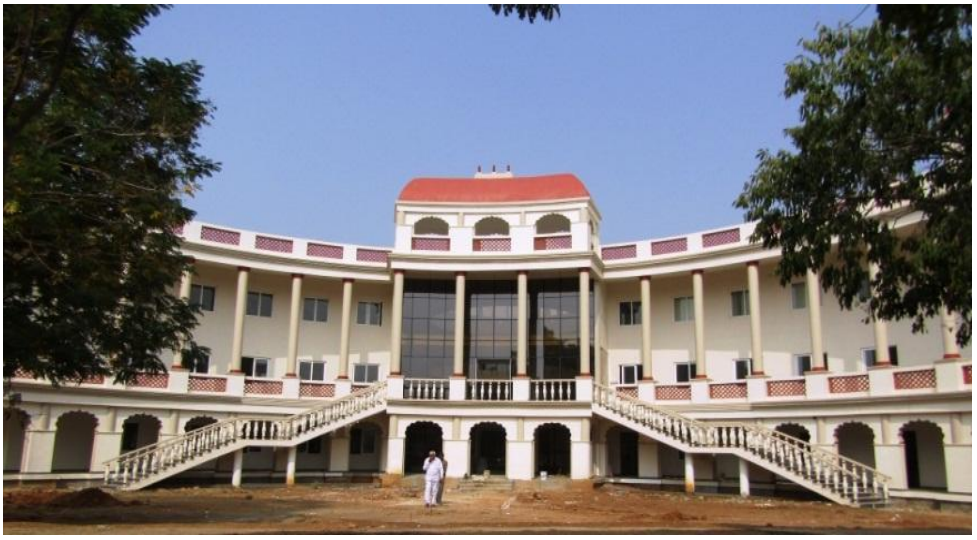
ACADEMIC REGULATIONS & CURRICULUM

Applicable to the students admitted from the Academic Year 2023-2024



MECHANICAL ENGINEERING
(B.Tech. Programme)

MAHARAJ VIJAYARAM GAJAPATHI RAJ COLLEGE OF ENGINEERING
(Autonomous)

(Approved by AICTE, New Delhi, and permanently affiliated to JNTUGV, Vizianagaram) Listed u/s 2(f) & 12(B) of UGC Act 1956.

Vijayaram Nagar Campus, Chintalavalasa,Vizianagaram-535005, Andhra Pradesh

The visionaries

Late Dr. P V G Raju
Raja Saheb of Vizianagaram
Founder Chairman-MANSAS
Ex-Minister for Education and Health, Govt. of AP
Ex Member of Parliament

Late Dr. P. Anand Gajapathi Raju
Ex-Chairman-MANSAS
Ex-Minister for Education and Health
Govt. of AP
Ex Member of Parliament

P. Ashok Gajapathi Raju
Chairman-MANSAS
Ex-Union Minister for Civil Aviation,
Govt. of India
Ex-Minister for Finance, Govt. of AP

Academic Regulations (R23) for B. Tech (Regular-Full time)
(Effective for the students admitted into I year from the Academic Year **2023-24** onwards)

1. Award of the Degree

(a) **Award of the B.Tech. Degree / B.Tech. Degree with a Minor if he/she fulfills the following:**

(i) Pursues a course of study for not less than four academic years and not more than eight academic years. However, for the students availing Gap year facility this period shall be extended by two years at the most and these two years would in addition to the maximum period permitted for graduation (Eight years).

(ii) Registers for 160 credits and secures all 160 credits.

(b) **Award of B.Tech. degree with Honors**

A student will be declared eligible for the award of the B.Tech. with Honors if he/she fulfills the following:

(i) Student secures additional 18 credits fulfilling all the requisites of B.Tech. program i.e., 160 credits.
(ii) Registering for Honors is optional.
(iii) Honors is to be completed simultaneously with B.Tech. programme.

Students, who fail to fulfill all the academic requirements for the award of the degree within eight academic years from the year of their admission, shall forfeit their seat in B.Tech. course and their admission stands cancelled. This clause shall be read along with clause 1 a) i).

2. Admissions

Admission to the B. Tech Program shall be made subject to the eligibility, qualifications and specialization prescribed by the A.P. State Government/University from time to time. Admissions shall be made either based on the merit rank obtained by the student in the common entrance examination conducted by the A.P. Government/University or any other order of merit approved by the A.P. Government/University, subject to reservations as prescribed by the Government/University from time to time.

3. Program related terms

Credit: A unit by which the course work is measured. It determines the number of hours of instruction required per week. One credit is equivalent to one hour of teaching (Lecture/Tutorial) or two hours of practical work/field work per week.

Credit definition:

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 Hr. Practical (P) per week	0.5 credit
2 Hrs. Practical (Lab) per	1 credit

a) ***Academic Year***: Two consecutive (one odd + one even) semesters constitute one academic year.
b) ***Choice Based Credit System (CBCS):*** The CBCS provides a choice for students to select from the prescribed courses.

4. Semester/Credits:

i. A semester comprises 90 working days and an academic year is divided into two semesters.
ii. The summer term is for eight weeks during summer vacation. Internship/ apprenticeship / work-based vocational education and training can be carried out during the summer term, especially by students who wish to exit after two semesters or four semesters of study.
iii. Regular courses may also be offered during the summer on a fast-track mode to enable students to do additional courses or complete backlogs in coursework.
iv. The Universities/HEIs can decide on the courses to be offered in the summer term depending on the availability of faculty and the number of students.

5. Structure of the Undergraduate Programme

All courses offered for the undergraduate program (B. Tech.) are broadly classified as follows:

S.No.	Category	Breakup of Credits (Total 160)	Percentage of total credits	AICTE Recommendation (%)
1.	Humanities and Social Science	13	8 %	8 – 9%
2.	Basic Sciences (BS)	20	13 %	12 - 16%
3.	Engineering Sciences (ES)	23.5	14%	10 – 18%
4.	Professional Core (PC)	54.5	34 %	30 – 36%
5.	Electives – Professional (PE) & Open (OE); Domain Specific Skill Enhancement Courses (SEC)	33	21 %	19 - 23%
6.	Internships & Project work	16	10 %	8 – 11%
7.	Mandatory Courses (MC)	Non-credit	Non-credit	-

6. Course Classification:

All subjects/ courses offered for the undergraduate programme in Engineering & Technology (B.Tech. degree programs) are broadly classified as follows:

S.No.	Broad Course Classification	Course Category	Description
1.	Foundation Core Courses	Foundation courses	Includes Mathematics, Physics and Chemistry; fundamental engineering courses; humanities, social sciences and
2.	Core Courses	Professional Core Courses (PC)	Includes subjects related to the parent discipline /department / branch of Engineering
3.	Elective Courses	Professional Elective	Includes elective subjects related to the parent
		Open Elective Courses (OE)	Elective subjects which include interdisciplinary subjects or subjects in an area outside the
		Domain specific skill enhancement	interdisciplinary/job-oriented/domain courses which are relevant to the industry
4.	Project & Internships	Project	B.Tech. Project or Major Project
		Internships	Summer Internships – Community based and Industry Internships; Industry oriented Full Semester
5.	Audit Courses	Mandatory non-	Covering subjects of developing desired attitude

7. Programme Pattern

i. Total duration of the B. Tech (Regular) Programme is four academic years.
ii. Each academic year of study is divided into two semesters.
iii. Minimum number of instruction days in each semester is 90 days.
iv. There shall be mandatory student induction program for fresher's, with three-week duration before the commencement of first semester. Physical activity, Creative Arts, Universal Human Values, Literary, Proficiency Modules, Lectures by Eminent People, Visits to local Areas, Familiarization to Dept./Branch & Innovations etc., are included as per the guidelines issued by AICTE.
v. Health/wellness/yoga/sports and NSS /NSS /Scouts & Guides / Community service activities are made mandatory as credit courses for all the undergraduate students.
vi. Courses like Environmental Studies, Ethics and Human values are offered as non-credit mandatory courses for all the undergraduate students.
vii. Increased flexibility for students through an increase in the elective component of the curriculum, with 05 Professional Elective courses and 08 Open Elective courses.
viii. Professional Elective Courses, include the elective courses relevant to the chosen specialization/branch. Proper choice of professional elective courses can lead to students specializing in emerging areas within the chosen field of study.
ix. A total of 29 credits are offered in the curriculum as Extended Open Elective Cluster (EOEC). A student can complete the requirement for B.Tech. Degree with a Minor within the 160 credits by opting for the

courses offered through various verticals/tracks under Extended Open Elective Cluster (EOEC).

x. While choosing the electives, students shall ensure that they do not opt for the courses with syllabus contents similar to courses already pursued.
xi. A pool of interdisciplinary/job-oriented/domain skill courses which are relevant to the industry are integrated into the curriculum of all disciplines.
xii. Students shall undergo summer internships, for a period of four week's duration at the end of second and third year of the programme. The internship at the end of second year shall be community oriented and industry internship at the end of third year.
xiii. There will be Project work in the final semester of the programme.
xiv. Undergraduate degree with Honors is introduced by the University for the students having good academic record.

8. Evaluation Process

The performance of a student in each semester shall be evaluated subject wise with a Maximum of 100 marks for theory and 100 marks for practical subject. Summer Internships shall be evaluated for 50 marks, Project work in final semester shall be evaluated for 200 marks, and mandatory courses with no credits shall be evaluated for 30 mid semester marks.

A student has to secure not less than 35% of marks in the end examination and a minimum of 40% of marks in the sum total of the mid semester and end examination marks taken together for the theory, practical, design, drawing subject or project etc. In case of a mandatory course, he/she should secure 40% of the total marks.

THEORY COUSES

Assessment Method	Marks
Continuous Internal	30
Semester End Examination	70
Total	100

i. For theory subject, the distribution shall be 30 marks for Continuous Internal Assessment and 70 marks for the End-Examination.
ii. For practical subject, the distribution shall be 30 marks for Internal Evaluation and 70 marks for Semester End Examination.
iii. If any course contains two different branch subjects, the syllabus shall be written in two parts with 3 units each (Part-A and Part-B) and external examination question paper shall be set with two parts each for 35 marks.

a) Continuous Internal Evaluation

i. For theory subjects, during the semester, there shall be two midterm examinations. Each midterm examination shall be evaluated for 30 marks of which 10 marks for objective paper (20 minute's duration), 15 marks for subjective paper (90 minutes duration) and 5 marks for assignment.
ii. Objective paper shall contain for 05 short answer questions with 2 marks each. Subjective paper shall contain 3 either or type questions (totally six questions from 1 to 6) of which student has to answer one from each either-or type of questions. Each question carries 10 marks. The marks obtained in the subjective paper are condensed to 15 marks.

iii. First midterm examination shall be conducted for I, II units of syllabus with one either or type question from each unit and third either or type question from both the units. The second midterm examination shall be conducted for III, IV and V units with one either or type question from each unit.
iv. Final mid semester marks shall be arrived at by considering the marks secured by the student in both the mid examinations with 80% weightage given to the better mid exam and 20% to the other.

For Example:
Marks obtained in first mid: 25
Marks obtained in second mid: 20
Final mid semester Marks: (25x0.8) + (20x0.2) = 24

If the student is absent for any one midterm examination, the final mid semester marks shall be arrived at by considering 80% weightage to the marks secured by the student in the appeared examination and zero to the other. For Example:

Marks obtained in first mid: Absent
Marks obtained in second mid: 25
Final mid semester Marks: (25x0.8) + (0x0.2) =20

b) End Examination Evaluation:

End examination of theory subjects shall have the following pattern: There shall be 6 questions and all questions are compulsory.

i. Question I shall contain 10 compulsory short answer questions for a total of 20 marks such that each question carries 2 marks.
ii. There shall be 2 short answer questions from each unit.
iii. In each of the questions from 2 to 6, there shall be either/or type questions of 10 marks each. Student shall answer any one of them.
iv. The questions from 2 to 6 shall be set by covering one unit of the syllabus for each question.

End examination of theory subjects consisting of two parts of different subjects, *for example*: Basic Electrical &Electronics Engineering shall have the following pattern:

i. Question paper shall be in two parts viz., Part A and Part B with equal weightage of 35 marks each.
ii. In each part, question 1 shall contain 5 compulsory short answer questions for a total of 5 marks such that each question carries 1mark.
iii. In each part, questions from 2 to 4, there shall be either/or type questions of 10 marks each. Student shall answer any one of them.
iv. The questions from 2 to 4 shall be set by covering one unit of the syllabus for each question.

PRACTICAL COURSES

Assessment Method	Marks
Continuous Internal	30
Semester End Examination	70
Total	100

a) For practical courses, there shall be a continuous evaluation during the semester for 30 sessional marks and end examination shall be for 70 marks.
b) Day-to-day work in the laboratory shall be evaluated for 15 marks by the concerned laboratory teacher based on the regularity/record/viva and 15 marks for the internal test.
c) The end examination shall be evaluated for 70 marks, conducted by the concerned laboratory teacher and a senior expert in the subject from the same department.

Procedure	: 20 Marks
Experimental work & Results	: 30 marks
Viva voce	: 20 marks.

d) In a practical subject consisting of two parts (Eg: Basic Electrical &Electronics Engineering Lab), the end examination shall be conducted for 70 marks as a single laboratory in 3 hours.

e) Engineering Graphics evaluation

For the subject having design and/or drawing, such as Engineering Drawing, the distribution of marks shall be 30 for mid semester evaluation and 70 for end examination.

Assessment Method	Marks
Continuous Internal	30
Semester End	70
Total	100

Day-to-day work shall be evaluated for 15 marks by the concerned subject teacher based on the reports/submissions prepared in the class and 15 marks for the internal test.

The end examination pattern for Engineering Graphics, shall consist of 5 questions, either/or type, of 14 marks each. There shall be no objective type questions in the end examination.

9. a) NSS/NCC/SCOUTS & GUIDES/COMMUNITY SERVICE

General Guidelines:

1. Institutes must assign slots in the Timetable for the activities.
2. Institutes are required to provide instructor to mentor the students.

Evaluation Guidelines:

- Evaluated for a total of 100 marks.
- A student can select 6 activities of his/her choice with a minimum of 01 activity per unit. Each activity shall be evaluated by the concerned teacher for 15 marks, totaling to 90 marks.
- A student shall be evaluated by the concerned teacher for 10 marks by conducting viva voce on the subject.

b) HEALTH AND WELLNESS, YOGA AND SPORTS

General Guidelines:

1. Institutes must assign slots in the Timetable for the activities of Health/Sports/Yoga.
2. Institutes must provide field/facility and offer the minimum of five choices of as many as Games/Sports.
3. Institutes are required to provide sports instructor / yoga teacher to mentor the students.

Evaluation Guidelines:

- Evaluated for a total of 100 marks.
- A student can select 6 activities of his/her choice with a minimum of 01 activity per unit. Each activity shall be evaluated by the concerned teacher for 15 marks, totalling to 90 marks.
- A student shall be evaluated by the concerned teacher for 10 marks by conducting viva voce on the subject.

There shall be no external examination for mandatory courses with zero credits. However, attendance shall be considered while calculating aggregate attendance and student shall be declared to have passed the mandatory course only when he/she secures 40% or more in the internal examinations. In case, the student fails, a re-examination shall be conducted for failed candidates for 30 marks satisfying the conditions mentioned in item 1 & 2 of the regulations.

The laboratory records and mid semester test papers shall be preserved for a minimum of 1 year in the respective institutions and shall be produced to the Committees of the University as and when the same are asked for.

10. Community Project:

There will be a summer break of 4 to 6 weeks at the end of each academic year to provide opportunity to students to engage in internships with industry/government agencies/NGO etc. These internships are intended to give exposure to the students through Community Projects and Mini Projects.

- A student shall identify and provide a solution to the problem relevant to society.
- A student shall engage at least 30 hours on community project. Community project shall be evaluated internally for 50 marks by Project Review Committee (PRC). PRC comprising of HoD, Two senior faculty and guide shall review the progress.
- There shall be no Continuous Assessment marks for these projects.
- A student shall secure minimum 40% of marks for successful completion.

In case, if a student fails, he/she shall reappear as and when semester supplementary examinations are conducted by the Institution.

11. Mini Project:

- A student shall undergo internship (Physical/Virtual) for a period of 4 weeks and provide solution to the problem relevant to Industry/ Modern tool during the vacation after VI semester and submit comprehensive report/certificate (For virtual internship) issued by external agencies.

- The recommended Virtual Internships offered by external agencies/regulating bodies like AICTE/APSCHE etc, conversions and appropriate grades/marks are to be approved by the BoS at the beginning of the semester.
- Mini project shall be evaluated internally for 50 marks by Project Review Committee (PRC). PRC shall prepare rubrics for assessment.

12. Skill Enhancement Course:

Skill Enhancement Course is assessed for 100 marks, of which, 30 marks for internal assessment and 70 marks for semester end examination.

Assessment Method	Marks
Continuous Internal	30
Semester End Examination	70
Total	100

Continuous Internal Assessment : (30 Marks)
Continuous assessment : 15 Marks
Internal test : 15 Marks

The end examination shall be evaluated for 70 marks, conducted by the concerned course teacher and a senior expert in the subject from the same department.

Procedure : 20 Marks
Experimental work & Results : 30 marks
Viva voce : 20 marks.

The student shall be given an option to choose either the skill courses being offered by the college or to choose a certificate course (Minimum 30 hours) being offered by industries / Professional bodies or any other accredited bodies. If a student chooses to take a Certificate Course offered by external agencies, the credits shall be awarded to the student upon producing the Course Completion Certificate from the agency. A committee shall be formed at the level of the college to evaluate the grades/marks given for a course by external agencies and convert to the equivalent marks/grades.

The recommended courses offered by external agencies, conversions and appropriate grades/marks are to be approved by the BoS at the beginning of the semester.
If a student prefers to take a certificate course offered by external agency and approved by BoS, the department shall mark attendance of the student for the remaining courses in that semester excluding the skill course in all the calculations of mandatory attendance requirements upon producing a valid certificate as approved by the BoS.

Evaluation pattern for Quantitative Problem Solving Techniques :

The Course is assessed for 100 marks, of which, 30 marks for internal assessment and 70 marks for semester end examination.

Assessment Method	Marks
Continuous Internal	30
Semester End Examination	70
Total	100

Continuous Internal Assessment : (30 Marks)
Continuous assessment : 15 Marks
Internal test : 15 Marks

The end examination shall be evaluated for 70 marks, conducted by the concerned course teacher and a senior expert in the subject from the same department.

Objective Test (MCQs, 50 Questions Each one mark) : 50 Marks
Viva voce : 20 marks.

13. Main Project Work:

The 4th Year of study comprises only self-study courses giving opportunity to students to spend one full year as an intern at various organizations (government/private) in pursuance of his/her career aspiration. The student is also expected to complete the Main Project during this period. At the end of the year, the candidate shall submit the main project report.

The project report shall be evaluated with an external examiner. The total marks for project work is **200 marks** and the distribution shall be **60 marks** for continuous assessment and **140 marks** for summative assessment. The supervisor assesses the student for 30 marks (Report: 20 marks, Seminar: 10 marks). At the end of the semester, all projects shall be showcased at the department for the benefit of all students and staff and the same is to be evaluated by the departmental Project Review Committee consisting of supervisor, a senior faculty and HOD for 30 marks. The external evaluation of Project Work is a Viva-Voce Examination conducted in the presence of internal examiner and external examiner and is evaluated for 140 marks.

The college shall facilitate and monitor the student main project/internship programs. Completion of the main project is mandatory. If any student fails to complete the main project, he/she will not be eligible for the award of degree. In such cases, the student shall repeat and complete the main project.

14. Massive Open Online Courses (MOOCs):

- It is recommended to register and complete minimum two courses through MOOCs approved by the BoS. A student can pursue courses other than core through MOOCs. A student is not permitted to register and pursue core courses through MOOCs.

- The student shall register for the (Minimum of 12 weeks) courses offered by SWAYAM/NPTEL as Program elective/Open elective with the approval of the BoS. The Head of the Department shall appoint one mentor for each MOOC. The student has to submit the pass certificate issued by SWAYAM/NPTEL after completion of the course.

- Students who have qualified in the proctored examinations conducted through MOOCs platform can apply for credit transfer as specified and are exempted from appearing internal as well as external examination (for the specified equivalent credit course only) conducted by the Institution.

  Necessary amendments in rules and regulations regarding adoption of MOOC courses would be proposed from time to time.

15. Academic Bank of Credits (ABC)

The Institution is part of the Academic Bank of Credits (ABC) initiative to promote increased opportunity of mobility for a student (as per NEP 2020). As such,

i. A student, upon joining the institution, will become part of the ABC.

ii. All credits earned by the students in the institution as well as through MOOCs will be reflected in his/her account in the ABC

iii. The student will be able to avail transfer of credits earned from other institutions to his account as per the regulations of UGC/AICTE/JNTUGV declared from time to time.

16. Guidelines for offering Honors

The objective of introducing B.Tech.(Honors) is to facilitate the students to choose additionally the specialized courses of their choice and build their competence in a specialized area in the UG level. The program is a best choice for academically excellent students having good academic record and interest towards higher studies and research.

i. Honors is introduced in the curriculum of all B. Tech. programs offering a major degree and is applicable to all B.Tech (Regular and Lateral Entry) students admitted in Engineering & Technology.
ii. A student shall earn additional 18 credits for award of B.Tech.(Honors) degree from same branch/department/discipline registered for major degree. This is in addition to the credits essential for obtaining the Undergraduate degree in Major Discipline.
iii. A student is permitted to register for Honors and is allowed to take maximum of two subjects per semester pertaining to the Honors.
iv. Separate class work and timetable of the courses offered under Honors program shall be arranged.
v. Courses that are used to fulfill the student's primary major may not be double counted towards the Honors. Courses with content substantially equivalent to courses in the student's primary Major may not be counted towards the Honors.
vi. Students can complete the courses offered under Honors either in the college or in online platforms like SWAYAM with a minimum duration of 12 weeks for a 3-credit course satisfying the criteria for credit mobility. If the courses under Honors are offered in conventional mode, then the teaching and evaluation procedure shall be similar to regular B. Tech courses.
vii. A student registered for Honors shall pass in all subjects that constitute the

requirement for the Honors degree program. No class/division (i.e., second class, first class and distinction, etc.) shall be awarded for Honors degree program.

viii. If a student drops or is terminated from the Honors program, the additional credits so far earned cannot be converted into open or core electives; they will remain extra. However, such students will receive a separate grade sheet mentioning the additional courses completed by them.

ix. The Honors will be mentioned in the degree certificate as Bachelor of Technology (Honors) in XYZ. For example, B.Tech. (Honors) in Mechanical Engineering.

Enrolment into Honors:

i. Students of a Department/Discipline are eligible to opt for Honors program offered by the same Department/Discipline.

ii. The enrolment of student into Honors is based on the CGPA obtained in the major degree program. CGPA shall be taken up to IV semester in case of regular and Lateral entry students. Students having 7 CGPA without any backlog subjects will be permitted to register for Honors.

iii. Transfer of credits from Honors to regular B. Tech degree and vice-versa shall not be permitted.

iv. Honors is to be completed simultaneously with a Major degree program.

Registration for Honors:

i. The eligible and interested students shall apply through the HOD of his/her parent department. The whole process should be completed within one week before the start of every semester. Selected students shall be permitted to register the courses under Honors.

ii. The selected students shall submit their willingness to the principal through his/her parent department offering Honors. The parent department shall maintain the record of student pursuing the Honors.

iii. The students enrolled in the Honors courses will be monitored continuously. An advisor/mentor from parent department shall be assigned to a group of students to monitor the progress.

iv. There is no fee for registration of subjects for Honors program offered in offline at the respective institutions.

17. Attendance Requirements:

i. A student shall be eligible to appear for the University external examinations if he/she acquires a minimum 75% of attendance in aggregate of all the subjects.

ii. Condonation of shortage of attendance in aggregate up to 10% (65% and above and below 75%) in each semester may be granted by the College Academic Committee.

iii. Shortage of Attendance below 65% in aggregate shall in NO CASE be condoned.

iv. Students whose shortage of attendance is not condoned in any semester are not eligible to take their end examination of that class and their registration shall stand cancelled.

v. A student will not be promoted to the next semester unless he satisfies the attendance requirements of the present semester. They may seek readmission for that semester from the date of commencement of class work.

vi. If the learning is carried out in blended mode (both offline & online), then the total attendance of the student shall be calculated considering the offline and online attendance of the student.

vii. For induction programme attendance shall be maintained as per AICTE norms.

18. Promotion Rules:

A student shall be promoted from IV semester to V semester if he fulfills the minimum attendance requirement (75%) and academic requirement of 40% of credits (any decimal fraction should be rounded off to lower digit) up to either III semester or IV semester from the following examinations irrespective of whether the candidate takes the examination or not.

- Two regular and Two supplementary examinations of I semester
- Two regular and One supplementary examinations of II semester
- One regular examination and One supplementary examination of III semester
- One regular examination of IV semester.

A student shall be promoted from VI semester to VII semester if he fulfills the minimum attendance requirement (75%) and academic requirement of 40% of credits (any decimal fraction should be rounded off to lower digit) up to either V Semester or VI semester from the following examinations irrespective of whether the candidate takes the examination or not.

- Three regular and Three supplementary examinations of I semester
- Three regular and Two supplementary examinations of II semester
- Two regular and Two supplementary examinations of III semester
- Two regular and One supplementary examinations of IV semester
- One regular and One supplementary examination of V semester
- One regular examination of VI semester.

19. Grading:

As a measure of the student's performance, a 10-point Absolute Grading System using the following Letter Grades and corresponding percentage of marks shall be followed:

After each course is evaluated for 100 marks, the marks obtained in each course will be converted to a corresponding letter grade as given below, depending on the range in which the marks obtained by the student fall.

Structure of Grading of Academic Performance

Range in which the marks in the subject fall	Grade	Grade points Assigned
90 & above	S (Superior)	10
80 - 89	A (Excellent)	9
70 - 79	B (Very Good)	8
60 - 69	C (Good)	7

50 - 59	D (Average)	6
40 - 49	E (Pass)	5
< 40	F (Fail)	0
Absent	Ab (Absent)	0

i. A student obtaining Grade "F" or Grade "Ab" in a subject shall be considered failed and will be required to reappear for that subject when it is offered the next supplementary examination.

ii. For non-credit audit courses, "Satisfactory" or "Unsatisfactory" shall be indicated instead of the letter grade and this will not be counted for the computation of SGPA/CGPA/Percentage.

Computation of Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

The Semester Grade Point Average (SGPA) is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student, i.e.,

$$SGPA = \Sigma (Ci \times Gi)/\Sigma Ci$$

where, Ci is the number of credits of the ith subject and Gi is the grade point scored by the student in the ith course.

The Cumulative Grade Point Average (CGPA) will be computed in the same manner considering all the courses undergone by a student over all the semesters of a program, i.e.,

$$CGPA = \Sigma (Ci \times Si)/ \Sigma Ci$$

where "Si" is the SGPA of the ith semester and Ci is the total number of credits up to that semester.

Both SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

While computing the SGPA the subjects in which the student is awarded Zero grade points will also be included.

Grade Point: It is a numerical weight allotted to each letter grade on a 10-point scale. Letter Grade: It is an index of the performance of students in a said course. Grades are denoted by the letters S, A, B, C, D and F.

20. Award of Class:

After a student has satisfied the requirements prescribed for the completion of the program and is eligible for the award of B. Tech. Degree, he/she shall be placed in one of the following four classes:

Class Awarded	CGPA Secured
First Class with Distinction	≥ 7.5 (Without any supplementary
First Class	≥ 6.5 < 7.5
Second Class	≥ 5.5 < 6.5
Pass Class	≥ 5.0 < 5.5

Note: * Students who have written supplementary examinations to fulfil the credit requirement will not be awarded First Class with Distinction. For such students the highest degree that is awarded will be First Class Only.

CGPA to Percentage conversion Formula – (CGPA – 0.5) x 10

21. With–holding of Results

If the candidate has any dues not paid to the university or if any case of indiscipline or malpractice is pending against him/her, the result of the candidate shall be withheld in such cases.

22. Multiple Entry / Exit option

With NEP setting in, the theme is we will need to give different entry-exit options for students and a possibility to tailor a 4-year course or even a 3-year exit degree to suit their interests and requirements.

- Exit-Entry at each year of study through the entire 4-year duration.
- Possible multiple Degree Options with different Credit requirements that provide an option to a student to pick an option that best suits his/her interests and requirements.

Note: Four Year undergraduate program (FYUP) with or without Honors is the most recommended exit. But if for some unavoidable reasons, a student needs to exit at the end of Year I, Year II, Year III, the following would be the respective exit requirements with a tentative certificate/ diploma/ degree defined.

Year of Exit	Degree	Credits Required to be Earned During Course Work	Exit Extra Credits (Crash Course & Exam)	Total Credits
End of Year I	Office Tools Certificate (Or something equivalent as determined by Affiliating University)	40	6	46
End of Year II	Diploma in Discipline 1 (Or something equivalent as determined by Affiliating University)	88	8	96
End of Year III	Bachelor in Vocational Sciences in **Discipline1** (Or something equivalent as determined by Affiliating University)	136	0	136
End of Year IV (Without Honors)	Bachelor of Technology in **Discipline 1**) (Or something equivalent as determined by Affiliating University)	160	0	160

Year of Exit	Degree	Credits Required to be Earned During Course Work	Exit Extra Credits (Crash Course & Exam)	Total Credits
End of Year IV (With Honors)	Bachelor of Technology with Honors in **Discipline 1**) (Or something equivalent as determined by Affiliating University)	176	0	176

Note: The exit extra credits at Year II and Year III would essentially come from critical courses as determined by BoS from the following semester.

(a) Exit Policy:

The students can choose to exit the four-year program at the end of first/second/third year.

i) **UG Certificate in (Field of study/discipline)** - Program duration:
First Year (first two semesters) of the undergraduate program, 40 credits followed by an additional exit 6 credit bridge course. The 6 extra credits would be to make the certificate self-sufficient, with one 3-Credit Course on Taxation and one 3-Credit Course on Accounting that would help the candidates acquire job-ready competencies required to enter the workforce.

ii) **UG Diploma (in Field of study/discipline)** - Program duration: First two years (first four semesters) of the undergraduate program, 88 credits followed by an additional exit of 8-credit bridge course with 2 Integrated 4 Credit courses in Major with 3+1 Theory and Lab distribution administrated as a Crash course in 1 month which would help the candidates acquire job-ready competencies required to enter the workforce.

iii) **Bachelor of Science (in Field of study/discipline) i.e., B.Sc. Engineering in (Field of study/discipline)-** Program duration: First three years (first six semesters) of the undergraduate program, 120 credits.

(b) Entry Policy:

Modalities on multiple-entry by the student into the B.Tech. program will be provided in due course of time.

Note: The institution shall resolve any issues that may arise in the implementation of Multiple Entry and Exit policies from time to time and shall review the policies in the light of periodic changes brought by UGC, AICTE, State government and the affiliating univeristy.

23. Gap Year Concept:

Gap year concept for Student Entrepreneur in Residence is introduced and outstanding students who wish to pursue entrepreneurship / become entrepreneur are allowed to take a break of one year at any time after II year to pursue full-time entrepreneurship programme/to establish startups. This period may be extended to two years at the most and these two years would not be counted for the time for the maximum time for graduation. The principal of the respective college shall forward such proposals submitted by the students to the University. An evaluation committee constituted by the University shall evaluate the proposal submitted by the student and the committee shall decide whether to permit the student(s) to avail the Gap Year or not

24. Transitory Regulations

Discontinued, detained, or failed candidates are eligible for readmission as and when the semester is offered after fulfillment of academic regulations. Candidates who have been detained for want of attendance or not fulfilled academic requirements or who have failed after having undergone the course in earlier regulations or have discontinued and wish to continue the course are eligible for admission into the unfinished semester from the date of commencement of class work with the same or equivalent subjects as and when subjects are offered, subject to Section 2 and they will follow the academic regulations into which they are readmitted.

Candidates who are permitted to avail Gap Year shall be eligible for re-joining into the succeeding year of their B. Tech from the date of commencement of class work, subject to Section 2 and they will follow the academic regulations into which they are readmitted.

25. Minimum Instruction Days for a Semester:

The minimum instruction days including exams for each semester shall be 90 days.

26. Medium of Instruction:

The medium of instruction of the entire B.Tech undergraduate programme in Engineering &Technology (including examinations and project reports) will be in English only.

27. Student Transfers:

Student transfers shall be as per the guidelines issued by the Government of Andhra Pradesh and the Universities from time to time.

