systems	**5 Hours**

Impulse excitation, Laplace transforms formulation, step input, pulse excitation, shock response spectrum, Finite difference numerical computation.

Vibration Control	**5 Hours**

Introduction, vibration isolation theory, vibration isolation for harmonic excitation for different types of foundations, undamped dynamic vibration absorbers, types of vibration absorbers, types of vibration dampers

UNIT-III

Non linear vibrations	**5 Hours**

Introduction, sources of nonlinearity, qualitative analysis of non linear systems, phase plane, conservative systems, Stability of equilibrium, Method of Isoclinics, Perturbation method, Method of Iteration, Self-excited oscillations

Vibration measurement and applications	**5 Hours**

Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis

UNIT IV

Random vibrations	**5 Hours**

Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier Transforms and response

Modal analysis and Condition Monitoring	**5 Hours**

Introduction, Dynamic testing of Machines and Structures, Experimental Modal analysis, Machine Condition Monitoring & Diagnosis

UNIT V	
Continuous systems	**5 Hours**
Transverse vibration of a string or cable, Lateral vibration of beams, Longitudinal vibration of rods, vibration of membranes.	
Eigen value problems	**5 Hours**
Solution of the eigen value problem, solution of the characteristic equation, orthogonality of normal modes, repeated eigen values, expansion theorem, unrestrained systems, free vibration of damped systems	

Course Outcomes: At the end of the course student will be able to

1.	**Explain** the basic concepts of mechanical vibrations related to undamped, damped and forced vibrations and **solve** problems related to these along with two-degree freedom systems.
2.	Apply the basic concepts of transient vibrations to **solve** problems. **Describe** vibration control through absorbers and dampers and **solve** problems related to vibration isolation and absorbers.
3.	**Describe** the concepts of nonlinear vibrations and its applications. **Solve** problems related to vibration measurement.
4.	**Solve** problems involving statistical parameters, frequency spectrum, probability density and use of Fourier transform in random vibrations. **Explain** modal analysis and machine condition monitoring techniques.
5.	**Derive** solutions for vibrations of string, beams, rods and membranes. **Determine** eigenvalue solutions.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	PSO↓ 1	2	3
22MMD201.1	**1**	**2**	**3**	**2**	**1**	**1**	**3**	**2**	**3**
22MMD201.2	**1**	**2**	**3**	**2**	**1**	**1**	**3**	**2**	**3**
22MMD201.3	**1**	**2**	**3**	**2**	**1**	**1**	**3**	**2**	**3**
22MMD201.4	**1**	**2**	**3**	**2**	**1**	**1**	**3**	**2**	**3**
22MMD201.5	**1**	**2**	**3**	**2**	**1**	**1**	**3**	**2**	**3**

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	William T. Thomson, Marie Dillon Dahleh and ChandramouliPadmanabhan- Theory of Vibrations with Applications, 5th Edition, Pearson Education, 2008.
2.	S.S.Rao - Mechanical Vibrations, 4th Edition, Prentice Hall, 2004.
3.	J.S.Mehta and A.S.Kailey - Mechanical Vibrations, S.Chand& Company Ltd., New Delhi, 2012.
4.	G.K.Grover – Mechanical Vibrations, Nem Chand & Brothers, 2009.

REFERENCE BOOKS:

1.	S. Graham Kelly – Fundamentals of Mechanical Vibration, 2nd Edition, Mcgraw Hill.
2.	S. Graham Kelly – Mechanical Vibrations, Schaum's Outlines, Tata Mcgraw Hill, 2007.
3.	ThammaiahGowda, Jagadeesha T. and D.V.Girish – Mechanical Vibrations, McGraw Hill, New Delhi, 2013

FATIGUE OF MATERIALS

Course Code:	**22MMD202**	**Course Type**	**PCC**
Teaching Hours/Week (L: T: P)	**4:0:0**	**Credits**	**04**
Total Teaching Hours	**50+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Understand the theories of failure relating to different ductile and brittle materials. Students should be able to develop the concept of fatigue testing of materials including criteria for fatigue design and different fatigue life models.
2.	Determine the stress life behavior using stress life curves and representation of these curves including different factors influencing stress life behavior. Students should be able to understand the strain life behavior with different test methods and factors influencing strain life behavior.
3.	Understand the concept of crack nucleation, crack growth and fracture of materials using fundamentals of linear elastic fracture mechanics.
4.	Understand the various cumulative damage theories and different cycle counting methods relating to fatigue from variable amplitude loading. Students should be able to define the various statistical aspects of fatigue using different probability distribution plots. Students should be able to analyze the fatigue strength for notched members and its effects using analytical models.
5.	Understand the different surface failure mechanisms with stress distribution of various contact surfaces. Students should be able to define the weldment nomenclature and fatigue behavior of various weldments.

UNIT-I

Static failure theories	**5 Hours**
Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Coulomb Mohr's theory and modified Mohr's theory, Numerical examples	
Fatigue failure theories	**5 Hours**
Introductory concepts of fatigue, High cycle and low cycle fatigue, Mechanism of fatigue failure, Strategies in fatigue design, Fatigue failure models, Fatigue design criteria, Fatigue loads, measuring fatigue failure criteria, Fatigue testing machines and specimens.	

UNIT-II

Stress-Life (S-N) Approach	**5 Hours**
S- N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Factors influencing S-N behavior, S-N curve representation and approximations, Constant life diagrams.	
Strain-Life(-N)approach	**5 Hours**
Monotonic stress-strain behavior, Strain controlled test methods, Cyclic stress-strain behavior, Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish.	

UNIT-III

LEFM Approach	**5 Hours**
LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation	
Notches and their effects	**5 Hours**
Concentration and gradients in stress and strain, S-N approach for notched members, mean stress effects and Haigh diagrams, Neuber's rule, Glinka's rule, applications of fracture mechanics to crack growth at notches	

UNIT IV	
Fatigue from Variable Amplitude Loading	**5 Hours**
Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle Counting methods.	
Statistical Aspects of Fatigue	**5 Hours**
Concentration and gradients in stress and strain, S-N approach for notched members, mean stress effects and Haigh diagrams, Neuber's rule, Glinka's rule, applications of fracture mechanics to crack growth at notches	
UNIT V	
Surface Failure	**5 Hours**
Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength.	
Fatigue of Weldments	**5 Hours**
Weldment Nomenclature and Discontinuities, Constant amplitude fatigue behavior of weldments, Improving weldment fatigue resistance, Weldment fatigue life estimation.	

Course Outcomes: At the end of the course student will be able to

1.	**Explain** the mechanical failure modes of components and **calculate** the safety factor due to static loads acting along different planes using failure theories of ductile and brittle materials; **Describe** the failure design models and methods based on fatigue design criteria and **explain** the procedures for determining the fatigue strength of specimens using fatigue testing machines.
2.	**Explain** the effect of microstructure, surface finish, size effect and frequency influencing stress life behavior and **determine** the fatigue strength and fatigue life of components based on stress life curve approximations; **Determine** the cyclic stress- strain curves, strain life curves and strain- life fatigue properties using stable cyclic stress- strain hysteresis loops under the influence of mean stress and surface finish effects.
3.	**Estimate** the fatigue crack growth rate and fatigue life of a cracked component with and without mean stress effects using the concept of Linear Elastic Fracture Mechanics.; **Estimate** the fatigue strength of notched members based on stress life and strain life approach using analytical models.
4.	**Calculate** the expected life of components subjected to variable amplitude load histories of fatigue data by converting them to simple constant amplitude load cycles using cyclecounting methods; **Describe** probability distribution plots related to statistical aspects of fatigue to estimate the probability associated with fatigue failure or product life.
5.	**Explain** the surface failure mechanisms and **derive** the expressions for maximum pressure distribution in case of cylindrical contact, spherical contact and general contact surfaces; **Explain** weldment discontinuities and fatigue design procedures for estimating fatigue life of weldments along with methods for improving weldment fatigue resistance.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	PSO↓		
↓ Course Outcomes							1	2	3
22MMD202.1	**3**	**3**	**3**	**3**	**2**	**2**	**3**	**3**	**2**
22MMD202.2	**2**	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**2**
22MMD202.3	**3**	**1**	**1**	**1**	**2**	**2**	**3**	**2**	**2**
22MMD202.4	**2**	**2**	**3**	**2**	**2**	**3**	**2**	**3**	**3**
22MMD202.5	**3**	**3**	**3**	**3**	**2**	**2**	**3**	**3**	**2**

1: Low 2: Medium 3: High

TEXT BOOKS:	
1.	Metal Fatigue in engineering, Ralph I. Stephens, Ali Fatemi, Robert .R. Stephens, Henry o. Fuchs, John wiley Newyork, Second edition. 2001.
2.	Failure of Materials in Mechanical Design, Jack. A. Collins, John Wiley, Newyork 1992.
3.	Machine Design, Robert L. Norton, Pearson.
REFERENCE BOOKS:	
1.	Fatigue of Materials, S.Suresh, Cambridge university press, Cambridge, U.K.
2.	Fundamentals of Metal Fatigue Analysis, Julie.A.Benantine Prentice Hall,1990
3.	Fatigue and Fracture, ASM Hand Book, Vol 19,2002.

DESIGN ENGINEERING LAB

Course Code:	**22MMD203**	**Course Type:**	**PCC Lab**
Teaching Hours/Week (L: T: P)	**0:0:2**	**Credits:**	**01**
Total Teaching Hours:	**0+0+26**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Demonstrate the different types of drives used while designing a machine component and analyse different types brakes and clutches.
2.	Conduct experiments on damped and undamped free vibration and dynamics of machines and mechanisms

List of Experiments

	UNIT – I	**13 Hours**
1.	Study of mechanisms derived from four bar chain, its equivalents and their inversions.	
2.	Study and analysis of belt, rope and chain drives.	
3.	Study and analysis of cam and follower mechanism.	
4.	Study and analysis of different types of gears and gear trains.	
5.	Study and analysis of brakes and clutches.	
	UNIT – II	**13 Hours**
1.	Undamped Free Vibrations: i. Trifilar Pendulum ii. A Slender Rod on a Cylindrical Surface iii. A Semi Cylindrical Shell on a Horizontal surface. iv. Compound Pendulum	
2.	Damped Free Vibrations: i. Viscous Damper ii. Logarithmic Decrement iii. Spring-Mass-Damper System Coulomb Damping	
3.	Damped Free Vibrations of Two Degree Freedom System: Coupled Pendulum	
4.	Vibrations of Continuous System: A Cantilever Beam	
5.	Balancing of Rotors: Rotor Balancing Machine	
6.	Balancing of Reciprocating Machines: Balancing a Twin Cylinder Engine (A Locomotive Engine)	
7.	Critical speeds of shafts with hinged and fixed end conditions	
8.	Tuning of Dynamic Absorber	
9.	Case studies on mechanisms and inversions.	

Course Outcomes: At the end of the course student will be able to

1.	Evaluate the different types of drives used in a machine component.
2.	Determine the vibration parameters using undamped and damped free and forced vibrations and Determine the critical speed of shafts with bearings.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	PSO↓		
↓ Course Outcomes							1	2	3
22MDE203.1	3	1	3	3	1	3	3	1	2
22MDE203.2	3	1	3	3	1	3	3	1	2

1: Low 2: Medium 3: High

PROGRAMMING LAB

Course Code:	**22MMD204**	**Course Type:**	**PCC Lab**
Teaching Hours/Week (L: T: P)	**0:0:2**	**Credits:**	**01**
Total Teaching Hours:	**0+0+26**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Understand built-in functions in MATLAB to solve numerical problems and model the code for solving problems involving different types of mathematics equations.
2.	Develop a simulation code and apply solutions to simulation problems in machine design.