28. General Instructions:

a. The academic regulations should be read as a whole for purpose of any interpretation.
b. Malpractices rules-nature and punishments are appended.
c. Where the words "he", "him", "his", occur in the regulations, they also include "she", "her", "hers", respectively.
d. In the case of any doubt or ambiguity in the interpretation of the above rules, the decision of the Vice-Chancellor is final.
e. The Universities may change or amend the academic regulations or syllabi at any time and the changes or amendments shall be made applicable to all the students on rolls with effect from the dates notified by the Universities.
f. In the case of any doubt or ambiguity in the interpretation of the guidelines given, the decision of the Vice-Chancellor / Head of the institution is final.

Regulations for MALPRACTICES during the conduct of examinations

	Nature of Malpractices/Improper conduct	Punishment
1.a	If the candidate possesses or keeps accessible in examination hall, any paper, note book, programmable calculators, Cell phones, pager, palm computers or any other form of material concerned with or related to the subject of the examination (theory or practical) in which he is appearing but has not made use of (material shall include any marks on the body of the candidate which can be used as an aid in the subject of the examination) - **FIRST TIME** (whether copied or not)	Expulsion from the examination hall and cancellation of the performance in that subject only. • To keep the CC footage of the act as an evidence. • To obtain a statement from student and get it authorized by observer and Chief superintendent.
1.b	If the candidate possesses or keeps accessible in examination hall, any paper, note book, programmable calculators, Cell phones, pager, palm computers or any other form of material concerned with or related to the subject of the examination (theory or practical) in which he is appearing but has not made use of (material shall include any marks on the body of the candidate which can be used as an aid in the subject of the examination) - **SECOND TIME**(whether copied or not)	Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations, project work and shall not be permitted to appear for the remaining examinations of the subjects of that Semester/year. • To keep the CC footage of the act as an evidence. • To obtain a statement from student and get it authorized by observer and Chief superintendent.
1.c	If the candidate possesses or keeps accessible in examination hall, any paper, note book, programmable calculators, Cell phones, pager, palm computers or any other form of material concerned with or related to the subject of the examination (theory or practical) in which he is appearing but has not made use of (material shall include any marks on the body of the candidate which can be used as an aid in the subject of the examination) - **REPITITION OF THE ABOVE ACT** (After second time and whether copied or not)	Nature of punishment to be given for the improper conduct shall be as per the recommendations of the committee. • The committee comprising of Principal, Vice principal, Chief superintendent, Controller of Examinations and HoD to discuss and initiate the action to be taken and recommend. • To keep the CC footage of the act as evidence. • To obtain a statement from student and invigilator and authorized by Chief superintendent.
2.a.	If the candidate gives assistance or guidance or receives it from any other candidate orally or by any	Expulsion from the examination hall and cancellation of the performance in that subject only

	other body language methods.	of all the candidates involved. • To keep the CC footage of the act as an evidence.
2.b	If the candidate communicates through cell phones / through any other means with any candidate or persons in or outside the exam hall in respect of any matter.	Confiscation of the mobile or electronic gadgets involved and Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations, project work and shall not be permitted to appear for the remaining examinations of the subjects of that Semester/year. • To obtain all relevant proofs of evidence from the Mobile/ gadgets and handing over of the same to the candidate. • To keep the CC footage of the act as evidence. • To obtain a statement from student and invigilator and authorized by observer and Chief superintendent.
	(i) If the communication is with the person(s) who belongs to our college.	Confiscation of the mobile or electronic gadgets involved and Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations, project work and shall not be permitted to appear for the remaining examinations of the subjects of that Semester/year.
	(ii) If the communication is with the person(s) outside the campus or people who are not related to our college.	To obtain all relevant proofs of evidence from the Mobile/ gadgets and handing over of the same to the candidate. To keep the CC footage of the act as evidence. To obtain a statement from student and invigilator and authorized by observer and Chief superintendent. The person(s) involved should be handed over to the police and a case is registered against him.
3.	If the candidate impersonates any other candidate in connection with the examination.	The candidate who has impersonated shall be expelled from examination hall. The candidate is also debarred and forfeits the seat. The performance of the original candidate, who has been impersonated, shall be cancelled in all the subjects of the examination (including practical's and project work) already appeared and shall not

		be allowed to appear for examinations of the remaining subjects of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all University examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. If the imposter is an outsider/candidate not on rolls, he will be handed over to the police and a case is registered against him. • To constitute a committee comprising of Principal, Vice principal, Chief superintendent, Observer, Controller of Examinations and HoD to discuss and initiate the above action with documented proofs. • To keep the CC footage of the act as an evidence. • To obtain a statement from student, invigilator, subject expert and authorized by observer and Chief superintendent.
4	If the candidate mishandles the Answer book or additional sheet or takes out or arranges to send out the question paper during the examination or answer book or additional sheet, during or after the examination. Also,if the answer script is mutilated / damaged disturbing the shape, of the script, answers, the bar code intentionally.	Expulsion from the examination hall and cancellation of performance in that subject and all the other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester. In addition to the above punishment, a committee shall be constituted and recommends appropriate punishment for the improper conduct. • To keep the CC footage of the act as an evidence. • To Obtain a statement from student and invigilator and authorized by observer and Chief superintendent.
5.	Uses objectionable, abusive or offensive language in the Examination hall.	Expulsion from the examination hall and cancellation of the performance in that subject only. • To Obtain a statement from student and invigilator and get it authorized by Observer and Chief superintendent.

6.	Refuses to obey the orders of the Chief Superintendent/ACE/ any officer on duty or misbehaves or creates disturbance of any kind in and around the examination hall or organizes a walk out or instigates others to walk out, or threatens the officer-in charge or any person on duty in or outside the examination hall of any injury to his person or to any of his relations whether by words, either spoken or written or by signs or by visible representation, assaults the officer-in-charge, or any person on duty in or outside the examination hall or any of his relations, or indulges in any other act of misconduct or mischief which result in damage to or destruction of property in the examination hall or any part of the College campus or engages in any other act which in the opinion of the officer on duty amounts to use of unfair means or misconduct or has the tendency to disrupt the orderly conduct of the examination.	In case of students of the college, they shall be expelled from examination halls and cancellation of their performance in that subject and all other subjects the candidate(s) has (have) already appeared and shall not be permitted to appear for the remaining examinations of the subjects of that semester. The candidates also are debarred and forfeit their seats. In case of outsiders, they will be handed over to the police and a police case is registered against them. • To constitute a committee comprising of Principal, Vice principal, Chief superintendent, Observer, Controller of Examinations and HoD to discuss and initiate the above action with documented proofs • To keep the CC footage of the act as an evidence. • To Obtain a statement from student and invigilator and authorized by observer and Chief superintendent.
7.	Leaves the exam hall taking away answer script or intentionally tears of the script or any part thereof inside or outside the examination hall.	Expulsion from the examination hall and cancellation of performance in that subject and all the other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all University examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. • To constitute a committee comprising of Principal, Vice principal, Chief superintendent, Observer, Controller of Examinations and HoD to discuss and initiate the above action. • To keep the CC footage of the act as an evidence. • To Obtain a statement from

		student and invigilator and authorized by observer and Chief superintendent.
8.	Possess any lethal weapon or firearm in the examination hall.	Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred and forfeits the seat. • To constitute a committee comprising of Principal, Vice principal, Chief superintendent, Observer, Controller of Examinations and HoD to discuss and initiate the above action with documented proofs • To keep the CC footage of the act as an evidence. • To obtain a statement from student and invigilator and authorized by observer and Chief superintendent. • The candidate shall be handed over to Police and register a case.
9.	If a student of the college, who is not a candidate for the particular examination or any person not connected with the college indulges in any malpractice or improper conduct mentioned in clause 6 to 8.	If the student belongs to our college: Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester. The candidate is also debarred and forfeits the seat. Person(s) who do not belong to the College will be handed over to police and, a police case will be registered against them. • To constitute a committee comprising of Principal, Vice principal, Chief superintendent, Observer, Controller of Examinations and HoD to discuss and initiate the above action. • To keep the CC footage of

		the act as an evidence. • To Obtain a statement from student and invigilator and authorized by observer and Chief Superintendent.
10	Comes in a drunken condition to the examination hall.	Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester. • To keep the CC footage of the act as an evidence(If any). • To obtain a statement from invigilator and any others as witness authorized by observer and Chief superintendent.
11	Copying detected on the basis of internal evidence, such as, during valuation or during special scrutiny.	Cancellation of the performance in that subject and all other subjects the candidate has appeared including practical examinations and project work of that semester/year examinations. • To Obtain a statement from Valuer / Chief Valuer authorized by Spot Coordinator and Controller of Examinations.

General :

- Wherever the words "he", "him", "his", occur in the regulations, they include "she", "her", "hers".
- The academic regulation should be read as a whole for the purpose of any interpretation.
- In the case of any doubt or ambiguity in the interpretation of the above rules, the decision of the Vice-Chancellor is final.
- The University may change or amend the academic regulations or syllabi at any time and the changes or amendments made shall be applicable to all the students with effect from the dates notified by the University.

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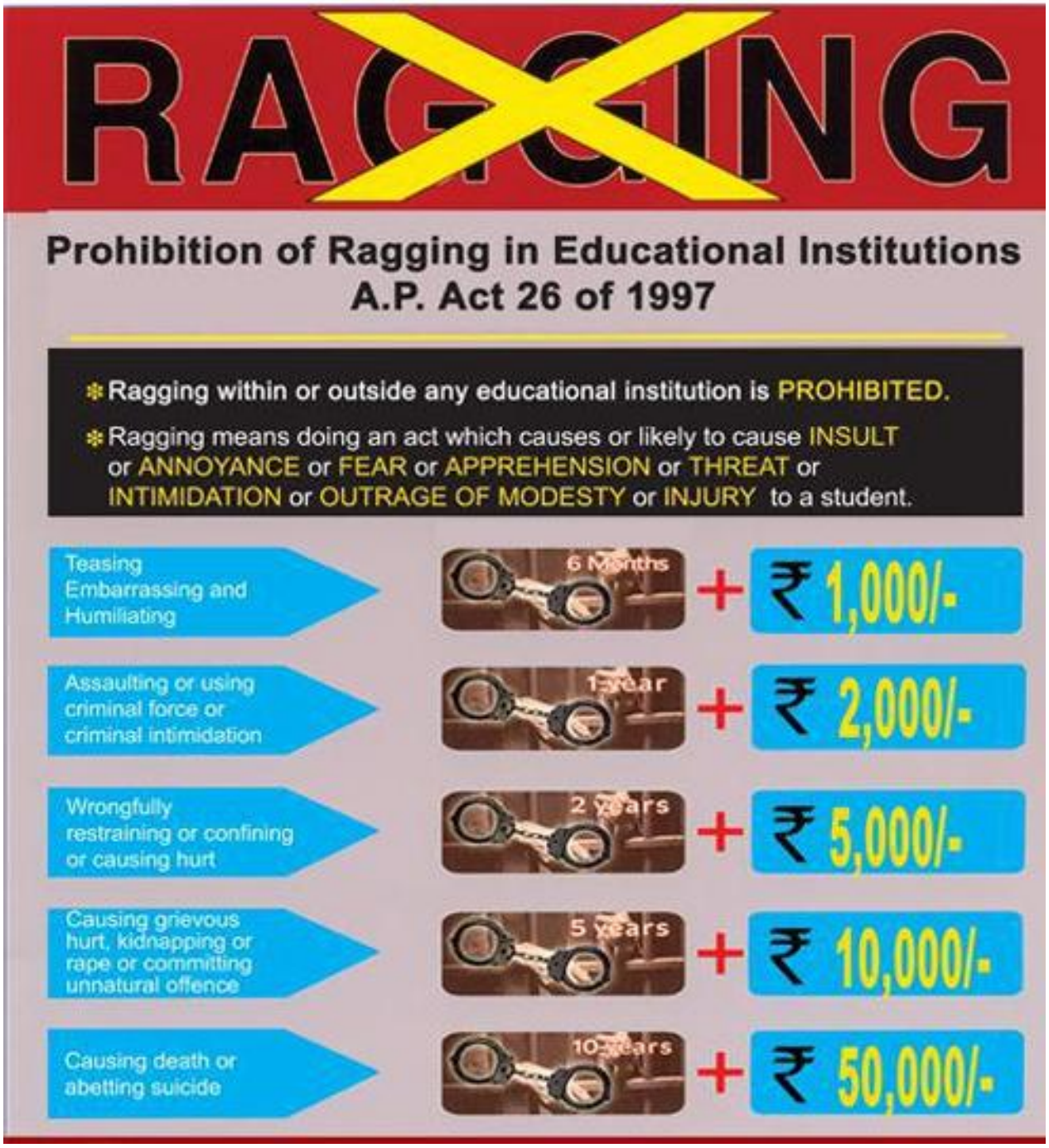

LET US MAKE MVGR A RAGGING FREE CAMPUS

ABSOLUTELY NO TO RAGGING

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1. Ragging is prohibited as per Act 26 of A.P. Legislative Assembly, 1997.
2. Ragging entails heavy fines and/or imprisonment.
3. Ragging invokes suspension and dismissal from the College.
4. Outsiders are prohibited from entering the College and Hostel without permission.
5. Girl students must be in their hostel rooms by 7.00 p.m.
6. All the students must carry their Identity Cards and show them when demanded
7. The Principal and the Wardens may visit the Hostels and inspect the rooms any time.

ACADEMIC REGULATIONS (R23)
FOR B.TECH. (LATERAL ENTRY SCHEME)

*(Effective for the students getting admitted into II year through Lateral Entry Scheme from the Academic Year **2024-2025** onwards)*

1. Award of the Degree

Award of the B.Tech. Degree / B.Tech. Degree with a Minor if he/she fulfils the following:

i. Pursues a course of study for not less than three academic years and not more than six academic years. However, for the students availing Gap year facility this period shall be extended by two years at the most and these two years would in addition to the maximum period permitted for graduation (Six years).

ii. Registers for 120 credits and secures all 120 credits.

2. Award of B.Tech. degree with Honors

A student will be declared eligible for the award of the B.Tech with Honors if he/she fulfils the following:

i. Student secures additional 18 credits fulfilling all the requisites of a B.Tech. program i.e., 120 credits. (ii)Registering for Honors is optional.

ii. Honors is to be completed simultaneously with B.Tech. programme.

Students, who fail to fulfil the requirement for the award of the degree within six consecutive academic years from the year of admission, shall forfeit their seat.

3. Minimum Academic Requirements

The following academic requirements have to be satisfied in addition to the requirements mentioned in item no.2

i. A student shall be deemed to have satisfied the minimum academic requirements and earned the credits allotted to each theory, practical, design, drawing subject or project if he secures not less than 35% of marks in the end examination and a minimum of 40% of marks in the sum total of the mid semester evaluation and end examination taken together.

ii. A student shall be promoted from VI semester to VII semester if he fulfills the minimum attendance requirement (75%) and academic requirement of 40% of credits (any decimal fraction should be rounded off to lower digit) up to either V Semester or VI semester from the following examinations irrespective of whether the candidate takes the examination or not.

- Three regular and Three supplementary examinations of I semester
- Three regular and Two supplementary examinations of II semester
- Two regular and Two supplementary examinations of III semester
- Two regular and One supplementary examinations of IV semester
- One regular and One supplementary examination of V semester
- One regular examination of VI semester.

iii. And in case if student is already detained for want of credits for particular academic year, the student may make up the credits through supplementary exams of the above exams before the commencement of IV year I semester class work of next year.

4. Course Pattern

i. The entire course of study is three academic years on semester pattern.
ii. A student eligible to appear for the end examination in a subject but absent at it or has failed in the end examination may appear for that subject at the next supplementary examination offered.
iii. When a student is detained due to lack of credits/shortage of attendance the student may be re-admitted when the semester is offered after fulfilment of academic regulations, the student shall be in the academic regulations into which he/she is readmitted.

5. All other regulations as applicable for B. Tech. Four-year degree course (Regular) will hold good for B. Tech. (Lateral Entry Scheme).

R23-MVGR
COURSE STRUCTURE
B. Tech. (Regular) - Mechanical Engineering
(Applicable from the Academic Year 2023-24 Onwards)

I Semester

S.No.	Course Code	Course Title	L	T	P	Credits
1	R23MATT101	Linear Algebra and Calculus	3	0	0	3
2	R23CHYT101	Engineering Chemistry	3	0	0	3
3	R23EEET201	Basic Electrical and Electronics Engineering	3	0	0	3
4	R23CSET201	Introduction to Programming	3	0	0	3
5	R23MECD201	Engineering Graphics	1	0	4	3
6	R23CHYL101	Engineering Chemistry Lab	0	0	2	1
7	R23EEEL201	Electrical and Electronics Engineering Lab	0	0	3	1.5
8	R23CSEL201	Computer Programming Lab	0	0	3	1.5
9	R23HSSM802	NSS/NCC/Scouts & Guides/Community Service	0	0	1	0.5
	Total Credits					**19.5**

II Semester

S.No.	Course Code	Course Title	L	T	P	Credits
1	R23HSST001	Communicative English	2	0	0	2
2	R23MATT102	Differential Equations and Vector Calculus	3	0	0	3
3	R23PHYT101	Engineering Physics	3	0	0	3
4	R23CMET201	Basic Civil and Mechanical Engineering	3	0	0	3
5	R23MECT301	Engineering Mechanics	3	0	0	3
6	R23HSSL001	Communicative English Lab	0	0	2	1
7	R23PHYL101	Engineering Physics Lab	0	0	2	1
8	R23MECL301	Engineering Mechanics Lab	0	0	3	1.5
9	R23MECW201	Engineering Workshop	0	0	3	1.5
10	R23CSEW201	IT workshop	0	0	2	1
11	R23HSSM801	Health and Wellness, Yoga and Sports	0	0	1	0.5
	Total Credits					**20.5**

III Semester

S.No.	Course Code	Course Title	L	T	P	Credits
1	R23MMECT002	Metallurgy and Material Science	3	0	0	3
2	R23MMECT003	Engineering Thermodynamics	3	0	0	3
3	R23MMECT004	Mechanics of Solids	3	0	0	3
4	R23MMECT005	Manufacturing Processes	3	0	0	3
5	R23MCSCT001	Data Structures and Algorithms	3	0	0	3
6	R23MSCST011	Operating Systems	3	0	0	3
7	R23MMECL001	Computer Aided Geometric Design and Assembly Lab	0	0	3	2
8	R23MMECL002	Materials Testing Lab	0	0	3	2
9	R23MCSCL001	Data Structures and Algorithms Lab	0	0	3	2
	Total Credits					**24**

IV Semester						
S.No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1	R23MMECT006	Fluid Mechanics and Hydraulic Machines	3	0	0	3
2	R23MMECT007	Design of Machine Elements	3	0	0	3
3	R23MMECT008	Manufacturing Technology	3	0	0	3
4	R23MMECT009	Automotive Technologies	3	0	0	3
5	R23MSCST007	Python Programming	3	0	0	3
6	R23MSCST010	Database Management Systems	3	0	0	3
7	R23MMECL003	Manufacturing Lab	0	0	3	2
8	R23MMECL004	Fluid Mechanics and Hydraulic Machines Lab	0	0	3	2
9	R23MSCSL005	Python Programming Lab	0	0	3	2
10	R23MENGAT01	Ethics and Human Values	2	0	0	-
Total Credits						**24**

V Semester						
S.No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1	R23MMECT010	Theory of Machines	3	0	0	3
2	R23MMECT011	Applied Thermodynamics	3	0	0	3
3	R23MMECT012	Computer-Aided Design and Analysis	3	0	0	3
4	R23MMECT013	Leadership and Team Management	3	0	0	3
5	R23MMECTXXX	DSC-E1	3	0	0	3
6	R23MSCST005	Software Engineering	3	0	0	3
7	R23MMECL005	Computer Aided Engineering Lab	0	0	3	2
8	R23MCSCL003	Database Management Systems Lab	0	0	3	2
9	R23MCIVAT02	Environmental Studies	2	0	0	-
10	R23MMECP001	Community Project	0	0	2	2
Total credits						**24**

VI Semester						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1	R23MMECT014	Heat Transfer	3	0	0	3
2	R23MMECT015	Operations Research	3	0	0	3
3	R23MMECT016	Manufacturing Systems	3	0	0	3
4	R23MCSCT006	OOP with JAVA	3	0	0	3
5	R23MMECTXXX	DSC-E2	3	0	0	3
6	R23MMECTXXX	DSC-E3	3	0	0	3
7	R23MMECL006	Thermal Engineering Lab	0	0	3	2
8	R23MCSCL004	OOP with JAVA Lab	0	0	3	2
9	R23MMATT007	Quantitative Problem Solving Techniques	2	0	0	2
Total Credits						**24**

VII Semester						
S.No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1	R23MMECT017	Logistics and Supply Chain Management (Self-Study/MOOCS)	3	0	0	3
2	R23MMECTXXX	DSC E4 (Self-Study/MOOCS)	3	0	0	3
3	R23MMECTXXX	DSC E5 (Self-Study/MOOCS)	3	0	0	3
4	R23MMECP002	Mini Project	0	0	2	2
5	R23MMECL007	Computer-Aided Manufacturing/ Rapid Prototyping/ CNC Programming/Training in Non-destructive Testing/ Piping Design	0	0	3	2
Total Credits						**13**

VIII Semester						
Sl. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1	R23MCSCT007	Computer Networks (Self-Study/MOOCS)	3	0	0	3
	R23MCSCT008	Artificial Intelligence: Principles and Techniques (Self-Study/MOOCS)	3	0	0	
	R23MCSCT009	OOAD and Design Patterns (Self-Study/MOOCS)	3	0	0	
2	R23MCIVP003	Major-Dissertation/Academic Project-Major	0	0	16	8
Total Credits						**11**

B.Tech. (Regular) Total Credits: 160

DEPARTMENT ELECTIVE COURSES

Manufacturing				
S. No	**Type of Course**	**Course Code**	**Course Title**	**Sem**
1	DSC-E1	R23MMECT018	Business Analysis	V
2	DSC-E2	R23MMECT019	Advanced Manufacturing Techniques	VI
3	DSC-E3	R23MMECT020	Product Lifecycle Management	VI
4	DSC-E4	R23MMECT021	Six Sigma(Self-Study/MOOCs)	VII
5	DSC-E5	R23MMECT022	Non-destructive Testing(Self-Study/MOOCs)	VII

Automotive and Aerospace				
S. No	**Type of Course**	**Course Code**	**Course Title**	**Sem**
1	DSC-E1	R23MMECT023	Robotics	V
2	DSC-E2	R23MMECT024	Finite Element Analysis	VI
3	DSC-E3	R23MMECT020	Product Lifecycle Management	VI
4	DSC-E4	R23MMECT021	Six Sigma(Self-Study/MOOCs)	VII
5	DSC-E5	R23MMECT022	Non-destructive Testing(Self-Study/MOOCs)	VII

Energy				
S. No	**Type of Course**	**Course Code**	**Course Title**	**Sem**
1	DSC-E1	R23MMECT025	Renewable Energy Conversion Technologies	V
2	DSC-E2	R23MMECT026	Heating, Ventilation and Air Conditioning	VI
3	DSC-E3	R23MMECT027	Computational Fluid Dynamics	VI
4	DSC-E4	R23MMECT028	Energy Management and Audit(Self-Study/MOOCs)	VII
5	DSC-E5	R23MMECT029	Sustainable Design of Buildings(Self-Study/MOOCs)	VII

R23-MVGR
COURSE STRUCTURE
B. Tech. (Honors) - Mechanical Engineering
(Applicable from the Academic Year 2023-24 Onwards)

Manufacturing

S.No	Course Code	Course Title	L	T	P	Credits	Sem
1	R23MMECHT01	Project Management	3	0	0	3	VI
2	R23MMECHT02	Nanotechnology	3	0	0	3	VI
3	R23MMECHT03	Additive Manufacturing	3	0	0	3	VII
4	R23MMECHT04	Design for Manufacturing and Assembly	3	0	0	3	VII
5	R23MMECHT05	Material Characterization Techniques	3	0	0	3	VIII
6	R23MMECHT06	Surface Engineering	3	0	0	3	VIII
Total Credits						**18**	

Automotive and Aerospace

S.No	Course Code	Course Title	L	T	P	Credits	Sem
1	R23MMECHT07	Mechanical Vibrations and Condition Monitoring	3	0	0	3	VI
2	R23MMECHT08	Advanced Strength of Materials	3	0	0	3	VI
3	R23MMECHT09	Design of Power Transmission Elements	3	0	0	3	VII
4	R23MMECHT04	Design for Manufacturing and Assembly	3	0	0	3	VII
5	R23MMECHT10	Mechanics of Composite Materials	3	0	0	3	VIII
6	R23MMECHT11	Product Design	3	0	0	3	VIII
Total Credits						**18**	

Energy

S.No	Course Code	Course Title	L	T	P	Credits	Sem
1	R23MMECHT12	Advanced Thermodynamics	3	0	0	3	VI
2	R23MMECHT13	Energy Storage Systems	3	0	0	3	VI
3	R23MMECHT14	Thermal Management of Electronics	3	0	0	3	VII
4	R23MMECHT15	Measurement Techniques in Fluid Flow and Heat Transfer	3	0	0	3	VII
5	R23MMECHT16	Design of Heat Exchangers	3	0	0	3	VIII
6	R23MMECHT17	Fuel Cells and Hydrogen Storage Technologies	3	0	0	3	VIII
Total Credits						**18**	

B.Tech. (Honors) Total Credits: 178

Computer Science Cluster(CSC) (for MEC, ECE, EEE, CIV and CHE) (Not for CSE/IT/CSIT/AIML/DS/ICB)							
Type of Course	**Course code**	**Course Title**	**Sem**	**Type of Course**	**Course Code**	**Course Title**	**Sem**
EOEC-T1	R23MCSCT001	Data Structures & Algorithms	III	EOEC-L1	R23MCSCL001	Data Structures & Algorithms Lab	III
EOEC-T2	R23MSCST011	Operating Systems	III	EOEC-L2	R23MSCSL005	Python Programming Lab	IV
EOEC-T3	R23MSCST007	Python Programming	IV	EOEC-L3	R23MCSCL003	Database Management Systems Lab	V
EOEC-T4	R23MSCST010	Database Management Systems	IV	EOEC-L4	R23MCSCL004	OOP with JAVA Lab	VI
EOEC-T5	R23MCSCT005	Software Engineering	V				
EOEC-T6	R23MCSCT006	OOP with JAVA	VI				
EOEC-E1 Selfstudy /Moocs	R23MCSCT007	Computer Networks	VIII				
	R23MCSCT008	Artificial Intelligence: Principles and Techniques					
	R23MCSCT009	OOAD and Design Patterns					

I Semester

<table>
<tr><td rowspan="3">R23MATT101</td><td colspan="6">LINEAR ALGEBRA AND CALCULUS
(Common to All Branches of Engineering)</td></tr>
<tr><td>Total Contact Hours</td><td>42 (L)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Pre-requisite</td><td>Basic Calculus and Matrices</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Objective</td></tr>
<tr><td colspan="7">To equip the students with standard concepts and tools of mathematics to handle various real-world problems and their applications.</td></tr>
<tr><td colspan="7">Course Outcomes</td></tr>
<tr><td>1</td><td colspan="6">Solve system of equation by Direct and Indirect methods.(BL3)</td></tr>
<tr><td>2</td><td colspan="6">Make use of Linear Algebra techniques to find higher powers and inverse of Matrices.(BL3)</td></tr>
<tr><td>3</td><td colspan="6">Make use of Mean value theorems to deduce Mathematical identities.(BL3)</td></tr>
<tr><td>4</td><td colspan="6">Use the concept of multivariable calculus to determine the maxima and minima of a multivariable function.(BL3)</td></tr>
<tr><td>5</td><td colspan="6">Estimate areas and volumes with help of Multiple integrals.(BL3)</td></tr>
<tr><td>6</td><td colspan="6">Formulate Mathematical models and estimate appropriate physical quantities.(BL6)</td></tr>
<tr><td colspan="7">SYLLABUS</td></tr>
<tr><td>Unit I</td><td colspan="5">MATRICES</td><td>9 hr</td></tr>
<tr><td colspan="7">Rank of a matrix by echelon form, normal form. Cauchy –Binet formulae (without proof). Inverse of Non-singular matrices by Gauss-Jordan method, System of linear equations: Solving system of Homogeneous and Non-Homogeneous equations by Gauss elimination method, Gauss Seidel Iteration Method.</td></tr>
<tr><td>Unit II</td><td colspan="5">LINEAR TRANSFORMATION AND ORTHOGONAL TRANSFORMATION</td><td>9 hr</td></tr>
<tr><td colspan="7">Eigenvalues, Eigenvectors and their properties, Diagonalization of a matrix, Cayley-Hamilton Theorem (without proof), finding inverse and power of a matrix by Cayley-Hamilton Theorem, Quadratic forms and Nature of the Quadratic Forms, Reduction of Quadratic form to canonical forms by Orthogonal Transformation.</td></tr>
<tr><td>Unit III</td><td colspan="5">CALCULUS</td><td>9 hr</td></tr>
<tr><td colspan="7">Mean Value Theorems: Rolle’s Theorem, Lagrange’s mean value theorem with their geometrical interpretation, Cauchy’s mean value theorem, Taylor’s and Maclaurin theorems with remainders (without proof), Problems and applications on the above theorems.</td></tr>
<tr><td>Unit IV</td><td colspan="5">PARTIAL DIFFERENTIATION AND APPLICATIONS (MULTI VARIABLE CALCULUS)</td><td>9 hr</td></tr>
<tr><td colspan="7">Partial derivatives, total derivatives, chain rule, change of variables, Taylor’s and Maclaurin’s series expansion of functions of two variables, Jacobians, maxima and minima of functions of two variables, method of Lagrange multipliers.</td></tr>
<tr><td>Unit V</td><td colspan="5">MULTIPLE INTEGRALS (MULTI VARIABLE CALCULUS)</td><td>9 hr</td></tr>
<tr><td colspan="7">Double integrals, triple integrals, change of order of integration, change of variables to polar, cylindrical and spherical coordinates. Finding areas (by double integrals) and volumes (by double integrals and triple integrals).</td></tr>
</table>

LEARNING RESOURCES	
TEXT BOOKS:	
1	B.S.Grewal,*Higher Engineering Mathematics*,44/e,KhannaPublishers,2017.
2	ErwinKreyszig, *Advanced Engineering Mathematics*, 10/e,JohnWiley&Sons, 2018.
REFERENCE BOOKS:	
1	R.K.Jain and S.R.K.Iyengar, *Advanced Engineering Mathematics*, 5/e, Alpha Science International Ltd.,2021 (9th reprint).
2	George B.Thomas, Maurice D. Weir and Joel Hass, *Thomas Calculus*,14/e, Pearson Publishers, 2018.
3	GlynJames, *Advanced Modern Engineering Mathematics*, 5/e, Pearson publishers, 2018.
4	Michael Green berg, *Advanced Engineering Mathematics*, 9th edition, Pearson edn.
5	K Das, Er. Rajnish Verma, *Higher Engineering Mathematics*, S. Chand, 2021.

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL 3	X				
CO2	BL 3		X			
CO3	BL 3			X		
CO4	BL 3				X	
CO5	BL 3					X
CO6	BL 6	X	X	X	X	X

R23CHYT101	ENGINEERING CHEMISTRY (Common to Civil, Mechanical and Metallurgical Engineering)					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Chemistry at 10 + 2 level education	**3**	**0**	**0**	**3**

Course Objective

Students will get exposure to

- To familiarize engineering chemistry and its applications
- To impart the concept of soft and hard waters, softening methods of hard water
- To train the students on the principles and applications of electrochemistry, polymers, surface chemistry, and cement.

Course Outcomes

1	The student will be able to **sugges**t a suitable water treatment method for a given industrial application through **assessing** the quality of water.(**BL5**)
2	The student will be able to **select** a suitable energy storage device for a given application as well he/she will also **design** a suitable process for corrosion prevention in industry.(**BL5**)
3	The student will be able to recommend a suitable polymer/ plastic/ elastomer for a given industrial application. He /She will also **assess** the suitability of a given fuel.(**BL5**)
4	The student will be able to **select** a suitable composite/ refractory/ lubricant/ binding material for a given application.(**BL5**)
5	The student will be able to **synthesize** a suitable colloid or nanomaterial for a given application.(**BL6**)
6	The student will be able to **synthesize** a colloid/ nanomaterial/ polymer; **recommend** a suitable building material/composite/ refractory/ lubricant; **select** a suitable energy storage device and **assess** the quality of water for a given industrial application.(**BL6**)

SYLLABUS

Unit I	**WATER TECHNOLOGY**	**8 hr**

Soft and hardwater, Estimation of hardness of water by EDTA Method, Estimation of dissolved Oxygen - Boiler troubles –Priming, foaming, scale and sludge, Caustic embrittlement, Industrial water treatment – Specifications for drinking water, Bureau of Indian Standards(BIS) and World health organization(WHO) standards, Ion-exchange processes - desalination of brackish water, reverse osmosis (RO) and electrodialysis.

Unit II	**ELECTROCHEMISTRY AND APPLICATIONS**	**8 hr**

Electrodes –electrochemical cell, Nernst equation, cell potential calculations.
Primary cells – Zinc-air battery, Secondary cells – Nickel-Cadmium (NiCad),and lithium ion batteries- working principle of the batteries including cell reactions; Fuel cells-Basic Concepts, the principle and working of hydrogen-oxygen Fuel cell.
Corrosion: Introduction to corrosion, electrochemical theory of corrosion, differential aeration cell corrosion, galvanic corrosion, metal oxide formation by dr y electrochemical corrosion, Pilling Bedworth ratios and uses, Factors affecting the corrosion, cathodic and anodic protection, electroplating and electro less plating (Nickel and Copper).

Unit III	**POLYMERS AND FUEL CHEMISTRY**	**8 hr**

Introduction to polymers, functionality of monomers, Mechanism of chain growth, step growth polymerization.

Thermoplastics and Thermo-setting plastics-: Preparation, properties and applications of poly styrene. PVC Nylon 6,6 and Bakelite.
Elastomers – Preparation, properties and applications of Buna S, Buna N, Thiokol rubbers.
Fuels – Types of fuels, calorific value of fuels, numerical problems based on calorific value; Analysis of coal (Proximate and Ultimate analysis), Liquid Fuels, refining of petroleum, Octane and Cetane number- alternative fuels- propane, methanol, ethanol and bio fuel-bio diesel.

Unit IV	**MODERN ENGINEERING MATERIALS**	**8 hr**

Composites- Definition, Constituents, Classification- Particle, Fibre and Structural reinforced composites, properties and Engineering applications
Refractories- Classification, Properties, Factors affecting the refractory materials and Applications.
Lubricants- Classification, Functions of lubricants, Mechanism, Properties of lubricating oils – Viscosity, Viscosity Index, Flash point, Fire point, Cloud point, saponification and Applications.
Building materials- Portland Cement, constituents, Setting and Hardening of cement.

Unit V	**SURFACE CHEMISTRY AND NANOMATERIALS**	**8 hr**

Introduction to surface chemistry, colloids, nanometals and nanometal oxides, micelle formation, synthesis of colloids (Braggs Method), chemical and biological methods of preparation of nanometals and metal oxides, stabilization of colloids and nanomaterials by stabilizing agents, adsorption isotherm (Freundlich and Longmuir), BET equation (no derivation) applications of colloids and nanomaterials – catalysis, medicine, sensors, etc.

LEARNING RESOURCES

TEXT BOOKS:

1	Jain and Jain, *Engineering Chemistry*, 16/e, DhanpatRai, 2013.
2	Peter Atkins, Julio de Paula and James Keeler, Atkins' *Physical Chemistry*, 10/e, Oxford University Press, 2010.

REFERENCE BOOKS:

1	H.F.W. Taylor, *Cement Chemistry*, 2/e, Thomas Telford Publications, 1997.
2	D.J. Shaw, *Introduction to Colloids and Surface Chemistry*, Butterworth-Heineman, 1992.
3	F. W. Billmeyer, *Textbook of Polymer Science*, 3 ed. Singapore: Wiley, 2009

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL5	X				
CO2	BL5		X			
CO3	BL5			X		
CO4	BL5				X	
CO5	BL6					X
CO6	BL6	X	X	X	X	X

R23EEET201	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING (Common to All Branches of Engineering)					
	Total Contact Hours	48 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Fundamental Physics and Maths	**3**	**0**	**0**	**3**

Course Objective

Students will gain understanding of laws and principles of electrical and electronics engineering and able to apply this knowledge to build simple circuits in relevant fields.

Course Outcomes: Student

1	Will be able to apply the basic principles of electrical and circuits to solve DC and AC circuits.(**BL3**)
2	Will be able to analyze the construction and operation of various electrical machines and measuring instruments also select a machine for an application.(**BL3**)
3	Will be able to analyze power generation, electric safety measures and examine electrical power consumption and tariff.(**BL4**)
4	Will be able to appraiser a profound comprehension of semiconductor devices, basic electronic circuits, and instrumentation by examining the principles, characteristics, & application and analyze the block diagrams and interactions within electronic instrumentation systems.(**BL4**)
5	Will be able to design simple combinational and sequential circuits of digital electronics.(**BL6**)
6	Will be able to combine the fundamental principles of electrical and electronics engineering to design & solve simple circuits and discuss power generation, control and safety.(**BL6**)

SYLLABUS

Unit I	**DC & AC CIRCUITS**	**8 hr**

Electrical circuit elements (R), Ohm's Law and its limitations; KCL; KVL; Electrical circuit elements (L, C); Superposition theorem; A.C. Fundamentals; Voltage and current relationship with phasor diagrams in R, L, and C circuits; Concept of Impedance, Active power, reactive power, apparent power and power factor;

Unit II	**MACHINES AND MEASURING INSTRUMENTS**	**8 hr**

Construction, principle and operation of & Applications - DC Motor; DC Generator; Single Phase Transformer; Three Phase Induction Motor;
Construction, principle and operation of & Applications – Alternator; Construction and working principle of PMMC Instruments; MI Instruments; Wheatstone bridge;

Unit III	**ENERGY RESOURCES, ELECTRICITY BILL & SAFETY MEASURES**	**8 hr**

Conventional and non-conventional energy resources, Layout and operation of various Power Generation systems - Hydel generation; Nuclear generation; Solar power generation.; Wind power generation. Power rating of household appliances, Definition of "unit" used for consumption of electrical energy; Two-part electricity tariff, calculation of electricity bill for domestic consumers; Working principle of Fuse and Miniature circuit breaker (MCB), merits and

demerits; Earthing and types of earthing, Safety Precautions to avoid shock;		
Unit IV	**SEMICONDUCTOR DEVICES**	**8 hr**
Evolution of Electronics and Classification of Materials; PN Junction Diode and Characteristics; Zener Diode and Characteristics; Transistor (NPN and PNP) Operation; Transistor CB configuration; Transistor CE Configuration; Transistor CC Configuration; Small signal Transistor CE amplifier;		
Unit V	**BASIC ELECTRONIC CIRCUITS AND INSTRUMENTATION**	**8 hr**
Half Wave Rectifier; Full Wave Bridge Rectifier; Rectifiers with filters; Zener regulator; DC Power supply (RPS); Public Address System; Frequency response of CE amplifier; Electronic Instrumentation System;		
Unit VI	**DIGITAL ELECTRONICS**	**8 hr**
Number Systems; Binary Codes; Logic gates; Boolean Algebra;Half and Full adder; Flip Flops; Registers; Counters		

LEARNING RESOURCES

TEXT BOOKS:	
1	D. C. Kulshreshtha, *Basic Electrical Engineering*, Tata McGraw Hill, 2019.
2	P.V. Gupta, M.L. Soni, U.S. Bhatnagar and A. Chakrabarti, *Power System Engineering*, Dhanpat Rai & Co, 2013.
3	R. S. Sedha, *A Textbook of Electronic Devices and Circuits*, S. Chand & Co, 2010.
REFERENCE BOOKS:	
1	V.K. Mehtha, *Principles of Electrical and Electronics Engineering*, S.Chand Technical Publishers, 2020.
2	S. K. Bhatacharya, *Basic Electrical and Electronics Engineering*, Person Publications, 2018.
3	R. P. Jain, *Modern Digital Electronics*, Tata Mc Graw Hill, 2009.
ONLINE COURSES:	
1	https://nptel.ac.in/courses/108105053
2	https://nptel.ac.in/courses/108108076

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V	Unit VI
CO1	BL3	X	X				
CO2	BL3		X				
CO3	BL4			X			
CO4	BL4				X	X	
CO5	BL6						X
CO6	BL6	X	X	X	X	X	X

R23CSET201	INTRODUCTION TO PROGRAMMING (Common to All branches of Engineering)					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	NIL	**3**	**0**	**0**	**3**

Course Objective

- The course aims to equip students with advanced proficiency in C programming, fostering problem-solving skills and algorithmic design, while ensuring mastery in data manipulation, function implementation, and file handling techniques.

Course Outcomes

1	Students will develop essential problem-solving skills and ability to design efficient algorithms to address a wide range of challenges effectively.
2	Students will formulate solutions by constructing well-organized and efficient C programs, effectively using data types, program flow, and loop structures with appropriate utilization of keywords, operators and identifiers.
3	Students will have the ability to experiment on arrays, pointers, and dynamic memory allocation, effectively to develop strategies for manipulates data with precision and efficiency.
4	Students will construct solutions by utilizing functions, string handling, applying variable scope and storage classes effectively, and implementing recursion through C programming principles.
5	Students will create and develop skills in handling structures, unions, and self-referential structures, and demonstrate proficiency in file handling techniques for input and output operations in C.
6	Students will develop and author comprehensive programming expertise in C, encompassing computer problem-solving skills, array and pointer manipulation, function implementation, string handling, and data structure utilization through file operations.

SYLLABUS

Unit I	**INTRODUCTION TO COMPUTER PROBLEM SOLVING**	**9 hr**

Programs and Algorithms, Computer Problem Solving Requirements, Phases of Problem Solving, Problem. Solving Strategies, Top-Down Approach, Algorithm Designing, Program Verification, Improving Efficiency, Algorithm Analysis and Notations.

Unit II	**INTRODUCTION TO C PROGRAMMING**	**9 hr**

Introduction, Structure of a C Program. Comments, Keywords, Identifiers, Data Types, Variables, Constants, Input/output Statements. Operators, Type Conversion. Control Flow, Relational Expressions: Conditional Branching Statements: if, if-else, if-else—if, switch. Basic Loop Structures: while, do-while loops, for loop, nested loops, The Break and Continue Statements, goto statement.

Unit III	**ARRAYS & POINTERS**	**9 hr**

Introduction, Operations on Arrays, Arrays as Function Arguments, Two Dimensional Arrays, Multidimensional Arrays. Pointers: Concept of a Pointer, Declaring and Initializing Pointer Variables, Pointer Expressions and Address Arithmetic, Null Pointers, Generic Pointers, Pointers as Function Arguments, Pointers and Arrays, Pointer to Pointer, Dynamic Memory Allocation, Dangling Pointer, Command Line Arguments.

Unit IV	**FUNCTIONS & STRINGS**	**9 hr**
Introduction Function: Declaration, Function Definition, Function Call, Categories of Functions, Passing Parameters to Functions, Scope of Variables, Variable Storage Classes. Recursion. Strings: String Fundamentals, String Processing with and without Library Functions, Pointers and Strings.		
Unit V	**STRUCTURES & FILE HANDLING**	**9 hr**
Structures, Unions, Bit Fields: Introduction, Nested Structures, Arrays of Structures, Structures and Functions, Self-Referential Structures, Unions, Enumerated Data Type —Enum variables, Using Typedef keyword, Bit Fields. Data Files: Introduction to Files, Using Files in C, Reading from Text Files, Writing to Text Files, Random File Access.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	B. A. Forouzan, *Computer science: a structured programming approach using C*, 3rd ed. India edition. New Delhi: Cengage Learning India Private Ltd., 2012	
2	R. G. Dromey, *How to solve it by computer*. Delhi: Pearson education, 2008.	
3	A. Mittal, *Programming in C: a practical approach.* New Delhi, India: Pearson Education, 2010.	
REFERENCE BOOKS:		
1	Byron Gottfried, *Schaum's Outline of Programming with C*, McGraw-Hill.	
2	Reema Thareja, *Computer Programming*, Oxford University Press	
3	Dennis Richie and Brian Kernighan, *The C Programming Language*, Pearson Education.	
4	Ashok Kamthane, *Programming In C*, Second Edition, Pearson Publication.	
5	Kanetkar, *Let us C*, Yaswanth, 16th Edition, BPB Publication.	
6	Balagurusamy, E., *Computing fundamentals and C Programming*, McGraw-Hill Education, 2008	
WEB REFERENCES:		
1	http://www.c4learn.com/	
2	http://www.geeksforgeeks.org/c/	
3	http://nptel.ac.in/courses/122104019/	
4	http://www.learn-c.org/	
5	https://www.tutorialspoint.com/cprogramming/	
ONLINE COURSES:		
1	https://mvgrce.codetantra.com	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL6		X			
CO3	BL3			X		
CO4	BL6				X	
CO5	BL6					X
CO6	BL6	X	X	X	X	X

R23MECD201	ENGINEERING GRAPHICS (Common to All Branches of Engineering)					
	Total Contact Hours	75(15L+60P)	**L**	**T**	**P**	**C**
	Pre-requisite	Basic mathematics, imagination skills	**1**	**0**	**4**	**3**

Course Objective: To enable the students with various concepts like dimensioning, conventions and standards related to Engineering Drawing

Course Outcomes: On completion of the course, the student should be able to

1	Apply the principles of curves, scales, orthographic and isometric projections. in engineering drawing.(**BL3**)
2	Interpret orthographic projections like front, top and side views related to points, lines, planes and solids.(**BL5**)
3	Demonstrate the projection of solids in various positions in the first quadrant. (**BL3**)
4	Examine the principles behind development of surfaces. (**BL4**)
5	Develop orthographic and isometric projections of solids. (**BL6**)

SYLLABUS

Unit I	**CURVES, SCALES AND POLYGONS**	**15 hr**

Introduction: Lines, Lettering and Dimensioning, Geometrical Constructions and Constructing regular polygons by general methods.
Curves: construction of ellipse, parabola and hyperbola by general, Cycloids, Involutes, Normal and tangent to Curves.
Scales: Plain scales, diagonal scales and vernier scales.

Unit II	**ORTHOGRAPHIC PROJECTIONS**	**15 hr**

Orthographic Projections: Reference plane, importance of reference lines or Plane, Projections of a point situated in any one of the four quadrants.
Projections of Straight Lines: Projections of straight lines parallel to both reference planes, perpendicular to one reference plane and parallel to other reference plane, inclined to one reference plane and parallel to the other reference plane. Projections of Straight Line Inclined to both the reference planes
Projections of Planes: regular planes Perpendicular to both reference planes, parallel to one reference plane and inclined to the other reference plane; plane inclined to both the reference planes.

Unit III	**PROJECTIONS OF SOLIDS**	**15 hr**

Projections of Solids: Types of solids: Polyhedra and Solids of revolution. Projections of solids in simple positions: Axis perpendicular to horizontal plane, Axis perpendicular to vertical plane and Axis parallel to both the reference planes, Projection of Solids with axis inclined to one reference plane and parallel to another plane.

Unit IV	**SECTIONS OF SOLIDS AND DEVELOPMENT OF SURFACES**	**15 hr**

Sections of Solids: Perpendicular and inclined section planes, Sectional views and True shape of section, Sections of solids in simple position only.
Development of Surfaces: Methods of Development: Parallel line development and radial line development. Development of a cube, prism, cylinder, pyramid and cone.

Unit V	**CONVERSIONS OF VIEWS**	**15 hr**

Conversion of Views: Conversion of isometric views to orthographic views; Conversion of orthographic views to isometric views.
Computer graphics: Creating 2D&3D drawings of objects including PCB and

Transformations using AutoCAD	
LEARNING RESOURCES	
TEXT BOOKS:	
1	N. D. Bhatt, *Engineering Drawing*, Charotar Publishing House, 2016.
REFERENCE BOOKS:	
1	K.L. Narayana and P. Kannaiah, *Engineering Drawing*, Tata McGraw Hill, Third Edition, 2013.
2	M.B.Shah and B.C. Rana, *Engineering Drawing*, Pearson Education Inc,2009.
3	Dhananjay Jolhe, *Engineering Drawing with an Introduction to AutoCAD*, Tata McGraw Hill, 2017.
ADDITIONAL REFERENCE MATERIAL:	
1	https://nitc.ac.in/imgserver/uploads/attachments/Ed__5c3343c5-c3f9-468a-b114-8f33556810b4_.pdf
ONLINE COURSES:	
1	https://www.mygreatlearning.com/academy/learn-for-free/courses/engineering-graphics-drawing
2	https://onlinecourses.nptel.ac.in/noc21_me128/preview
3	https://www.udemy.com/course/engineering-drawing-graphics/

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X	X	X		
CO2	BL5	X	X	X		
CO3	BL3			X	X	X
CO4	BL4				X	X
CO5	BL6	X	X	X	X	X

R23CHYL101	ENGINEERING CHEMISTRY LAB (Common to Civil, Mechanical and Metallurgical Engineering)					
	Total Contact Hours	30 (P)	**L**	**T**	**P**	**C**
	Pre-requisite	Chemistry at 10 + 2 level education	**0**	**0**	**2**	**1**

Course Objective	
Verify the fundamental concepts with experiments	
Course Outcomes: At the end of the course, the student will be able to	
1	Determine the cell constant and conductance of solutions.
2	Prepare advanced polymers and nanomaterials.
3	Measure the strength of an acid present in secondary batteries.
4	Understand, analyze and apply the principles of UV - Visible and IR spectroscopic techniques.
5	Understand and determine the potentials using Potentiometry.
List of Experiments	
1	Measurement of 10Dq by spectrophotometric method.
2	Conductometric titration of strong acid vs. strong base.
3	Conductometric titration of weak acid vs. strong base.
4	Determination of cell constant and conductance of solutions.
5	Potentiometry - determination of redox potentials and emfs.
6	Determination of Strength of an acid in Pb-Acid battery.
7	Preparation of a Bakelite.
8	Verify Lambert-Beer's law.
9	Wavelength measurement of sample through UV-Visible Spectroscopy.
10	Identification of simple organic compounds by IR.
11	Preparation of nanomaterials by precipitation method.
12	Estimation of Ferrous Iron by Dichrometry.
LEARNING RESOURCES	
TEXT BOOKS:	
1	Chemistry lab Manual. Prepared by Department of Chemistry, MVGR College of Engineering (A)
REFERENCE BOOKS:	
1	J. Mendham, R. C. Denney, J. D. Barnes, and B. Sivasankar, *Vogel's textbook of quantitative chemical analysis*. New Delhi: Pearson, 2009.
ADDITIONAL REFERENCE MATERIAL:	
1	https://www.youtube.com/@spardhayavardhatheyvidya3470

R23EEEL201	ELECTRICAL AND ELECTRONICS ENGINEERING LAB (Common to All Branches of Engineering)					
	Total Contact Hours	45 (P)	**L**	**T**	**P**	**C**
	Pre-requisite	BEEE	**0**	**0**	**3**	**1.5**

Course Objective	
To impart knowledge on design and practical verification basic electrical and electronic circuits and simple energy calculation.	
Course Outcomes: Student will be able to	
1	Design and analyze simple circuits to verify basic electrical laws and theorems.
2	Design and analyze electrical circuits to measure resistance, power and energy consumption.
3	Understand the voltage buildup procedure in DC shunt generator.
4	Design simple electronic circuits to analyze the behavior of electronic components and verify their applications.
5	Explain the operation of digital circuits.
List of Experiments	
1	Verification of KCL and KVL
2	Verification of Superposition theorem
3	Measurement of Resistance using Wheat stone bridge
4	Magnetization Characteristics of DC shunt Generator
5	Measurement of Power and Power factor using Single-phase wattmeter
6	Calculation of Electrical Energy for Domestic Premises
7	Plot V-I characteristics of PN Junction diode A) Forward bias B) Reverse bias.
8	Plot V – I characteristics of Zener Diode and its application as voltage Regulator.
9	Implementation of half wave and full wave rectifiers
10	Plot Input & Output characteristics of BJT in CE and CB configurations
11	Verification of Truth Table of AND, OR, NOT, NAND, NOR, Ex-OR, Ex-NOR gates using ICs.
12	Verification of Truth Tables of S-R, J-K& D flip flops using respective ICs.
Additional experiments	
1	Measurement of Earth Resistance using Megger
2	Frequency response of CE amplifier
3	Simulation of RC coupled amplifier with the design supplied
LEARNING RESOURCES	
TEXT BOOKS:	
1	D. C. Kulshreshtha, *Basic Electrical Engineering*, Tata McGraw Hill, 2019.
2	P.V. Gupta, M.L. Soni, U.S. Bhatnagar and A. Chakrabarti, *Power System Engineering*, Dhanpat Rai & Co, 2013.
3	R. S. Sedha, *A Textbook of Electronic Devices and Circuits*, S. Chand & Co, 2010.
REFERENCE BOOKS:	
1	V.K. Mehtha, *Principles of Electrical and Electronics Engineering*, S.Chand Technical Publishers, 2020.
2	S. K. Bhatacharya, *Basic Electrical and Electronics Engineering*, Person Publications,2018.
3	R. P. Jain, *Modern Digital Electronics*, Tata Mc Graw Hill, 2009

ADDITIONAL REFERENCE MATERIAL:	
1	https://www.udemy.com/course/complete-course-on-electronic-devices-and-circuits/
2	http://nptel.iitm.ac.in/
3	http://www.learningware.in/

R23CSEL201	COMPUTER PROGRAMMING LAB (Common to all branches of Engineering)					
	Total Contact Hours	45 (P)	**L**	**T**	**P**	**C**
	Pre-requisite	NIL	**0**	**0**	**3**	**1.5**

Course Objective

- The course aims to give students hands – on experience and train them on the concepts of the C- programming language.

Course Outcomes

1	Read, understand, and trace the execution of programs written in C language.
2	Select the right control structure for solving the problem.
3	Develop C programs which utilize memory efficiently using programming constructs like pointers.
4	Develop, Debug and Execute programs to demonstrate the applications of arrays, functions, basic concepts of pointers in C.

LIST OF EXPERIMENTS

1	**WEEK 1:** Familiarization with programming environment. i Basic Linux environment and its editors like Vi, Vim & Emacs, gedit etc. ii Exposure to Turbo C, gcc iii Writing simple programs using printf(), scanf()
2	**WEEK 2** Developing the algorithms/flowcharts for the following sample programs i Sum and average of 3 numbers ii Conversion of Fahrenheit to Celsius and vice versa iii Simple interest calculation
3	**WEEK 3** Simple computational problems using arithmetic expressions. i Finding the square root of a given number ii Finding compound interest iii Area of a triangle using heron's formulae iv Distance travelled by an object
4	**WEEK 4:** Simple computational problems using the operator' precedence and associativity i Evaluate the following expressions. a. A+B*C+(D*E) + F*G b. A/B*C-B+A*D/3 c. A+++B---A d. J= (i++) + (++i) ii Find the maximum of three numbers using conditional operator iii Take marks of 5 subjects in integers, and find the total, average in float
5	**WEEK 5:** Problems involving if-then-else structures.: i Write a C program to find the max and min of four numbers using if-else. ii Write a C program to generate electricity bill.

	iii Find the roots of the quadratic equation. iv Write a C program to simulate a calculator using switch case. v Write a C program to find the given year is a leap year or not.
6	**WEEK 6:** Iterative problems: i Find the factorial of given number using any loop. ii Find the given number is a prime or not. iii Compute sine and cos series iv Checking a number palindrome v Construct a pyramid of numbers.
7	**WEEK 7:** Array manipulation, linear search i Find the min and max of a 1-D integer array. ii Perform linear search on1D array. iii The reverse of a 1D integer array iv Find 2's complement of the given binary number. v Eliminate duplicate elements in an array
8	**WEEK 8:** Matrix problems, String operations, Bubble sort i Addition of two matrices ii Multiplication two matrices iii Sort array elements using bubble sort iv Concatenate two strings without built-in functions v Reverse a string using built-in and without built-in string functions
9	**WEEK 9:** Pointers and structures, memory dereference. i Write a C program to find the sum of a 1D array using malloc() ii Write a C program to find the total, average of n students using structures iii Enter n students data using calloc() and display failed students list iv Read student name and marks from the command line and display the student details along with the total. v Write a C program to implement realloc()
10	**WEEK 10:** i Read and print a date using dd/mm/yyyy format using bit-fields and differentiate the same without using bit- fields ii Create and display a singly linked list using self-referential structure. iii Demonstrate the differences between structures and unions using a C program. iv Write a C program to shift/rotate using bitfields. iv) Write a C program to copy one structure variable to another structure of the same type.
11	**WEEK 11:** Simple functions using call by value, solving differential equations using Eulers theorem. i Write a C function to calculate NCR value. ii Write a C function to find the length of a string. iii Write a C function to transpose of a matrix. iv Write a C function to demonstrate numerical integration of differential equations using Euler's method

12	**WEEK 12:** Recursive functions: i Write a recursive function to generate Fibonacci series. ii Write a recursive function to find the lcm of two numbers. iii Write a recursive function to find the factorial of a number. iv Write a C Program to implement Ackermann function using recursion. v Write a recursive function to find the sum of series.
13	**WEEK 13:** Simple functions using Call by reference, Dangling pointers. i Write a C program to swap two numbers using call by reference. ii Demonstrate Dangling pointer problem using a C program. iii Write a C program to copy one string into another using pointer. iv Write a C program to find no of lowercase, uppercase, digits and other characters using pointers.
14	**WEEK 14:** File operations i Write a C program to write and read text into a file. ii Write a C program to write and read text into a binary file using fread() and fwrite() iii Copy the contents of one file to another file. iv Write a C program to merge two files into the third file using command-line arguments. v Find no. of lines, words and characters in a file vi) Write a C program to print last n characters of a given file.
TEXT BOOKS:	
1	Ajay Mittal, *Programming in C: A practical approach*, Pearson.
2	Byron Gottfried, *Schaum' s Outline of Programming with C*, McGraw Hill
REFERENCE BOOKS:	
1	Brian W. Kernighan and Dennis M. Ritchie, *The C Programming Language*, Prentice- Hall of India,1988.
2	Forouzan, Gilberg, Prasad, *C Programming, A Problem-Solving Approach*, CENGAGE, 2011.
ONLINE COURSES:	
1	https://mvgrce.codetantra.com

R23HSSM802	NSS/NCC/SCOUTS AND GUIDES/COMMUNITY SERVICE (Common to All Branches of Engineering)					
	Total Contact Hours	15 (P)	**L**	**T**	**P**	**C**
	Pre-requisite	Nil	**0**	**0**	**1**	**0.5**

Course Objective

The objective of introducing this course is to impart discipline, character, fraternity, teamwork, social consciousness among the students and engaging them in selfless service.

Course Outcomes

1	Demonstrate the importance of discipline, character and service motto.
2	Solve some societal issues by applying acquired knowledge, facts, and techniques.
3	Explore human relationships by analyzing social problems.
4	Develop service-oriented approach to extend their help for the fellow beings and downtrodden people.
5	Develop leadership skills and civic responsibilities.

SYLLABUS

Unit I	General Orientation on NSS/NCC/ Scouts & Guides/Community Service activities, career guidance. **Activities:** i) Conducting –ice breaking sessions-expectations from the course-knowing personal talents and skills ii) Conducting orientations programs for the students –future plans-activities-releasing road map etc. iii) Displaying success stories-motivational biopics- award winning movies on societal issues etc. iv) Conducting talent show in singing patriotic songs-paintings- any other contribution.	**5 hr**
Unit II	**NATURE & CARE** **Activities:** i) Nature & Care Best out of waste competition. ii) Poster and signs making competition to spread environmental awareness. iii) Recycling and environmental pollution article writing competition. iv) Organizing Zero-waste day. v) Digital Environmental awareness activity via various social media platforms. vi) Virtual demonstration of different eco-friendly approaches for sustainable living. vii) Write a summary on any book related to environmental issues.	**5 hr**
Unit III	**COMMUNITY SERVICE** **Activities:** i) Community Service Conducting One Day Special Camp in a village contacting village-area leaders- Survey in the village, identification of problems- helping them to solve via media-authorities- experts-etc. 24 JNTUGV B. Tech. R23 Regulations ii) Conducting awareness programs on Health-related issues such as General Health, Mental health, Spiritual Health, HIV/AIDS, iii) Conducting consumer Awareness. Explaining various legal provisions etc. iv) Women Empowerment Programmes- Sexual Abuse, Adolescent Health and Population Education. v) Any other programmes in collaboration with local charities, NGOs etc.	**5 hr**

LEARNING RESOURCES	
REFERENCE BOOKS:	
1	Nirmalya Kumar Sinha & Surajit Majumder, *A Text Book of National Service Scheme Vol;.I*, Vidya Kutir Publication, 2021 (ISBN 978-81-952368-8-6)
2	Red Book - *National Cadet Corps – Standing Instructions Vol I & II*, Directorate General of NCC, Ministry of Defence, New Delhi
3	Davis M. L. and Cornwell D. A., *Introduction to Environmental Engineering*, McGraw Hill, New York 4/e 2008
4	Masters G. M., Joseph K. and Nagendran R. *Introduction to Environmental Engineering and Science*‖, Pearson Education, New Delhi. 2/e 2007.
5	Ram Ahuja. *Social Problems in India*, Rawat Publications, New Delhi.

II Semester

<table>
<tr><td rowspan="3">R23HSST001</td><td colspan="6">COMMUNICATIVE ENGLISH
(Common to All Branches of Engineering)</td></tr>
<tr><td>Total Contact Hours</td><td>30 (L)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Pre-requisite</td><td>Nil</td><td>2</td><td>0</td><td>0</td><td>2</td></tr>
<tr><td colspan="7">Course Objective</td></tr>
<tr><td colspan="7">The student will be able to apply the concepts of comprehension, Interpretation and structured presentation in varied contexts and demonstrate skilled communication.</td></tr>
<tr><td colspan="7">Course Outcomes</td></tr>
<tr><td>1</td><td colspan="6">Developing the ability to comprehend, analyze and elicit information.(BL6)</td></tr>
<tr><td>2</td><td colspan="6">Demonstrating the skill of Structured thinking. (BL3)</td></tr>
<tr><td>3</td><td colspan="6">Developing Competency to summarize and paraphrase content in different materials.(BL6)</td></tr>
<tr><td>4</td><td colspan="6">Demonstrating the skill of constructive presentation.(BL3)</td></tr>
<tr><td>5</td><td colspan="6">Building communicative competence.(BL6)</td></tr>
<tr><td colspan="7">SYLLABUS</td></tr>
<tr><td>Unit I</td><td colspan="5">THEME: HUMAN VALUES
Sample Text: The Power of a Plate of Rice (short story) by Ifeoma Okoye
Supplementary Text: The Lament by Anton Chekov
Listening: Identifying the topic, the context and specific pieces of information by listening to short audio texts and answering a series of questions.
Speaking: Asking and answering general questions on familiar topics such as home, family, work, studies and interests; introducing oneself and others.
Reading: Skimming to get the main idea of a text; scanning to look for specific pieces of information.
Writing: Mechanics of Writing-Capitalization, Spellings, Punctuation-Parts of Sentences. (Remedial learning with additional resources.)
Grammar: Parts of Speech, Basic Sentence Structures-forming questions. (Remedial learning with additional resources.)
Vocabulary: Synonyms, Antonyms, Affixes (Prefixes/Suffixes), Root words</td><td>6 hr</td></tr>
<tr><td>Unit II</td><td colspan="5">Theme: NATURE
Sample Text: Night of the Scorpion (poem) by Nissim Ezekiel
Supplementary Text: 'IF' by Rudyard Kipling
Listening: Answering a series of questions after listening to audio texts.
Speaking: Discussion in pairs/small groups on specific topics.
Reading: Identifying sequence of ideas; recognizing verbal techniques that help to link the ideas in a paragraph together.
Writing: Structure of a paragraph - Paragraph writing (specific topics)
Grammar: Cohesive devices - linkers, use of articles and zero article prepositions.
Vocabulary: Homonyms, Homophones, Homographs.</td><td>6 hr</td></tr>
<tr><td>Unit</td><td colspan="5">Lesson: BIOGRAPHY of Steve Jobs</td><td>6</td></tr>
</table>

III	Supplementary Text: Biography of Tenzing Norgay **Listening**: Listening for global comprehension and summarizing. **Speaking**: Discussing specific topics in pairs or small groups and reporting what is discussed. **Reading:** Reading a text in detail by making basic inferences-recognizing and interpreting specific context clues; strategies to use text clues for comprehension. **Writing:**Summarizing, Note-making, paraphrasing **Grammar**: Verbs - tenses; subject-verb agreement **Vocabulary**: Compound words, Collocations	**hr**
Unit IV	**Lesson: INSPIRATION: *The Toys of Peace* by Saki** Supplementary Text: *The Man Who Planted Trees* by Jean Giono **Listening**: Making predictions while listening to conversations/ transactional dialogues without video; listening with video. **Speaking:** Role plays for the practice of conversational English in academic contexts (formal and informal) - asking for and giving information/directions. **Reading**:Studying the use of graphic elements in texts to convey information, reveal trends/patterns/relationships, communicate processes or display complicated data. **Writing**: Letter Writing: Official Letters, Resumes. **Grammar:** Reporting verbs, Direct & Indirect speech, Active & Passive Voice. **Vocabulary**: Words often confused, Jargon.	**6 hr**
Unit V	**Lesson: MOTIVATION: The Power of Intrapersonal Communication (An Essay)** **Listening**: Identifying key terms, understanding concepts and answering a series of relevant questions that test comprehension. **Speaking**: Formal oral presentations **Reading**: Reading comprehension. **Writing**: Writing structured essays on specific topics. **Grammar**: Editing short texts –identifying and correcting common errors in grammar (articles, prepositions, tenses, subject-verb agreement) **Vocabulary:** Technical Jargon.	**6 hr**

LEARNING RESOURCES

TEXT BOOKS:

1	Pathfinder: *Communicative English for Undergraduate Students*, 1st Edition, Orient Black Swan, 2023.
2	*Empowering English* by Cengage Publications, 2023.