List of Experiments

UNIT – I	**13 Hours**
	Introduction to MATLAB and practice
	Practice session on handling basic arithmetic etc
	Writing codes with control loops, functions and scripts
	Developing codes for visualization and plotting
	Solving problems involving linear and nonlinear equations
	Solving problems involving curve fitting and interpolations
	Solving problems involving ordinary and partial differential equations
	Solving problems related to optimization
	Solving problems involving numerical differentiation and integrations

UNIT – II	**13 Hours**
1.	Introduction to Simulink
2.	Case studies and working on projects using Simulink
3.	Case studies and working on projects using Simulink
4.	Case studies and working on projects using Simulink

Course Outcomes: At the end of the course student will be able to

1.	Apply built-in functions in MATLAB to solve numerical problems and develop code for solving problems involving different types of mathematical models and equations.
2.	Model a system and Develop a simulation code and Solve simulation problems encountered in mechanical design, vibration analysis and CAD.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	**PSO↓**		
↓ Course Outcomes							1	2	3
22MDE204.1	**1**	**1**	**2**	**3**	**3**	**1**	**2**	**1**	**2**
22MDE204.2	**1**	**1**	**2**	**3**	**3**	**1**	**2**	**1**	**2**

1: Low 2: Medium 3: High

RESEARCH EXPERIENCE THROUGH PRACTICE -2

Course Code:	**22MMD205**	**Course Type**	**RETP**
Teaching Hours/Week (L: T: P)	**0:0:4**	**Credits**	**2**
Total Teaching Hours	**0+0+52**	**CIE**	**100**

Teaching Department: Mechanical Engineering

Course Objectives: The research purposes are

1. To foresee future problems through pursuit of truth as a "global centre of excellence for intellectual creativity".
2. To respond to current social demands, and to contribute to the creation and development of scientific technologies with the aim of realizing an affluent society and natural environment for humanity.
3. At the same time, the course aims to create excellent educational resources and an excellent educational environment through frontline researches.
4. To Understand professional writing and communication contexts and genres, analyzing quantifiable data discovered by researching, and constructing finished professional workplace documents.

The students are expected to carry out Mathematical modelling/Design calculations/computer simulations/Preliminary experimentation/testing of the research problems identified during Research Experience through Practice-I carried out in the first semester.
At the end of the second semester, students are expected to submit a full research paper based on the Mathematical modelling/ Design calculations/computer simulations/Preliminary experimentation/testing carried out during second semester.
The research paper prepared based on the work carried out by the PG Student is evaluated for 50 marks and 20 minutes presentation on the research work carried out will be evaluated for 50marks jointly by the examiners.

Course Outcomes: At the end of the course student will be able to

1.	Create a model/prototype through fabrication, simulation, data analysis, Experimentation for the proposed problem.
2.	Analyse and validate the results obtained.
3.	Compose a technical paper as per the given format.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	**PSO↓**		
↓ Course Outcomes							1	2	3
22MMD205.1	3	3	1						2
22MMD205.2	3	3	1						2
22MMD205.3	3	3	1						2

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1. The Undergraduate Research Hand book. Gina Wisker, 2018

E Resource

1. https://www.coursera.org/learn/academic-writing-capstone

Professional Elective Courses

DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS

Course Code:	**22MMD111**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	To provide student with knowledge on the application of fluid power in process, construction, and manufacturing Industries.
2.	To study the fundamental principles, design and operation of hydraulic and pneumatic machines, components and systems and their application in recent automation revolution.
3.	To provide students with an understanding of the fluids and components utilized in modern industrial fluid power system.
4.	To develop a measurable degree of competence in the design, construction, and operation of fluid power circuits.
5.	To emphasize basic theory, components sizing, construction and function, how to read pneumatics and fluid power circuit diagrams using the correct symbols and troubleshooting techniques.

UNIT-I

Fluid Power Principles and Hydraulic Pumps — **15 Hours**

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection – Basics of Hydraulics – Pascal's Law, Sources of Hydraulic power, Pump Classification – Construction, Working, Design, Advantages, and Disadvantages.

Basic Principles of Pneumatics

Difference between hydraulics and pneumatics-compressor types-two stage piston compressor - rotary vane compressor-rotary screw compressor -vacuum pumps- double acting pneumatic cylinder-gear motor pressure regulator -filters-lubricators-FRL unit-water removal – air preparation and distribution – Electronic control of fluid power -solenoid valves-servo valves pump controls

UNIT-II

Hydraulic Actuators and Control Components — **16 Hours**

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.

Pneumatics Actuators and Control Components

Directional Control Valves:- Check Valve-Shuttle Valves-Two Way Directional Control Valves -Three Way Directional Control Valves -Four Way Directional Control Valves – Directional Control Valves Actuation types-Symbols- Working Principles-Pressure Control Valve: Pilot Operated, Pressure Relief Valve -Pressure Reducing Valve -Sequence Valve – Symbols- Working Principles Flow Control Valve Type -Needle Valve -Pressure Compensated Flow Control Valve-Cushioned Cylinders -Flow Dividers -Balanced Spool Flow Divider- Rotary Flow Divider

UNIT-III

Hydraulic Circuits and Systems — **09 Hours**

Accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double-Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail-Safe, Speed Control, Hydrostatic transmission, Electrohydraulic circuits, Mechanical hydraulic servo systems

Pneumatic Circuits and Systems

Active components. Compressor. Transmission lines. Air tank. Pneumatic hoses. Open atmosphere (for returning the spent gas to the compressor) Valves. Passive components. Pneumatic cylinders. Service Unit. FRL - Filter Regulator and Lubricator. Regulators and gauges. Accumulator or buffer tank. Feed lines. Pneumatic Fittings

Trouble Shooting and Applications

Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Design of hydraulic circuits for Drilling, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for Pick and Place applications and tool handling in CNC Machine tools.

Course Outcomes: At the end of the course student will be able to

1.	Explain the Fluid power and operation of different types of pumps.
2.	Summarize the features and functions of Hydraulic motors, actuators, and Flow control valves
3.	Explain the different types of Hydraulic circuits and systems
4.	Explain the working of different pneumatic circuits and systems
5.	Summarize the various trouble shooting methods and applications of hydraulic and pneumatic systems.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	**PSO↓** 1	2	3
22MMD111.1	**1**	**1**	**3**				**1**	**1**	**1**
22MMD111.2	**1**	**2**	**3**				**1**	**1**	**1**
22MMD111.3	**1**	**2**	**3**				**1**	**1**	**1**
22MMD111.4	**1**	**2**	**3**				**1**	**1**	**1**
22MMD111.5	**1**	**2**	**3**				**1**	**1**	**1**

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	Anthony Esposito, “Fluid Power with Applications”, Pearson Education 2005.
2.	Majumdar S.R., “Oil Hydraulics Systems- Principles and Maintenance”, Tata McGraw-Hill, 2001.
3.	**“**Anthony Lal, “Oil hydraulics in the service of industry”, Allied publishers, 1982.

REFERENCE BOOKS:

1.	Dudelyt, A. Pease and John T. Pippenger, “Basic Fluid Power”, Prentice Hall, 1987.
2.	Majumdar S.R., “Pneumatic systems – Principles and maintenance”, Tata McGraw Hill, 1995
3.	Michael J, Prinches and Ashby J. G, “Power Hydraulics”, Prentice Hall, 1989.
4.	Shanmuga sundaram.K, “Hydraulic and Pneumatic controls”, Chand & Co, 2006.

INDUSTRIAL PROCESS EQUIPMENT DESIGN

Course Code:	**22MMD112**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	To be able to apply the requirements of the relevant industry standards to the mechanical design of equipments used in the process industry.
2.	Design process equipment and modify the design of existing equipment to new process conditions or new required capacity.
3.	Bridge the gap between theoretical and practical concepts used for designing the equipment in any process industry.
4.	Create understanding of equipment design with mechanical concepts.
5.	Design heat exchangers, absorbers, distillation columns, reactors and pressure vessels.

UNIT-I

Introduction to Process Equipment Design — **15 Hours**

Criteria, need and factors for design, general considerations in equipment design, criteria for materials selection, nature of design, types of process, design codes and standards, factor of safety, symbols of equipments or instruments used in flowsheet, fundamental principles and equations-principal stresses, theories of failure.

Mechanical Design of Pressure Vessel

Introduction of ASME Code, classification of pressure vessel as per IS-2825, mechanical design of shell subjected to internal pressure, design of shell for external pressure with and without stiffening ring, mechanical design of heads subjected to internal pressure, different types of nozzles, flanges, flange facings and gaskets and their selection criteria, welded joint efficiency.

UNIT-II

Process design of Absorbers — **16 Hours**

Introduction, criteria for selection among different types of absorption equipment, process design of packed tower type absorber, determination of actual amount of solvent, selection of packing, determination of tower diameter and pressure drop, process design and selection criteria of liquid distributors, redistributors and packing support, process design of spray chamber or spray tower type absorber, Venturi scrubber.

Mechanical design of Reaction Vessel

Mechanical design of jacket, coil, agitator etc., different types of agitators and their selection criteria, different types of agitator shaft sealing systems and their selection criteria, different types of power transmission systems, determination of power required for agitation, shaft diameter, blade thickness, etc., different types of jackets and their selection criteria, selection between coil and jacket.
Supports : Different types of supports, mechanical design of bracket support, skirt support and saddle support.

UNIT-III

Process design of Distillation Column (Tray Tower) — **09 Hours**

Introduction, criteria of selection, selection of equipment for distillation, distillation column design, continuous distillation, design variables in distillation, design methods for binary systems, McCabe Thiele method, selection of key components for multi-component distillation, Fenskey- Underwood-Gilliland's (F-U-G) correlation method, different types of tray supports & their selection criteria.

Design of Heat transfer operation equipment

Heat-exchanger standards and codes, shell and tube heat exchangers, general design considerations, tube-side heat-transfer coefficient and pressure drop (single phase), shell-side heat-transfer and pressure drop (single phase), Kern's method, Bell's method, criteria of selection for horizontal and vertical condenser.

Course Outcomes: At the end of the course student will be able to

1.	Discuss general design considerations involving process design development; Acquire basic understanding of design parameters and knowledge of design procedures for pressure vessels.
2.	Explain the process design of various absorption equipments.
3.	Explain designing various parts of reaction vessels.
4.	Demonstrate the procedures in designing of tray distillation columns.
5.	Apply fundamental knowledge and design equipment for heat transfer operations like heat exchangers.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	**PSO↓**		
↓ Course Outcomes							1	2	3
22MMD112.1	**2**	**3**	**3**	**2**	**1**	**2**	**1**	**1**	**2**
22MMD112.2	**2**	**3**	**3**	**2**	**1**	**2**	**1**	**1**	**2**
22MMD112.3	**2**	**3**	**3**	**2**	**1**	**2**	**1**	**1**	**2**
22MMD112.4	**2**	**3**	**3**	**2**	**1**	**2**	**1**	**1**	**2**
22MMD112.5	**2**	**3**	**3**	**2**	**1**	**2**	**1**	**1**	**2**

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	Bhattacharyya, B.C., “Introduction to chemical Equipment Design: Mechanical aspects”, CBS Publishers & Distributors, New Delhi.
2.	Serth, R.W., “Process Heat Transfer: Principles and Applications” 2007, Elsevier Ltd.
3.	Brownell, H. and Young, E.H., “Process Equipment Design: Vessel Design”, John Wiley & sons.
4.	James R. Couper, James R. Fair and W. Roy Penney, “Chemical Process Equipment - Selection and Design”, 2nd Edition, Butterworth - Heinemann, 2010.
5.	IS Code book - I.S.; 4503 - 1967, “Indian Standard Specification for Shell and Tube Type Heat Exchangers”.
6.	I.S.:2825-1969, "Code for Unfired Pressure Vessels".

REFERENCE BOOKS:

1.	Towler, G. P. and R. K. Sinnott, “Chemical Engineering Design, Principles, Practice and Economics of Plant and Process Design”, 2nd Edition, Butterworth Heinemann, 2012.
2.	M.V.Joshi , V. V. Mahajani, “Process Equipment Design” , 3rd Edition, Macmillan Publishers, 2009.
3.	S B Thakore and B I Bhatt, “Introduction to Process Engineering and Design”, Tata McGraw Hill, 1st Edition, 2007.

MECHANISM DESIGN

Course Code:	**22MMD113**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Understand the terminologies in kinematics and mechanism, Analyze the mechanisms for displacement.
2.	Analyze the mechanisms for velocity and acceleration using different methods.
3.	Design and Synthesis of four bar mechanisms for two positions using graphical methods.
4.	Design and Synthesis of four bar mechanisms for three and four positions using graphical and analytical methods.
5.	Analyze mechanisms subjected to static and dynamic forces, friction forces and Engine forces.

UNIT-I

Geometry of Motion — **15 Hours**

Introduction, analysis and synthesis, Mechanism terminology, planar, spherical and spatial mechanisms, mobility, Grubbler's rule, Equivalent mechanisms, Grashoff's law.

Kinematic Analysis: Displacement Analysis, Transmission angle, Deviation angle, Range of motion.
Velocity Analysis: Relative velocity method, Auxiliary point method.
Acceleration Analysis: Relative acceleration, Coriolis Acceleration.

UNIT-II

Synthesis of Linkages — **16 Hours**

Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance mechanisms, Precision positions, Structural error, Chebyshev's spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle, Time ratio. Poles and relative poles, Location of poles and relative poles. Two position synthesis of Slider crank, crank and rocker mechanisms.

Graphical Methods of Dimensional Synthesis

Function generation, Path generation and Body guidance mechanisms.
Analytical Methods of Dimensional Synthesis: Freudenstein's equation for four bar mechanism, Bloch's method of synthesis.

UNIT-III

Dynamics of Mechanism — **09 Hours**

Introduction, static forces, dynamic forces, D'Alembert's principle, Inertia forces in linkages, Center of percussion, Kineto-static Analysis, The superposition method.

Friction in Mechanisms

Force analysis considering friction for slider crank and four bar mechanisms.

Engine Force Analysis

Piston Effort, thrust on connecting rod, bearings and crank effort

Course Outcomes: At the end of the course student will be able to

1.	**Determine** the transmission angle, deviation angle and range of motion for mechanisms by using the knowledge of kinematics.
2.	**Determine** the velocity and acceleration of links in mechanisms using relative velocity method, auxiliary point method and Coriolis acceleration method.
3.	**Determine** precision position using Chebyshev's spacing for function generation mechanisms and **Develop** Slider crank and crank rocker mechanism for two positions using optimum transmission angle and relative pole method.

4.	**Develop** motion, path, and function generation for four bar mechanisms using graphical method. **Develop** function generation for four bar mechanisms for three positions using Freudenstein's method and Bloch's method.
5.	**Determine** static forces, dynamic forces in four bar mechanisms using kineto-static analysis and friction force and Engine forces for four bar mechanisms using analytical methods.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	PSO↓ 1	2	3
22MMD113.1	**3**	**1**	**2**	**3**	**1**	**1**	**3**	**2**	**1**
22MMD113.2	**3**	**1**	**2**	**3**	**1**	**1**	**3**	**2**	**1**
22MMD113.3	**3**	**1**	**2**	**3**	**1**	**1**	**3**	**2**	**1**
22MMD113.4	**3**	**1**	**2**	**3**	**1**	**1**	**3**	**2**	**1**
22MMD113.5	**3**	**1**	**2**	**3**	**1**	**1**	**3**	**2**	**1**

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	Mechanism Design Analysis and Synthesis by Arthur G Erdman and George N Sandor, Prentice Hall of India Pvt Ltd, New Delhi.
2.	Kinematics, Dynamics and Design of machinery – K.J. Waldron & G.L.Kinzel, Willey India,2007.
3.	Theory of Machines and Mechanism - E.Shigley & J.J.Jicker McGraw Hill company, Third edition, 2013

REFERENCE BOOKS:

1.	Mechanism and Machine Theory - A.G.Ambedkar, PHI, 2007.
2.	Theory of Machines – S S Ratan, McGraw Hill company, Fourth edition, 2015.
3.	Theory of Machines and Mechanism - Ghosh and Mallick, East West press 2007.
4.	Machines and Mechanisms - David H. Myszka, Pearson Education, 2005.

CONTINUUM MECHANICS

Course Code:	**22MMD121**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	**Understand** the concept of stress and determine the stress components.
2.	**Understand and determine** the components of strains and the stress-strain relations.
3.	**Carry out** analysis of two-dimensional problems in cartesian co-ordinates.
4.	**Solve** two-dimensional problems in polar co-ordinates.
5.	**Understand** the concepts of torsion and viscoelasticity.

UNIT-I

Introduction to Stress	**15 Hours**

Definition and notation for forces and stresses, body force, surface force, components of stresses, equations of equilibrium, specification of stress at a point- stress tensor, deviatorial and spherical stress tensors, Cauchy's equations and principal stresses, stress invariants, boundary conditions, stress transformation, Octahedral stresses.

Introduction to Strain	

Deformation, strain displacement relations, strain components, state of strain at a point, principal strains, strain invariants, strain transformation, compatibility equations, cubical dilatation, spherical and deviatorial strain tensors.

UNIT-II

General equations of Elasticity	**16 Hours**

Generalized Hooke's law in terms of engineering constants, formulation of elasticity problems, existence and uniqueness of solution, Saint - Venant's principle, principle of super position and reciprocal theorem.

Two dimensional problems in Cartesian co-ordinates	

Plane stress, plane strain, Beltrami-Michell equations for plane stress and plane strain, Airy's stress function, investigation of simple beam problems, bending of a narrow cantilever beam under end load, simply supported beam with uniformly distributed load, use of Fourier series to solve two dimensional problems.

UNIT-III

Two dimensional problems in Polar co-ordinates	**09 Hours**

Basic relations in polar coordinates, Equilibrium equation and strain-displacement relations in polar coordinates, compatibility equation and biharmonic equation in polar coordinates, thick walledcylinder subjected to internal and external pressure, rotating disks of uniform thickness, pure bendingof curved beams.

Torsion of Prismatic Bars

Introduction, Torsion of circular and elliptical cross section bars, Prandtl's Membrane analogy, Torsion of thin-walled sections.

Viscoelasticity

Linear viscoelastic behavior. Simple viscoelastic models-generalized models, linear differential operator equation.

Course Outcomes: At the end of the course student will be able to

1.	Describe the concept of state of stress at a point and determine the components of stress on any given plane and principal stresses;
2.	Compute the state of strain in an arbitrary plane and principal strains. Co-relate the stress components with strain components using generalized Hooke's law.
3.	Analyze the two-dimensional problems in Cartesian co-ordinates by applying the concept of Airy's stress function and bi harmonic equations.
4.	Analyze the stresses for two-dimensional problems on rotating disks in the polar coordinate system.
5.	Determine the shear flow and shear stress distribution in thin walled sections; Describe the generalized models used for modeling viscoelastic behavior.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	**PSO↓** 1	2	3
22MMD121.1	**2**	**2**	**3**	**2**	**2**	**1**	**3**	**1**	**2**
22MMD121.2	**2**	**2**	**3**	**2**	**2**	**1**	**3**	**1**	**2**
22MMD121.3	**2**	**2**	**3**	**2**	**2**	**1**	**3**	**1**	**2**
22MMD121.4	**2**	**2**	**3**	**2**	**2**	**1**	**3**	**1**	**2**
22MMD121.5	**2**	**2**	**3**	**2**	**2**	**1**	**3**	**1**	**2**

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	Timoshenko and Goodier, "Theory of Elasticity", Third Edition, Tata McGraw Hill Book Company, 2010.
2.	Dym C. L and Shames. I. H, "Solid Mechanics : A variational approach", Springer, 2013.

3.	G. T. Mase, R.E. Smelser, R.M. Smelser, G.E. Mase, “Continuum Mechanics for Engineers”, Taylor and Francis, 2009.
4.	Sadhu Singh, “Theory of Plasticity and Metal forming Process”, Khanna Publishers, Delhi, 1999.
REFERENCE BOOKS:	
1.	T.G.Sitharam, “Applied Elasticity”, Interline publishing, 2008.
2.	L S Srinath, “Advanced Mechanics of Solids”, Third Edition, Tata McGraw Hill Company, 2009.
3.	Sadhu Singh, “Theory of Elasticity”, Khanna publishers, 2010..
4.	Wang. C. T., “Applied Elasticity”, McGraw Hill, 1953.
5.	Haffman and Sachs, “Introduction to the Theory of Plasticity for Engineers”, Literary Licensing, LLC, 2012.
6.	Dill, Ellis Harold, “Continuum Mechanics: Elasticity, Plasticity, Viscoelasticity”, CRC Press, 2006.

COMPUTER GRAPHICS

Course Code:	**22MMD122-1**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Apply various types of geometric transformations of 2D objects to place in a coordinate system.
2.	To describe mathematically the different types of curves to draw an object
3.	To describe mathematically the different types of surfaces for representing objects
4.	To describe mathematically the different types of solid entities for representing three dimensional solids.
5.	To understand the transformation of a given continuous graphics object to discrete pixels

UNIT-I

Transformations	**15 Hours**

Representation of points, Transformations: Rotation, Reflection, Scaling, Shearing, Combined Transformations, Translations and a geometric interpretation of homogeneous coordinates, Rotation about an arbitrary point, arbitrary axis in space and axis parallel to coordinate axis. Reflection through an arbitrary line and plane.

Types and Mathematical Representation of Curves

Curve representation, Explicit, Implicit and parametric representation. Nonparametric and parametric representation of Lines, Circles, Ellipse, Parabola, Hyperbola, Conics. Parametric representation of synthetic curve, Hermite cubic splines, Bezier curves: Blending function, Properties, generation, B-spline curves

UNIT-II

Types and Mathematical Representation of Surfaces	**16 Hours**

Surface entities and parametric representation- Plane, Ruled, surface of revolution, Offset surface, Coons patch, Bezier surface, B-spline surface

Types and Mathematical Representation of Solid entities

Block, Cylinder, Cone, Sphere, Wedge, Torus, Solid representation, Fundamentals of solid modeling, Set theory, Regularized set operations, Set membership classification, Half spaces, Basic elements, Building operations, Boundary representation and Constructive solid geometry, Basic elements, Building operations.

UNIT-III

Scan Conversion and Clipping	**09 Hours**
Representation of points, lines, Drawing Algorithms: DDA algorithm, Bresenham's integer line algorithm, Bresenham's circle algorithm, Polygon filling algorithms: Scan conversion, Seed filling, Scan line algorithm. Viewing transformation, Clipping - Points, lines, Text, Polygon, Cohen-Sutherland line clipping, Sutherland-Hodgmen algorithm.	

Course Outcomes: At the end of the course student will be able to

1.	Apply various types of geometric transformations of 2D objects to place in a coordinate system.
2.	Describe mathematically the different types of curves to draw an object
3.	Describe mathematically the different types of surfaces for representing objects
4.	Describe mathematically the different types of solid entities for representing three dimensional solids.
5.	Apply the transformation of a given continuous graphics object to discrete pixels

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	**PSO↓**		
↓ Course Outcomes							1	2	3
22MMD122.1	**3**	**1**	**3**	**2**	**2**	**1**	**2**	**2**	**2**
22MMD122.2	**3**	**1**	**3**	**2**	**3**	**1**	**3**	**3**	**3**
22MMD122.3	**3**	**1**	**3**	**2**	**3**	**1**	**3**	**1**	**2**
22MMD122.4	**2**	**1**	**3**	**2**	**2**	**1**	**2**	**2**	**2**
22MMD122.5	**3**	**1**	**3**	**2**	**3**	**1**	**3**	**3**	**2**

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	IbrahamZeid, CAD/CAM-Theory and Practice-McGraw Hill, 2006.
2.	David Rogers & Alan Adams, Mathematical Elements for Computer Graphics-Tata McGraw Hill, 2002.

REFERENCE BOOKS:

1.	Xiang Z, Plastock, R. A, Computer Graphics- Schaum's Outline, McGraw Hill, 2007.
2.	Foley, van Dam, Feiner and Hughes, Computer Graphics- Principles and Practice-Addison Wesley, 1996.
3.	Sinha A N., Udai A D., Computer Graphics- Tata McGraw Hill, 2008.

COMPUTER APPLICATIONS IN DESIGN

Course Code:	**22MMD123**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Understand the geometric transformations and projection methods in CAD.
2.	Identify and develop the geometric models to represent curves and surface modelling.
3.	Understand the concept of solid models designing for engineering.
4.	Analyze the visual realism to the solid modelling.
5.	Understand the mesh generation techniques for engineering analysis

UNIT-I

Introduction to computer graphics fundamentals — **15 Hours**

Output primitives (points, lines, curves etc.,), 2-D & 3-D transformation (Translation, scaling, rotation) windowing - view ports - clipping transformation.

Curves and surfaces modelling

Introduction to curves - Analytical curves: line, circle and conics – synthetic curves: Hermite cubic spline- Bezier curve and B-Spline curve – curve manipulations. Introduction to surfaces - Analytical surfaces: Plane surface, ruled surface, surface of revolution and tabulated cylinder – synthetic surfaces: Hermite bicubic surface- Bezier surface and B-Spline surface- surface manipulations.

UNIT-II

NURBS and solid modeling — **16 Hours**

NURBS- Basics- curves, lines, arcs, circle and bi linear surface. Regularized Boolean set operations - primitive instancing - sweep representations - boundary representations – constructive solid Geometry - comparison of representations - user interface for solid modeling.

Visual realism

Hidden – Line – Surface – solid removal algorithms shading – coloring. Introduction to parametric and variational geometry based software's and their principles creation of prismatic and lofted parts using these packages.