REFERENCE BOOKS:

1	Dubey, Sham Ji & Co. *English for Engineers*, Vikas Publishers, 2020.
2	Bailey, Stephen. *Academic writing: A Handbook for International Students*. Routledge, 2014.
3	Murphy, Raymond. *English Grammar in Use*, Fourth Edition, Cambridge University Press, 2019.
4	Lewis, Norman. Word Power Made Easy- *The Complete Handbook for Building Superior Vocabulary*. Anchor, 2014.

WEB RESOURCES:
1. www.bbc.co.uk/learningenglish 2. https://dictionary.cambridge.org/grammar/british-grammar/ 3. www.eslpod.com/index.html 4. https://www.learngrammar.net/32 5. https://english4today.com/english-grammar-online-with-quizzes/ 6. https://www.talkenglish.com/grammar/grammar.aspx

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL6	X	X	X	X	X
CO2	BL3		X			
CO3	BL6			X		
CO4	BL3	X	X	X	X	X
CO5	BL6	X	X	X	X	X

R23MATT102	DIFFERENTIAL EQUATIONS AND VECTOR CALCULUS (Common to All Branches of Engineering)					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Basic Calculus	**3**	**0**	**0**	**3**

Course Objective

- To enlighten the learners in the concept of differential equations and multivariable calculus.
- To furnish the learners with basic concepts and techniques at plus two level to lead them in to advanced level by handling various real-world applications.

Course Outcomes

1	Solve first order differential equations and make use of them to deal with real word problems like law of cooling, growth, decay and electrical circuits.(**BL3**)
2	Solve the higher order differential equations to make use of them to deal with real word problems like LCR circuits and simple harmonic motion.(**BL3**)
3	Solve the partial differential equations by various methods.(**BL3**)
4	Interpret the physical meaning of different operators such as gradient, curl and divergence.(**BL3**)
5	Estimate the work done against a field, circulation and flux using vector calculus.(**BL5**)
6	Formulate Mathematical models and estimate appropriate physical quantities.(**BL6**)

SYLLABUS

Unit I	**DIFFERENTIAL EQUATIONS OF FIRST ORDER AND FIRST DEGREE**	**8 hr**

Linear differential equations – Bernoulli's equations- Exact equations and equations reducible to exact form. Applications: Newton's Law of cooling – Law of natural growth and decay- Electrical circuits.

Unit II	**LINEAR DIFFERENTIAL EQUATIONS OF HIGHER ORDER (CONSTANT COEFFICIENTS)**	**8 hr**

Definitions, homogenous and non-homogenous, complimentary function, general solution, particular integral, Wronskean, method of variation of parameters. Simultaneous linear equations, Applications to L-C-R Circuit problems and Simple Harmonic motion.

Unit III	**PARTIAL DIFFERENTIAL EQUATIONS**	**8 hr**

Introduction and formation of Partial Differential Equations by elimination of arbitrary constants and arbitrary functions, solutions of first order linear equations using Lagrange's method. Homogeneous Linear Partial differential equations with constant coefficients.

Unit IV	**VECTOR DIFFERENTIATION**	**8hr**

Scalar and vector point functions, vector operator del, del applies to scalar point functions -Gradient, del applied to vector point functions - Divergence and Curl, vector identities.

Unit V	**VECTOR INTEGRATION**	**8 hr**
Line integral – circulation - work done, surface integral - flux, Green's theorem in the plane (without proof), Stoke's theorem (without proof), volume integral, Divergence theorem (without proof) and applications of these theorems.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	Erwin Kreyszig, *Advanced Engineering Mathematics*, 10/e, John Wiley & Sons, 2018.	
2	B.S.Grewal, *Higher Engineering Mathematics*, 44/e, Khanna Publishers, 2017.	
REFERENCE BOOKS:		
1	Dennis G.Zill and Warren S.Wright, *Advanced Engineering Mathematics*, Jones and Bartlett, 2018.	
2	Michael Green Berg, *Advanced Engineering Mathematics*, 9th edition, Pearson edn	
3	George B.Thomas, Maurice D. Weir and Joel Hass, *Thomas Calculus*,14/e, Pearson Publishers, 2018.	
4	R. K. Jain and S. R. K. Iyengar, *Advanced Engineering Mathematics*, 5/e, Alpha Science International Ltd., 2021 (9th reprint).	
5	B.V. Ramana, Higher Engineering Mathematics, Mc Graw Hill Education, 2017.	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL 3	X				
CO2	BL 3		X			
CO3	BL 3			X		
CO4	BL 3				X	
CO5	BL 5					X
CO6	BL 6	X	X	X	X	X

R23PHYT101	ENGINEERING PHYSICS (Common to All Branches of Engineering)					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Higher Secondary School Physics	**3**	**0**	**0**	**3**

Course Objective

To bridge the gap between the Physics in school at 10+2 level and UG level engineering courses by identifying the importance of the optical phenomenon like interference, diffraction etc. Enlightening the periodic arrangement of atoms in crystalline solids and concepts of quantum mechanics, introduce novel concepts of dielectric and magnetic materials, physics of semiconductors.

Course Outcomes

1	Student will be able to **analyze** the intensity variation of light due to interference, diffraction and polarization. (**BL4**)
2	Student will be able to **investigate** the crystallographic phase of the unknown specimen by using the X-ray diffraction method. (**BL5**)
3	Student will be able to **interpret** the various polarization mechanisms and their frequency dependence in dielectrics; and **choose** a magnetic material for a given application based on the domain model.(**BL5**)
4	Student will be able to **deduce** the quantized facets for a free electron in a potential box, and extend the same to **explain** the electrical conductivity and Fermi energy of metals. (**BL4**)
5	Student will be able to **classify** the solids, **analyze** the semiconductor charge carrier concentrations, and **identify** the semiconductor typeby using the Hall effect. (**BL4**)
6	Student will be able to **elaborate** the optical phenomena, crystallographic phase, magneto-dielectric physiognomies, quantum confinement effects, and the rudiments of semiconductor band model.(**BL6**)

SYLLABUS

Unit I	**WAVE OPTICS**	**8 hr**

Interference: Introduction **-** Principle of superposition –Interference of light - Interference in thin films (Reflection Geometry) & applications - Colors in thin films- Newton's Rings- Determination of wavelength and refractive index. **Diffraction:** Introduction - Fresnel and Fraunhofer diffractions - Fraunhofer diffraction due to single slit, double slit & N-slits (Qualitative) – Diffraction Grating - Dispersive power and resolving power of Grating (Qualitative). **Polarization:** Introduction -Types of polarization - Polarization by reflection, refraction and Double refraction - Nicol's Prism -Half wave and Quarter wave plates.

Unit II	**CRYSTALLOGRAPHY AND X-RAY DIFFRACTION**	**8 hr**

Crystallography: Space lattice, Basis, Unit Cell and lattice parameters – Bravais Lattices – crystal systems (3D) – coordination number - packing fraction of SC, BCC & FCC - Miller indices – separation between successive (hkl) planes. **X-ray diffraction:** Bragg's law - X-ray Diffractometer – crystal structure determination by Laue's and powder methods.

Unit III	**DIELECTRIC AND MAGNETIC MATERIALS**	**8 hr**

Dielectric Materials: Introduction - Dielectric polarization - Dielectric polarizability, Susceptibility, Dielectric constant and Displacement Vector –Relation between the electric vectors - Types of polarizations- Electronic (Quantitative), Ionic (Quantitative) and Orientation polarizations (Qualitative) - Lorentz internal field - Clausius- Mossotti equation - complex dilectric constant – Frequency

dependence of polarization – dielectric loss. **Magnetic Materials:** Introduction - Magnetic dipole moment - Magnetization-Magnetic susceptibility and permeability – Atomic origin of magnetism - Classification of magnetic materials: Dia, para, Ferro, anti-ferro&Ferri magnetic materials - Domain concept for Ferromagnetism & Domain walls (Qualitative) - Hysteresis - soft and hard magnetic materials.		
Unit IV	**QUANTUM MECHANICS AND FREE ELECTRON THEORY**	**8 hr**
Quantum Mechanics: Dual nature of matter – Heisenberg's Uncertainty Principle – Significance and properties of wave function – Schrodinger's time independent and dependent wave equations– Particle in a one-dimensional infinite potential well. **Free Electron Theory:** Classical free electron theory (Qualitative with discussion of merits and demerits) – Quantum free electron theory –electrical conductivity based on quantum free electron theory - Fermi-Dirac distribution - Density of states - Fermi energy.		
Unit V	**SEMICONDUCTORS**	**8 hr**
Semiconductors: Formation of energy bands – classification of crystalline solids - Intrinsic semiconductors: Density of charge carriers – Electrical conductivity – Fermi level – Extrinsic semiconductors: density of charge carriers – dependence of Fermi energy on carrier concentration and temperature - Drift and diffusion currents – Einstein's equation - Hall effect and its applications.		

LEARNING RESOURCES

TEXT BOOKS:

1	M. N. Avadhanulu, P.G.Kshirsagar & TVS Arun Murthy, *A Text book of Engineering Physics*, 11th Edition, S.Chand Publications, 2019.
2	D.K.Bhattacharya and Poonam Tandon, *Engineering Physics*, 1st Edition, Oxford press, 2015.

REFERENCE BOOKS:

1	B.K. Pandey and S. Chaturvedi, *Engineering Physics*, 2nd Edition, Cengage Learning, 2021.
2	Shatendra Sharma, Jyotsna Sharma, *Engineering Physics*, 1st Edition, Pearson Education, 2018.
3	Sanjay D. Jain, D. Sahasrabudhe and Girish, *Engineering Physics*, 1st Edition, University Press, 2010.
4	M.R. Srinivasan, *Engineering Physics*, 1st Edition, New Age international publishers, 2009

ONLINE COURSES:

1	https://archive.nptel.ac.in/courses/122/107/122107035/
2	https://www.youtube.com/watch?v=GQ5XpeS3e3U&list=PLLy_2iUCG87B_Tmfs0y2tR8GNIkyRIKpW
3	https://archive.nptel.ac.in/courses/112/106/112106227/
4	https://archive.nptel.ac.in/courses/115/101/115101107/
5	https://archive.nptel.ac.in/courses/108/108/108108122/

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL4	X				
CO2	BL5		X			
CO3	BL5			X		
CO4	BL4				X	
CO5	BL4					X
CO6	BL6	X	X	X	X	X

R23CMET201	BASIC CIVIL AND MECHANICAL ENGINEERING (Common to All branches of Engineering)					
	Total Contact Hours	48	**L**	**T**	**P**	**C**
	Pre-requisite	Nil	**3**	**0**	**0**	**3**

Course Objectives

- Get familiarized with the scope and importance of Civil and Mechanical Engineering in different sectors and industries.
- Introduce the preliminary concepts of Building Planning, Building Construction, Materials and the related tests.
- Provide preliminary knowledge of surveying and understand the importance of transportation and the water resources in terms of quantity and quality.
- Explain different engineering materials and manufacturing processes.
- Provide an overview of different thermal and mechanical systems; introduce basics of robotics and its applications.

Course Outcomes

1	Compile the role of a Civil Engineer in his multifaceted tasks and Discuss the principles of building planning and various construction aspects including materials. (**BL6**)
2	Solvefor areas of irregular boundaries by means of lengths and bearings and for reduced level of an object. (**BL6**)
3	Elaborate the importance of Transportation in Nation's economy and the engineering measures related to highways in terms of geometrics and water resources and storage structures to appreciate the social responsibility of water conservation in terms of quality and quantity.(**BL6**)
4	Adapt and integrate the mechanical engineering technologies in various Industrial sectors, and choose appropriate engineering materials for engineering applications.(**BL6**)
5	Express the working of different manufacturing processes, refrigeration and air-conditioning cycles, IC engines, electric and hybrid vehicles.(**BL6**)
6	Express and write the working of power plants, mechanical power transmission systems, and different robotic configurations.(**BL6**)

SYLLABUS

PART A: BASIC CIVIL ENGINEERING

Unit I	**BASICS OF CIVIL ENGINEERING**	**8 hr**

Basics of Civil Engineering: Role of Civil Engineers in Society- Various Disciplines of Civil Engineering- Structural Engineering- Geo-Technical Engineering- Transportation Engineering - Hydraulics and Water Resources Engineering - Environmental Engineering-Scope of each discipline - Building Construction and Planning- Construction Materials-Cement - Aggregate - Bricks-Cement concrete- Steel-Tests on these materials.

Factors to be considered in Building Planning- Nature of Buildings- Typical Layouts of a Residential Building- Industrial Building- Commercial Building like a Supermarket / Hotel / Theatre.

Unit II	**SURVEYING**	**8 hr**

Surveying: Objectives of Surveying- Horizontal Measurements- Vertical Measurements- Angular Measurements- Levelling instruments used for levelling-Introduction to Bearings-Simple problems on levelling and bearings-Contour mapping.

Unit	**TRANSPORTATION ENGINEERING, WATER RESOURCES**	**8 hr**

III	AND ENVIRONMENTAL ENGINEERING	
Transportation Engineering, Water Resources and Environmental Engineering: Importance of Transportation in Nation's economic development- Types of Highway Pavements- Flexible Pavements and Rigid Pavements - Simple Differences - Basic geometric design elements of a highway- Camber- Stopping Sight Distance- Super elevation-Introduction. **Water Resources and Environmental Engineering**: Sources of water- Quality of water- Specifications and Tests- Introduction to Hydrology- Hydrograph –Rain water Harvesting- Rain water runoff- Water Storage Structures (Simple introduction to Dams and Reservoirs).		
PART B: BASICMECHANICAL ENGINEERING		
Unit IV	**INTRODUCTION TO MECHANICAL ENGINEERING AND ENGINEERING MATERIALS**	**8 hr**
Introduction to Mechanical Engineering: Role of Mechanical Engineering in Industries and Society- Technologies in different sectors such as Energy, Manufacturing, Automotive, Aerospace, and Marine sectors. **Engineering Materials -** Metals-Ferrous and Non-ferrous, Ceramics, Composites, Smart materials.		
Unit V	**MANUFACTURING PROCESSES AND THERMAL ENGINEERING**	**8 hr**
Manufacturing Processes: Principles of Casting**,** Forming, joining processes, Machining, Introduction to CNC machines, 3D printing, and Smart manufacturing. **Thermal Engineering**– working principle of Boilers, Otto cycle, Diesel cycle, Refrigeration and air-conditioning cycles, IC engines, 2-Stroke and 4-Stroke engines, SI/CI Engines, Components of Electric and Hybrid Vehicles.		
Unit VI	**POWER PLANTS, MECHANICAL POWER TRANSMISSION AND INTRODUCTION TO ROBOTICS**	**8 hr**
Power plants – working principle of Steam, Diesel, Hydro, Nuclear power plants. **Mechanical Power Transmission -** Belt Drives, Chain, Rope drives, Gear Drives and their applications. **Introduction to Robotics -** Joints & links, configurations, and applications of robotics.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	M.S.Palanisamy, *Basic Civil Engineering*,Fourth Edition, Tata Mcgraw Hill publications (India) Pvt. Ltd, 2017.	
2	S.S. Bhavikatti,*Introduction to Civil Engineering*, First Edition, New Age International Publishers, 2022.	
3	Satheesh gopi, *Basic Civil Engineering*, First Edition, Pearson publications,2009.	
4	V.Ganesan, *Internal Combustion Engines*, 4th edition, Tata McGraw Hill publications Pvt. Ltd, 2017.	
5	S.S. Rattan, *Theory of Machines*, Fourth edition, McGraw Hill Education; 2017	
6	Jonathan Wicker and Kemper Lewis, *An introduction to Mechanical Engineering*, 3rd edition, Cengage learning India Pvt. Ltd, 2012.	
REFERENCE BOOKS:		
1	S.K. Duggal, *Surveying, Vol- I and Vol-II*, 4th Edition, Tata McGraw Hill Publishers, 2017.	

2	Santhosh Kumar Garg, *Hydrology and Water Resources Engineering*, 23rd Edition, Kahnna publishers, Delhi, 2016.
3	Santhosh Kumar Garg, *Irrigation Engineering and Hydraulic Structures*, 38th Edition, Kahnna publishers, Delhi, 2023.
4	S K Khanna and C E G Justo and Veeraraghavan, *Highway Engineering*,10th Edition Nemchand Brothers Publications,2019
5	Indian Standard Drinking water Specifications – IS 10500-2012
6	Appuu Kuttan KK, *Robotics, I.K. Volume-I*, International Publishing House Pvt. Ltd, 2013.
7	L. Jyothish Kumar, Pulak M Pandey, *3D printing & Additive Manufacturing Technology*, Springer publications, 2017.
8	Mahesh M Rathore, *Thermal Engineering*, Tata McGraw Hill publications (India) Pvt. Ltd, 2010.
ADDITIONAL REFERENCE MATERIAL:	
1	Subramanian KP, *Highway, Railway, Airport and Harbour Engineering*, First Edition, Scitech Publications (India) Pvt. Limited, 2010.
2	M S Shetty, *Concrete Technology (Theory & Practice)*, Revised Edition, S Chand Publishers, 2006.
3	Dr. S.C. Rangwala, *Engineering Materials*, 3rd edition, Charotor Publishing House, 2018.
4	P. K. Nag,*Power Plant Engineering*, 4th edition, McGraw Hill Education, 2017.
5	James D. Halderman, Curt Ward, *Electric and Hybrid Electric Vehicles*, Pearson Education, 2023.
ONLINE COURSES:	
1	https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-ce40/
2	https://www.udemy.com/course/surveying/
3	https://archive.nptel.ac.in/courses/112/103/112103316/
4	https://nptel.ac.in/courses/112107291

Bloom'slevel - Unitscatchmentarticulationmatrix

CO	Blooms Level	UnitI	UnitII	Unit III	UnitIV	UnitV	UnitVI
CO1	BL6	X					
CO2	BL6		X				
CO3	BL6			X			
CO4	BL6				X		
CO5	BL6					X	
CO6	BL6						X

R23MECT301	ENGINEERING MECHANICS					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Prerequisite	Mathematics & Physics	**3**	**0**	**0**	**3**

Course Objective

Students will gain understanding of different types of force systems and various methods to solve the problems of statics and dynamics

Course Outcomes: On completion of the course, the student should be able to

1	Apply the concepts of statics to determine the resultant of different force systems.(**BL3**)
2	Analyze trusses and coplanar force systems including friction using equations of equilibrium.(**BL4**)
3	Determine the centroids, center of gravity and moment of inertia of different geometrical shapes.(**BL5**)
4	Apply the D Alembert's principle, work-energy and Impulse momentum methods for particle and rigid body motion.(**BL3**)
5	Justify various methods of approach to analyse particle and rigid body motion.(**BL5**)
6	Formulate and analyse the particles/bodies using the concepts of engineering mechanics.(**BL6**)

SYLLABUS

Unit I	**SYSTEMS OF FORCES**	**9 hr**

Introduction to Engineering Mechanics– Basic Concepts. Scope and Applications, Systems of Forces: Coplanar Concurrent Forces– Components in Space–Resultant– Moment of Force and its Application –Couples and Resultant of Force Systems.

Friction: Introduction, limiting friction and impending motion, Coulomb's laws of dry friction, coefficient of friction, Cone of Static friction.

Unit II	**EQUILIBRIUM OF SYSTEMS OF FORCES**	**9 hr**

Free Body Diagrams, Lami's Theorem, Equations of Equilibrium of Coplanar Systems, Graphical method for the equilibrium, Triangle law of forces, converse of the law of polygon of forces condition of equilibrium, Equations of Equilibrium for Spatial System of forces, Numerical examples on spatial system of forces using vector approach, Analysis of plane trusses. Principle of virtual work with simple examples

Unit III	**CENTROID AND MOMENT OF INERTIA**	**9 hr**

Centroid: Centroids of simple figures (from basic principles)–Centroids of Composite Figures. Centre of Gravity: Centre of gravity of simple body (from basic principles), Centre of gravity of composite bodies, Pappus theorems.

Area Moments of Inertia: Definition– Polar Moment of Inertia, Transfer Theorem, Moments of Inertia of Composite Figures, Products of Inertia, Transfer Formula for Product of Inertia. **Mass Moment of Inertia**: Moment of Inertia of Masses, Transfer Formula for Mass Moments of Inertia, Mass Moment of Inertia of composite bodies.

Unit IV	**RECTILINEAR AND CURVILINEAR MOTION OF A PARTICLE**	**9 hr**

Kinematics and Kinetics –D'Alembert's Principle - Work Energy method and applications to particle motion-Impulse Momentum method.

Unit V	**RIGID BODY MOTION**	**9 hr**

Kinematics and Kinetics of translation, Rotation about fixed axis and plane motion, Work Energy method and Impulse Momentum method.

LEARNING RESOURCES	
TEXT BOOKS:	
1	S. Timoshenko, D. H. Young, J.V. Rao, and S. Pati, *Engineering Mechanics*, 5th ed. McGraw Hill Education, 2017.
2	P.C. Dumir, S. Sengupta, and Srinivas V. Veeravalli, *Engineering Mechanics*, 1st ed. University Press, 2020
3	S.S. Bhavikatti, *A Textbook of Engineering Mechanics*, 4th ed. New Age International Publications, 2018.
REFERENCE BOOKS:	
1	Rogers and M. A. Nelson, *Engineering Mechanics*, *Statics and Dynamics*, 1st ed. McGraw Hill Education, 2017.
2	I. H. Shames, *Engineering Mechanics, Statics and Dynamics*, 4th ed. PHI, 2002.
3	J. L. Meriam and L. G. Kraige, *Engineering Mechanics, Volume-I: Statics, Volume-II: Dynamics*, 6th ed. John Wiley, 2008.
4	Basudev Bhattacharya, *Introduction to Statics and Dynamics*, 2nd ed. Oxford University Press, 2014.
5	R.C. Hibbeler, *Engineering Mechanics: Statics and Dynamics*, 14th ed. Pearson Education, Inc., New Delhi, 2022.
ONLINE COURSES:	
1	https://archive.nptel.ac.in/courses/112/106/112106180/
2	https://ocw.mit.edu/courses/1-050-engineering-mechanics-i-fall-2007/

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL 4	X	X			
CO3	BL 5			X		
CO4	BL3				X	X
CO5	BL5				X	X
CO6	BL6	X	X	X	X	X

R23HSSL001	COMMUNICATIVE ENGLISH LAB (Common to All Branches of Engineering)					
	Total Contact Hours	30 (P)	**L**	**T**	**P**	**C**
	Pre-requisite	Nil	**0**	**0**	**2**	**1**

Course Objective

The main objective of the course is to expose the students to a variety of self-instructional, learner friendly modes of language learning. The students will get trained in basic communication skills to become industry ready.

Course Outcomes

1	Demonstrate understanding of the different aspects of English language proficiency with emphasis on LSRW skills.
2	Develop communication skills by exposing the student to various language learning activities.
3	Analyse and apply techniques to comprehend information in audio/video material.
4	Develop professionalism by facilitating debates and group discussions.
5	Demonstrate effective presentation skills.

List of Topics

1	Communication Skills & JAM
2	Articulation of sounds & Listening to comprehend information
3	Role Play or Conversational Practice
4	E-mail Writing
5	Resume Writing, Cover letter writing
6	Group Discussions-methods & practice
7	Debates - Methods & Practice
8	PPT Presentations/ Poster Presentation
9	Interview skills

LEARNING RESOURCES

REFERENCE BOOKS:

1	Raman Meenakshi, Sangeeta-Sharma, *Technical Communication*, Oxford Press, 2018.
2	Taylor Grant, *English Conversation Practice*, Tata McGraw-Hill Education India, 2016.
3	Hewing's, Martin, *Cambridge Academic English (B2)*, CUP, 2012.
4	J. Sethi & P.V. Dhamija, *A Course in Phonetics and Spoken English*, (2nd Ed), Kindle, 2013.

WEB RESOURCES:

1. www.esl-lab.com
2. www.englishmedialab.com
3. www.englishinteractive.net
4. https://www.britishcouncil.in/english/online
5. http://www.letstalkpodcast.com/

R23PHYL101	ENGINEERING PHYSICS LAB (Common to All Branches of Engineering)					
	Total Contact Hours	30 (P)	**L**	**T**	**P**	**C**
	Pre-requisite	Higher Secondary School Physics	**0**	**0**	**2**	**1**

Course Objective

To complement classroom learning with laboratory experiments. Calibration of instruments like travelling-microscope, spectrometer, etc. and to make precise measurements. Understand the physical principles involved in the conduct of experiment and measure the relevant experimental variables. Apply the analytical techniques and graphical analysis to experimental data and draw necessary conclusions. Prepare a concise and clear technical report to communicate his/her experimental understanding.

Course Outcomes

1	Student will be able to **conduct** experiments to reconnoitre the interference and diffraction patterns of light.
2	Student will be able to **find** the signature variation of magnetic field due to current; and the hysteresis energy loss in a magnetic material.
3	Student will be able to **measure** the physiognomies of the semiconductor devices like the energy band gap (E_g) and the temperature coefficient of resistance (α).
4	Student will be able to **observe** the pendulum oscillations and **determine** the impelling parameters like rigidity modulus (η), acceleration due to gravity (g), etc.
5	Student will be able to **verify** the laws of vibrations and **determine** the unknown fork frequency by forming standing waves on stretched strings.

List of Experiments

1	Determination of radius of curvature of a given plano-convex lens by Newton's rings.
2	Determination of wavelengths of different spectral lines in mercury spectrum using diffraction grating in normal incidence configuration.
3	Study the variation of B versus H by magnetizing the magnetic material (B-H curve).
4	Determination of wavelength of Laser light using diffraction grating
5	Determination of energy gap of a semiconductor using p-n junction diode
6	Magnetic field along the axis of a current carrying circular coil by Stewart and Gee's Method
7	Determination of temperature coefficients of a thermistor
8	Determination of rigidity modulus of the material of the given wire using Torsional pendulum
9	Determination of frequency of the electrically maintained tuning fork by Melde's experiment
10	Sonometer: Verification of the laws of stretched string

Additional Experiments

1	Determination of acceleration due to gravity and radius of Gyration by using a compound pendulum

LEARNING RESOURCES

TEXT BOOKS:

1	S. Balasubramanian, M.N. Srinivasan, *A Textbook of Practical Physics*, S. Chand Publishers, 2017.

REFERENCE BOOKS:	
1	C.S. Robinson and Dr. Ruby Das, *A Textbook of Engineering Physics Practical*,1st Edition Laxmi Publications Pvt. Ltd., 2016.
ADDITIONAL REFERENCE MATERIAL:	
1	www.vlab.co.in

R23MECL301	ENGINEERING MECHANICS LAB					
	Total Contact Hours	45 (P)	**L**	**T**	**P**	**C**
	Pre-requisite	Nil	**0**	**0**	**3**	**1.5**

Course Objective	
The objectives of an Engineering Mechanics lab typically involve providing students with hands-on experience and practical understanding of fundamental concepts related to mechanics.	
Course Outcomes: On completion of the course, the student should be able to	
1	Apply the concepts of statics to verify the equilibrium conditions of a rigid body under the action of different force systems.
2	Analyze and predict the static and rolling coefficient of friction between two different surfaces
3	Estimate the centroids and moment of inertia of different geometrical shapes.
List of Experiments	
1	Verification of Law of Parallelogram of Forces.
2	Verification of Law of Triangle of Forces.
3	Verification of the Law of polygon for coplanar-concurrent forces acting on a particle in equilibrium and to find the value of unknown forces considering particle to be in equilibrium using universal force table.
4	Determination of coefficient of Static and Rolling Frictions
5	Determination of Centre of Gravity of different shaped Plane Lamina.
6	Verification of the conditions of equilibrium of a rigid body under the action of coplanar non-concurrent, parallel force system with the help of a simply supported beam.
7	Study of the systems of pulleys and draw the free body diagram of the system.
8	Determine the acceleration due to gravity using a compound pendulum.
9	Determine the Moment of Inertia of the compound pendulum about an axis perpendicular to the plane of oscillation and passing through its centre of mass.
10	Determine the Moment of Inertia of a Flywheel.
11	Verification of Law of Moment using Rotation Disc Apparatus and Bell Crank Lever.
Additional Experiments	
1	Determination of angle of repose and cone friction.
LEARNING RESOURCES	
REFERENCE BOOKS:	
1	S. Timoshenko, D. H. Young, J.V. Rao, S. Pati., *Engineering Mechanics*, 5 th Edition, McGraw Hill Education, 2017.
2	Hibbeler R.C., *Engineering Mechanics: Statics and Dynamics*, 14 th Edition, Pearson Education, Inc., New Delhi, 2022.
ADDITIONAL REFERENCE MATERIAL:	
1	https://archive.nptel.ac.in/courses/112/106/112106180/
2	https://ocw.mit.edu/courses/1-050-engineering-mechanics-i-fall-2007/

R23MECW201	ENGINEERING WORKSHOP (Common to All Branches of Engineering)					
	Total Contact Hours	45 (P)	**L**	**T**	**P**	**C**
	Pre-requisite	Nil	**0**	**0**	**3**	**1.5**

Course Objective

Students will understand various engineering trades such as carpentry, tin smithy, foundry, fabrication, fitting and electrical house wiring skills and required safety practice required and address common trouble shooting in day- today practice.

Course Outcomes

1	Identify workshop tools and their operational capabilities.
2	Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding.
3	Apply concept of fitting and sheet metal understanding in various applications.
4	Apply basic electrical engineering knowledge for House Wiring Practice.

Syllabus

1	**Demonstration**: Safety practices and precautions to be observed in workshop.
2	**Wood Working:** Familiarity with different types of woods and tools used in wood working and make following joints. a)Half – Lap joint b) Mortise and Tenon joint c) Corner Dovetail joint or Bridle joint
3	**Sheet Metal Working**: Familiarity with different types of tools used in sheet metal working, Developments of following sheet metal job from GI sheets. a)Tapered tray b)Conical funnel c)Elbow pipe d)Brazing
4	**Fitting:** Familiarity with different types of tools used in fitting and do the following fitting exercises. a) V-fit b)Dovetail fit c) Semi-circular fit d) Bicycle tire puncture and change of two-wheeler tyre
5	**Electrical Wiring:** Familiarity with different types of basic electrical circuits and make the following connections. a) Paralleland series b) Two-way switch c)Godownlighting d) Tubelight e) Threephasemotor f) Soldering ofwires
6	**Foundry Trade:** Demonstration and practice on Moulding tools and processes, Preparation of Green Sand Moulds for given Patterns.
7	**Welding Shop**: Demonstration and practice on Arc Welding and Gas welding. Preparation of Lap joint and Butt joint.
8	**Plumbing:** Demonstration and practice of Plumbing tools, Preparation of Pipe joints with coupling for same diameter and with reducer for different diameters.

Additional Experiments

1	Making of study lamp using combination of carpentry and house wiring trades.
2	Frame making of dissemination using carpentry and welding.
3	Electric Load calculation in a living room.
4	Demonstration of connection in street lights using single control.

LEARNING RESOURCES

TEXT BOOKS:

1	W.Felix, Basic *Workshop Technology: Manufacturing Process*, Independently

	Published,2019.
2	Bruce J. Black, *Workshop Processes, Practices and Materials*, Routledge publishers, 5th Edn. 2015.
3	B.S. Raghuwanshi, Dhanpath Rai & Co., *A Course in Workshop Technology Vol I. & II*, Dhanpat Rai& Co. 2015 & 2017.
REFERENCE BOOKS:	
1	S. K. Hajra Choudhury, *Elements of Workshop Technology, Vol. I.* 14th edition,Media Promoters and Publishers, Mumbai, 2007.
2	H. S. Bawa,Workshop Practice,Tata-McGraw Hill, 2004.
3	P.M.Soni &P.A.Upadhyay, Wiring Estimating, Costing and Contracting,Atul Prakashan, 2021-22.
ADDITIONAL REFERENCE MATERIAL:	
1	https://mrcet.com/downloads/hs/EWS-ITWS%20%20LAB%20MANUAL.pdf
2	https://sjce.ac.in/wp-content/uploads/2018/04/Workshop-Laboratory-Manual.pdf
3	https://manavrachna.edu.in/latest/virtual-lab-workshop-for-first-year-engineering-students-mru/

<table>
<tr><td rowspan="3">R23CSEW201</td><td colspan="6">IT WORKSHOP
(Common to all branches of Engineering)</td></tr>
<tr><td>Total Contact Hours</td><td>30 (P)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Pre-requisite</td><td>NIL</td><td>0</td><td>0</td><td>2</td><td>1</td></tr>
<tr><td colspan="7">Course Objective</td></tr>
<tr><td colspan="7">● To introduce the internal parts of a computer, peripherals, I/O ports, connecting cables, operating systems, Compression, Multimedia, Antivirus tools and Office Tools such as Word processors, spreadsheets, and Presentation tools.</td></tr>
<tr><td colspan="7">Course Outcomes</td></tr>
<tr><td>1</td><td colspan="6">Students will be able to analyze Hardware troubleshooting.</td></tr>
<tr><td>2</td><td colspan="6">Students will be able to identify Hardware components and inter dependencies.</td></tr>
<tr><td>3</td><td colspan="6">Students will be able to choose safeguard computer systems from viruses/worms.</td></tr>
<tr><td>4</td><td colspan="6">Students will be able to Create document and power point presentation.</td></tr>
<tr><td>5</td><td colspan="6">Students will be able to develop calculations using spreadsheets.</td></tr>
<tr><td colspan="7">List of Experiments</td></tr>
<tr><td>1</td><td colspan="6">Week-1: PC Hardware & Software Installation
1) Identify the peripherals of a computer, components in a CPU, and functions. Draw the block diagram of the CPU along with the configuration of each peripheral and submit to your instructor.
2) Every student should disassemble and assemble the PC back to working condition. Lab instructors should verify the work and follow it up with a Viva. Also, students must go through the video showing the PC assembling process. A video would be given as part of the course content.</td></tr>
<tr><td>2</td><td colspan="6">Week-2:
1) Students should install MS windows on their personal computer. The lab instructor should verify the installation and follow it with a Viva.</td></tr>
<tr><td>3</td><td colspan="6">Week-3:
1) Every student should install Linux on the computer. This computer should have Windows installed. The system should be configured as dual boot (VMWare) with Windows and Linux. Lab instructors should verify the installation and follow it up with a Viva.
2) Every student should install BOSS on the computer. The system should be configured as dual boot (VMWare) with Windows and BOSS. Lab instructors should verify the installation and follow it up with a Viva.</td></tr>
<tr><td>4</td><td colspan="6">Week-4: Internet & World Wide Web
1) Orientation & Connectivity Boot Camp: Students should connect to their Local Area Network and access the Internet. In the process, they configure the TCP/IP setting. Finally, students should demonstrate to the instructor how to access the websites and email. Without internet connectivity, instructors must simulate the WWW on the LAN.</td></tr>
</table>

	2) Web Browsers, Surfing the Web: Students customize their web browsers with the LAN proxy settings, bookmarks, search toolbars, and pop-up blockers. Also, plug-ins like Macromedia Flash and JRE for applets should be configured.
5	Week-5: 1) Search Engines & Netiquette: Students should know what search engines are and how to use the search engines. A few topics would be given to the students for which they need to search on Google. This should be demonstrated to the instructors by the student. 2) Cyber Hygiene: Students would be exposed to the various threats on the internet and asked to configure their computers to be safe on the internet. They need to customize their browsers to block pop-ups, and block active X downloadsto avoid viruses and worms.
6	Week-6: LaTeX and WORD 1) Word Orientation: The mentor needs to give an overview of LaTeX and Microsoft (MS) Office or equivalent (FOSS) tool word: Importance of LaTeX and MS office or equivalent(FOSS) tool Word as word Processors, Details of the four tasks and features that would be covered in each, Using LaTeX and word – Accessing, overview of toolbars, saving files, Using help and resources, rulers, format painter in word. 2) Using LaTeX and Word to create a project certificate. Features to be covered:- Formatting Fonts in Word, Drop Cap in Word, Applying Text effects, Using Character Spacing, Borders, and Colors, Inserting Header and Footer, Using Date and Time options in LaTeX and Word.
7	Week-7: 1) Creating project abstract Features to be covered: Formatting Styles, Inserting table, Bullets and Numbering, Changing Text Direction, Cell alignment, Footnote, Hyperlink, Symbols, Spell Check, Track Changes. 2) Creating a Newsletter: Features to be covered:- Table of Contents, Newspaper columns, Images from files and clipart, Drawing toolbar and Word Art, Formatting Images, Textboxes, Paragraphs, and Mail Merge in word.
8	Week-8: EXCEL Excel Orientation: The mentor needs to tell the importance of the MS Office or equivalent (FOSS)tool Excel as a Spreadsheet tool give the details of the four tasks and features that would be covered in each. Using Excel – Accessing an overview oftool bars, saving Excel files, Using help and resources. 1) Creating a Scheduler - Features to be covered: Gridlines, Format Cells, Summation, auto-fill, Formatting Text. 2) Calculating GPA -. Features to be covered:- Cell Referencing, Formulae in Excel – average, std. deviation, Charts, Renaming and Inserting worksheets, Hyperlinking, Count function.

9	Week-9: 1) LOOKUP/LOOKUP : Split cells, freeze panes, group and outline, Sorting, Boolean and logical operators, Conditional formatting.
10	Week-10: POWERPOINT 1) Students will be working on essential PowerPoint utilities and tools which help them create introductory PowerPoint presentations. PPT Orientation, Slide Layouts, Inserting Text, Word Art, Formatting Text, Bullets and Numbering, Auto Shapes, Lines and Arrows in PowerPoint. 2) Interactive presentations - Hyperlinks, Inserting –Images, Clip Art, Audio, Video, Objects, Tables and Charts.
11	Week-11: 1) Master Layouts (slide, template, and notes), Types of views (basic, presentation, slide slotter, notes, etc.), and Inserting – Background, textures, Design Templates, Hidden slides.
12	Week-12: AI TOOLS – Chat GPT 1) Prompt Engineering: Experiment with different prompts to see how the model responds. Try asking questions, starting conversations, or even providing incomplete sentences to see how the model completes them. 2) Creative Writing: Use the model as a writing assistant. Provide the beginning of a story or a scene description, and let the model generate the rest of the content. This can be a funway to brainstorm creative ideas. 3) Language Translation: Experiment with translation tasks by providing a sentence in one language and asking the model to translate it into another language. Compare the output to see how accurate and fluent the translations are.
LEARNING RESOURCES	
TEXT BOOKS:	
1	Comdex Information Technology course tool kit, Vikas Gupta, WILEY Dream Tech, 2003
2	Introduction to Information Technology, ITL Education Solutions Limited, Pearson Education, 2012, 2nd edition
REFERENCE BOOKS:	
1	The Complete Computer Upgrade and Repair Book, Cheryl A Schmidt, WILEY Dream tech, 2013, 3rd edition
2	PC Hardware - A Handbook, Kate J. Chase, PHI (Microsoft)
3	LaTeX Companion, Leslie Lamport, PHI/Pearson

R23HSSM801	HEALTH AND WELLNESS, YOGA AND SPORTS (Common to All Branches of Engineering)					
	Total Contact Hours	15 (P)	**L**	**T**	**P**	**C**
	Pre-requisite	Nil	**0**	**0**	**1**	**0.5**

Course Objective

The main objective of introducing this course is to make the students maintain their mental and physical wellness by balancing emotions in their life. It mainly enhances the essential traits required for the development of the personality.

Course Outcomes

1	Demonstrate the importance of yoga and sports for Physical fitness and sound health.
2	Demonstrate an understanding of health-related fitness components.
3	Compare and contrast various activities that help enhance their health.
4	Assess current personal fitness levels.
5	Develop Positive Personality

SYLLABUS

Unit I	Concept of health and fitness, Nutrition and Balanced diet, basic concept of immunity Relationship between diet and fitness, Globalization and its impact on health, Body Mass Index (BMI) of all age groups. **Activities:** Organizing health awareness programmes in community ii) Preparation of health profile iii) Preparation of chart for balance diet for all age groups	**5 hr**
Unit II	Concept of yoga, need for and importance of yoga, origin and history of yoga in Indian context, classification of yoga, Physiological effects of Asanas- Pranayama and meditation, stress management and yoga, Mental health and yoga practice. **Activities:** Yoga practices – Asana, Kriya, Mudra, Bandha, Dhyana, Surya Namaskar	**5 hr**
Unit III	Concept of Sports and fitness, importance, fitness components, history of sports, Ancient and 49 Modern Olympics, Asian games and Commonwealth games. **Activities:** i) Participation in one major game and one individual sport viz., Athletics, Volleyball, Basketball, Handball, Football, Badminton, Kabaddi, Kho-kho, Table tennis, Cricket etc. Practicing general and specific warm up, aerobics ii) Practicing cardiorespiratory fitness, treadmill, run test, 9 min walk, skipping and running.	**5 hr**

LEARNING RESOURCES

REFERENCE BOOKS:

1	Gordon Edlin, Eric Golanty, *Health and Wellness*, 14th Edn. Jones & Bartlett Learning, 2022.
2	T.K.V.Desikachar, *The Heart of Yoga: Developing a Personal Practice*, Inner Traditions,1999.
3	Archie J.Bahm, *Yoga Sutras of Patanjali*, Jain Publishing Company, 1993.
4	Wiseman, John Lofty, *SAS Survival Handbook: The Ultimate Guide to Surviving Anywhere*, Third Edition, William Morrow Paperbacks, 2014.
5	Thomas Hanlon, *The Sports Rules Book/ Human Kinetics*, 3rd ed. Human Kinetics, Inc.2014.

III Semester

R23MMECT002	METALLURGY AND MATERIAL SCIENCE					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Engineering chemistry & Physics	**3**	**0**	**0**	**3**

Course Objective

Students will get exposure to correlate grain morphology, phase and precipitate of microstructure with mechanical properties and recommend suitable material for an intended application. In addition to above, students will become acquainted with different heat treatment practices for desire mechanical properties.

Course Outcomes

1	Able to discuss various types of grain morphology formed during different industry practice and correlate with mechanical property. **(BL6)**
2	Elaborate grain morphology and phase formation for widely used binary alloys systems industry practice and correlate with mechanical property. **(BL6)**
3	Propose suitable materials for specific intended engineering applications based on correlating mechanical properties.**(BL6)**
4	Choose suitable heat treatment for desired mechanical properties. **(BL6)**
5	Adapt proper surface treatment for specific applications. **(BL6)**

SYLLABUS

Unit I	**CRYSTALLIZATION**	**8 hr**

Crystallization - Nucleation; & Grain Growth; Critical radius; Grain size measurement; Crystal imperfection; Grain morphology in casting; Grain morphology in Metal working; and Grain morphology welding.

Unit II	**ALLOYING AND PHASE DIAGRAMS**	**8 hr**

Alloy, Alloy system, Classification of alloy systems; Solid solution; Intermediate alloy phase; Phase diagrams:Construction, Gibb's phase rule, Concept of Tie line and Lever rule; Classification of Binary Phase diagrams: Isomorphous system; eutectic system; Fe-Fe_3C Phase diagram; problems on Fe-Fe_3C diagram.

Unit III	**FERROUS, NON-FERROUS METALS AND ALLOYS**	**8 hr**

Steels and its classification with Designating system; Special types of steels - Tool & Die steel, Stainless Steel; Cast iron and its classification - Grey CI, White CI; and Spheroidal CI, malleable CI; Aluminum and its alloys; Titanium and its alloys; Copper and its alloys; Composites and its classification.

Unit IV	**BULK HEAT TREATMENT**	**8 hr**

Need Of Heat treatment and Stages of it; Classification of Annealing; and Normalizing; Construction of TTT & application of it on C-curve, applications; special heat treatments - Martempering, Aus tempering; Cryogenic Heat treatment, Age hardening; Hardening & Tempering; Hardenability (Jominy End Quench Test).

Unit V	**SURFACE HEAT TREATMENT**	**8 hr**

Surface hardening Techniques: Carburizing, Nitriding; Carbo- Nitriding & Cyaniding; Ferritic Thermo chemical Treatment (FTCT) Nitriding; Selective Heating method: Flame hardening, Induction hardening; Plasma hardening, Vacuum Hardening; Laser hardening; Surface treatment techniques: Plasma vapour deposition; Chemical vapour deposition.

TEXT BOOKS:

1	W. D. Callister, Materials Science and Engineering-An Introduction", 6th Edition, Wiley India. 2006

2	Sidney H. Avner: Introduction to Physical Metallurgy, TMH Publishing Co. Ltd. New Delhi,1997.
REFERENCE BOOKS:	
1	Physical Metallurgy, Principles and Practice V. Raghavan, Prentice-Hall of India Private Limited,2006.
2	V.D.Kodgire, Sushil V. Material Science and Metallurgy,43rd Edition, Everest Publishing house,2018.
3	Material Science and Metallurgy. O.P.Khanna. Dhanpat Rai Publications.
ADDITIONAL REFERENCE MATERIAL	
1	https://mrcet.com/downloads/digital_notes/ME/II%20year/Materials%20Engineering%20Digital%20Notes.pdf
2	https://newtondesk.com/material-science-study-notes-hand-written/
ONLINE COURSES	
1	https://archive.nptel.ac.in/courses/113/102/113102080/
2	https://www.coursera.org/courses?query=material%20science
3	https://www.coursera.org/learn/introduction-to-materials-science

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO 1	BL 6	X				
CO 2	BL 6		X			
CO 3	BL 6			X		
CO 4	BL 6				X	
CO 5	BL 6					X

R23MMECT003	ENGINEERING THERMODYNAMICS					
	Total Contact hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Differential Equations and Engineering Physics	**3**	**0**	**0**	**3**

Course Objective

Students will get exposure about basic laws of thermodynamics and how to apply them to analyze energy systems and thermodynamic cycles.

Course Outcomes

Students are able

1	Apply the basic concepts and the first law of thermodynamics to solve energy transfer problems for closed systems. **(BL3)**
2	Use data tables to determine thermodynamic properties of pure substances and apply the psychrometric chart to analyse basic psychrometric processes. (**BL3**)
3	Apply the Steady Flow Energy Equation (SFEE) to various systems and use the second law of thermodynamics to explain Carnot principles and their implications for idealized devices. (**BL3**)
4	Analyze processes involving pure substances and ideal gases using entropy concepts, and examine the exergy and second-law efficiency of thermodynamic systems**. (BL4)**
5	Evaluate gas power cycles and vapor-compression refrigeration cycles based on thermodynamic performance parameters. (**BL5**)
6	Design and formulate thermodynamic models that integrate the first law, second law, property relations, cycle analysis, and exergy concepts to develop efficient energy conversion systems. (BL6)

SYLLABUS

Unit I	**HEAT, WORK, AND FIRST LAW OF THERMODYNAMICS**	**8 hr**

Thermodynamic System and Control Volume with examples; Thermodynamic Equilibrium, State, Property, Process, Cycle; Work, and Heat for constant pressure, constant volume and isothermal process; Work, and Heat transfer for adiabatic and polytrophic process, zeroth law of TD; First Law of Thermodynamics, Joule's experiment; First law of TD applied for cycle; Application of the first law to non-flow processes. (constant pressure, constant volume and isothermal process); Application of the first law to non-flow processes. (adiabatic and polytrophic process).

Unit II	**PROPERTIES OF SUBSTANCES**	**8hr**

Pure Substances and p-V-T Surfaces, critical state properties; Steam Property Tables, and Phase Diagrams; Utilizing Steam Tables and h-s diagrams for evaluating steam properties; Mollier Charts, Use of Mollier charts for various processes; Steam Calorimetry for measurement of dryness fraction; Psychometric Properties of Atmospheric Air, Degree of Saturation; Psychrometry Chart; Evaluating psychrometric properties.

Unit III	**SECOND LAW OF THERMODYNAMICS**	**8hr**

First Law Applied to a Process, Steady Flow Energy Equation; Application of SFEE for work developing devices; Application of SFEE for work consuming devices;

Application of SFEE for Heat transfer devices; Heat engine, Heat pump, Refrigerator, COP;Kelvin-Planck and Clausius Statements, Equivalence; Carnot Cycle and analysis; Reversed Carnot cycle.		
Unit IV	**ENTROPY & EXERGY**	**8hr**
Clausius inequality and entropy; Principle of Increase of Entropy; Entropy of solids and liquids; Entropy of ideal gases; Availability of systems: Irreversibility and Quantifying irreversibility. Second-law efficiency. Third Law of Thermodynamics; Problems on Availability and Irreversibility.		
Unit V	**THERMODYNAMIC CYCLES**	**8 hr**
Otto cycle; Diesel Cycle; Dual cycle; Brayton cycle; Air refrigeration cycle; Vapor compression refrigeration cycle; Analysis of VCR cycle; Vapour absorption refrigeration cycle.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	PK Nag, *Engineering Thermodynamics*, sixth edition. Tata McGraw-Hill Education, 2017.	
2	Yunus Cengel., Boles Mehmet Kanoğlu, *Thermodynamics – An Engineering Approach*, Tenth Edition. McGraw-Hill Education (India) Pvt Ltd., 2023.	
REFERENCE BOOKS:		
1	Sonntag, Borgnakke and van wylen,*Fundamentals of Thermodynamics*, Tenth edition. John Wiley &sons (ASIA) Pvt Ltd.,2022.	
2	R.K.Rajput, *Engineering Thermodynamics*, Third edition, Laxmi publications (p) ltd,2017.	
3	C.P. Kothandaraman, *Steam Tables with Mollier Charts*, New Age International Private Limited; Fifth Edition, 2022	
4	C.P. Kothandaraman,*Refrigerant Tables and Charts Including Air Conditioning Data*,New Age International Private Limited, Fourth Edition, 2015.	
ADDITIONAL REFERENCE MATERIAL		
1	Introduction to Engineering Thermodynamics - Open Textbook Library (umn.edu)	
ONLINE COURSES		
1	NPTEL :: Mechanical Engineering - Basic Thermodynamics	
2	NPTEL :: Aerospace Engineering - NOC: Engineering Thermodynamics	
3	Engineering Thermodynamics - Course (nptel.ac.in)	
4	Thermodynamics And Kinetics Of Materials - Course (nptel.ac.in)	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X		x	x	x
CO2	BL3		X			x
CO3	BL3			X	x	x
CO4	BL4				X	
CO5	BL5	x		x		X
CO6	BL6	X	X	X	X	X

R23MMECT004	MECHANICS OF SOLIDS					
	Total Contact Hours:	42 (L)	**L**	**T**	**P**	**C**
	Prerequisites:	Simple integrations and differential Equations, Engineering Mechanics	**3**	**0**	**0**	**3**

Course Objective: The primary objective of a Mechanics of solids course in mechanical engineering is to provide students with a fundamental understanding of how materials behave under various loading conditions. This knowledge is essential for designing and analyzing structures and mechanical components.

Course Outcomes

After completing this course, the students will be able to

1	Apply basic stress-strain concepts to assess the behavior of various members like bars, shafts, pressure vessels, subjected to different loading conditions. **(BL3)**
2	Analyze various members like bars, shafts, pressure vessels subjected to different loads. **(BL4)**
3	Estimate strain energy and principal stresses for the mechanical components subjected to various loads. **(BL6)**
4	Identify different types of beams and demonstrate the variation of Shear force, bending moments and deflections in beams. **(BL3)**
5	Evaluate the stress distribution/deflections in beams. **(BL5)**
6	Predict the behavior of the members subjected to different types of loads using the concepts of deformable body mechanics. **(BL6)**

SYLLABUS

Unit I	**SIMPLE STRESS AND STRAINS**	**8 hr**

Concept of stress and strain - Types of stresses and strains, Hooke's law, Poisson's ratio; Mechanical properties of materials, Stress-strain diagram for ductile and brittle materials; Analysis of bar of varying sections - Uniform, Stepped bars; Principle of superposition; Compound / Composite bars; Temperature stresses; Volumetric strain - Cylindrical rod and rectangular bar subjected to an axial tensile load in the direction of its length; A rectangular bar subjected to three mutually perpendicular forces

Unit II	**PRINCIPAL STRESSES - ELASTIC CONSTANT**S	**8 hr**

Principal planes and principal stresses -Analytical method for determining stresses on oblique section - Member is subjected to like direct stress in two mutually perpendicular directions; Member is subjected to direct stresses in two mutually perpendicular directions accompanied by a simple shear stress; MOHR'S circle – A body subjected to two mutually perpendicular principal tensile stresses of unequal like intensities and unequal and unlike intensities; A body subjected to two mutually perpendicular principal tensile stresses accompanied by a simple shear stress;Relation between elastic constants -Young's modulus and rigidity modulus; Young's modulus and bulk modulus; Strain energy – Resilience – Gradual, sudden loadings; Impact loading.

Unit III	**THIN AND THICK CYLINDERS - TORSION OF CIRCULAR SHAFTS**	**8 hr**

Thin cylinders - Stresses in thin cylinders - derivation for longitudinal and hoop stresses; Change in dimensions; Thick Cylinders -Lame's equation – assumptions; Cylinders subjected to inside & outside fluid pressures; Torsion – Introduction -

derivation with assumptions - polar modulus, strength of a shaft and torsional rigidity / stiffness; Torque and power transmitted by solid and hollow circular shafts; Comparison of solid and hollow shafts.		
Unit IV	**SHEAR FORCE - BENDING MOMENT DIAGRAMS AND STRESSES IN BEAMS**	**8 hr**
Beam – classification – loads and reactions – concept of SF and BM – Sign convention – Cantilever beam and simply supported beams subjected to point loads; Uniformly distributed loads; Uniformly varying loads; Combined loading; Bending stresses in beams – Flexure formula – assumptions – derivation; Bending stress distribution in beams for symmetrical sections; Shear stresses in beams – assumptions - derivation; Shear stresses distribution in beams for symmetrical sections		
Unit V	**DEFLECTION OF BEAMS**	**8 hr**
Deflection of Beams - Relation between slope, deflection and radius of curvature; Double integration Method - Cantilever beam subjected to point loads; Uniformly distributed loads; Uniformly varying loads; Simply supported beam subjected to point loads; Uniformly distributed load; Uniformly varying load; Beams subjected to Couples and Macaulay's method		

EARNING RESOURCES

TEXT BOOKS:	
1	Popov E.P, *Engineering Mechanics of Solids*, PHI, New Delhi, 2010.
2	R K Bansal, *Strength of materials* -5th Edition-Laxmi publications-2013.
3	S.S.Bhavikatti, *Strength of Materials*, Vikas publications House -1 Pvt. Ltd., 2nd Ed., 2006.
REFERENCE BOOKS:	
1	Ferdinand Beer & Russell Johnston, *Mechanics of materials*, TATA McGraw Hill-2005.
2	S.S. Rattan, *Strength of Materials*, Tata McGraw Hill, 2009.
3	R C Hibbeler, *Mechanics of materials*, 8th edition, PHI, New Delhi, 2010.
ADDITIONAL REFERENCE MATERIAL	
1	https://www.engineer4free.com/mechanics-of-materials.html
2	https://nptel.ac.in/courses/112107146
ONLINE COURSES	
1	https://onlinecourses.nptel.ac.in/noc22_ce54/preview
2	https://nptel.ac.in/courses/105106172
3	https://archive.nptel.ac.in/noc/courses/noc18/SEM1/noc18-ce04/

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X	X	X		
CO2	BL 4	X	X	X		
CO3	BL 6		X			
CO4	BL3				X	X
CO5	BL5				X	X
CO6	BL6	X		X	X	X

R23MMECT005	MANUFACTURING PROCESSES					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Engineering workshop, Material science	**3**	**0**	**0**	**3**

Course Objective

Students will get exposure to get an overview on different manufacturing processes ranging from casting, fabrication, forming and plastic processing and their capability.

Course Outcomes

1	Design suitable casting methods for specific industrial applications in foundry practice to produce defect free casting. **(BL6)**
2	Develop advanced proficiency by recommending the optimal welding method for specific materials and structural applications, integrating safety, and efficiency, in industrial and construction contexts. **(BL6)**
3	Integrate the complex factors influencing forming process selection for a specific application. **(BL6)**
4	Solve the complex engineering problems using sheet metal processes for an intended application. **(BL6)**
5	Propose an in-depth investigation of plastic processing technologies, including their abilities in various applications. **(BL6)**

SYLLABUS

Unit I	**METAL CASTING PROCESSES**	**8 hr**

Sand Casting : Sand Mould; Type of patterns, Pattern Materials, Pattern allowances; Moulding sand Properties and testing; Cores, Types and applications; Melting furnaces: Induction and Cupola Furnaces; Principle of special casting processes : Investment, Pressure die casting; Centrifugal Casting, Stir casting; Defects in Sand casting.

Unit II	**JOINING PROCESSES**	**8 hr**

Introduction to welding processes: Definition, Classification, Advantages, Disadvantages and Applications; Operating principle, basic equipment, merits and applications of: Gas welding, Manual metal arc welding; Gas Tungsten arc welding, Gas metal arc welding, Submerged arc welding; Operating principle and applications of: Resistance welding; Thermit welding, Electron beam welding, Laser beam welding; Friction welding and Friction Stir Welding; Brazing and soldering; Weld defects: types, causes and cure.

Unit III	**METAL FORMING PROCESSES**	**8 hr**

Hot working and cold working of metals; Forging processes – Open, impression and closed die forging; forging operations; Rolling of metals, Types of Rolling; Flat strip rolling, shape rolling operations; Defects in rolled parts;. Principle of rod and wire drawing, Tube drawing; Principles of Extrusion, Types, Hot and Cold extrusion.

Unit IV	**SHEET METAL PROCESSES**	**8 hr**

Sheet metal characteristics, shearing, bending and drawing operations; Stretch forming operations, Formability of sheet metal; Test methods; special forming processes, Working principle and applications, Hydro forming; Rubber pad forming, Metal spinning; Introduction of Explosive forming, magnetic pulse forming; peen forming, Super plastic forming; Micro forming.

Unit V	**MANUFACTURE OF PLASTIC COMPONENTS**	**8 hr**

Types and characteristics of plastics; Moulding of thermoplastics; working

principles and typical applications, injection moulding; Plunger and screw machines; Compression moulding, Transfer Moulding, Typical industrial applications; introduction to blow moulding Rotational moulding; Film blowing, Extrusion; Thermoforming, Bonding of Thermoplastics.	
LEARNING RESOURCES	
TEXT BOOKS:	
1	Rao P.N., Manufacturing Technology, Volume I, 5/e, McGraw-Hill Education, 2018.
2	Hajra Chouldhary S.K and Hajra Choudhury. AK., "Elements of workshop Technology". volume I and II, Media promoters and Publishers Private Limited, Mumbai, 2008.
3	Kalpakjian. S. "Manufacturing Engineering and Technology", Pearson Education India Edition.
REFERENCE BOOKS:	
1	Gowri P. Hariharan, A. Suresh Babu, "Manufacturing Technology I", Pearson Education, 2008.
2	Paul Degarma E. Black J.T and Ronald A. Kosher, "Materials and Processes, in Manufacturing" Eight Edition, Prentice - Hall of India.
3	Sharma, P.C., "A Text book of production Technology". S.Chand and Co. Ltd., 2019.
ADDITIONAL REFERENCE MATERIAL	
1	https://mrcet.com/downloads/digital_notes/ME/II%20year/Manufacturing%20Processes.pdf
2	https://www.cet.edu.in/noticefiles/257_Basic%20Manufacturing%20Processes-ilovepdf-compressed.pdf
3	https://www.vssut.ac.in/lecture_notes/lecture1427132579.pdf
4	https://www2.isikun.edu.tr/personel/ahmet.aran/mfgprop.pdf
5	https://www.vssut.ac.in/lecture_notes/lecture1423905304.pdf
6	https://soaneemrana.org/onewebmedia/Manufacturing%20Processes%20By%20H.N.%20Gupta.pdf
ONLINE COURSES	
1	https://www.classcentral.com/course/manufacturing-massachusetts-institute-of-technolo-7224
2	https://alison.com/course/manufacturing-processes-metalworking
3	https://onlinecourses.nptel.ac.in/noc19_me44/preview

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL6	X				
CO2	BL6		X			
CO3	BL6			X		
CO4	BL6				X	
CO5	BL6					X

R23MCSCT001 (EOEC-T1)	DATA STRUCTURES & ALGORITHMS (for MEC, ECE, EEE, CIV and CHE)					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Basic Programming	**3**	**0**	**0**	**3**

Course Objective

Students will get exposure to use data structures such as arrays, linked lists, stacks, queues, trees, graphs, hashing and will be able to select and implement the appropriate data structures to solve the given problem.

Course Outcomes

1	Will be able to **apply** various searching and sorting techniques and **analyze** their time complexities. **(BL3)**
2	Will be able to **apply** Linked Lists and its variants and **utilize** them for various applications. **(BL3)**
3	Will be able to **compare** arrays and Linked Lists and **conclude** which storage structure is appropriate for the given problem/data structure. **(BL4)**
4	Will be able to **develop** novel **solutions** to small scale programming challenges involving data structures such as stacks, queues, trees and graphs.
5	Will be able to recognize scenarios where hashing is advantageous, and **design** hash-based **solutions** for specific problems. **(BL6)**
6	Will be able to collaborate in teams to **design** and implement innovative **solutions** by **choosing** and **combining** the appropriate data structure(s). **(BL6)**

SYLLABUS

Unit I	**INTRODUCTION TO LINEAR DATA STRUCTURES**	**8 hr**

Data Structures- Introduction, need for a data structure, Types of Data Structures; Overview of time and space complexity analysis, asymptotic notations; Recursion-Introduction, Types of recursions; Searching-Linear Search algorithm, Binary Search algorithm

Sorting techniques- Bubble Sort, Selection Sort; Insertion Sort; Quick Sort; Merge Sort.

Unit II	**LINKED LISTS**	**8 hr**

Introduction to Linked List, Variations/Types of Linked Lists, Applications; Single Linked List Operations: creation, insertion; Deletion, Traversal/Search; Circular Linked Lists-Insertion, Deletion, Traversal/Search.

Double Linked Lists and Operations- Creation, Insertion; Deletion, Traversal/Search; Applications of Linked List-Representation of Sparse Matrix using Single Linked List, Representation of Polynomials using Single Linked List; Polynomial Operations (Addition) using Linked List.

Unit III	**STACKS AND QUEUES**	**8 hr**

Introduction to Stack data structures, basic operation, implementation of Stack using array; Stack implementation using Linked Lists, advantages & disadvantages; Applications of Stack: Infix to postfix conversion; postfix expression evaluation, Factorial using Stack.

Introduction to Queue data structures, basic operation, implementation of Queue using array; Queue operations implementation using Linked Lists; Circular Queues using Arrays; Double Ended Queues.

Unit IV	**TREE- BINARY TREE, BINARY SEARCH TREE, BALANCED TREE**	**8 hr**

Tree – Introduction, Types of Trees; Binary Tree – Introduction, Properties,

Various ways of representing Binary Tree in memory; Recursive Binary tree traversals, Construction of Binary tree given tree traversals (In-order, Pre-order & In-order, Post-order); Tree applications- Heap(Min/Max) Binary Search tree operations- Creation, Insertion; Deletion, Traversal/Search; Balanced Binary trees – Introduction, Operations on AVL Trees –Insertion; AVL Tree Deletion, Search.		
Unit V	**GRAPHS AND HASHING**	**8 hr**
Basic concepts, Representation of Graph using Adjacency Matrix and Adjacency List; Graph Traversals (BFS, DFS); minimum spanning tree using Prim's Algorithm; minimum spanning tree using Kruskal's algorithm Single Source Shortest Distance- Dijkstra's algorithm, transitive closure; Introduction to Hashing, Hash Functions; Collision Resolution Techniques: Open hashing -chaining, Open Addressing- linear probing; quadratic probing, double hashing.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	Mark Allen Weiss, *Data Structures and algorithm analysis in C*, Pearson, 2nd Edition.	
2	Ellis Horowitz, Sartaj Sahni, Susan Anderson-Freed, *Fundamentals of data structures in C*, Silicon Press, 2008.	
3	Richard F, Gilberg , Forouzan, Cengage, *Data Structures*, 2/e.	
REFERENCE BOOKS:		
1	Algorithms and Data Structures: The Basic Toolbox by Kurt Mehlhorn and Peter Sanders.	
2	C Data Structures and Algorithms by Alfred V. Aho, Jeffrey D. Ullman, and John E. Hopcroft	
3	Problem Solving with Algorithms and Data Structures" by Brad Miller and David Ranum	
4	Introduction to Algorithms by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein.	
5	Algorithms in C, Parts 1-5 (Bundle): Fundamentals, Data Structures, Sorting, Searching, and Graph Algorithms" by Robert Sedgewick	
ADDITIONAL REFERENCE MATERIAL		
1	https://www.javatpoint.com/data-structure-tutorial	
2	https://www.programiz.com/dsa	
3	https://www.cs.bham.ac.uk/~jxb/DSA/dsa.pdf	
ONLINE COURSES		
1	https://onlinecourses.nptel.ac.in/noc24_cs45/preview	
2	https://www.coursera.org/learn/data-structures	
3	https://www.coursera.org/specializations/boulder-data-structures-algorithms	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL3		X			
CO3	BL4	X	X	X	X	X
CO4	BL6			X	X	X
CO5	BL6					X
CO6	BL6	X	X	X	X	X

R23MSCST011 (EOEC-T2)	OPERATING SYSTEMS (Common to all Branches)					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	-	**3**	**0**	**0**	**3**

Course Objective

Students will gain a comprehensive understanding of operating systems, covering topics such as system architecture, functionalities, structures, processes, file systems, storage management, and advanced concepts like inter-process communication, multithreading, disk scheduling, and RAID, enabling them to grasp the fundamental principles and practical aspects of managing computer systems effectively.