UNIT-III

Assembly of parts and product data exchange — **09 Hours**

Assembly modeling - interferences of positions and orientation - tolerances analysis – mass property calculations - mechanism simulation. Graphics and computing standards- Open GL Data Exchange standards – IGES, STEP- Communication standards**.**

Course Outcomes: At the end of the course student will be able to

1.	Apply geometric transformations and projection methods in CAD
2.	Develop geometric models to represent curves and surface modelling.
3.	Design solid models for engineering design.
4.	Apply visual realism to the solid modelling
5.	Apply mesh generation techniques for engineering analysis

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	**PSO↓**		
↓ Course Outcomes							1	2	3
22MMD123.1	**3**	**1**	**2**	**3**	**3**	**1**	**3**	**1**	**1**
22MMD123.2	**3**	**1**	**2**	**3**	**3**	**1**	**3**	**1**	**1**
22MMD123.3	**3**	**1**	**2**	**3**	**3**	**1**	**3**	**1**	**1**

22MMD123.4	**3**	**1**	**2**	**3**	**3**	**1**	**3**	**1**	**1**
22MMD123.5	**3**	**1**	**2**	**3**	**3**	**1**	**3**	**1**	**1**

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	David F. Rogers, James Alan Adams "Mathematical elements for computer graphics" second edition, Tata McGraw-Hill edition.2003
2.	Donald Hearn and M. Pauline Baker "Computer Graphics", Prentice Hall, Inc., 1992.

REFERENCE BOOKS:

1.	Foley, Wan Dam, Feiner and Hughes – Computer graphics principles & practices, Pearson Education – 2003.
2.	Ibrahim Zeid Mastering CAD/CAM – McGraw Hill, International Edition, 2007.
3.	William M Neumann and Robert F. Sproull "Principles of Computer Graphics", Mc Graw Hill Book Co. Singapore, 1989.

AUTOMOBILE SYSTEM DESIGN

Course Code:	**22MMD131**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Select and design the clutch and propeller of automobile system for a given situation.
2.	Design different types of axles in automobile system
3.	Design different types of breaking system in automobile system
4.	Design different types of steering system in automobile system
5.	Design different types of suspension system in automobile system

UNIT-I

Design of clutch system — **15 Hours**

Design of various clutch system components (Single plate, multiple plates, centrifugal clutch, lining material) and Pressure Plate Assembly components. Hydraulic Clutch system components (Master Cylinder, Slave cylinder, reservoir) clutch fluid – its properties, hydraulic pipes. Clutch Pedal & Clutch hand lever design. Clutch cable Design / selection considerations.

Design of propeller shaft

Design of propeller shaft for bending, torsion, rigidity and critical speed criteria. Design of universal joint and slip joint.

UNIT-II

Design of Axle — **16 Hours**

Front Axle beam, Steering Knuckle, King pin. Rear Axle (drive Axle) tube, Design of fully floating, half floating axle and dead axle. Design of Final drive and differential: Design of spiral bevel and hypoid type of final drive/differential.

Design of braking system

Brake balance, Stopping distance, Brake fade, Work done in braking, Braking efficiency, Braking of vehicle, Braking of vehicle moving in a curved path, Design of drum brake, Design of disc brake, Design of hydraulic brake system, Design of hand brake or parking brake.

UNIT-III

Design of steering system — **09 Hours**

Condition for true rolling, Turning circle radius, Principle of Ackermann steering, Ackermann-linkage geometry, Steering gear ratio, Steering box torque, Design of various steering gear box.

Design of suspension system

Function of suspension, Forces act on suspension, Suspension springs (laminated or leaf, coil, torsion bar, rubber spring, pneumatic spring), Design of laminated or leaf spring, Design of helical or coil spring, Design of torsion bar spring.

Course Outcomes: At the end of the course student will be able to

1.	Design the clutch for a given situation of automobile vehicle and design the propeller shaft for given situation of automobile vehicle.
2.	Design the Axle for a given situation of automobile vehicle.
3.	Design the steering system for given situation of automobile vehicle
4.	Design the braking system for given situation of automobile vehicle
5.	Design the suspension system for given situation of automobile vehicle

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	**PSO↓**

↓ Course Outcomes							1	2	3
22MMD131.1	**3**	**2**	**3**	**3**	**2**	**1**	**2**	**2**	**3**
22MMD131.2	**3**	**2**	**3**	**3**	**2**	**1**	**2**	**2**	**3**
22MMD131.3	**3**	**2**	**3**	**3**	**2**	**1**	**2**	**2**	**3**
22MMD131.4	**3**	**2**	**3**	**3**	**2**	**1**	**2**	**2**	**3**
22MMD131.5	**3**	**2**	**3**	**3**	**2**	**1**	**2**	**2**	**3**

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	Elements of Motor Vehicles Design by DTB donkins, TMH
2.	Automobile Chassis Design and calculations by P.Lukin, Mir Publishers
3.	Auto design Problems by K.M.Agrawal, Satyaprakashan.
4.	Automotive Mechanics by N.K.GIri, Khanna Publishers
5.	Machine Design by Sadhusingh, Khanna Publishers
6.	Automobile Chassis Design by Dean Averns, Lllife Books Ltd (1992)
7.	Automobile Engg. Vol - I & II by Kirpal Singh, Standard Pub.
8.	Automobile Engg. Vol - I & II by K.M.Gupta, Umesh Pub.
9.	Auto Design by R.B. Gupta, Satya Prakashan
10.	“Mechanical Engineering Design”, Fourth Edition, by Joseph E. Shigley & Larry D. Mitchell, McGraw-Hill International Book Company
11.	Design of Machine Elements by Bhandari , Tata McGraw-Hill Publishing Company Ltd
12.	Machine Design by, Sharma and Agrawal, S.K.Kataria & Sons
13.	Transmission System Design by R.B.Patil, TechMax Pub., Pune.
14.	Machine Design Vol - II & III by F.Haideri, Nirali Prakashan, Pune.
15.	PSG Design Data Book.
16.	Automotive Chassis by P.M.Heldt , Chilton Co., NY (1992)
17.	Machine Design by Pandya and Shah, Charotar Publishing House.
18.	Machine Design by R S Khurmi J.K.Gupta, S chand & Co.
19.	Elements of Motor Vehicles Design by DTB donkins, TMH
20.	Automobile Chassis Design and calculations by P.Lukin, Mir Publishers
21.	Auto design Problems by K.M.Agrawal, Satyaprakashan.
22.	Automotive Mechanics by N.K.GIri, Khanna Publishers
23.	Machine Design by Sadhusingh, Khanna Publishers

E-Source

1.	http://nptel.ac.in/
2.	www.learnerstv.com
3.	http://auto.howstuffworks.com/
4.	nptel.iitk.ac.in/

CREATIVE ENGINEERING

Course Code:	**22MMD132**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	To prepare students to understand the steps involved in the creative thinking process
2.	To prepare students to apply the various techniques for stimulating creativity and innovation thinking
3.	To prepare students to analyze the techniques to design and develop new products.
4.	To prepare students to synthesize the creative design with analysis to develop new products
5.	To prepare students to develop CEDA approach for realistic applications.

UNIT-I

Introduction Creative thinking — **15 Hours**

Blocks to creativity, factors that influence creative design, engineering design and creative design, influence of society, technology and business on creativity, force field analysis, market pull & technology push, attribute of a creative person, creative thinking in groups, creating a creative climate. CREATIVITY & PRODUCT DESIGN Need or identification of a problem, market survey, data collection, review & analysis, problem definition, Kipling method, challenge statement, problem statement initial specifications

Idea Generation Brain storming, analogy technique or synectics, check list, trigger words, morphological method, interaction matrix method, analysis of interconnected decision making, CREATIVE THINKING PROBLEM / OPPORTUNITY Pictures of situation, environment, quantification, Heros, boundary conditions, record discuss-clarify-verify, recording of ideas, evaluation of ideas, detail design, prototyping, product deployment, useful life assessment, recycling.

UNIT-II

Emotional Design — **16 Hours**

Three levels of Design – Viceral, Behavioral and Reflective- design by individual and design in groups, designs with personality – machines that senses emotions and induce emotions- Robots, personality products, products for games, fun, people and places; Simulation – dimensional or mathematical, virtual simulation, physical simulation, scale down models.

Theory Of Inventive Problem Solving (Triz) Common features of good solutions – resolve contradiction, use available resource, increase the ideality, trade-off, inherent contradiction, 30 key TRIZ principles – multifunction, preliminary action, compensation, nested doll, blessing in disguise, segmentation, separation, regional influences, symmetry change, opaque & porous, inflate and deflate, color, recycle & recover, phase transformation, energy, imaging, environment, composition, economical, surface response, equipotential, static & dynamic, continuous & intermittent, servo systems, smart systems, dimensions

UNIT-III

Application of Ceda Approach — **09 Hours**

(a) Cooking stove for rural India; (b) utilizing solar energy; (c) water filtration systems; (d) automation in healthcare; (e) technologies for law enforcement; (f) application of robots to reduce human fatigue (g) Layout of berths in a railway coach.

Course Outcomes: At the end of the course student will be able to

1.	Explain the steps involved in the creative thinking process
2.	Apply the various techniques for stimulating creativity and innovation thinking

3.	Analyze the techniques to design and develop new products.
4.	Synthesize the creative design with analysis to develop new products
5.	Develop CEDA approach for realistic applications.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	PSO↓ 1	2	3
22MMD132.1	**3**	**2**	**2**	**2**	**1**	**1**	**3**	**2**	**3**
22MMD132.2	**3**	**1**	**1**	**2**	**1**	**1**	**3**	**2**	**3**
22MMD132.3	**3**	**2**	**1**	**2**	**1**	**1**	**3**	**2**	**3**
22MMD132.4	**3**	**1**	**1**	**2**	**1**	**1**	**3**	**2**	**3**
22MMD132.5	**2**	**2**	**1**	**2**	**1**	**1**	**3**	**2**	**3**

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	Amaresh Chakrabarti, Creative Engineering Design Synthesis, Springer, 2009
2.	Floyd Hurt, Rousing Creativity: Think New Now, Crisp Publ Inc. 1999, ISBN 1560525479
3.	Donald A. Norman,Emotional Design, Perseus Books Group New York , 2004, ISBN 123-1-118- 027-6
4.	Kalevi Rantanen & Ellen Domb, Simplified TRIZ – II edn., Auerbach Publications, Taylor & Francis Group, 2010, ISBN: 978-142-0062-748

MECHATRONICS SYSTEM DESIGN

Course Code:	**22MMD133**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Design a mechatronics system for a specific application
2.	Select the sensors and actuators required for mechatronics system
3.	Design a signal conditioning circuit
4.	Understand dynamics and control of a mechatronics system
5.	Understand MEMS based systems and their fabrication methods

UNIT-I

Introduction — **15 Hours**

Definition and Introduction to Mechatronic Systems, Overview of Mechatronic products and their functioning, measurement systems, Control Systems, Simple Controllers, Integrated Design Issues in Mechatronics, Mechatronics Design Process, Key Elements of Mechatronics system.

System Models

Mathematical models, mechanical system building blocks, electrical system building blocks, thermal system building blocks, pneumatic systems build blocks. Electro-mechanical systems, hydro-mechanical systems.
Active learning of System Models using computer simulations.

Sensors

Introduction, Sensors for Motion and Position Measurement, Proximity sensors, Electrical strain and stress measurement, Force measurement, Vibration–Acceleration Sensors, Time of flight sensors, Binary force sensors, Temperature measurement, Sensors for Flow Measurement, Pressure measurement, Problems, Laser Displacement Sensors.
Active Learning of sensors and their application.

UNIT-II

Actuators — **16 Hours**

Introduction, Electromagnetic Principles, Solenoids and Relays, Electric Motors, DC Motors, DC Motor Electrical Equation, Permanent Magnet DC Motor, Dynamic Equations, Electronic Control of a Permanent Magnet DC Motor, the servo motor, Stepper Motors, Stepper Motor Drive Circuits, Selecting a Motor, Hydraulics, Hydraulic Valves, Hydraulic Actuators, Pneumatics. Piezoelectric Actuators, Different types of Piezoelectric Actuators.
Active Learning of actuators and their application.