Course Outcomes

1	Students will be able to analyze the diverse structures and functionalities of operating systems. (**BL4**)
2	Students will be able to design and make use of efficient process management strategies, employing system calls and various threading models to improve overall system responsiveness. **(BL6**)
3	Students will be able to analyze the system's performance and effectiveness by comparing different strategies for deadlock resolution and memory management.(**BL3**)
4	Students will be able to analyze the performance of virtual memory management techniques, including TLB, different page table structures, and page replacement algorithms. Examine system behavior to identify and understand the causes of thrashing and evaluate the effectiveness of various file management methods and directory structures.(**BL5**)
5	Students will be able to analyze the effectiveness of various file system structures and management techniques. Evaluate the efficiency of free space management techniques and disk scheduling algorithms. Examine RAID levels to assess their impact on disk and swap space management.(**BL5**)
6	Students will be able to adapt to build basic internals of operating system framework that integrates diverse OS concepts (process management strategies, efficient file system structures, and virtual memory management techniques), choose different approaches for inter-process communication to enhance system responsiveness and collaboration, and discuss various solutions for ensuring improved performance and reliability in storage systems.(**BL6**)

SYLLABUS

Unit I	**INTRODUCTION TO OS AND CONCEPTS OF PROCESS AND THREADING**	**8 hr**

What Operating Systems do? Computer System architecture; OS Functionalities: Process Management, Memory Management, Storage Management, Protection and Security; Computing Environment: Traditional Computing, Client Server computing, Peer to Peer computing, web based computing, OS Services; System calls, Types of System calls; Operating System Structure: Simple, Layered, Microkernels, Modules; Introduction to Processes: Process, Process States, Process Control Block. Threads.; Operations On Processes: Process Creation, Process Termination (fork(),exec(),exit() system calls); Inter-Process communication: Shared memory, Message Passing;

Unit II	**PROCESS SCHEDULING AND SYNCHRONIZATION**	**8 hr**

Multithreading Models: Overview, Benefits, Many to One, One to One, Many to

Many. Process Scheduling: Scheduling queues, Schedulers, Context switch;
Process Scheduling: Basic Concepts, CPU Scheduler, Preemptive Scheduling, Dispatcher, Scheduling Criteria; Scheduling Algorithms (Non-pre-emptive): FCFS, SJF; Scheduling Algorithms II(pre-emptive): Priority Scheduling, Round Robin; Multilevel Queue, Multilevel Queue feedback, Process Synchronization: Introduction to process synchronization. Producer Consumer Problem; Critical Section Problem, Peterson's Solution, Synchronization Hardware; Semaphore, Classical problems of synchronization: Bounded-buffer Problem, Readers Writers Problem; Dining Philosophers Problem, Monitors: Introduction, Usage;

Unit III	**DEADLOCKS AND MEMORY MANAGEMENT**	**8 hr**

Deadlocks: Introduction, System Model, Deadlock Characterization; Methods for Handling Deadlocks Deadlock Prevention; Deadlock Avoidance (Part -1) Safe state, resource allocation graph algorithm; Deadlock Avoidance (Part -2) Banker's algorithm, Deadlock Detection single instance of each resource type; Deadlock Detection several instances of resource type and Recovery from Deadlocks;
Memory Management, Address Binding, Logical vs Physical Address space; Swapping, Contiguous Memory; Paging (Basic Method);

Unit IV	**PAGING TECHNIQUES, PAGE REPLACEMENT AND ACCESSING FILES TECHNIQUES**	**8 hr**

Hardware, TLB, Protection, Shared Pages,; Structure of the Page table, hierarchy, hashed,; Inverted page table, Segmentation; Virtual memory management, Demand paging; Page Replacement Algorithms: FIFO, Optimal page replacement; LRU Page replacement, Thrashing: causes of thrashing,; File concept, File Attributes, File operations, File types, File Structure; Access methods: Sequential Access, Direct Access, Directory Structure: Single level directory, Two level directory;

Unit V	**FILE ORGANIZATION AND DISK SCHEDULING TECHNIQUES**	**8 hr**

Tree structured directories, Acyclic graph directories, File System Mounting File Sharing; File Protection: types of access, Access control, File allocation methods: Contiguous allocation,; File allocation methods: Linked allocation, Indexed allocation, Free space management: Bit vector, Linked list, Grouping,; Overview of Mass Storage Structure: Magnetic disks, Magnetic Tapes, Disk Structure; Disk Scheduling: FCFS,SSTF,SCAN,; CSCAN,LOOK,CLOOK; Disk Management, Swap Space Management; Raid Structure: Levels: 0-6, RAID levels 0+1;

LEARNING RESOURCES

TEXT BOOKS:

1	"Operating System Concepts" by Abraham Silberschatz, Peter B. Galvin, and Greg Gagne.
2	"Modern Operating Systems" by Andrew S. Tanenbaum.

REFERENCE BOOKS:

1	"Operating Systems: Internals and Design Principles" by William Stallings.

ADDITIONAL REFERENCE MATERIAL

1	"Operating Systems: Three Easy Pieces" by Remzi H. Arpaci-Dusseau and Andrea C. ArpaciDusseau (Free online book available at: http://pages.cs.wisc.edu/~remzi/OSTEP/)
2	"Linux Kernel Development" by Robert Love.
3	"File System Forensic Analysis" by Brian Carrier.

ONLINE COURSES	
1	**Coursera: "Operating Systems and System Programming"** ● Offered by Stanford University, this course covers fundamentalconcepts and principles of operating systems. ● https://www.coursera.org/specializations/codio-introduction-operating-systems
2	**edX: "Introduction toss Operating Systems"** ● Provided by Georgia Institute of Technology, this course exploresthe design and implementation of modern operating systems. ● Link: https://www.udacity.com/course/introduction-to-operating- systems--ud923
3	**MIT OpenCourseWare: "Operating System Engineering"** ● A free online course from MIT, offering in-depth coverage of operating system design and implementation. **Link:** ● https://ocw.mit.edu/courses/6-828-operating-system-engineering- fall-2012/

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL4	X				
CO2	BL6		X			
CO3	BL3			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MMECL001	COMPUTER AIDED GEOMETRIC DESIGN AND ASSEMBLY LAB					
	Total Contact Hours	42 (P)	**L**	**T**	**P**	**C**
	Pre-requisite	Computer Aided Engineering Graphics	**0**	**0**	**3**	**2**

Course Objective

To equip students with the knowledge and skills to proficiently utilize computer-aided design (CAD) software, specifically focusing on geometric design and assembly, enabling them to create, modify, and analyze complex geometric models and assemblies for applications in various industries.

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

1	Prepare 2-D drawings of different components
2	Model 3-D geometries of components used for different engineering applications
3	Explain the importance of assembly drawings and prepare the assembly drawings.
4	Convert the assembly drawings into 2-D drawings by using different draughting tools

List of Exercises

1	Basic Sketching: Creating 2D sketches, applying constraints and dimensions.
2	Advanced Sketching: Complex sketch constraints, relations
3	Basic Modeling Techniques: Extrusions, revolve, Hole and basic solid modeling operations.
4	Boolean operations (Union, Subtract, Intersect), Creation of Datum coordinate system, axis and planes
5	Solid Modified Features: Editing and modifying features such as Move, Delete, Replace, Offset etc
6	Solid Modified Features: Edge Blend, Chamfer, shell, patterns, mirror.
7	Basic Assembly Constraints: Applying constraints (Touch, Align, Parallel and Perpendicular) for defining relationships.
8	Basic Assembly Constraints: Applying constraints (Bond, Distance, Concentric) for defining relationships.
9	Creating and managing sub-assemblies.
10	Creating detailed engineering drawings, annotations, and part lists.

Additional Exercises

1	Surface Modeling: Creating and editing surfaces
2	Sheet Metal Design: Creating sheet metal parts, Bending, flanging, and forming tools, Flattening and exporting sheet metal parts

LEARNING RESOURCES

TEXT BOOKS:

1	Sham Tickoo,*CATIA V5R14 for Designers*, Cadcim Technologies, 2005.
2	Louis Gary Lamit,*Creo Parametric 2.0*,CL Engineering, 2013.
3	NX Basic Design with Teamcenter Integration Student Guide October 2011 MT10053_TC_S — NX 8.
4	Solid Works User's Manual.

R23MMECL002	MATERIAL TESTING LAB					
	Total Contact Hours	42 (P)	**L**	**T**	**P**	**C**
	Prerequisite	Nil	**0**	**0**	**3**	**2**

Course Objective

The objective of a material testing laboratory is to evaluate and analyze the mechanical properties of materials such as metals, concrete, wood etc., by conducting testing on standard test specimens.Students will gain understanding of various steps involved in preparing metallurgical sample and role of etchant in revealing the microstructure and correlate the mechanical properties with revealed microstructure for a specific sample.

Course Outcomes

1	Demonstrate the procedures of making a standard test specimen and conduct experimentation by setting up standard testing parameters to find various mechanical properties of Engineering Materials
2	Correlate, comprehend and report on important mechanical properties of materials.
3	Suggest/Select suitable materials for different applications based on required mechanical properties.
4	Demonstrate the systematic methodology involved in preparing making a standard test specimen.
5	Identify various phases of revealed micro-structure.
6	Select suitable etchant as per the material for investigation.

List of Experiments

1	Tensile Test - Uniaxial tension test on mild steel rod
2	Brinell, Rockwell and Vickers's Hardness test
3	Compression tests of non-metallic specimens
4	Torsion Test - Torsion test on mild steel rod
5	Bending Test on metallic specimens.
6	Impact test on a metallic specimen - Izod and Charpy Tests on M.S, C.I Specimen.
7	Microstructural analysis of low carbon steel
8	Microstructural analysis of grey cast iron
9	Microstructural analysis of pure copper
10	Microstructural analysis of bronze
11	Microstructural analysis of hardened and tempered steel
12	Standard test methods for estimation of grain size

Additional Experiments

1	Microstructural analysis of Aluminium
2	Identification of HAZ of weldment
3	Failure analysis of engineering components like refrigerator tubes/ connecting rod/ crankshaft.
4	Pin on disc -To study the wear characteristics of ferrous, non-ferrous and composite materials for different parameters.
5	shear test
6	Deflection Test on beams

LEARNING RESOURCES

TEXTBOOKS:

1	Popov E.P, *Engineering Mechanics of Solids*, PHI, New Delhi, 2010.
2	S.S.Bhavikatti, *Strength of Materials*, Vikas publications House -1 Pvt. Ltd., 2nd Ed., 2006.
3	Material testing laboratory manual
4	W. D. Callister, Materials Science and Engineering-An Introduction", 6th Edition, Wiley India. 2006
5	Sidney H. Avner: Introduction to Physical Metallurgy, TMH Publishing Co. Ltd. New Delhi,1997.
REFERENCE BOOKS:	
1	Ferdinand Beer & Russell Johnston, *Mechanics of materials*, TATA McGraw Hill-2005
2	S.S. Rattan, *Strength of Materials*, Tata McGraw Hill, 2009
3	Physical Metallurgy, Principles and Practice V. Raghavan, Prentice-Hall of India Private Limited, 2006
4	V.D.Kodgire, Sushil V. Material Science and Metallurgy,43rd Edition, Everest Publishing house,2018.
5	Material Science and Metallurgy. O.P.Khanna. Dhanpat Rai Publications.
ADDITIONAL REFERENCE MATERIAL	
1	https://eerc01-iiith.vlabs.ac.in/List%20of%20experiments.html

<table>
<tr><td rowspan="3">R23MCSCL001
(EOEC-L1)</td><td colspan="6">DATA STRUCTURES & ALGORITHMS LAB
(for MEC, ECE, EEE, CIV and CHE)</td></tr>
<tr><td>Total Contact Hours</td><td>42 (P)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Pre-requisite</td><td>Basic Programming</td><td>0</td><td>0</td><td>3</td><td>2</td></tr>
<tr><td colspan="7">Course Objective</td></tr>
<tr><td colspan="7">To get hands-on exposure to linear and non-linear data structures and to identify and apply the suitable data structures for the given real-world problem.</td></tr>
<tr><td colspan="7">Course Outcomes</td></tr>
<tr><td>1</td><td colspan="6">Student will be able to implement recursive algorithms and will be able to understand the role of linear data structures in organizing and accessing data efficiently using searching and sorting techniques.</td></tr>
<tr><td>2</td><td colspan="6">Student will be able to implement, and apply linked lists for dynamic data storage, demonstrating understanding of memory allocation.</td></tr>
<tr><td>3</td><td colspan="6">Student will be able to develop programs using stacks to handle recursive algorithms, manage program states, and solve related problems.</td></tr>
<tr><td>4</td><td colspan="6">Student will be able to apply queue-based algorithms for efficient task scheduling and breadth-first traversal in graphs and distinguish between linear queues and circular queues, and apply them appropriately.</td></tr>
<tr><td>5</td><td colspan="6">Student will be able to devise novel solutions to small scale programming challenges involving data structures such as stacks, queues, trees, graphs.</td></tr>
<tr><td>6</td><td colspan="6">Student will be able to recognize scenarios where hashing is advantageous, and design hash-based solutions for specific problems.</td></tr>
<tr><td colspan="7">LIST OF EXPERIMENTS</td></tr>
<tr><td>1</td><td colspan="6">WEEK 1(SEARCH TECHNIQUES)
Write a C Program to search an element in the given list using Linear Search Technique. (using recursive and non-recursive functions)
Write a C Program to search an element in the given sorted list using Binary Search Technique. (using recursive and non-recursive functions)</td></tr>
<tr><td>2</td><td colspan="6">WEEK 2(SORTING TECHNIQUES)
Write a C Program using recursive function to sort a given list of integers in ascending order using Bubble Sort Technique.
Write a C Program using recursive function to sort a given list of integers in ascending order using Quick Sort Technique.
Write a C Program using recursive function to sort a given list of integers in ascending order using Merge Sort Technique.</td></tr>
<tr><td>3</td><td colspan="6">WEEK 3(LINKED LIST)
Write a C Program to create a Single linked list and perform basic operations on Single Linked List.</td></tr>
<tr><td>4</td><td colspan="6">WEEK 4 (OTHER VARIANTS OF LINKED LIST)
Write a C Program to create a Circular linked list and perform basic operations.
Write a C Program to create a Double linked list and perform</td></tr>
</table>

	basic operations.
5	**WEEK 5 (STACKS & APPLICATIONS)** • Write a C Program to implement Stack operations using arrays. • Write a C Program to implement Stack operations using linked list. • Write a C Program to implement Infix to postfix conversion using stacks. • Write a C Program to evaluate the Postfix Expression using stacks.
6	**WEEK 6 (QUEUES)** • Write a C Program to implement Queue operations using arrays. • Write a C Program to implement Queue operations using linked list • Write a C Program to implement Circular Queue operations.
7	**WEEK 7 (BINARY TREE)** • Write a C Program to implement Binary Tree Creation. • Write a C Program to implement Recursive Binary Tree Traversals.
8	**WEEK 8 (BINARY SEARCH TREE(BST))** • Write a C Program to implement Binary Search Tree creation. • Write a C program to implement Insertion, Deletion, Search operations on Binary Search Tree.
9	**WEEK 9 (GRAPHS & TRAVERSAL TECHNIQUES)** • Write a C Program to create a Graph (using Adjacency Matrix or Adjacency List). • Write a C Program to implement Graph Traversals -Breadth First Search and Depth First Search.
10	**WEEK 10 (GRAPH APPLICATIONS)** • Write a C Program to implement Prim's & Kruskal's Algorithm for finding Minimum Cost Spanning Tree. • Write a C Program to implement Single Source Shortest Path - Dijkstra's Algorithm.
11	**WEEK 11 (HEAPS)** • Write a C Program to implement Binary Heap (Min Heap or Max Heap).
12	**WEEK 12 (HASHING)** • Write a C Program to implement Collision Resolution Techniques using Linear probing (Open Addressing) Technique using Division method as hash function.
LEARNING RESOURCES	
TEXT BOOKS:	
1	Mark Allen Weiss, *Data Structures and algorithm analysis in C*, Pearson, 2nd Edition.
2	Ellis Horowitz, Sartaj Sahni, Susan Anderson-Freed, *Fundamentals of data structures in C*, Silicon Press, 2008.
3	Richard F, Gilberg , Forouzan, Cengage, *Data Structures*, 2/e.

REFERENCE BOOKS:	
1	Algorithms and Data Structures: The Basic Toolbox by Kurt Mehlhorn and Peter Sanders.
2	C Data Structures and Algorithms by Alfred V. Aho, Jeffrey D. Ullman, and John E. Hopcroft
3	Problem Solving with Algorithms and Data Structures" by Brad Miller and David Ranum
4	Introduction to Algorithms by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein.
5	Algorithms in C, Parts 1-5 (Bundle): Fundamentals, Data Structures, Sorting, Searching, and Graph Algorithms" by Robert Sedgewick
ADDITIONAL REFERENCE MATERIAL	
1	https://www.javatpoint.com/data-structure-tutorial
2	https://www.programiz.com/dsa
3	https://www.cs.bham.ac.uk/~jxb/DSA/dsa.pdf
ONLINE COURSES	
1	https://onlinecourses.nptel.ac.in/noc24_cs45/preview
2	https://www.coursera.org/learn/data-structures
3	https://www.coursera.org/specializations/boulder-data-structures-algorithms

IV Semester

R23MMECT006	FLUID MECHANICS AND HYDRAULIC MACHINES					
	Total Contact Hours	42(L)	**L**	**T**	**P**	**C**
	Pre-requisite	Differential Equations and Vector Calculus, Engineering Physics	**3**	**0**	**0**	**3**

Course Objective

This course aims to help students grasp the principles of fluid mechanics and fluid machines, enabling them to analyse fluid behaviour, apply relevant equations, and understand the design and operation of various fluid machines used in engineering applications.

Course Outcomes

After completing this course, the students will be able to

1	Estimate the pressure distribution in incompressible fluids using principles of fluid statics.(**BL4**)
2	Analyze problems related to fluid flow and dynamics.(**BL4**)
3	Investigate the fluid behavior in situations involving viscosity, pipe networks, and boundary layer effects.(**BL4**)
4	Assess the performance of different hydraulic turbines.(**BL5**)
5	Evaluate the performance parameters of rotodynamic pumps.(**BL5**)
6	Adapt fluid mechanics concepts to analyze, design, and enhance fluid systems for improved efficiency and performance.(**BL6**)

SYLLABUS

Unit I	**PROPERTIES OF FLUIDS AND FLUID STATICS**	**8 hr**

Properties of fluids- density, specific weight, specific volume, specific gravity, viscosity; vapor pressure, compressibility, bulk modulus, surface tension and capillarity; Newton's law of viscosity, Newtonian and non-Newtonian fluids; pressure in a static fluid; pressure Measurement, Manometers-simple; U-tube differential manometer; Concept of buoyancy; Stability of submerged and floating bodies.

Unit II	**FLUID KINEMATICS AND DYNAMICS**	**8 hr**

Introduction to fluid kinematics, velocity, and acceleration of a fluid particle; Conservation of mass; potential function and stream function; Bernoulli's equation and its Applications-Pitot tube; Applications of Bernoulli's equation-Venturimeter and orifice meter; Need for dimensional analysis and Methods of dimensional analysis;Application of Buckingham's pi theorem for different fluid flow systems; Similitude; Dimensionless parameters.

Unit III	**VISCOUS FLUID FLOW AND BOUNDARY LAYER THEORY**	**8 hr**

Exact flow solutions of Navier-Stokes Equations-Parallel flow in a straight channel; Couette flow; Hagen Poiseuille flow; Darcy Weisbach equation, friction factor, Moody's diagram; Concept of boundary layer; boundary layer parameters; Flow through pipes- head loss in pipes and fittings; Flow through pipes when pipes in series and parallel.

Unit IV	**HYDRAULIC TURBINES**	**8 hr**

Classification of water turbines, heads and efficiencies; Pelton wheel; Francis turbine; Kaplan turbine and draft tube; Specific speed and Unit quantities; Similarity laws of turbines; Performance curves for turbines; Governing of turbines.

Unit V	**HYDRAULIC PUMPS**	**8 hr**
Centrifugal pump, various heads and efficiencies; Concept of velocity triangles of centrifugal pumps; Different vane configurations of impellers;Pumps in series and Parallel; Specific speed and Similarity laws; NPSH and Cavitation; performance curves; Reciprocating pump-Working Principle, Work required, Slip.		
LEARNING RESOURCES		
TEXTBOOKS:		
1	S. K. Som, G. Biswas, and S. Chakraborty, *Introduction to Fluid Mechanics and Fluid Machines*, Third edition. Tata McGraw-Hill Education, 2017.	
2	K. Subramanya, *Fluid Mechanics and Hydraullic Machines,* Second Edition*.* McGraw-Hill Education (India) Pvt Ltd., 2018.	
REFERENCE BOOKS:		
1	Yunus A. Cengel, John M. Cimbala, *Fluid Mechanics-Fundamentals and Applications*, Fourth edition. McGraw-Hill Education, 2019.	
2	P. M. Modi, S. M. Seth, *Hydraulics and Fluid Mechanics Including Hydraulic Machines*, 22nd edition. Standard Book House, 2018.	
ADDITIONAL REFERENCE MATERIAL		
1	https://nptel.ac.in/courses/112104118	
2	https://nitsri.ac.in/Department/Mechanical%20Engineering/PPT_Fluid_Mechanics_(MEC_303)_NIT_Srinagar.pdf	
ONLINE COURSES		
1	NPTEL :: Mechanical Engineering - NOC:Introduction to Fluid Mechanics	
2	Fluid Machines - Course (nptel.ac.in)	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL4	X				
CO2	BL4		X			
CO3	BL4			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MMECT007	DESIGN OF MACHINE ELEMENTS					
	Total Contact Hours	42(L)	L	T	P	C
	Pre-requisite	Engineering Mechanics and Strength of Materials	3	0	0	3

Course Objective

To impart the knowledge of the design procedures and principles so as to enable the student, understand and design basic mechanical elementals that are subjected to various loading conditions to meet service requirements.

Course Outcomes

After completing this course, the students will be able to

1	Apply fundamental principles of stress analysis, static and fatigue failure theories to design basic machine elements subjected to combined, eccentric, and fluctuating loads. **(BL3)**
2	Apply material selection, safety factors, and standard codes to design machine components such as springs, couplings, bearings, joints, and power transmission elements. **(BL3)**
3	Apply mathematical relations and empirical formulas (Lewis equation, endurance limit modification, etc.) in solving design problems for gears, belts, bearings, and joints. **(BL3)**
4	Analyze the effect of stress concentration, fluctuating stresses, and eccentric loading on machine elements, and evaluate their performance under static and dynamic conditions. **(BL4)**
5	Evaluate and compare the suitability of design alternatives for springs, couplings, bearings, and gear drives considering strength, wear, life, and reliability. **(BL5)**
6	Develop robust & suitable machine components for diverse structural applications by considering material properties, loading conditions, failure prevention strategies, service, reliability etc,. **(BL6)**

SYLLABUS

Unit I	INTRODUCTION TO MECHANICAL ENGINEERING DESIGN & FAILURES RESULTING FROM STATIC LOADING	8 hr

Introduction to the Design Process: Types of Design and Design Procedure; Factors influencing the design; Selection of materials for engineering purposes; Equivalent stresses in combined loading; Eccentric loading; Static failure (ductile and brittle), factor of safety; Yield criterion for distortion-strain energy theory; Yield criterion for maximum shear Stress theory and fracture criterion for maximum normal stress theory

Unit II	FATIGUE FAILURE RESULTING FROM VARIABLE LOADING & MECHANICAL SPRINGS	8 hr

Fatigue failure mechanisms & Stress concentration, SCF-theoretical methods for reducing stress concentration; Fluctuating stresses & types, endurance limit & S-N Diagram; Notch sensitivity & Modified endurance limit; Gerber, Goodman and Soderberg criteria; Types of springs, function, materials for helical springs, standard size of spring wire, terms used in compression Springs; Stresses and deflections of helical springs; Design of tension and compression springs; Springs for fatigue loading and energy storage capacity of spring.

Unit III	DESIGN OF KEYS, COUPLINGS & BEARINGS	8 hr

Design of keys; Couplings: Definition and design procedure for flange coupling; Bearings: Introduction, Applications & Classification; Journal Bearings: hydrostatic and hydrodynamic journal bearings, Wedge Film Journal Bearings, Squeeze Film Journal Bearings; Properties and materials, bearing characteristic

number and design of journal bearing; Rolling contact bearings: Advantages and Disadvantages, Types of rolling contact bearings; Standard dimensions and designation of ball bearings, basic dynamic load rating and dynamic equivalent load of rolling contact bearings; Life of a bearing, reliability & Selection of radial ball bearings		
Unit IV	**DESIGN OF POWER TRANSMISSION ELEMENTS**	**8 hr**
Introduction to belt drives, Velocity Ratio; Length of open and cross belts; Limiting Ratio of Belt Tensions; Centrifugal Tension, Maximum Tension in the Belt, Initial tension; Transmission of power by belt drives, Condition for Transmission of Maximum Power, causes of gear tooth failure; Transmission of Power by Spur Gears, stresses in gear tooth; Lewis equation and form factor, Design for strength; Dynamic load and wear load, Design Procedure for Spur Gears		
Unit V	**DESIGN OF SCREW, WELDED & RIVETED JOINTS**	**8 hr**
Introduction & Terminology of Screw Joints; Stresses due to screw up forces; Stresses due to external loads, Bolts of Uniform Strength; Design of Bolted joints under eccentric loading; Welded Joints: Strength of weld joints; Eccentrically loaded welded joints; Riveted Joints: Terms used in riveted joints, Types, Strength of riveted joints; Eccentrically loaded riveted joints.		
LEARNING RESOURCES		
TEXTBOOKS:		
1	V B Bhandari*, Design of Machine Elements,* 4th edition,, McGraw Hill Education (India) Pvt.Ltd., 2016.	
2	Dr.N. C. Pandya, Dr.C. S. Shah*, Machine Design,* 20th Edition, Charotar Publishing House Pvt. Ltd., 2015.	
REFERENCE BOOKS:		
1	Shigley, J.E. and Mischke, C.R., *Mechanical Engineering Design,* 10th Edition, McGraw-Hill International, 2015.	
2	R.L.Norton, *Mechanical Design – An Integrated Approach*, 4th edition, Prentice Hall Pearson., 2011.	
3	K. Mahadevan and K. Balaveera Reddy, Design Data Handbook for Mechanical Engineers in SI and Metric Units, 4th Edition, CBS Publishers & Distributors Pvt Ltd.	
ADDITIONAL REFERENCE MATERIAL		
1	https://archive.nptel.ac.in/courses/112/105/112105125	
2	https://archive.nptel.ac.in/courses/112/106/112106137	
3	https://archive.nptel.ac.in/courses/112/105/112105124	
4	https://www.me.iitb.ac.in/~ramesh/courses/ME423/me423.html	
ONLINE COURSES		
1	https://www.coursera.org/learn/machine-design1	

Bloom's level and-Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	x	x			x
CO2	BL3	x	x	x	x	x
CO3	BL3		x	x	x	
CO4	BL 4	x	x			x
CO5	BL 5		x	x	x	
CO6	BL 6	x	x	x	x	x

R23MMECT008	MANUFACTURING TECHNOLOGY					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Prerequisite	Manufacturing process, Material science	**3**	**0**	**0**	**3**

Course Objective

Students will get exposure tocutting tool geometry and its effect on metal cutting dynamics, different varieties of machine tools, their configurations and mechanisms adopted to achieve the required motion and select suitable cutting tool, work handling system and operations for an intended application.

Course Outcomes

1	Identify different types of cutting tools and various angles associated with them and the inter conversion between different systems can also be solved (**BL3**).
2	Analyze the strategies for tool life improvement and various types of metal cutting machine tools and their applications in different manufacturing scenarios (**BL4**).
3	Identify different types of drives and mechanisms to facilitate relative movements in machine tools (**BL3**).
4	Design and select suitable accessories for complicated work pieces.(**BL6**).
5	Propose a process sheet for a given component to be manufactured (**BL6**).
6	Develop the competence to effectively utilize metal cutting concepts, use different machine tools and optimize cutting processes (**BL6**).

SYLLABUS

Unit I	**PRINCIPLES OF METAL CUTTING**	**8hr**

Theory of metal cutting, cutting motions; Chip formation, Piispanen card model; Orthogonal and Oblique cutting; Tool designations, ASA/ORS; Conversion between systems; Types of chips, Chip breakers; Cutting tool materials; Cutting fluids.

Unit II	**METAL CUTTING ANALYSIS AND MACHINE TOOLS**	**8 hr**

Merchant circle analysis; Dynamometry, Wear and tool life; Cutting temperature, Machinability; Lathe Machine tool specification, Operation principles; Operation principles; Milling Machine tool specification, Operation principles; Drilling and Grinding Machine tool specification, Operation principles; Shaper, Slotter and Plannar Machine tool specification, Operation principles.

Unit III	**KINEMATIC SCHEME OF MACHINES**	**8hr**

Speed Drive in Lathe; Feed Drive in Lathe; Speed and Feed Drive in Shaper; Speed and Feed Drive in Plannar machine; Speed and Feed Drive in Slotter machine; Speed and Feed Drive in Drilling Machine; Speed and Feed Drive in Milling Machine; Speed and Feed Drive in Grinding Machines.

Unit IV	**CUTTING TOOLS, TOOL AND WORK HOLDING SYSTEMS**	**8 hr**

Single Point Tools, Two-point Tools, Multi-point Tools; Grinding Wheels; Tool Post, Arbors; Collets, Chucks and Accessories; Concept of Jigs and Fixtures, Types of Jigs; Principles of Location, Locating and Clamping Methods; Work Holding Accessories on Turning, Milling, Drilling and Grinding Machines; Work Indexing Systems.

Unit V	**MACHINING OPERATIONS**	**8 hr**

Turning Operations; Drilling Operations; MillingOperations; Gear cutting; Grinding Operations; Broaching Operation; Lapping, honing operations; Burnishing, buffing, tumbling, super finishing operations;

LEARNING RESOURCES

TEXT BOOKS:	
1	Boothroyd, Geoffrey. Fundamentals of metal machining and machine tools. Vol. 28. Crc Press, 1988.
2	Shaw, Milton Clayton, and J. O. Cookson. Metal cutting principles. Vol. 2, no. 3. New York: Oxford university press, 2005.
3	Raghuwanshi, B. S. Course in Workshop Technology. Dhanpat Rai and Company (P) Limited, 2009.
REFERENCE BOOKS:	
1	Juneja, B. L. Fundamentals of metal cutting and machine tools. New Age International, 2003.
2	P. N. Rao. Manufacturing Technology-Metal cutting and Machine Tools.Volume 2, McGraw Hill, 2013.
3	Kibbe, Richard R., John E. Neely, Roland O. Meyer, Warren T. White, Mark Bonkoski, and Paul Bradshaw. Machine tool practices. Wiley, 1982.
ADDITIONAL REFERENCE MATERIAL	
1	https://zlib.pub/book/fundamentals-of-metal-machining-and-machine-tools-2tg7ggcpvlo0
2	https://archive.nptel.ac.in/courses/112/105/112105233/
ONLINE COURSES	
1	https://onlinecourses.nptel.ac.in/noc24_me50/preview
2	https://onlinecourses.nptel.ac.in/noc24_me46/preview
3	https://onlinecourses.nptel.ac.in/noc24_me48/preview

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL3			X		
CO4	BL6				X	
CO5	BL6					X
CO6	BL6	X	X	X	X	X

R23MMECT009	AUTOMOTIVE TECHNOLOGIES					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Engineering Thermodynamics	**3**	**0**	**0**	**3**

Course Objective

This course aims to cover the fundamentals of internal combustion engines, automobile engineering principles including chassis design and braking systems, and emerging technologies in electric and hybrid vehicles, ensuring students gain both theoretical knowledge and practical skills relevant to modern automotive engineering.

Course Outcomes

Students are able

1	Analyze the operating principles, and combustion characteristics of SI and CI engines. (**BL4**)
2	Evaluate the performance parameters and efficiency of IC engines. (**BL5**)
3	Evaluate steering and suspension systems for efficiency, analyze gear ratio calculations. (**BL4**)
4	Assess braking system efficiency and calculate gear ratios for optimal performance. (**BL4**)
5	Analyze the different powertrain architectures used in EVs, motors, batteries, and systems to improve performance and efficiency. (**BL4**)

SYLLABUS

Unit I	**INTERNAL COMBUSTION ENGINES**	**8 hr**

Basics and Components Engine: Classification, nomenclature; SI and CI engine operation; two-stroke and four-stroke engines; construction, working principle; Theoretical and Actual Indicator Diagrams; Valve and Port Timing Diagram, measurement and testing of power efficiency; Stages of combustion in SI and CI engines; abnormal combustion, combustion chambers.

Unit II	**FUELS, IGNITION, LUBRICATION, AND COOLING SYSTEMS**	**8 hr**

Fuels: Rating engine fuels; carburetor working principle; fuel injection systems - CRDI; MPFI; Ignition Systems: Battery, magneto; electronic ignition systems; Lubrication Systems: For petrol and diesel engines; Cooling Systems: Water-cooled engine, air-cooled engine.

Unit III	**AUTOMOBILE ENGINEERING - CHASSIS, STEERING, AND SUSPENSION**	**8 hr**

Chassis: Types of chassis, drives; various types of frames, constructional details; Performance of Automobiles: Taxable power, power and torque curves; resistances to a moving vehicle; power required to propel a vehicle; Steering System: steering geometry; types of steering gear boxes, power and power-assisted steering; Suspension System: Types of suspension, shock absorbers.

Unit IV	**AUTOMOBILE ENGINEERING - BRAKES, CLUTCH, AND GEAR BOX**	**8 hr**

Braking System: Classification of brakes, constructional details; anti-lock braking systems, basic braking calculations; Clutch and Gear Box: Clutches - types, construction and working principle; Gear Box - types, construction and working; gear ratio calculation based on vehicle gradeability and top speed, gear shifting mechanisms; Hybrid Transmission: CVT, DCT, AMT, and automatic transmission; Propeller shaft, universal joints,Hotchkiss drive, torque tube drive, and radius

rods. front-wheel drive; Differential Principles , Rear Axles: Types and construction		
Unit V	**ELECTRIC AND HYBRID VEHICLES**	**8 hr**
Components of EV; types of EV, Typical power ratings of charger; motors used in EVs, power and torque calculations; Basic Electronic Devices, Battery management systems and Safety; Hybrid Electric Vehicles: Classification - micro, mild, full, plug-in EV; Layout and architecture - series, parallel, and series-parallel hybrid; Propulsion systems and components, regenerative braking; EV regulations for design or retrofit.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	Ganesan, V.,*Internal Combustion Engines*, 4th ed., McGraw-Hill Education, 2017.	
2	Giri N K., *Automobile Mechanics*, Khanna Publishers, 2006.	
3	William H Crouse & Anglin D L., *Automotive Mechanics*, Tata McGraw Hill Publishing Company., 2006	
4	Denton, T.,*Electric and Hybrid Vehicles*, 2nd ed., Routledge,2020.	
5	Chandler, M.,*The Tech Behind Electric Cars*, Energy Startups, 2020	
REFERENCE BOOKS:		
1	Robert Bosch, Automotive Handbook, 8th ed, Bentley (Robert) Inc.,US, 2011.	
2	Kirpal Singh, *Automobile Engineering*, Vol 1 & 2., 14th ed., The world book depot, 2021.	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL4	X				
CO2	BL5		X			
CO3	BL4			X		
CO4	BL4				X	
CO5	BL4					X

R23MSCST007	PYTHON PROGRAMMING (Common to all branches)					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Basic C Programming	**3**	**0**	**0**	**3**

Course Objective

Students will gain knowledge on the basic programming constructs of python language to develop both desktop and Graphical user applications.

Course Outcomes

1	Students will be able to apply the basic building blocks of python language. **(BL3)**
2	Students will be able to distinguish between various conditional control statements and simplify the problems using functions. **(BL4)**
3	Students will be able to experiment with various non-scalar data types. **(BL3)**
4	Students will be able to examine the data using file operations and pandas library. **(BL4)**
5	Students will be able to decide suitable widgets to implement Graphical User applications. **(BL5)**
6	Students will be able to design and develop real time applications using Python Programming constructs and GUI tkinter module. **(BL6)**

SYLLABUS

Unit I	**BASICS – DATA TYPES, OPERATORS, BUILT-IN MODULES**	**8 hr**

Data Types, Escape Sequences, Variables and Basic Input/Output; Assignment Statements, Operators; Arithmetic Expressions, Operator precedence, Type Casting, Program Comments and Docstrings; Program Format and Structure, REPL, IDLE, Running a Script from a Terminal Command Prompt;
Built-In Functions and Modules; User Defined modules creation and importing a user defined module; NumPy – Functions on 1D arrays, Functions on 2D arrays; Pandas Module- Creation of Series, DataFrames, indexing objects;

Unit II	**DECISION-MAKING STATEMENTS, LOOPS AND USER-DEFINED FUNCTIONS**	**8 hr**

Conditional Statements; While loop, for loop; range () function, nested loops; While-else, For- else, break, continue, pass;
Functions: Syntax and basics of function and usage; Passing Parameters, arguments in a function – Default, keyword, positional and Variable - length arguments; local and global scope of variable; return statement, recursive function, recursion vs iteration;

Unit III	**STRINGS, LISTS, TUPLES AND DICTIONARIES**	**8 hr**

Strings- A String is a sequence, Strings are immutable, String slice, String methods; Membership and Identity operators, String search; List- Lists are mutable, List operations; Lambda functions, Map, filter and reduce;
Tuples- Tuples are immutable, Tuple operations; Tuple as return values, List Comprehension, Comparison of Lists and tuples; Dictionaries – Dictionary Creation, operations, Looping through dictionaries; Dictionary Comprehension, Applying dictionary methods to counter objects, Reverse Lookup dictionary;

Unit IV	**FILES AND PANDAS**	**8 hr**

Introduction to Files, modes, types of files, File handling functions: open(),

close(), read(), readline(), readlines(); write(), writeline(), append(); seek(), tell(), flush(); file copy using shutil (), delete a file (os.remove ()); Pandas-DataFrame creation with dictionaries, list of dictionaries, dictionary of series, renaming columns and rows labels; Importing data from CSV to DataFrame (Pandas), Inspecting data in DataFrame (head (), tail (), info()), Statistical summary (describe ()); Slicing and Sorting in Pandas; Modifying DataFrames, Data Cleaning in Pandas;		
Unit V	**TKINTER GUI, EVENT DRIVEN PROGRAMMING, WIDGETS**	**8 hr**
The Behavior of Terminal-Based Programs and GUI-Based Programs, Label, Entry and Button widget; Tkinter Geometry methods (pack(), grid(), place()); Event-Driven Programming, Command Buttons and Responding to Events; CheckButton and Radiobutton widgets; Menu and Menu button widgets; Listbox and Scrollbar widgets; Messagebox and Toplevel widget; File Dialog widget;		
LEARNING RESOURCES		
TEXTBOOKS:		
1	Kenneth A. Lambert. -Fundamentals of Python: First Programs‖, 2nd Edition, Publisher: Cengage Learning	
2	Reema Thareja.-Python Programming using Problem Solving Approach	
3	R. Nageswara Rao, -Core Python Programming	
REFERENCE BOOKS:		
1	Wesley J. Chun. -Core Python Programming - Second Edition‖, Prentice Hall	
2	John V Guttag. -Introduction to Computation and Programming Using Python‖, Prentice Hall of India	
ONLINE COURSES		
1	https://www.w3schools.com/python/	
2	https://www.tutorialspoint.com/python/index.htm	
3	https://docs.python.org/3/tutorial/	
4	https://www.pythontutorial.net/tkinter	
5	https://www.python-course.eu/python3_course.php	
6	https://www.geeksforgeeks.org/python-tkinter-tutorial/	
7	https://www.tutorialspoint.com/python/python_gui_programming.htm	
8	https://www.programiz.com/python-programming	

Bloom's level – Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL3			X		
CO4	BL4				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MSCST010 (EOEC-T4)	DATABASE MANAGEMENT SYSTEMS (Common to all branches)					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	-	**3**	**0**	**0**	**3**

Course Objective

Students will get Exposure on basics of designing relational Database without having any redundancy and also gain the knowledge on handling transaction data in concurrent way and recovering from the failures.

Course Outcomes

1	Students will be able to **choose** and appreciate the RDBMS over file system and also be able to **apply** the knowledge of ER Modeling design the database from the client requirements. (**BL3**)
2	Students Will be able to **analyze** the SQL query pattern and classify the query patterns based on the client requirements. (**BL4**)
3	Students will be able to **Examine** the database design and classify the different levels of dependencies using Normal Forms and students will be able to identify how triggers are useful in data auditing purpose.(**BL4**)
4	Students will be able to **compare and choose** different indexing mechanisms to store data in secondary storage devices as per the requirements.(**BL5**)
5	Students will be able to **justify** the importance of concurrency and recovery Management. (**BL5**)
6	Students will be able to **design** the complete database without redundant storage and able to solve the user queries. (**BL6**)

SYLLABUS

Unit I	**INTRODUCTION TO DATABASE MANAGEMENT SYSTEM, ER MODELING**	**8 hr**

Need for DBMS, Advantages of DBMS over File Systems, Database applications; Database Users, Different Data Models; 3 Levels of Abstraction in DBMS (External, Conceptual & Physical Schema) and data independence, Database Management System Structure.; Introduction to ER Model, Entity, Entity Set, Attribute – Entity Vs Attribute;

Relationship & Relationship Set – Entity Vs Relationship – Binary Relationship, Ternary Relationship; Introduction to Keys (Candidate Key, Primary Key, Super Key, Unique Key, Not Null Key) – Modeling Key Constraints; Modeling Weak Entities – Mapping concept of Weak Entities to Composite, Primary Key Concept, Referential Integrity Constraint (include cascaded operations of Delete & Update) ; Modeling Participation Constraints – Cardinality, Full participation & Partial, Modeling Class Hierarchies – Mapping concept of class Hierarchies to covering constraints, Modeling Aggregation – Ternary Vs Aggregation;

Unit II	**RELATIONAL ALGEBRA & RELATIONAL CALCULUS**	**8 hr**

Introduction to Relational Model (Translating Entity Set & Relationship set into Tables) ; Introducing Basic operations on Relations: Selection and Projection , Cartesian product, examples; Introducing Basic operations on Relations : Joins, Set Operations and examples ; Introducing Basic operations on relations: Division & Renaming and example; Syntax & Semantics of Tuple Relational Calculus (notations used to represent a query using DRC); Syntax & Semantics of Domain Relational Calculus (notations used to represent a query using DRC);

TRC, DRC Query representations using AND, OR, NOT OPERATORS; IMPLIES operator , Comparison between TRC and DRC;		
Unit III	**SQL (STRUCTURED QUERY LANGUAGE)**	**8 hr**
Basic Structure of SQL queries(Basic format of select query, DDL,DML commands) ; Integrity and Referential constraints (Includes syntax for all key constraints, Translating Constraints associated with ER into Tables); Additional Basic Operations(Arithmetic, logical, relational, pattern matching); Functions(String, Date, Numeric); Aggregate Functions, Clauses and Set Operations**;** Join Expressions; Nested Queries, Correlated Queries; Introduction to Views, Destroying/Altering/Updating of views, Handling Null values;		
Unit IV	**NORMALIZATION**	**8 hr**
FDs and Decomposition: Problems caused by redundancy, FD (definition), Armstrong 's axioms; FD identification from relations, Equivalence of two FD sets; Dependency preserving Decomposition, examples; Lossless join, verification, examples; **Normal Forms:** First normal form, partial dependency, Second normal Form; Transitive dependency, third normal form, Motivation for BCNF; BCNF, Multivalued dependency, Fourth normal form.; Triggers;		
Unit V	**INDEXING, TRANSACTION MANAGEMENT, CONCURRENCY CONTROL & RECOVERY MANAGEMENT**	**8 hr**
Types of indexes (Clustered index, un clustered index primary index, secondary index), Tree based index versus and Hash based index; ISAM, B+ Tree construction (Insertion and Deletion of nodes); Transaction concept, Transaction states, ACID properties of transaction; Transactions and Schedules, Concurrent executions of transactions (anomalies); Serializability, Testing for serializability,2PL; Strict 2PL, Deadlocks, timestamp based protocols; Recoverability, Introduction to Log based recovery, check pointing and shadow paging; ARIES algorithm;		
LEARNING RESOURCES		
TEXTBOOKS:		
1	Data base System Concepts, Silberschatz, Korth, McGraw hill, Sixth Edition. McGrawHill.	
2	Data base Management Systems, Raghurama Krishnan, Johannes Gehrke	
REFERENCE BOOKS:		
1	Fundamentals of Database Systems, Elmasri Navathe Pearson Education.	
2	An Introduction to Database systems, C.J. Date, A.Kannan, S.Swami Nadhan, Pearson, Eight Edition for UNIT III.	
ADDITIONAL REFERENCE MATERIAL		
1	https://docs.oracle.com/cd/B19306_01/server.102/b14200/toc.htm	
2	https://dev.mysql.com/doc/refman/8.0/en/select.html	

Bloom's level – Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL4		X	X		
CO3	BL4				X	
CO4	BL5					X
CO5	BL5					X
CO6	BL6	X	X	X	X	

R23MMECL003	MANUFACTURING LAB					
	Total Contact Hours	42 (P)	**L**	**T**	**P**	**C**
	Prerequisite	Nil	**0**	**0**	**3**	**2**
Course Objective						
To identify the most suitable process for a given component based on practical considerations and performance metrics derived from the experiments conducted in the manufacturing domain.						
Course Outcomes						
1	Identify various manufacturing techniques involve to produce a component					
2	Prepare a detailed process chart for an intended product					
3	Develop part programming for components using sinumerik software					
SYLLABUS						
1	Prepare a report on sand testing lab for its suitability (GFN, Shear test, Permeability)					
2	Manufacture a simple component of a given geometry in foundry					
3	Fabricate a weld joint using ARC welding					
4	Fabricate a weld joint using Resistance welding					
5	Sheet metal operation using mechanical Crank press					
6	Machine tool alignment test					
7	Manufacture a product in machine shop using multiple machine tools.					
8	Manufacture a component in plastic processing unit					
9	Develop a part programming of a component using HMC (TOOL PATH CYCLE)					
10	Develop a part programming of a component using HMC (Canned cycle)					
11	Develop a part programming of a component using VMC					
LEARNING RESOURCES						
TEXT BOOKS:						
1	Production technology by R.K Jain and S.C Gupta					
2	A Course in Workshop Technology Vol I. & II, B.S. Raghuwanshi, Dhanpath Rai & Co., 2015 & 2017.					
3	M. P groover,"Automation, Production systems and computer integrated manufacturing" PHI Learning Pvt. Ltd., New Delhi, 2016					
REFERENCE BOOKS:						
1	Elements of Workshop Technology, Vol. I. by S. K. Hajra Choudhury & Others, Media Promoters and Publishers, Mumbai. 2007, 14th edition					
2	Production technology by P N Rao					
3	Chennakesava R Alavala," CAD/CAM: Concepts and Applications" PHI learning Pvt. Ltd., New Delhi, 2016					

R23MMECL004	FLUID MECHANICS AND HYDRAULIC MACHINES LAB					
	Total Contact Hours	42(P)	**L**	**T**	**P**	**C**
	Pre-requisite	Fluid Mechanics and Hydraulic Machines, Differential Equations and Vector Calculus	**0**	**0**	**3**	**2**

Course Objective

This course aims to help students grasp the principles of fluid mechanics and fluid machines, enabling them to analyse fluid behaviour, apply relevant equations, and understand the design and operation of various fluid machines used in engineering applications.

Course Outcomes

After completing this course, the students will be able to

1	Measure and calibrate flow using Venturimeters, orifice meters, and turbine flow meters.
2	Analyse friction factors, additional loss coefficients, and head losses in pipelines and pipe fittings.
3	Conduct experiments and analyze the performance characteristics of pumps and turbines

LIST OF EXPERIMENTS

1.	Calibration of Venturimeter: To study the variation of C_d of given Venturi meter for different rates of flow.
2.	Calibration of Orifice meter: To study the variation of C_d of given orifice meter for different rates of flow.
3.	Determination of friction factor for a given pipe line. Determine the additional loss coefficient for various pipe fittings.
4.	Determination of loss of head due to sudden contraction in a pipeline. Determine the friction factor for a given pipe line system and find out the Reynolds number.
5.	Turbine flow meter. To know the importance of Turbine flow meter calibration.
6.	Impact of jets on Vanes. Study the variation of coefficient of impact of vane for flat and curved vanes with different rates of flow.
7.	Performance Test on Pelton Wheel. Study the performance of the Pelton wheel by determining Constant head characteristic curves.
8.	Performance Test on Francis Turbine. Study the performance of the Francis turbine by determining Constant head characteristic curves.
9.	Performance Test on Kaplan Turbine. Study the performance of the Kaplan turbine by determining Constant head characteristic curves.
10.	Performance Test on Single Stage Centrifugal Pump. Study the performance of the centrifugal pump by determining Constant speed characteristic curves.
11.	Performance Test on Multi Stage Centrifugal Pump. Study the performance of the multi stage centrifugal pump by determining Constant speed characteristic curves.
12.	Performance Test on Reciprocating Pump. Study the performance of the reciprocating pump by determining Constant speed characteristic curves.

LEARNING RESOURCES	
TEXTBOOKS:	
1	S. K. Som, G. Biswas, and S. Chakraborty, *Introduction to Fluid Mechanics and Fluid Machines*, Third edition. Tata McGraw-Hill Education, 2017.
2	K. Subramanya, *Fluid Mechanics and Hydraullic Machines,* Second Edition. McGraw-Hill Education (India) Pvt Ltd., 2018.
REFERENCE BOOKS:	
1	Yunus A. Cengel, John M. Cimbala, *Fluid Mechanics- Fundamentals and Applications*, Fourth edition. McGraw-Hill Education, 2019.
2	P. M. Modi, S. M. Seth, *Hydraulics and Fluid Mechanics Including Hydraulic Machines*, 22nd edition. Standard Book House, 2018.
ADDITIONAL REFERENCE MATERIAL	
1	Fluid Mechanics and Hydraulic Machines Laboratory Manual(MVGR)
2	https://nitsri.ac.in/Department/Mechanical%20Engineering/PPT_Fluid_Mechanics_(MEC_303)_NIT_Srinagar.pdf
ONLINE COURSES/VIRTUAL LABS	
1	https://fm-nitk.vlabs.ac.in/
2	https://fmc-nitk.vlabs.ac.in/List%20of%20experiments.html
3	https://archive.nptel.ac.in/courses/112/106/112106311/
4	https://me.iitp.ac.in/Virtual-Fluid-Laboratory/

<table>
<tr><td rowspan="3">R23MSCSL005
(EOEC-L2)</td><td colspan="6">PYTHON PROGRAMMING LAB
(Common to all branches)</td></tr>
<tr><td>Total Contact Hours</td><td>42 (P)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Pre-requisite</td><td>C Programming</td><td>0</td><td>0</td><td>3</td><td>2</td></tr>
<tr><td colspan="7">Course Objective</td></tr>
<tr><td colspan="7">Students will implement python programming constructs which are used to develop both desktop and graphical user applications.</td></tr>
<tr><td colspan="7">Course Outcomes</td></tr>
<tr><td>1</td><td colspan="6">Students will be able to apply the basic building blocks of python language like variables, operators and modules.</td></tr>
<tr><td>2</td><td colspan="6">Students will be able to apply conditional control statements and functions.</td></tr>
<tr><td>3</td><td colspan="6">Students will be able to apply various file operations and analyze the data using pandas library.</td></tr>
<tr><td>4</td><td colspan="6">Students will be able to choose and decide the suitable widgets to design and develop Graphical User Interface (GUI) applications.</td></tr>
<tr><td colspan="7">List of Experiments</td></tr>
<tr><td>1</td><td colspan="6">Week – 1: DATA TYPES, OPERATORS, BUILT-IN FUNCTIONS

1. Write a python script to illustrate data types (int, char, float, string).
2. Write a python program to perform the following expressions using operator precedence
(1) 5+3*2
(2) 2*3**2
(3) 2**3**2
(4) (2**3)**2
3. Write a python program to illustrate type conversion functions
4. Write a python program to illustrate pi, sqrt, cos, sin functions of mathmodule</td></tr>
<tr><td>2</td><td colspan="6">Week – 2: PROGRAMS WITHOUT CONTROL STATEMENTS

1. Write a program to calculate simple interest
2. Write a python program to calculate compound interest
3. Write a python program to print ASCII value of a character
4. Write a python program to find the area of a circle
5. Write a python program to find the area of a triangle
6. Write a program to perform string concatenation</td></tr>
<tr><td>3</td><td colspan="6">Week – 3: PROGRAMS ON NUMPY MODULE

1. Write a program to work with 1D array operations including indexing and slicing.
2. Write a program to work with 2D array operations</td></tr>
<tr><td>4</td><td colspan="6">Week – 4: PROGRAMS ON CONTROL STATEMENTS

1. Write a python program find the power of a number without built-in functions.
2. Write a python program to count the number of even and odd numbers upto the given range.
3. Write a python program to print the multiplication table for a given number.</td></tr>
</table>

	4. Write a python program to display minimum and maximum among three numbers.
5	**Week – 5: PROGRAMS ON FUNCTIONS** 1. Write a python program to find if a number is prime or not with and without recursion. 2. Write a python program to display Fibonacci series using iteration and recursion. 3. Write a python program to find the factorial of a number with and without recursion.
6	**Week – 6: PROGRAMS ON STRINGS** 1. Write a program to work with string built-in functions 2. Write a python program to determine number of times a given letter occurs in a string 3. Write a python program to check if a string is a palindrome or not. 4. Illustrate in operator and write a python program to count number of lowercase characters in a string. 5. Write a program to replace all the occurrences of letter 'a' with letter 'x' in a string.
7	**Week – 7: PROGRAMS ON LISTS** 1. Write a program to implement the following list functions a)len() b)extend() c)sort() d) append() e)insert() f)remove() 2. Write a program to pass list as an argument to a function 3. Write a python program to find the largest and smallest number in a list. 4. Write a python program to merge two lists and sort it. 5. Write a python program to remove the duplicate items from a list. 6. Write a python program to find sum of elements in a list
8	**Week – 8: PROGRAMS ON TUPLES , DICTIONARIES** 1. Write a program to create a list of tuples with the first element as the number and the second element as the square of the first element. 2. Write a python program that takes the list of tuples and sorts the list of tuples in increasing order by the last element in each tuple. 3. Write a program to implement the following dictionary methods a) keys() b) values() c)items() d) pop() e)delete() 4. Write a python program to add a key value pair to a dictionary and update the dictionary based on the key. 5. Write a Program to do a reverse dictionary lookup in python.
9	**Week – 9: PROGRAMS ON FILES** 1. Write a program to implement read(), readline(), readlines(), write(), writelines() methods on files. 2. Write a program to implement seek(), tell() and flush() methods with different arguments in a file. 3. Write a program to generate 20 random numbers in the range of 1 to100 and write to a file.
10	**Week – 10: PROGRAMS ON PANDAS MODULE**

	1. Write a program to import data from CSV to DataFrame and inspect data in DataFrame using head(), tail (), info() and describe() functions in pandas. 2. Write a program to perform sorting and slicing operations in pandas. 3. Write a program to perform dataframe modification and data cleaning in pandas.
11	**Week – 11: PROGRAMS ON GUI** 1. Design and develop a GUI application to display -Hello World. 2. Design and develop a GUI application using Label, Entry and Button widgets. 3. Design and develop a GUI application using Tkinter Geometry methods pack(),grid(), place(). 4. Design and develop a GUI application using CheckButton and Radiobutton widgets.
12	**Week – 12: PROGRAM ON GUI CONTI…** 1. Design and develop a GUI application using Menu and Menubutton widgets. 2. Design and develop a GUI application using Listbox and Scrollbar widgets. 3. Design and develop a GUI application using Messagebox and File Dialog widget
Demonstration experiments	
1	Demonstration of Python IDLE to implement solutions.
2	Demonstration on Colab notebook to read, access and display data from google drive.
3	Demonstration on jupyter notebook to link and access data.
LEARNING RESOURCES	
TEXTBOOKS:	
1	Kenneth A. Lambert. -Fundamentals of Python: First Programs‖, 2nd Edition, Publisher: Cengage Learning
2	Reema Thareja.-Python Programming using Problem Solving Approach
3	R. Nageswara Rao, -Core Python Programming
REFERENCE BOOKS:	
1	Wesley J. Chun. -Core Python Programming - Second Edition‖, Prentice Hall
2	John V Guttag. -Introduction to Computation and Programming Using Python‖, Prentice Hall of India.
3	Python Practice Book Release 2014, Anand Chitipothu.
ADDITIONAL REFERENCE MATERIAL	
1	https://www.w3schools.com/python/
2	https://www.tutorialspoint.com/python/index.htm
3	https://docs.python.org/3/tutorial/
4	https://www.pythontutorial.net/tkinter
5	https://www.python-course.eu/python3_course.php
6	https://www.geeksforgeeks.org/python-tkinter-tutorial/
7	https://www.tutorialspoint.com/python/python_gui_programming.htm
8	https://www.programiz.com/python-programming

R23MENGAT01	ETHICS AND HUMAN VALUES					
	Total Contact Hours	28 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	…..	**2**	**0**	**0**	**2**

Course Objective

The course creates awareness regarding the need for the development of a holistic perspective in understanding the nuances of personal, professional and social life. It enables the student to grasp the ethical principles that govern human existence.

Course Outcomes

After completing this course, the students will be able to

1	Identify the relevance of the concepts of Self -Exploration and Natural Acceptance in day-to-day life to achieve continuous happiness and prosperity. (**BL 3**)
2	Discuss the impact of trust and respect as foundational values in human relationships to achieve comprehensive human goals. (**BL 3)**
3	Understand the relevance of ethical theories and their applications in societal living. (**BL3**)
4	Understand the concept of ethics in engineering practice **(BL 3)**
5	Discuss the concepts of ethics in the context of understanding global issues pertaining to different fields. (**BL 3)**

SYLLABUS

Unit I	**UNDERSTANDING THE SELF**	**5 hr**

Characteristics of Universal Human Values; Self-Exploration– Meaning and Process; Basic Human Aspirations – Meaning and Basic Requirements for fulfilment; Concept of Human Existence – Conscious and Material Entities; Difference between the Conscious and the Material Entities of Human Existence.

Unit II	**UNDERSTANDING THE FAMILY AND SOCIETY**	**5 hr**

Understanding the importance of harmony in a family; Exploring value of feelings in relationships; Measures to ensure Harmony in the family. Understanding conflict (meaning, types); Dimensions of Human order for harmony in society – Physical, mental, social and spiritual; Universal values of justice, democracy.

Unit III	**ETHICAL THEORIES**	**5 hr**

Professionalism and ethics; Ethical Theories: Golden mean theory, Rights-based theory, Duty-based theory, Utilitarian theory, Kohlberg's Theory. Moral issues; Moral Dilemmas; Types of Inquiries – Normative, Conceptual, factual/descriptive.

Unit IV	**ETHICS AND ENGINEERING**	**5 hr**

Engineering ethics - Social Experimentation; Safety Responsibility and Rights: Engineers as responsible Experimenters, Engineer's Responsibility for Safety, Risk – Benefit Analysis.

Case Studies: The challenger disaster, The Three Mile Island, Fukushima Nuclear Disaster, Bhopal Gas Tragedy, The Titan submersible disaster.

Unit V	**ETHICS AND GLOBAL CONTEXTS**	**5 hr**

Ethics and Global Contexts: Environmental ethics; computer ethics; Business Ethics; Corporate Social responsibility; Code of ethics.

LEARNING RESOURCES	
TEXTBOOKS:	
1	R R Gaur, R Sangal, G P Bagaria, "*A Foundation Course in Human Values and Professional Ethics*" Excel Books, New Delhi, 2010.
REFERENCE BOOKS:	
1	A.N. Tripathi, "*Human Values*", 2nd Edition, New Age International Publishers, 2004.
2	Charles D. Fleddermann, "*Engineering Ethics*", Pearson Education / Prentice Hall, New Jersey, 2004.

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL3		X			
CO3	BL3			X		
CO4	BL3				X	
CO5	BL3					X

V Semester

<table>
<tr><td rowspan="3">R23MMECT010</td><td colspan="6">THEORY OF MACHINES</td></tr>
<tr><td>Total Contact Hours</td><td>42 (L)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Pre-requisite</td><td>Engineering Mechanics and Differential Equations</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Objective: The objective of Theory of Machines is that students will develop a strong foundation in the kinematics and dynamics of mechanisms, enabling them to analyze and design mechanical systems effectively.</td></tr>
<tr><td colspan="7">Students will get exposure to</td></tr>
<tr><td colspan="7">Course Outcomes</td></tr>
<tr><td>1</td><td colspan="6">Demonstrate proficiency in analyzing mechanisms, including the identification of links, joints, kinematic pairs, velocity & acceleration methods and emphasis on knowledge of higher pairs. (BL3)</td></tr>
<tr><td>2</td><td colspan="6">Evaluate different concepts and apply their knowledge to analyze lower and higher pair mechanisms.(BL5)</td></tr>
<tr><td>3</td><td colspan="6">Demonstrate the principles of brakes, turning moment diagrams, flywheels, governors, and balancing in engineering applications. (BL3)</td></tr>
<tr><td>4</td><td colspan="6">Critically evaluate the performance of engines based on the principles of braking, turning moment, flywheel dynamics, governor systems, and balancing techniques. (BL5)</td></tr>
<tr><td>5</td><td colspan="6">Utilize specialized knowledge to solve complex engineering problems related to mechanisms, kinematics, and dynamic systems. (BL6)</td></tr>
<tr><td colspan="7">SYLLABUS</td></tr>
<tr><td>Unit I</td><td colspan="5">MECHANISMS</td><td>8 hr</td></tr>
<tr><td colspan="7">Mechanisms: Elements or Links – Classification – Rigid Link, flexible and fluid link - Types of Joints;Types of kinematic pairs – sliding, turning, rolling, screw and spherical pairs – lower and higher pairs – closed and open pairs; Constrained motion – completely, partially or successfully constrained and incompletely constrained; Degree of freedom of plane mechanism; Inversion-Properties of inversion, Inversions of four bar chain-Beam engine, Locomotive coupled wheel mechanism; Single slider crank chain inversions- reciprocating engine mechanism; With-worth quick return;Crank and slotted lever mechanism</td></tr>
<tr><td>Unit II</td><td colspan="5">VELOCITY ANALYSIS OF PLANE MECHANISMS</td><td>8 hr</td></tr>
<tr><td colspan="7">Velocity Analysis of plane mechanisms: Kinematics: Velocity– Motion of link in machine; Application of relative velocity method for four bar chain and; Single slider crank mechanism; Instantaneous center of rotation and Three centres in line theorem, Graphical determination of instantaneous centre, determination of angular velocity of points and links of 4 bar chain; Velocity of single slider crank mechanism by I center method;Acceleration Analysis of plane mechanisms: Determination of acceleration diagrams;Analysis of slider crank chain for velocity and acceleration of slider;Acceleration diagram for a given mechanism</td></tr>
<tr><td>Unit III</td><td colspan="5">GEARS, GEAR TRAINS & BRAKES, CLUTCHES</td><td>8 hr</td></tr>
<tr><td colspan="7">Higher pairs, friction wheels and toothed gears – types; Law of gearing, condition for constant velocity ratio for transmission of motion; Gear Trains: Introduction – Train value – Types and simple gear train; Reverted and Epicyclic gear Train; Brakes: Classification of brakes and braking torque; Simple block brake and band brake; Clutches and classification, Torque transmitted by single plate clutch; Centrifugal clutch</td></tr>
</table>

Unit IV	**FLYWHEEL AND GOVERNORS**	**8 hr**
Turning Moment Diagram and Flywheels: Connecting rod angular velocity and acceleration; Crank effort and turning moment; Torque diagrams – double acting steam engine and four stroke internal combustion engine; Fluctuation of energy – Flywheels; Governors: types, terms and height of Watt governor; Porter; Proell and; Hartnell governor		
Unit V	**BALANCING**	**8 hr**
Balancing: Balancing of rotating masses Single and Multiple planes; Different masses rotating in different planes; Balancing of Reciprocating Masses; Primary and Secondary balancing of reciprocating masses; Analytical and graphical methods. Unbalanced forces and couples – primary balancing of multi cylinder in-line engine; Secondary balancing of multi cylinder in line; Primary balancing of V- engine; Secondary balancing of V -engine.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	S.S.Rattan, Theory of machines, 5th edition,McGraw Hill companies, 2019,	
2	Gordon R. Pennock, J.E.Shigley and John J. Uicker, Theory of machines and Mechanisms, 4th edition,Oxford University Press, 2014.	
REFERENCE BOOKS:		
1	Thamos Beven, Theory of machines, Pearson Education India, 3rd edition, 2009.	
2	Amitabha Ghosh and Ashok Kumar Mallik, Theory of Mechanisms and Machines, 4th edition,East West Publisher, 2008.	
ADDITIONAL REFERENCE MATERIAL		
1	https://archive.nptel.ac.in/courses/112/105/112105268/	
2	https://archive.nptel.ac.in/courses/112/104/112104114/	
3	https://www.digimat.in/nptel/courses/video/112105268/L01.html	
ONLINE COURSES		
1	https://www.udemy.com/course/theory-of-machines	
2	https://archive.nptel.ac.in/courses/112/106/112106270/	
3	https://archive.nptel.ac.in/courses/112/104/112104121/	

Bloom's level - Units catchment articulation matrix

CO	**Blooms Level**	**Unit I**	**Unit II**	**Unit III**	**Unit IV**	**Unit V**
CO1	BL3	X	X	X		
CO2	BL5	X	X	X		
CO3	BL3			X	X	X
CO4	BL5				X	X
CO5	BL6	X	X	X	X	X

R23MMECT011	Applied Thermodynamics					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Basic thermodynamics, Fluid mechanics, Differential equations	**3**	**0**	**0**	**3**

Course Objective

This course aims to equip students with foundational and applied knowledge of vapor power and gas turbine cycles, preparing them to analyze, design, and evaluate performance improvements for industrial applications.