Signal Conditioning

Amplifiers, ideal operational amplifier model, inverting amplifier, non-inverting amplifier, unity-gain buffer summing amplifier, difference amplifier, instrumentation amplifier, integrator amplifier, differentiator amplifier, comparator, sample and hold amplifier, active filters, Problems, Data acquisition, Introduction, Sampling and aliasing, Quantization theory, Digital-to-analog conversion hardware, Analog-to-digital conversion hardware, Problems, Protection, Filtering, Wheatstone Bridge, Digital signals, Multiplexers, Data Acquisition.
Active Learning of Data Acquisition Systems

UNIT-III

Control theory-Analysis — **09 Hours**

Introduction System response, Dynamic characteristics of a control system Zero-order systems, First-order systems, Second-order systems, General second-order transfer function Systems, Modeling and interdisciplinary analogies, Stability, The Routh-Hurwitz stability criterion, Steady-state errors, Proportional, Proportional-Integral, Proportional-Integral-Derivative controllers, Problems.

Micro Electro Mechanical Systems (MEMS)

Benefits of miniaturization, Working principles of MEMS and microsystems, Scaling Effect, Sensitivity of resonance frequency to the mass change in a micro cantilever beam, sensitivity of change in displacement with respect to change in acceleration in a spring mass damper system, Trimmer's Force Scaling Vector, scaling in electro static forces, micro sensors, acoustic wave sensors, biomedical sensor, chemical sensors, optical sensors, micro pressure sensors, micro thermal sensors, micro actuators, micro actuation using thermal forces, actuation using shape memory alloys (SMA), micro actuation using electrostatic forces, applications of micro actuations, micro-valves, micro-pumps and micro heat pipes, micro-accelerometers and micro gyroscopes

Microfabrication Processes

Photolithography, Ion implantation, Diffusion, Oxidation Chemical vapor deposition, Physical vapor deposition (Sputtering), Deposition by epitaxy, Etching.

Micromanufacturing

Bulk micromanufacturing, Surface micromachining, LIGA process

Active learning of MEMS Sensors like Accelerometers, gyroscopes, and Pressure Sensors

Course Outcomes: At the end of the course student will be able to

1.	**Develop** a mathematical model for a mechatronics system consisting of Mechanical, electrical, hydraulic, pneumatic, and thermal systems and **simulate** the same using software tool.
2.	**Design** a sensor subsystem for a mechatronics system using IR sensor, laser displacement sensor, ultrasonic sensor, load cell, rotary encoder, draw wire sensor, temperature sensor and tool force dynamometer, inductive pick up, hall effect sensor and force sensing resister. **Design** an actuator subsystem for a mechatronics system using mechanical relays, solid state relays, DC Motor, Stepper Motor, AC Motor, Piezoelectric actuator, and pneumatic actuator
3.	**Design** a data acquisition subsystem for Mechatronics system implementing signal conditioning using operational amplifiers for filtering noise signal, summing, differentiating, integrating, subtracting, and comparing the input signals. **Design** analog to digital converters and digital to analog converters for the specified bit number capacity in a mechatronics system.
4.	**Design** a PLC controlled pneumatic actuation and control system for sequencing and control of pneumatic cylinders using direction control valves, pressure-to-electric converters, limit switches, proximity sensors, flow control valves and delay valves. **Develop** the mathematical model for the control of first order and second order systems (Electro-mechanical system) and their simulation using software tool. **Analyse** the effect of P, P-I, P-I-D controllers for the speed control of Dc motor
5.	**Describe** the concept of scaling in mechanical system and the MEMS based sensors and actuators and the microfabrication techniques used to develop the MEMS device. **Design** a MEMS sensor-based mechatronics system to measure the displacement, velocity, acceleration of vibrating cantilever beam.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	**PSO↓** 1	2	3
22MMD133.1	**1**	**1**	**3**				**1**	**1**	**1**
22MMD133.2	**1**	**2**	**3**				**1**	**1**	**1**
22MMD133.3	**1**	**2**	**3**				**1**	**1**	**1**
22MMD133.4	**1**	**2**	**3**				**1**	**1**	**1**
22MMD133.5	**1**	**2**	**3**				**1**	**1**	**1**

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	**"Introduction to Mechatronics & Measurement Systems"** Michel. B. Histand & David. Alciatore, McGrewHill

2.	Devdas Shetty and Kolk "**Mechatronics System Design**"-Thomson.
3.	HSU"**MEMS and Microsystems design and manufacture**"-TMH
REFERENCE BOOKS:	
1.	**"Mechatronics"**-W. Bolton,2 Ed. Addison Wesley Longman, Pub,1999
2.	Mahalik "**Mechatronics**"-TMH
3.	**"Mechatronics"–**HMT, TMH.
4.	Kamm,"**Understanding Electro Mechanica lEngineering an Introduction to Mechatronics"-**PHI.
5.	**"Fine Mechanics and Precision Instruments"**-PergamonPress,1971.

BIOMECHANICS

Course Code:	**22MMD211**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1. Describe the biological, mechanical, and neurological mechanisms by which muscles produce movement.
2. Analyze the forces at a skeletal joint for various static and dynamic human activities.
3. Demonstrate a basic understanding of human Bio-fluid Mechanics.
4. Understand the cardiovascular, Respiratory, and Implants mechanics.
5. Recall the general characteristics, material properties, appropriate constitutive model, and adaptation potential for tissue and organs studied.

UNIT-I

Introduction of Mechanics — **7 Hours**

Introduction – Issues in Real Time Computing – Structure of a Real Time System – Task classes – Performance Measures for Real Time Systems – Estimating Program Run Times – Task, Assignment and Scheduling – Classical uniprocessor scheduling algorithms – Uniprocessor scheduling of IRIS tasks – Task assignment – Mode changes and Fault Tolerant Scheduling. Operating System Fundamentals, General and Unix OS architecture Embedded Linux.

Biomechanics of Joints — **7 Hours**

Skeletal Joints, Skeletal Muscles, Joint Function, forces and stresses in human joints, Mechanics of the Elbow, Shoulder, Spinal Column, Hip, Knee, and Ankle.

UNIT-II

Bio-fluid Mechanics — **7 Hours**

The Circulatory System in the Human Body, The Heart as a Pump, Nature of Blood, Nature of Blood Vessels, Modeling of Flow In Blood Vessels, **Steady Blood Flow Theory**, **Pulsatile Blood Flow Theory,** Blood Vessel Bifurcation: An Application of Poiseuille's Formula and Murray's Law, Flow in a Rigid-Walled Curved Tube, Flow in Collapsible Tubes, Pulmonary Circulation, The Pressure-Pulse Curve in the Right Ventricle, Effect of Pulmonary Arterial Pressure on Pulmonary Resistance

5 Hours

Introduction to cardiovascular Mechanics, Respiratory Mechanics, Applied Biomechanics, and Biomechanics of Implants

UNIT-III

Hard Tissues — **7 Hours**

Common Characteristics of Biological Tissues Structure of Bone, Biomechanics of Bone-Composition of Bone, Mechanical Properties of Bone, Structural Integrity of Bone, Bone Fractures, Elastic Properties, Viscoelasticity, Empirical Models of Viscoelasticity.

Soft Tissues — **7 Hours**

Structure and function of soft tissues: Tendons and Ligaments, Skeletal Muscles, Articular Cartilage.

Course Outcomes: At the end of the course student will be able to

1.	Describe human movement in both anatomical and mechanical terms.
2.	Explain and apply the principles of kinetic and kinematic data collection and analysis for different joints.
3.	Apply knowledge of fluid mechanics to understand the flow properties of blood and its laws to cardiovascular, Respiratory, and Implant systems.
4.	Discuss and present emerging new technologies in the biomechanics field and appreciate the multi-disciplinary collaborative nature of biomechanics research.
5.	Apply the concepts and theory of viscoelasticity to soft tissues, hard tissues, cartilage, and bone.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6		PSO↓	
↓ Course Outcomes							1	2	3
22MMD211.1	3	2	3	1	1	3	1	1	1
22MMD211.2	3	2	3	1	1	3	1	1	1
22MMD211.3	3	2	3	1	1	3	1	1	1
22MMD211.4	3	2	3	1	1	3	1	1	1
22MMD211.5	3	2	3	1	1	3	1	1	1

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	Y C Fung, Biomechanics: Mechanical Properties of Living Tissues, Springer, 2nd edition, 1993.
2.	N. Ozkaya and M. Nordin, Fundamentals of Biomechanics-Equilibrium, Motion and Deformation, Springer-Verlag, 2nd edition 1999
3.	Duane Knudson, Fundamental of biomechanics, Springer, 2nd edition 2007
4.	D. J. Schneck and J. D. Bronzino, Biomechanics- Principles and Applications, CRC Press, 2nd Edition, 2000
5.	Joseph D, Bronzino, "The Biomedical Engineering Handbook", CRC Press, 3rd edition, 2006.
6.	Mow, Van C.; Huiskes, Rik, Basic Orthopaedic Biomechanics and Mechano-Biology, 3rd Edition,2005, Lippincott Williams & Wilkins
7.	Krishnan B Chandran, Ajit P Yoganathan, Stanley E Rittgers, Biofluid Mechanics the human circulation, CRC Press, Taylor & Francis Group
8.	Daniel J Schneck, Joseph D Bronzino, Biomechanics Principles and applications, CRC Press
9.	Ayyaswamy, P. S. (2016).Introduction to Biofluid Mechanics. Fluid Mechanics, e1-e73. doi:10.1016/b978-0-12-405935-1.00016-2

EXPERIMENTAL STRESS ANALYSIS

Course Code:	**22MMD212**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Differentiate between stress and strain and between experimental stress analysis with other techniques and be aware about the latest developments in the field
2.	Use electric resistance strain gauges for strain measurement by identifying the types, their characteristics, performance, influence of the environment, the circuits used for measurement and the commonly used strain gauge arrangements.
3.	Discuss about photoelasticity for stress measurements by recognizing the laws, effects, materials used, instrumentation required, data obtained and its analysis.
4.	Discuss about photoelastic coatings for stress and strain measurements and differentiate its behaviour from photoelastic model materials.
5.	Present information about Holography and Moire techniques for stress and strain measurements

UNIT-I — **15 Hours**

Overview of Experimental stress analysis – analytical, numerical and experimental approaches, specific domain of these approaches, advantages and disadvantages
Introduction to stress and strain
Recent developments in experimental stress analysis techniques - Shearography, Speckle Interferometry, Thermoelastic stress analysis and Digital Image Correlation
Electrical resistance gauges - Introduction - physical principle, strain sensitivity of gage metals, gage construction, gage sensitivity and gage factor, transverse sensitivity factor performance characteristics, environmental effects, strain gage circuits – Potentiometer, Wheatstone bridge, constant current and voltage circuits.
Strain rosettes – introduction, two element, three element, rectangular and delta rosettes.

UNIT-II — **15 Hours**

Transmission photoelasticity – physical principle, historical development, birefringence, nature of light, Polarization, methods to get polarized light, plane and circular polariscope, stress-optic law, waveplates, Isoclinics and Isochromatics, Fringe order determination, Tardy's Compensation method and fringe multiplication techniques
Photoelastic coatings – introduction, strain-optic relation for coating, evaluation of coating and specimen stresses, correction factors for photoelastic coatings, coating materials, properties of coating materials, selection of coating thickness
Brittle coatings – introduction, brittle coating technique principles, crack patterns produced, steps in brittle coating tests, coating selection and surface preparation.

UNIT-III — **10 Hours**

Moire technique – introduction, geometrical approach, displacement approach, in-plane and out-plane moiré methods, moiré photography and moiré grid production.
Holography - introduction, difference between normal photography and holography, equation for plane and spherical waves, recording and reconstruction process, intensity and coherence, Holographic interferometry, Real time and Double exposure methods.

Course Outcomes: At the end of the course student will be able to

1.	Differentiate between experimental stress analysis with analytical and numerical techniques and explain about the latest developments in the field.
2.	Explain the use of electric resistance strain gauges for strain measurement by identifying the types, their characteristics, performance, influence of the environment, the circuits used for measurement and the commonly used strain gauge arrangements.
3.	Discuss about photo elasticity for stress measurements by recognizing the laws, effects, materials used, instrumentation required, data obtained and its analysis.
4.	Discuss about photo elastic coatings for stress and strain measurements and differentiate its behaviour from photo elastic model materials.
5.	Discuss about Holography and Moire techniques for stress and strain measurements

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	**PSO↓** 1	2	3
22MMD212-1.1	1	2	3	2	3	3	1	3	3
22MMD212-1.2	1	2	3	3	2	3	1	1	3
22MMD212-1.3	1	2	3	1	3	3	1	2	3
22MMD212-1.4	1	2	3	2	1	3	1	1	3
22MMD212-1.5	1	2	3	2	2	2	1	3	2

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	K.Ramesh, e-book on Experimental Stress Analysis (DVD Media), IIT Madras, 2009.
2.	J.W.Dally and W.F.Riley, Experimental Stress analysis, McGraw Hill, 1991.
3.	L.S.Srinath, M.R.Raghavan, K.Lingaiah, G.Gargesa, B.Pant and K.Ramachandra, "Experimental Stress Analysis, Tata McGraw Hill, 1984.

REFERENCE BOOKS:

1.	Sadhu Singh, Experimental Stress Analysis, Khanna Publishers, 2009.
2.	U.C.Jindal, Experimental Stress Analysis, Pearson 2013.

SMART MATERIALS AND STRUCTURES

Course Code:	**22MMD213**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Study the basic concepts and applications of various types of smart structures along with the properties and effects of piezoelectric material.
2.	To carry out modeling of beams subjected to pure bending harmonic excitation and understand the mechanism of actuation using single and double actuators.
3.	To study the concept and effect of shape memory alloys along with their applications
4.	To understand the mechanism, properties and applications of electrorheological and magnetorheological fluids.
5.	To study the mechanical properties and scaling of MEMS materials along with modeling and active control of smart structures.

UNIT-I

15 Hours

Smart structures: Types of Smart Structures, Potential Feasibility of Smart Structures, Key elements of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, De poling and Coercive Field, field strain relation. Hysteresis, Creep and Strain rate effects, Inchworm Linear Motor.

Beam Modeling: Beam modeling with induced strain Rate effects, Inchworm Linear Motor Beam Modeling with induced strain actuation, single actuators, dual actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli-Euler beam Model, problems, Piezo-electrical applications.

UNIT-II

15 Hours

Shape memory Alloy: Experimental Phenomenology, Shape Memory Effect, Phase Transformation, Tanaka's Constitutive Model, testing of SMA Wires, Vibration Control through SMA, Multiplexing. Applications of SMA and Problems.

ER and MR Fluids: Mechanisms and properties, Fluid Composition and behavior, The Bingham Plastic and related models, Pre-Yield Response, Post-Yield flow applications in Clutches, Dampers and Others.

UNIT-III

MEMS **10 Hours**

Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration. Modeling, Control Strategies and Limitations, Active Structures in Practice.

Course Outcomes: At the end of the course student will be able to

1.	Explain the basic concept, types and applications of various smart structures along with hysteresis, creep and strain rate effect of piezoelectric materials.
2.	Model beams using Bernoulii-Euler beam model subjected to pure bending harmonic excitation.
3.	Describe the shape memory effect along with applications of shape memory alloys and vibration control through shape memory alloys
4.	Explain the mechanism and properties of ER and MR fluids along with their applications.
5.	Discuss the mechanical properties of MEMS materials and scaling of mechanical systems along with modeling and active control of smart structures.

Course Outcomes Mapping with Program Outcomes & PSO

	Program Outcomes→	1	2	3	4	5	6		**PSO↓**	

↓ Course Outcomes							1	2	3
22MMD213.1	2	2	2	3	2	2	2	2	2
22MMD213.2	3	3	3	2	3	2	3	3	3
22MMD213.3	3	2	2	3	3	2	3	1	3
22MMD213.4	2	3	1	2	2	2	1	2	2
22MMD213.5	3	1	3	3	3	2	3	3	3

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	M. V. Gandhi and B. S. Thompson, Smart Materials and Structures, Chapman and Hall, London, New York,1992(ISBN:0412370107).
2.	B.Culshaw,SmartStructuresandmaterials,ArtechHouse,Boston,1996(ISBN:0890066817).
3.	A. V. Srinivasan, Smart Structures: Analysis and Design, Cambridge University Press, Cambridge; New York, 2001(ISBN:0521650267).

REFERENCE BOOKS:

1.	A. J. Moulson and J. M. Herbert, Electro ceramics: Materials, Properties and Applications, John Wiley & Sons, ISBN:0471497429.
2.	Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin NewYork,2002(ISBN:3540422595).
3.	K.Uchino,PiezoelectricActuatorsandWtrasonicMotors,KluwerAcademicPublishers,Boston,1997(ISBN: 0792398114).
4.	G. Engdahl, Handbook of Giant Magnetostrictive Materials, Academic Press, San Diego, Calif, London,2000 (ISBN:012238640X).

DESIGN AND CONTROL OF ROBOTIC MANIPULATOR

Course Code:	**22MMD221**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Understand 3D Homogeneous vector transformations with reference to the robotic applications
2.	Formulate the direct and inverse kinematics solution for Robotic manipulators
3.	Understand the robot differential motions and manipulator Jacobian
4.	Formulate the equation of motion for robot manipulators
5.	Understand robot trajectory planning and control

UNIT-I

Introduction to robotics **14 Hours**

Robot anatomy, Links and joints, Degree of Freedom, arm configuration, Wrist configuration, End effectors, Coordinate frames, Mapping, Mapping between rotated frames, Mapping between translated frames, Mapping between rotated and translated frames, Description of object in space, Problems

Active Learning of 3D homogeneous Transformations.

Direct Kinematics and Inverse kinematics: Mechanical structure and Notations, Description of links and joints, Kinematic Modeling of the manipulator, Denavit – Hartenberg notation, Kinematic relationship between adjacent links, Manipulator transformation matrix, Problems, Manipulator workspace, Solvability of inverse kinematic model, Existence of solution, Multiple solutions, Solution technique, Closed form solution, Guidelines to obtain closed form solutions, Problems.

Active Learning of Direct and inverse kinematics.

UNIT-II

13 Hours

Manipulator Differential Motion and Statics: Linear and angular velocity of rigid body, Linear velocity, Angular velocity, Linear velocity due to angular motion, Combined linear and angular motion, Relationship between transformation matrix and angular velocity, Mapping velocity vector, Velocity propagation of a link, Angular velocity of a link, Manipulator Jacobian, Jacobian computation, The prismatic joint Jacobian, The rotary joint Jacobian, Jacobian inverse, Jacobian singularity, Computation of singularities, Wrist singularities, Arm singularities, Problems.

Active Learning of Robot Jacobian and robot singularities.

UNIT-III

13 Hours

Robot Dynamics: Lagrangian mechanics, Two degree of freedom manipulator – dynamic model, Lagrange – Euler formulation, Velocity of a point on the manipulator, The inertia tensor, the kinetic energy, The potential energy, Equation of motion, The LE dynamic model algorithm

Robot Trajectory Planning and Control

Definitions and planning tasks, Terminology, joint space techniques, Use of a p- Degree polynomial as interpolation function, Cubical polynomial trajectories, A straight -line path, A circular path, Position path, Orientation path, Joint-space versus Cartesian space, trajectory planning, problems, Open and closed loop control, The manipulator control problems, Characteristic of the second order linear system, Model of a DC motor, Partitioned PD control scheme, Effect of an external disturbance,PID control scheme, Computed Torque Control, Force control of Robotic Manipulator.

Active Learning on Derivation of Dynamic equation of motion for 2DOF and 3DOF robot configurations

Course Outcomes: At the end of the course student will be able to

1.	Solve complex 3D homogeneous transformations involving multiple rotation and multiple translations of moving coordinate system with respect to a reference coordinate system. Compute the rotation matrix for the rotation of moving coordinate system about an arbitrary axis. Compute the inverse transformation matrices. Represent the vector in different coordinate system
2.	Compute the direct kinematics and Inverse kinematics solution for 2R Planar, Cylindrical, 3R, 5R and SCARA robot. Compare the direct and inverse kinematics solution obtained for different home positions of a robot.
3.	Compute the Jacobian matrix for 2R Planar, Cylindrical, 3R, 5R, SCARA robot and calculate their singular configurations. Develop a robot configuration and demonstrate its arm and wrist singularities
4.	Compute the Kinetic energy and potential energy of 2R Planar robot. Solve the dynamic equation of motion for a 2R Planar robot using Lagrange- Euler method.
5.	Compute the joint trajectories (Displacement, velocity, and Acceleration with respect to time) of prismatic and rotary joint for the given joint displacement and time specifications using cubic polynomial trajectory planning and Trapezoidal velocity trajectory planning schemes. Design a PID controller for dc motor driven robot joint.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6		**PSO↓**	
↓ Course Outcomes							1	2	3
22MMD221.1	**2**	**1**	**3**				**1**	**1**	**1**
22MMD221.2	**2**	**1**	**3**				**1**	**1**	**1**
22MMD221.3	**2**	**1**	**3**				**1**	**1**	**1**
22MMD221.4	**2**	**1**	**3**				**1**	**1**	**1**
22MMD221.5	**2**	**1**	**3**				**1**	**1**	**1**

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	Robotics and Control, R K Mithal and I J Nagrath, McGraw Hill
2.	Introduction to Robotics Analysis, Niku, S.B., Systems, Applications, Pearson Education, 2008.

REFERENCE BOOKS:

1.	Introduction to Robotics: Mechanics and Control -2nd Edition-Craig, J.J., Addison, Welsey, 2nd edition 1989.
2.	Fundamentals of Robotics, Analysis and Control- Schilling R.J., PHI, 2006
3.	Robotics Control, Sensing, Vision and Intelligence- Fu K.S., Gonzalez R C., Lee C., S.G., McGraw Hill,1987.

DESIGN FOR MANUFACTURING

Course Code:	**22MMD222**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	To teach students various steps in the product development process and the significance of early phases of design
2.	To teach fundamental principles of design and application of these principles in practical design problems.
3.	To teach design of systems for ease of assembly and manufacture
4.	To teach interrelations among part geometry, tolerances, materials and manufacturing processes
5.	To teach principles of robust design procedures and how to set values for various design variables.

UNIT-I

15 Hours

Material and Process Selection: Introduction, Advantages of applying DFMA, General requirements of early materials and process selection, Selection of Manufacturing processes, Process capabilities, Selection of materials, Primary process/ materials selection, Systematic selection of processes and materials.

Engineering Design Features: Dimensioning, Tolerances, General Tolerance, Geometric Tolerances, Assembly limits, achieving larger machining tolerances. Screw threads, Ground surfaces, holes. Examples.

Datum features – Functional datum, Machining sequence, manufacturing datum, changing the datum. Examples

Component Design - Machining Considerations: Drills, Milling cutters, Drilling, Keyways, Dowels, Screws, Reduction in machining areas, Simplification by separation and amalgamation, work piece holding, surface grinding, Examples.

UNIT-II

15 Hours

Component Design – Casting Considerations: Pattern, Mould, parting line, cast holes, machined holes, identifying parting line, special sand cores, designing to obviate sand cores. Examples

Design for Injection Molding and Sheet Metal Working: Injection molding materials, Molding cycle, Systems, molds, machine size, cycle time, Cost estimation, Insert molding, Design guidelines, Introduction to sheet metalworking, Dedicated Dies and Press working, Press selections, Design Rules. 8 Hours.

Design for Die Casting and Powder Metal Processing: Die casting alloys, cycle, machines, dies, finishing, Assembly techniques, Design principles, Powder metallurgy processing, stages, compaction characteristics, Tooling, Sintering, Design guidelines

UNIT-III

Geometric Tolerance **10 Hours**

Symbols, Three datum concept of dimensioning, Straightness, concentricity, Run-out, Location Tolerance, Assembly of parts having concentric cylinders, Control of feature location by true position, Body of revolution, Roundness, Profile dimensioning, Tapers, Shaft of two diameters. Examples.

Course Outcomes: At the end of the course student will be able to

1.	Establish a list of candidate materials for each component of design through identification of functional requirements and selection criteria based on loading.

2.	Identify control factors, noise factors, and an appropriate orthogonal array to set up an experiment to establish relation between various design variables and performance requirements.
3.	Evaluate and improve the assembly efficiency for a given product.
4.	Identify and apply the suitable manufacturing process to product or product mix.
5.	Apply all of the design methods learned in this course to redesign a product for ease of manufacture, and robustness (insensitive to variations).

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6		**PSO↓**	
↓ Course Outcomes							1	2	3
22MMD222.1	2	2	2	2	3	3	1	3	3
22MMD222.2	2	1	1	3	2	3	1	1	3
22MMD222.3	2	2	1	1	3	3	1	2	3
22MMD222.4	2	1	1	2	1	3	1	1	3
22MMD222.5	2	2	2	2	2	2	1	3	2

1: Low 2: Medium 3: High

TEXT/REFERENCE BOOKS:

1.	Product Design for Manufacture and Assembly – Geoffrey Boothroyd - Peter Dewhurst - Winston Knight – Marcel Dekker, Inc. – Newyork - Second Revision, ISBN 0-8247-0584-X
2.	Designing for Manufacturing – Harry Peck - Pitman Publications – 1983.
3.	Dimensioning and Tolerance for Quantity Production – Merhyle F Spotts –Inc. Englewood Cliffs - New Jersey – Prentice Hall, 5th edition.

FRACTURE MECHANICS

Course Code:	**22MMD223**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Understand material failure for any combination of applied stresses & estimate failure conditions of a structure.
2.	Determine the near field equations to determine the stress-strain and load-displacement fields around a crack tip
3.	Identify and formulate stress intensity factor, and the stress and strain fields around a crack tip for linear materials.
4.	Identify and formulate stress intensity factor, CTOD and strain energy release rate for nonlinear materials.
5.	Calculate and predict fracture toughness of materials and be familiar with the experimental methods to determine the fracture toughness.

UNIT-I

15 Hours

Fracture mechanics principles: Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, Griffith's energy balance approach. Fracture mechanics approach to design. NDT and Various NDT methods used in fracture mechanics, Numerical problems.
The Airy stress function: Complex stress function. Solution to crack problems. Effect of finite size. Special cases, Elliptical cracks, Numerical problems

UNIT-II

15 Hours

Linear plastic fracture mechanics: Plasticity effects, Irwin plastic zone correction. Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, Different forms of Dugdale model. Plastic constraint factor. The Thickness effect, Residual stress effect on plastic zone, Numerical problems.
Elastic plastic fracture mechanics: Fracture beyond general yield, The energy release rate, Criteria for crack growth. The crack resistance (R curve), Compliance, J integral, Tearing modulus, Stability. The Use of CTOD criteria. Parameters affecting the critical CTOD.
Crack branching. Principles of crack arrest. Crack arrest in practice**. Fatigue crack propagation and applications of fracture mechanics:** Crack growth and the stress intensity factor. Factors affecting crack propagation.

UNIT-III

Determination of Stress intensity factors and plane strain fracture toughness **10 Hours**

Introduction, experimental methods, estimation of stress intensity factors. Experimental determination of CTOD**,** Plane strain fracture toughness test, The Standard test, numerical problems. Size requirements. Non-linearity, Numerical problems.

Course Outcomes: At the end of the course student will be able to

1.	Elaborate fracture mechanics approach to design and failure conditions of a structure using Griffith's criterion.
2.	**Compute** the near field equations to **calculate** the stress-strain and load-displacement fields around a crack tip using complex stress function method.
3.	**Determine** stress intensity factor, strain energy release rate, and the stress and strain fields around a crack tip for linear materials.

4.	**Compute** J-Integral and CTOD as elastic fracture mechanics parameters and **explain** stability criterion for non-linear materials and **Calculate** the fatigue life of structures using fracture mechanics approach.
5.	**Calculate** fracture toughness of materials using numerical methods, and ASTM standards for metals and non-metals.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6		**PSO↓**	
							1	2	3
22MMD223.1	**3**	**1**	**2**	**3**	**-**	**1**	**3**	**2**	**1**
22MMD223.2	**3**	**1**	**2**	**3**	**-**	**1**	**3**	**2**	**1**
22MMD223.3	**3**	**1**	**2**	**3**	**-**	**1**	**3**	**2**	**1**
22MMD223.4	**3**	**1**	**2**	**3**	**-**	**1**	**3**	**2**	**1**
22MMD223.5	**3**	**1**	**2**	**3**	**-**	**1**	**3**	**2**	**1**

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	Broek David, Elementary Engineering Fracture Mechanics, 3rd Rev. Ed. Springer, 1984
2.	Anderson T.L., Fracture Mechanics, 2nd Edition, CRC Press, 2005.

REFERENCE BOOKS:

1.	Engineering fracture mechanics - S.A. Meguid Elsevier.
2.	Prashant Kumar, Elements of fracture mechanics, McGraw hill Education (I) Pvt., Ltd
3.	Fracture and Fatigue Control in Structures - Rolfe and Barsom, Prentice Hall.
4.	Introduction to fracture mechanics - Karen Hellan, McGraw Hill

COMPOSITE MATERIALS TECHNOLOGY

Course Code:	**22MMD231**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Student should be able to identify the properties of fiber and matrix materials used in commercial composites, as well as some common manufacturing techniques.
2.	Student should apply constitutive equations of composite materials and understand mechanical behavior at micro, macro and meso level.
3.	Student should apply the different failure theories during the failure analysis of composite materials.
4.	Student should be able to describe fundamental fabrication processes for polymer matrix, metal matrix, and ceramic matrix composites.
5.	Student should be able to use the ideas developed in the analysis of composites towards using composites in Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment

UNIT-I — **16 Hours**

Introduction to Composite Materials: Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Pre pegs, and sandwich construction.
Micro Mechanical Analysis of a Lamina: Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical Problems
Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two- dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants –Numerical problems.

UNIT-II — **15 Hours**

Biaxial Strength Theories: Maximum stress theory, Maximum strain theory, Tsa-Hill theory, Tsai-wu tensor theory, Numerical problems.
Manufacturing: Layup and curing- open and closed mould processing, Handlayup techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermo forming, Injection moulding
Fabrication of Composite Structures: Cutting, machining, drilling, mechanical fasteners and adhesive bonding, joining, tooling, fabrication equipments. Introduction, material qualification, Types of defects

UNIT-III — **9 Hours**

Application Developments: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites.
Metal Matrix Composites: Reinforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications.

Course Outcomes: At the end of the course student will be able to

1.	**Explain** composite materials and **derive** four elastic moduli of the composite lamina to **solve** numerical problems associated with micro lamina
2.	**Derive** hook's law for three dimensional unidirectional lamina and two dimensional angle lamina. **Determine** stress, strain and principal stress of the composite lamina.

3.	Use different failure theories for composite lamina to determine the strength of the composite lamina. Explain special cases of laminates and derive A, B, D matrices, solve numerical problems associated with special cases of laminates.
4.	Explain different techniques for manufacturing and fabrication of composite materials.
5.	Explain application of composite material in engineering sectors. Describe Metal matrix composite and its application.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6		**PSO↓**	
↓ Course Outcomes							1	2	3
22MMD231.1	1	2	3	3	2	1	2	2	3
22MMD231.2	1	2	3	3	2	1	2	2	3
22MMD231.3	1	2	3	3	2	1	2	2	3
22MMD231.4	1	2	3	3	2	1	2	2	3
22MMD231.5	1	2	3	3	2	1	2	2	3

1: Low 2: Medium 3: High3

TEXT BOOKS:

1.	Composite Materials handbook, Mein Schwartz McGrawHill Book Company,1984.
2.	Mechanics of composite materials, AutarK.Kaw CRC Press NewYork.

REFERENCE BOOKS:

1.	Mechanics of Composite Materials, Rober M. Joness Mc- GrawHill Kogakusha Ltd.
2.	Stress analysis of fiber Reinforced Composite Materials, Michael W, Hyer McGrawHill International.
3.	Composite Material Science and Engineering, Krishan K. Chawla Springer.
4.	Fibre Reinforced Composites,P.C.MallikMarcelDecker

DESIGN OF WHEELED MOBILE ROBOTS

Course Code:	**22MMD232**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Understand the fundamental concepts and applications of mobile robotics
2.	Present the fundamental analytical concepts required for the study of mobile robot kinematics
3.	Learn mathematical models and computational and motion control methods applicable to wheeled mobile robotic systems
4.	Understand basic sensor systems related to state measurements, navigation and localization
5.	Learn different motion planning and navigation schemes related to mobile robots

UNIT-I — **14 Hours**

Introduction: Introduction to mobile robots and mobile manipulators. Components of a mobile robot. Types of mobile robots.

Locomotion: Introduction, Key issues for locomotion, Types of land-based mobile robots, wheeled locomotion case studies.

Mobile Robot Kinematics: Introduction, Need of mathematical model, degree of freedom. Differential Kinematics: Representing robot position, forward differential kinematics, Inverse differential kinematics, Degree of maneuverability, Types of wheels for mobile robots. Kinematic simulation of a mobile robot. A generalized wheel model, Examples: Differential wheel drive mobile robot, Skid steering wheel drive mobile robot, Omni wheel drive mobile robot, Mecanum wheel drive mobile robot, Tricycle wheel drive mobile robot.

Types of Mobile Robots based on Wheel configuration: Holonomic and non-holonomic systems, kinematic model, Pseudo Inverse.

Dynamics of mobile robot: Lagrange-Euler and Newton-Euler methods. Equation of motion and dynamic simulation of a mobile robot, Computer based dynamic (numerical) simulation of different wheeled mobile robots,

UNIT-II — **13 Hours**

Kinematic Simulation of Wheeled Mobile Robots: Kinematic Model, Wheel Model, Differential wheel drive, Omni-directional wheel drive, Mecanum wheel drive.

Perception: Sensors for Mobile Robots, Sensor classification, characterizing sensor performance, Wheel/motor sensors, Heading sensors, Ground-based beacons, Active ranging, Motion/speed sensors, Vision-based sensors

Mobile Robots -Localization and Mapping: Autonomy for Robots, Building Blocks of Navigation, Challenges of Localization, Noise and Aliasing, Mobile robot localizations: Odometry, Dead reckoning, Map based localization, Markov Localization, Kalman Filter. Autonomous map building: SLAM, EKF SLAM

UNIT-III — **13 Hours**

Mobile Robot Navigation: Competences for Navigation, Path Planning Methods, Graph Construction: Visibility graph, Voronoi diagram, Cell decomposition methods. Graph Search Methods and Algorithms: Deterministic Graph Search, Breadth-first search, Depth-first search, Grass fire, Dijkstra's algorithm. Path Planning- A* Algorithm and Potential Field methods. Obstacle Avoidance: Bug Algorithm.

Motion control of mobile robots: Motion controlling methods, kinematic control, dynamic control and cascaded control, feedback control of nonholonomic wheeled mobile robots; odometry for wheeled mobile robots; and mobile manipulation, Simulation of land based mobile robots along with Kinematic control.

Course Outcomes: At the end of the course student will be able to

1.	Acquire knowledge about the fundamental concepts and applications of mobile robots
2.	Build kinematic models of holonomic and nonholonomic mobile robots.
3.	Apply mathematical models and computational and motion control methods applicable to mobile robotic systems.
4.	Apply Localization and Mapping techniques for wheeled mobile robot control
5.	Apply algorithms and methodologies for wheeled mobile robot navigation and path planning.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6		**PSO↓**	
↓ Course Outcomes							1	2	3
22MMD232.1	**1**	**1**	**3**				**1**	**1**	**1**
22MMD232.2	**1**	**2**	**3**				**1**	**1**	**1**
22MMD232.3	**1**	**2**	**3**				**1**	**1**	**1**
22MMD232.4	**1**	**2**	**3**				**1**	**1**	**1**
22MMD232.5	**1**	**2**	**3**				**1**	**1**	**1**

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	R Siegwart, IR Nour bakhsh, D Scaramuzza, Introduction to Autonomous Mobile Robots, MIT Press, USA, 2011.
2.	SG Tzafestas, Introduction to Mobile Robot Control, Elsevier, USA, 2014.

REFERENCE BOOKS:

1.	A Kelly, Mobile Robotics: Mathematics, Models, and Methods, Cambridge University Press, USA, 2013.
2.	S Thrun, W Burgard, D Fox, Probabilistic Robotics, MIT Press, USA, 2005
3.	G Dudek, M Jenkin, Computational Principles of Mobile Robotics, Cambridge University Press, USA, 2010.
4.	https://archive.nptel.ac.in/courses/112/106/112106298/
5.	https://onlinecourses.nptel.ac.in/noc21_me44/preview

DIGITAL MANUFACTURING

Course Code:	**22MMD233**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	Learn the fundamentals of Digital manufacturing, Design processes and methods and CAD/CAM/CAE technologies and product lifecycle management (PLM)
2.	Use of Finite Element Analysis (FEA) to validate functional performance
3.	Learn the General stages of the process, solid and FEA models, materials definition, loading (loads, displacements constraints...), post-processing, results and verifications
4.	Learn about the Digitizing methods and main technologies: applications and selection of reverse engineering systems
5.	Know about the Main additive manufacturing technologies, principles and applications

UNIT-I — **15 Hours**

Introduction - Importance of Digital manufacturing, Fundamental concepts of Industry 4.0 & Industrial Robotics

Conception and development of products: Design processes and methods. CAD/CAM/CAE technologies and product lifecycle management (PLM). Concepts generation and embodiment. Expression of product design ideas using 2D sketches

Drivers for digital transformations, Digital transformation challenges

UNIT-II — **15 Hours**

Computer Aided Design (CAD): 3D modeling. Parametric design. Assembly modeling. Render the appearance of a product. CAD

Computer Aided Engineering (CAE): Finite Element Analysis (FEA) to validate functional performance: general stages of the process, solid and FEA models, materials definition, loading (loads, displacements constraints...), post-processing, results and verifications. Topology optimization in additive manufacturing.

UNIT-III — **10 Hours**

Reverse engineering: General methodology: point clouds, meshes (.stl), NURBS surface models and parametric CAD models. Digitizing methods and main technologies: applications and selection of reverse engineering systems. Hardware and software involved. Reverse engineering and additive manufacturing

Additive manufacturing: General methodology, stages and components of the process. Main technologies, principles and applications. Strengths, weaknesses, challenges, and limitations of additive manufacturing technologies. Main brands and suppliers available. Design for Additive Manufacturing (DFAM). Design for functionality and 3D printability. Planning and slicing additive manufacturing software

Course Outcomes: At the end of the course student will be able to

1.	Explain the fundamental concepts of Digital manufacturing, about product development and the drivers and challenges regarding digital transformation
2.	Discuss the use of CAD in product development.
3.	Discuss about FEA for validating the functional performance of products.
4.	Discuss the application and selection of reverse engineering systems.
5.	Discuss about the major additive manufacturing technologies, its principles and applications

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6		PSO↓	
↓ Course Outcomes							1	2	3
22MMD233.1	1	2	3	3		1	1	1	3
22MMD233.2	1	2	3	3		1	1	1	3
22MMD233.3	1	2	3	3		1	1	1	3
22MMD233.4	1	2	3	3		1	1	1	3
22MMD233.5	1	2	3	3		1	1	1	3

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	K. T. Ulrich and S. D. Eppinger, Product Design and Development, 6th Ed., McGraw-Hill Education, 2015. ISBN-13: 978-0-078-02906-6
2.	Parametric Technology Corporation (PTC), Simulation using Creo Parametric user guides.
3.	V. Raja and K. J. Fernandes (eds.), Reverse Engineering. An Industrial Perspective, 1st Ed., Springer-Verlag London, 2008. ISBN-13: 978-1-849-96660-3
4.	N. Hopkinson, R. J. M. Hague and P. M. Dickens (eds.), Rapid Manufacturing: An Industrial Revolution for the Digital Age, 1st Ed., John Wiley & Sons, 2005. ISBN-13: 978-0-470-01613-8
5.	K. Otto and K. Wood, Product Design: Techniques in Reverse Engineering and New Product Development, 1st Ed., Prentice Hall, 2000. ISBN-13: 978-0-130-21271-9
6.	Z. Zhou, S. Xie, and D. Chen, Fundamentals of Digital Manufacturing Science, 1st Ed., Springer-Verlag London, 2012. ISBN-13: 978-1-447-12714-7
7.	I. Gibson, D. W. Rosen, and B. Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing. Springer-Verlag Boston, 2010. ISBN-13: 978-1-441-91119-3
8.	C. K. Chua, K. F. Leong, and C. S. Lim, Rapid Prototyping: Principles and Applications, 3rd Ed., World Scientific, 2010. ISBN-13: 978-9-812-77898-7

E-Resources

1.	Jack C Chaplin, Claudia Pagano & Santi Fort, “Digital Manufacturing for SMEs – An Introduction”, Digit -T, Digital Manufacturing Training, file:///G:/digital%20manufacturing/Digital%20Manufacturing%20for%20SMEs.pdf
2.	Mark J. Barrenechea & Tom Jenkins, “Digital Manufacturing”, Open Text Corporation, Canada, ISBN 978-0-9936047-8-2, 2018. file:///G:/digital%20manufacturing/opentext-wp-digital-manufacturing-ebook-en.pdf

AIRCRAFT DESIGN(NPTEL)

Course Code:	**22MMD234**	**Course Type**	**PEC**
Teaching Hours/Week (L: T: P)	**3:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	**Understand** the design process while designing aircraft by considering the different types of loading. Define the aerodynamic of aircraft
2.	Know the fuel system and fuel system integration and landing gear arrangements.
3.	**Describe** the stability, and control of flight dynamics
4.	Understand the flight mechanics and performance of flight.
5.	Understanding of Cost and Weight Analysis and Estimation of aircraft.

UNIT-I — **15 Hours**

Overview of the Design Process: Airfoil and Geometry Selection, Thrust-to-Weight Ratio and Wing Loading.
Initial Sizing: Control-Surface Sizing, Configuration Layout.
Aerodynamic Considerations: Structural Considerations, Vulnerability Considerations
Crew Station, Passengers, and Payload
Propulsion and Fuel System Integration, Fuel System, Landing Gear Arrangements.

UNIT-II — **15 Hours**

Step-by-Step Development of a New Design: Aerodynamics Propulsion
Structures and Loads Weights: Group Weights Method
Stability, Control, and Handling Qualities Longitudinal Static Stability and Control Lateral-Directional Static Stability and Control
Performance and Flight Mechanics: Equations of Motion Operating Envelope

UNIT-III — **10 Hours**

Cost Analysis, Operations and Maintenance Costs, Aircraft and Airline Economics.
Sizing and Trade Studies, Vertical Flight--Jet and Prop, Extremes of Flight
Design of Unique Aircraft Concepts, Flying Wing, Tailless, Lifting Fuselage, and Blended Wing-Body, Conceptual Design Examples

Course Outcomes: At the end of the course student will be able to

1.	Describe the aircraft design process and stages. Explain the methods, objectives, and challenges of initial sizing.
2.	Compute the weight and engine parameters of an aircraft.
3.	Describe the concepts, layout possibilities, and technologies in aircraft design.
4.	Identify information requirements and critically appraise sources of data and analysis for aircraft design and evaluation
5.	Understanding of, and ability to apply, basic concepts for: Cost and Weight Analysis and Estimation

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2	PSO↓ 3
22MMD234.1	1	2	3	3		1	1	1	3
22MMD234.2	1	2	3	3		1	1	1	3
22MMD234.3	1	2	3	3		1	1	1	3
22MMD234.4	1	2	3	3		1	1	1	3
22MMD234.5	1	2	3	3		1	1	1	3

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	Introduction to Flight By – Anderson
2.	Aircraft Design: A Conceptual Approach by Daniel P. Raymer
3.	Anderson, J. D., Fundamentals of Aerodynamics, 6th Ed., Boston: McGraw-Hill Higher Education, 2016.
4.	Anderson, J. D., Aircraft Performance and Design, Boston: McGraw-Hill, 1999.
5.	Nicolai, L., Carichner G., Fundamentals of Aircraft and Airship Design, Volume 1 Aircraft Design, AIAA, 2010.
6.	Nicolai, L., Carichner G., Fundamentals of Aircraft and Airship Design, Volume 2 -Airship Design and Case Studies, AIAA, 2013.
7.	Torenbeek, E., Synthesis of Subsonic Airplane Design, Delft University Press, 1982.
8.	Torenbeek, E., Advanced Aircraft Design: Conceptual Design, Technology and Optimization of Subsonic Civil Airplanes, John Wiley & Sons, Incorporated, 2013.
9.	Gere, J. M., Goodno, B., Mechanics of Materials, 8th Ed., Cengage Learning, 2012.
10.	Hill, P. G., Peterson, C. R., Mechanics and Thermodynamics of Propulsion, 2nd Ed., Reading, Mass.: Addison-Wesley, 1991.
11.	Mattingly, J., Heiser, W., Boyer, K., Haven, B., Pratt, D., Aircraft Engine Design, 3rd Ed., AIAA, 2018.
12.	Nelson, R. C., Flight Stability and Automatic Controls, 2nd Ed., Boston, Mass.: McGraw Hill, 1998

E-Resources

1.	https://onlinecourses.nptel.ac.in/noc22_ae01/preview

Audit Courses

AUTOMOTIVE SAFETY

Course Code:	**22MMDAU1-1**	**Course Type:**	**AUDIT**
Teaching Hours/Week (L: T: P)	**1:0:1**	**Credits:**	**-**
Total Teaching Hours:	**13+0+26**	**CIE + SEE Marks:**	**-**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	To provide students an overall introduction to areas of automotive Safety spanning over accidence avoidance, pre-crash technologies, mitigation of injuries, and post-crash technologies

List of Experiments

Unit-I **5 Hours**

Introduction to Automotive Safety: need for increased road safety, definitions involved in automotive safety, driving forces for increased road safety, regulations and consumer tests

Unit-II **5 Hours**

Integrated Automotive safety : Accidence avoidance and factors associated ,contributing factors of driver, Vehicle and environment

Unit-III **5 Hours**

Passive Safety: Mitigation of injuries: Introduction to Primary and secondary restraints systems, mechanisms involved

Unit-IV **5 Hours**

Anthropomorphic Test Devices: Historical background, evolution and current ATDs in use, biomechanics, injury assessments

Unit-V **5 Hours**

Crash Simulations: component, sub-system and system level simulations, optimizing restraint system function, future of Automotive safety

Course Outcomes: At the end of the course student will be able to

1.	Explain the need for automotive safety
2.	Recall the different definitions and concepts involved in active safety (accidence avoidance) and Passive safety (Injury mitigations)
3.	Describe about safety devices.
4.	Describe about anthropomorphic test devices and injury assessments
5.	Simulation involved in designing and fine-tuning restraint systems

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	**PSO↓** 1	2	3
22MMDAU1-1.1	**1**					**3**	**1**		
22MMDAU1-1.2	**1**					**3**	**1**		
22MMDAU1-1.3	**1**					**3**	**1**		
22MMDAU1-1.4	**1**					**3**	**1**		
22MMDAU1-1.5	**1**					**3**	**1**		

1: Low 2: Medium 3: High

TEXT BOOKS:	
1.	Integrated Automotive Safety Handbook, SAE International, Ulrich Seiffert, Mark Gonter
REFERENCE BOOKS:	
1.	Vehicle Crash Mechanics, Mathew Huang
2.	Vehicle crashworthiness and occupant protection: Paul Du Bois Clifford C. Chou Bahig B. Fileta Tawfik B. Khalil Albert I. King Hikmat F. Mahmood Harold J. Mertz Jac Wismans

DESIGN OPTIMIZATION

Course Code:	**22MMDAU2-1**	**Course Type:**	**AUDIT**
Teaching Hours/Week (L: T: P)	**1:0:1**	**Credits:**	**-**
Total Teaching Hours:	**13+0+26**	**CIE + SEE Marks:**	**-**

Teaching Department: Mechanical Engineering

Course Objectives:

1.	The purpose of this course is to introduce the students to mathematical modeling, optimization theory and computational methods for analytical and simulation-based optimal design.

List of Experiments

Unit-I	**5 Hours**
Introduction to Design Optimization, Optimum Design Problem Formulation	
Unit-II	**5 Hours**
Graphical Solution Methods, Optimality Conditions, Optimum Design Concepts	
Unit-III	**5 Hours**
Optimum Design, Numerical Solution Process, Linear Programming Methods	
Unit-IV	**5 Hours**
Unconstrained Optimum Design, Practical Applications of Optimization	
Unit-V	**5 Hours**
Advanced Topics, Discrete Variable, Global Optimization Concepts, MDO, Nature Inspired Methods	

Course Outcomes: At the end of the course student will be able to

1.	Explain about optimization techniques
2.	Apply the techniques for engineering design optimization
3.	Identify which methods are appropriate for a given optimization application
4.	Formulate engineering problems as optimization problems that are appropriate for a chosen method
5.	Use the computer and available software to solve engineering design problems for optimality.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	**PSO↓** 1	2	3
22MMDAU2-1.1	1	1					1		
22MMDAU2-1.2	1	1					1		
22MMDAU2-1.3	1	1					1		
22MMDAU2-1.4	1	1					1		
22MMDAU2-1.5	1	2					1		

1: Low 2: Medium 3: High

TEXT BOOKS:

1.	Introduction to Optimum Design, 3rd or 4th Edition, Jasbir Sign Arora, Academic Press, 2017

REFERENCE BOOKS:

1.	Principles of Optimal Design: Modeling and Computation, 3rd Edition, by P.Y. Papalambros and D.J. Wilde, Cambridge University Press, 2015