Course Outcomes

After completing this course, the students will be able to

1	Analyze and assess the performance of steam power plant.**(BL4)**
2	Evaluate the performance of steam nozzles, including calculations of velocity, discharge, and efficiency under various conditions.**(BL5)**
3	Develop and critically analyze velocity diagrams to assess the performance of impulse turbines.**(BL6)**
4	Evaluate the reaction steam turbines performance and degree of reaction.**(BL5)**
5	Apply and assess performance improvement techniques to optimize gas turbine efficiency.**(BL3)**
6	Discuss and evaluate the performance and efficiency of steam and gas power cycles.**(BL6)**

SYLLABUS

Unit I	**VAPOR POWER CYCLES**	**8 hr**

Introduction to steam power plant, Rankine cycle layout and working; Analysis of the Rankine cycle (simple problems on the Rankine cycle); Reheating Rankine cycle; Regenerating Rankine cycle; Classification of boilers and working of water tube and fire tube boilers; Boiler Requirements, Mountings, and Accessories, Boiler performance; Boiler draught classification, height of chimney for given draught and discharge; condition for maximum discharge, efficiency.

Unit II	**STEAM NOZZLES**	**8 hr**

Steam nozzle (types, functions and applications); thermodynamic analysis: assumptions, velocity of fluid at nozzle exit-Ideal and actual expansion in a nozzle, Velocity coefficient; Discharge, Condition for maximum discharge; Problems on Discharge, Condition for maximum discharge; critical pressure and its Significance, critical velocity; problems on critical conditions; Supersaturated Flow-Theory (Wilson line), its effects, degree of supersaturation and degree of undercooling; criteria to decide nozzle shape: Relationship between area velocity and pressure

Unit III	**STEAM TURBINES**	**8 hr**

Classification of steam turbines, Impulse turbine-working principle; Construction of Velocity Diagram-Impulse turbine; problems on Velocity Diagram-Impulse turbine; Power developed, axial thrust. Blade efficiency; Condition for maximum efficiency; Compounding- features, Velcocity compounding; Pressure compounding; Velocity and Pressure compounding

Unit IV	**REACTION TURBINES AND STEAM CONDENSERS**	**8 hr**

Reaction Turbine-Principle of operation; Velocity diagrams, Blade efficiency; Condition for maximum efficiency and problems; Blade height, degree of reaction and problems; Elements of a steam condensing plant-classification; Jet condensers; Surface condensers; Vacuum efficiency, Condenser efficiency and problems

Unit V	**GAS TURBINES**	**8 hr**
Gas turbine- Introduction, Applications, Comparison of gas turbines with steam turbines and IC Engines; Working of open cycle gas turbine and thermodynamic analysis; Closed cycle and thermodynamic analysis; Deviation of actual cycle and problems; Methods to improve performance -Intercooling; Reheating ; Regeneration; Problems on performance improving methods		
LEARNING RESOURCES		
TEXTBOOKS:		
1	Rathore, Mahesh M. *Thermal engineering*. Tata McGraw-Hill Education, 2018.	
2	Rajput, R. K. *Thermal engineering*. Laxmi Publications, 2018.	
REFERENCE BOOKS:		
1	Vasandani, V.P., and Kumar, D.S., *Treatise on Heat Engineering*. Metropolitan book Co. (P) Ltd., 2008.	
2	Moran, M. J. and Shapiro, H. N., *Fundamentals of Engineering Thermodynamics*. John Wiley and Sons, 2010.	
3	Sadusingh, Sukumar pati, *Thermal engineering,*Pearson India Education Services Pvt. Ltd*,* 2018	
ONLINE COURSES		
1	https://nptel.ac.in/courses/112103277	
2	https://archive.nptel.ac.in/content/storage2/courses/112104117/ui/TOC.htm	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT V
CO1	BL4	**X**				
CO2	BL5		**X**			
CO3	BL6			**X**		
CO4	BL5				**X**	
CO5	BL3					**X**
CO6	BL6	**X**	**X**	**X**	**X**	**X**

R23MMECT012	COMPUTER-AIDED DESIGN AND ANALYSIS					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Computer Aided Engineering Graphics (CAEG)	**3**	**0**	**0**	**3**

Course Objective:

This course covers geometric modeling, transformations, and the Finite Element Method (FEM). Students will learn solid modeling, parametric curves, and surfaces, along with FEM for solving engineering problems, preparing them to apply CAD and FEM techniques in practical applications.

Course Outcomes:

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

1	Generate 2D & 3D geometric models by applying principles of transformations **(BL 5)**
2	Create and manipulate analytic and synthetic curves using effective representation for design applications **(BL 6)**
3	Create analytic and synthetic surfaces using an effective representation for design applications **(BL 6)**
4	Assess various Representations schemes for effective solid modeling and appraise the need of neutral file formats for CAD/CAM data exchange. (**BL 5)**
5	Develop finite element models to solve 1-Dimensional problems by applying the principles of FEM **(BL 5)**

SYLLABUS

Unit I	**GEOMETRIC MODELS & TRANSFORMATIONS**	**8 hr**

CAD process & Product life cycle; Geometric Modeling Techniques; 2D Transformations: Translation & Scaling; Reflection & Rotation; 3D Transformations: Translation/Scaling; Reflection & Rotation; Homogeneous representation; Concatenated Transformations.

Unit II	**MATHEMATICAL REPRESENTATION OF CURVES**	**8 hr**

Introduction & Curve entities; Types of Mathematical representation of curves; Parametric representation of Analytic Curves: Lines, Cirle; Conic sections (Ellipse/ Parabola/ Hyperbola); Parametric representation of Synthetic curves: Hermite cubic Spline; Bezier Curve; B-Spline; Manipulations of curves.

Unit III	**MATHEMATICAL REPRESENTATION OF SURFACES**	**8 hr**

Surface modeling & Surface entities; Parametric representation of Analytical surfaces: plane surface & Rule Surface; surface of revolution; Tabulated Cylinder; Parametric representation of Synthetic surfaces: Hermite Bi-cubic surface; Bezier surface; B- Spline surface; COONs surface.

Unit IV	**MATHEMATICAL REPRESENTATION OF SOLIDS**	**8 hr**

Solid Modeling & Solid Entities; Set theory & Euler theory; Boundary Representation (B-Rep); Constructive Solid Geometry (CSG); Solid manipulations; Solid Modeling based applications; CAD/CAM Data Exchange; Neutral file formats

Unit V	**FINITE ELEMENT METHOD**	**8 hr**

Introduction to Finite Element Method for solving field problems; Stress and Equilibrium & strain Displacement relations; Stress–strain relations in three dimensional elasticity; Plane stress and Plane strain; One Dimensional problem: Finite element modeling coordinates and shape functions; Potential Energy

approach: Assembly of Global stiffness matrix and load vector, Finite element equations; Treatment of boundary conditions; Quadratic shape functions	
*****	
LEARNING RESOURCES	
TEXT BOOKS:	
1	Ibrahim Zeid & R Sivasubramanian, CAD/CAM : Theory and Practice - 2nd Edition, McGraw Hill Education,ISBN-10: 0070151342, 2009.
2	Chandraputla, Ashok and Belegundu, Introduction to Finite Elements in Engineering, Prentice –Hall 2011.
3	M.Groover & E. Zimmers, CAD/CAM: Computer-Aided Design and Manufacturing - 1st Edition, Pearson Education, ISBN (13): 978-8174906700, 2003.
REFERENCE BOOKS:	
1	P N Rao, CAD/CAM: Principles and Applications - 3rd Edition, Tata McGraw Hill Education pvt ltd., ISBN (13): 978-0-07-068193-4, 2010.
2	J. E. Akin, Finite Elements for Analysis and Design, Academic Press,ISBN: 0-12-047653-3, 1994.
3	David F Rogers & James Alan Adams, Mathematical Elements for Computer Graphics – 2nd Edition, McGraw Hill international, ISBN (13): 978-0070535305, 1990.
ONLINE RESOURCES	
1	https://www.khanacademy.org/ (Linear Algebra: Transformations)
2	https://www.geeksforgeeks.org/ (Bezier and B-Spline Curves)
3	https://paulbourke.net/ (Bezier and B-Spline Surfaces)
4	https://www.pre-scient.com/knowledge-center/geometric-modelling/
5	https://onlinecourses.nptel.ac.in/noc22_me43/preview

Bloom's level - Units Catchment Articulation Matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL5	×				
CO2	BL6		×			
CO3	BL6			×		
CO4	BL5				×	
CO5	BL5					×

R23MMECT013	LEADERSHIP AND TEAM MANAGEMENT					
	Total Contact Hours	40 (L) + 2 (Introduction) + 6 (Case Discussion)	**L**	**T**	**P**	**C**
	Pre-requisite	Nil	**3**	**0**	**0**	**3**

Course Objective:

This course is aimed at helping students:

- To understand ***what leadership is*** and the ***various perspectives*** put forward by the scientific community
- To understand the ***intrinsic challenges*** faced by the individual in his/her development of leadership abilities
- To understand the ***extrinsic challenges*** faced by the individual in discharging his/her role as a leader

Course Outcomes:

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

1	Assess the current world leadership scenario and critique different approaches taken **(BL5)**
2	Evaluate leadership styles and determine applicability to various societal contexts **(BL5)**
3	Evaluate ability for self-awareness and perception, mental and emotional ability, courage and morality and followership **(BL5)**
4	Evaluate ability to motivate and empower others, communicate better, lead teams, handle diversity, influence others and provide direction **(BL5)**
5	Evaluate organisational ecosystem and develop a leadership style to meet current challenges **(BL6)**

SYLLABUS

Unit I	**INTRODUCTION**	**8 hr**

Need for leadership, Goal of an Organisation- Forces of Change- New Realities and Learning Organisations- Prime Task of Leadership- Management and Leadership- Great Man Theory and Leadership Evolution- Leader Fatal Flaws- Systemic Leadership

Unit II	**PERSPECTIVES ON LEADERSHIP**	**8 hr**

Trait Theory-Behaviour Approaches: Autocratic v/s Democratic, Ohio State Studies - University of Michigan Studies, Leadership Grid- Individualised Leadership-Contingency Approach: Hersey Blanchard Theory-Fiedler's Contingency Model-Path-Goal Theory- Vroom-Jago Model

Unit III	**PERSONAL SIDE OF LEADERSHIP**	**8 hr**

Personality and Leadership (Values/Attitudes, Social Perception, Cognitive Difference)-Mental Models, Developing Leader's Mind- Emotional Intelligence- Leading with Love Versus Leading With Fear- Moral Leadership- Leading with Courage-Art of Followership- Strategies for Managing Up

Unit IV	**LEADERSHIP AND RELATIONSHIP**	**8 hr**

Leadership and Motivation, Theories of Motivation- Empowering People to Meet Higher Needs-Leadership and Communication, Channels of Communication- Leading Teams- Handling Diversity- Inclusive Leadership-Influential Leadership- Hard and Soft Power, Increasing Power

Unit V	**LEADER AS A SOCIAL ARCHITECT**	**8 hr**

Vision and Strategic Leadership-Themes of Vision, Mission-Strategic Direction- Organisational Culture- Competing Values Approach-Value-Based Leadership-

Leading Change: Appreciative Inquiry- Implementing Change	
LEARNING RESOURCES	
TEXT BOOKS:	
1	Richard L. Daft, "*The Leadership Experience*", 6TH Edition, Cengage Learning, 2015.
2	Annabel Beerel, "*Leadership and Change Management*", Sage Publication, 2009.
REFERENCE BOOKS:	
1	Gary Yukl, "*Leadership in Organizations*", Eighth edition, Pearson, 2017.
ONLINE COURSES	
1	https://hbsp.harvard.edu
2	https://www.coursera.org/learn/leading-diverse-teams-and-organizations
3	https://www.coursera.org/learn/leadershipskills
4	https://www.coursera.org/specializations/inspired-leadership

Bloom's level - Units Catchment Articulation Matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL5	x				
CO2	BL5	x	x			
CO3	BL5			x		
CO4	BL5				x	
CO5	BL6			x	x	x

R23MMECT018 DSC-E1	BUSINESS ANALYSIS					
	Total Contact Hours	40 (L) + 2 (Introduction) + 6 (Case Discussion)	**L**	**T**	**P**	**C**
	Pre-requisite	Nil	**3**	**0**	**0**	**3**

Course Objective:

This course is aimed at helping students:

- To understand the need for business analysis and the challenges faced
- To understand the key concepts in Business Analysis and their applications
- To understand the major techniques that are adopted in the field of Business Analysis

Course Outcomes:

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

1	Assess the scenario of a business establishment and evaluate the competencies required to handle it **(BL5)**
2	Plan the requirements for a business in terms of approach, stakeholder engagement and governance **(BL5)**
3	Evaluate the strategy, requirements and performance of a business scenario **(BL5)**
4	Evaluate a business scenario and define the scope of the project **(BL5)**
5	Develop a detailed business analysis plan adopting the techniques involved **(BL6)**

SYLLABUS

Unit I	**INTRODUCTION**	**8 hr**

Business Analysis and Scope; Key Concepts and Competencies; Role of Techniques and Perspectives; The Agile Perspective; The Business Intelligence Perspective; The Information Technology Perspective; The Business Architecture Perspective; The Business Process Management Perspective

Unit II	**BUSINESS ANALYSIS: PLANNING, COLLABORATION AND LIFE CYCLE MANAGEMENT**	**8 hr**

Planning Business Analysis Approach; Planning Stakeholder Engagement; Planning Business Analysis Governance;4. Information Management and Performance Improvement; Elicitation in Business Analysis; Collaboration in Business Analysis; Tracing and Prioritising Requirements;8. Assess and Approve Requirement Changes

Unit III	**STRATEGY AND REQUIREMENTS ANALYSIS, DESIGN DEFINITION AND SOLUTION EVALUATION**	**8 hr**

Analyse Current State; Define Future State; Assess Risks; Define Change Strategy; Specify, Verify and Validate Requirements; Design Definition; Measure Solution Performance; Assess and Recommends Actions to Increase Solution Value.

Unit IV	**BUSINESS ANALYSIS COMPETENCIES AND TECHNIQUES - I**	**8 hr**

Analytical Thinking and Problem Solving; Behavioural Characteristics; Business Knowledge; Communication Skills, Interaction Skills, Tools and Technology; Technique Set: Understand 1 (Brainstorming, Collaborative Games, Concept Modelling, Data Flow Diagrams);Technique Set: Understand 2 (Data Modelling, Focus Groups, Interviews, Observation);Technique Set: Understand 3 (Prioritisation, Process Modelling, Scope Modelling, Sequence Diagrams); Technique Set:

Understand 4 (State Modelling, Survey or Questionnaire, SWOT Analysis, Use Cases and Scenarios)		
Unit V	**BUSINESS ANALYSIS COMPETENCIES AND TECHNIQUES - II**	**8 hr**
Technique Set: Define 1 (Acceptance and Evaluation Criteria, Business Capability Analysis, Business Cases, Business Model Canvas);Technique Set: Define 2 (Business Rules Analysis, Decision Analysis, Glossary, Mind mapping);Technique Set: Define 3 (Non-functional Requirements Analysis, Organisational Modelling, Roles and Permissions Matrix, User Stories);Technique Set: Manage (Backlog Management, Balanced Scorecard, Functional Decomposition, Item Tracking, Workshops); Technique Set: Analyse 1 (Benchmarking and Market Analysis, Data Mining, Decision Modelling, Document Analysis); Technique Set: Analyse 2 (Estimation, Financial Analysis, Interface Analysis, Process Analysis); Technique Set: Analyse 3 (Risk Analysis and Management, Root Cause Analysis, Stakeholder List, Map or Personas, Vendor Assessment);Technique Set: Validate (Data Dictionary, Lessons Learned, Metrics and Key Performance Indicators (KPIs), Prototyping, Reviews)		
LEARNING RESOURCES		
TEXT BOOKS:		
1	"BABOK: A Guide to the Business Analysis Body of Knowledge", Version 3, International Institute of Business Analysis, 2015	
REFERENCE BOOKS:		
1	"Business Analysis" by Debra Paul, James Cadle, and Donald Yeates	
2	"Business Analysis Techniques: 99 Essential Tools for Success" by James Cadle, Debra Paul, and Paul Turner	
3	Business Analysis: Solving Business Problems by Visualizing Effective Processes and IT Solutions" by Pradeep Hari Pendse	
4	"Business Analysis: Concepts and Practice" by Dr. N. Sasikala Devi	

Bloom's level - Units Catchment Articulation Matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL5	×				
CO2	BL5		×			
CO3	BL5			×		
CO4	BL5				×	
CO5	BL6		×	×	×	×

R23MMECT023 DSC-E1	ROBOTICS					
	Total Contact Hours	42(L)	**L**	**T**	**P**	**C**
	Prerequisite	Matrices ,Differential Equations.	**3**	**0**	**0**	**3**

Course Objective

To provide a comprehensive understanding of automation principles and robotics evolution. Thus delve into the intricacies of end effectors, motion analysis, manipulator kinematics, and path description and generation, addressing real-world challenges through problem-solving exercises. The course will also explore programming languages for robotics with the knowledge to select appropriate actuators, transmission systems, and sensors for designing efficient robot systems.

Course Outcomes

After completing this course, the students will be able to

1	Apply foundational principles of automation and robotics in real-world scenarios, demonstrating a practical understanding of key concepts. (**BL3**)
2	Analyze and break down different levels of automation, dissect robot anatomy, and critically evaluate the components, summarizing specifications of matrices and homogeneous transformations for precise motion analysis.(**BL4**)
3	Analyze and solve complex problems involving 2D and 3D transformations, scaling, rotation, translation, applying Denavit-Hartenberg (D-H) notation, and algorithmic approaches for manipulator kinematics. (**BL4**)
4	Break down and analyze end effector requirements, conduct gripper force analysis, and critically evaluate trajectory planning methods, ensuring a comprehensive understanding of path description and generation. (**BL4**)
5	Synthesize knowledge acquired to design efficient robot systems, creating and implementing robot programs using programming languages, showcasing a high level of creativity and integration of concepts (**BL5**)
6	Evaluate the entire spectrum of automation and robotics, including the advantages and disadvantages of sensors, the selection of appropriate levels of automation, and making informed decisions on system design and components, showcasing a high level of critical thinking and judgment in the field. (**BL5**)

SYLLABUS

Unit I	**INTRODUCTION TO ROBOTICS**	**8 hr**

An overview of Robotics-History, Evolution of robots; Laws of robots, what is robot and what is not a robot; Progressive advancements in robots; Robot anatomy, links, joints, degree of feedom; Work volume; Classification based on control system; Classification based on coordinate system; Future prospects.

Unit II	**END EFFECTORS AND MOTION ANALYSIS**	**8 hr**

Types of End effector; mechanical grippers; Other type of grippers; Requirements and challenges of end effectors and Gripper design considerations; Mapping, mapping between rotated frames; Mapping between translated frames, mapping between translated and rotated frames ,Transformation of vectors, rotation,

translation of vectors; Principal axes rotation, fixed angel rotation; Euler angel representation, equivalent angel representation		
Unit III	**KINEMATICS**	**8 hr**
Mechanical structure and notations, description of links and joints; Kinematic modelling of the manipulator; Denavit-Hartenberg notation; Kinematic relationship between adjacent links; Manipulator transformation matrix; solvability of inverse kinematic model; Solution techniques ;Closed form solution.		
Unit IV	**PATH PROGRAMMING**	**8 hr**
Definition of trajectory planning, terminology, steps in trajectory planning; Jst; Cst; methods of robot programming, lead through programming methods; Wait, signal delay commands, branching, capabilities of lead through methods; Generation of robot programming languages; structure, constants, variables, motion commands; End effector ,sensor commands, computations , operations.		
Unit V	**SENSORS AND ACTUATORS**	**8 hr**
Sensors in robotics, classification of sensors; Encoders; Proximity and range sensors; Tactile, force & torque sensor, hydraulic actuator ;Pneumatic actuators ;Electric actuators		
LEARNING RESOURCES		
TEXTBOOKS:		
1	Mikell P. Groover, Mitchell Weiss, Roger N Nagel, Nicholas G Odrey, *"Industrial Robotics Technology, Programming and Applications",* Tata – McGraw Hill Pub. Co.,2nd Edition,2017.	
2	R. K. Mittal, I. J. Nagrath*, Robotics and Control*, TATA McGraw Hill Publishing Co Ltd, New Delhi.,1 July 2017.	
REFERENCE BOOKS:		
1	S. K. Saha, *Introduction to Robotics* 2e, TATA McGraw Hills Education.,1 July 2017.	
2	Fu. K. S, Gonzalez. R. C & Lee. C. S. G, *"Robotics control, sensing, vision and intelligence"*, Tata- McGraw Hill Pub. Co., 2017.	
3	Deb. S. R and Sankha Deb, *"Robotics Technology and Flexible Automation",* Tata McGraw Hill Publishing Company Limited., 2017.	
ADDITIONAL REFERENCE MATERIAL		
1	Robert J Schilling, *Fundamentals of Robotics*, Prentice Hall India, 2001	
2	John J Craig, *Introduction to Robotics*, Prentice Hall International, 2005	
ONLINE COURSES		
1	https://onlinecourses.nptel.ac.in/noc20_de11/preview	
2	https://ocw.mit.edu/courses/2-12-introduction-to-robotics-fall-2005/	
3	https://www.coursera.org/learn/robotics-motion-planning?specialization=robotics	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL 3	X	X	X		
CO2	BL 4		X	X	X	
CO3	BL 4	X	X	X	X	
CO4	BL 4	X	X	X	X	
CO5	BL 5	X	X	X	X	X
CO6	BL 5			X	X	X

R23MMECT025 DSC-E1	RENEWABLE ENERGY CONVERSION TECHNOLOGIES					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Thermodynamics, Fluid Mechanics, Heat Transfer	**3**	**0**	**0**	**3**

COURSE OBJECTIVE

Student has to get the exposure to analyze different renewable energy sources, conversion methods and economic aspects of renewable energy sources.

COURSE OUTCOMES

Students are able to

1	Discuss the prospects of renewable sources of energy and the methods of solar energy production and the various components used in the energy production. **(BL6)**
2	Analyze the conversion principles of wind and biomass energy. **(BL4)**
3	Categorize and compare the different types of energies from Oceans. **(BL4)**
4	Design the fuel cells, hydrogen energy systems and estimate the work output and EMF of fuel cells. **(BL6)**
5	Analyze the principles of direct energy conversion systems. **(BL4).**

SYLLABUS

UNIT I	**SOLAR ENERGY**	**8 hr**

Fundamentals of Solar Radiation; Solar radiation collection 1 (Flat plate collectors); Solar radiation collection 2 (Concentric collectors); Solar energy storage systems; Solar energy applications 1; Solar energy applications 2; Solar roof top design1; Solar roof top design 2.

UNIT II	**WIND AND BIOMASS ENERGY**	**8 hr**

Principle of wind energy conservation and its availability in INDIA; Components of Wind Energy Conversion Systems (WECS); Different types of wind turbines and their working principles; Wind data and site selection considerations; Biomass Energy introduction and resources of bio energy; Biofuels and biomass conversion processes; Biomass conversion technologies-fixed dome; Biogas digester design for community.

UNIT III	**ENERGY FROM OCEANS AND EARTH**	**8 hr**

Introduction to Ocean Thermal Energy Conversion (OTEC) Systems and methods of ocean thermal electric power generation; Open and closed cycle OTEC plants; Principles of tidal power, methods of utilization of tidal energy; Single and double basin tidal power plants; Wave energy conversion systems; Geothermal energy and geothermal sources; Geothermal Systems (dry steam, wet steam, hot water systems; Site selection for OTEC, Tidal plants, Wave energy and Geothermal Plants.

UNIT IV	**FUEL CELLS AND ENERGY FROM HYDROGEN**	**8 hr**

Fuel cells, classification of fuel cells, design and operation of fuel cells; Ion exchange membrane fuel cell, molten carbonate fuel cell, Aluminium - Oxygen cell; Work output and EMF of fuel cells; Hydrogen energy, introduction, hydrogen production by electrolysis, thermo-chemical methods; Hydrogen production by fossil fuel methods and solar energy methods; Storage of hydrogen; Hydrogen transportation and utilization of hydrogen gas; Safety and management, Hydrogen Technology development in INDIA.

UNIT V	**DIRECT ENERGY CONVERSION SYSTEMS**	**8 hr**

Magneto Hydrodynamic (MHD) Power Generation, open and closed cycles; Materials for MHD generators and Design Problems of MHD generators; Thermo-electric Power generation principles and generators; Applications of MHD Power generation; Hybrid systems of solar and MHD generators; Thermo-electric refrigerators; Thermionic power generation; Thermionic emission and analysis of thermionic generators.	
LEARNING RESOURCES	
TEXT BOOKS:	
1	Bhatia S.C. and Gupta .R. K., *Textbook of Renewable Energy*, 1st Edition, WPI publications, 2019.
2	Mehmet Kanoglu, Yunus A. Cengel John M. Cimbala, *Fundamentals and Applications of Renewable Energy*, 1st Edition, McGraw-Hill publications, 2020.
3	Rai. G. D, *Nonconventional Energy Sources*, 4th Edition, Khanna Publication, 2004.
REFERENCE BOOKS:	
1	Sukhatme . P. S, *Solar Energy: Principles of Thermal Collection and Storage,* 3rd Edition, McGraw-Hill Education (India), 2009.
2	Vaughn C. Nelson, Kenneth L. Starcher, *Introduction to Renewable Energy*, 2nd Edition, CRC Press, 2016.
3	Shobh Nath Singh, *Non-Convention Energy Resources*, 1st Edition, Pearson Education India, 2015
4	Nilamoni Saikia, *Renewable Energy and Energy Harvesting, 1st Edition,* Mahaveer Publications, 2022.
ONLINE COURSES	
1	https://www.pdfdrive.com/non-conventional-energy-sources-e10086374.html
2	https://www.pdfdrive.com/non-conventional-energy-systems-npteld17376903.html
3	https://www.pdfdrive.com/renewable-energy-sources-and-their-applications- e33423592.html

Bloom's level and-Units catchment articulation matrix

CO	Blooms Level	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT V
CO1	BL6	X				
CO2	BL4		X			
CO3	BL4			X		
CO4	BL6				X	
CO5	BL4					X

R23MCSCT005 (EOEC-T5)	SOFTWARE ENGINEERING (Common to all Branches)					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Prerequisite	None	**3**	**0**	**0**	**3**

Course Objective

This course introduces students to fundamental Software Engineering principles, including software processes, requirements engineering, design, testing, quality assurance, and risk management.

Course Outcomes

After completing this course, the students will be able to

1	Students will have the ability to apply the core concepts of software engineering, including the nature of software, layered technology, and common software myths, to analyze real-world software development scenarios. (**BL3**)
2	Students will have the ability to analyze various software process models to determine their suitability for different types of projects.(**BL4**)
3	Students will have the ability to apply requirements engineering techniques to elicit, document, and validate software requirements and utilize software design models. (**BL3**)
4	Students will evaluate various software testing strategies, assess the effectiveness of black box and white box testing methods, and recommend improvements in testing strategies based on product metrics and testing outcomes to optimize software quality.(**BL5**)
5	Students will have the ability to analyze software project risks and develop strategies for risk mitigation and management. (**BL6**)
6	Students will write the entire software engineering process, assess the effectiveness of each phase from requirements gathering to deployment, and recommend improvements for optimizing the overall workflow and activities involved in software engineering.(**BL6**)

SYLLABUS

Unit I	**INTRODUCTION TO SOFTWARE ENGINEERING**	**8 hr**

The Nature Of Software; Software Engineering - A Layered Technology; Software Engineering Practice; Software Myths; A Generic Process Model, Software Process Framework; Process flow, Identifying Task set, Process pattern; Process Assessment and Improvement (SCAMPI, CMM-IPI,SPICE, ISO 9001:2000); The Capability Maturity Model Integration (CMMI);

Unit II	**PROCESS MODELS & SOFTWARE REQUIREMENTS**	**8 hr**

The Waterfall Model, Incremental Process Models; Evolutionary Process Models: The Prototype Model, Spiral Model; Unified Process, Personal And Team Process Models; Agile Process Model; Feasibility Studies, User Requirements and System Requirements; Functional and Non - Functional Requirements; The software requirements document; Requirements engineering processes;

Unit III	**REQUIREMENTS ENGINEERING & DESIGN ENGINEERING**	**8 hr**

Establishing The Groundwork, Requirements Elicitation; Requirement Analysis - DFD, Data Dictionaries; Developing Use Cases, Use Case Diagrams; Requirements Negotiation and Validation; Requirements Management; Preparation of SRS; Design Concepts - Abstraction, Architecture, Patterns, Separation of concerns and Modularity ;The Design Model - Data Design Elements, Architectural Elements-Interface, Component and Deployment design elements;

Unit IV	**TESTING STRATEGIES & METRICS**	**8 hr**

A Strategic Approach to Software Testing, Test Strategies for Conventional Software -

Unit and Integration Testing; Testing Strategies - Validation Testing, System Testing; Black Box Testing - Graph-Based Testing Methods; White box testing - Basis path testing;A Framework for Product Metrics - Measures, Metrics, and Indicators; Metrics for the Requirements Model - Function-Based Metrics; Metrics for the Design Model- Architectural Design Metrics and Metrics for Source Code; Metrics for Testing		
Unit V	**QUALITY MANAGEMENT & RISK MANAGEMENT**	**8 hrs**
Quality Management - Software Quality (McCall's software quality factors) ; Review Techniques - Informal and Formal Review Techniques; Software Quality Assurance - Elements of SQA, SQA Tasks, Goals and Metrics; Statistical SQA, ISO 9000 Quality Standards; Reactive vs. Proactive Risk Strategies; Software Risks; Risk Identification; Risk Projection, Risk Refinement; RMMM Plan;		
LEARNING RESOURCES		
TEXTBOOKS:		
1	Software Engineering, A practitioner's Approach- Roger S. Pressman, 6th Edition, McGrawHill International Edition.	
2	Software Engineering- Sommerville, 7th edition, Pearson education.	
REFERENCE BOOKS:		
1	Software Engineering- K.K. Agarwal & Yogesh Singh, New Age International Publishers	
2		
ADDITIONAL REFERENCE MATERIAL		
1	https://ocw.mit.edu/courses/16-355j-software-engineering-concepts-fall-2005/pages/lecture-notes/	
2		
ONLINE COURSES		
1	https://nptel.ac.in/courses/106101061	
2		

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X	X			
CO2	BL4		X			
CO3	BL3			X		
CO4	BL5				X	
CO5	BL6					X
CO6	BL6	X	X	X	X	X

R23MMECL005	**Computer Aided Engineering (CAE) Lab**					
	Total Contact Hours	42(L)	L	T	P	C
	Prerequisite	Differential Equations and Vector Calculus, Engineering Physics, Design of Machine Elements, Fluid Mechanics & Hydraulic Machines	0	0	3	2
Course Objective: The objective of the Computer-Aided Engineering Lab is to equip students with the skills to model, simulate, and analyze engineering systems using industry-standard software.						
Course Outcomes After completing this lab course, the students will be able to						
1	Import and use geometries in ANSYS and generate basic meshes for simulations.					
2	Evaluate the behavior of mechanical components under various loading conditions using simulation tools.					
3	Analyse thermal and fluid flow problems by using computational software					
4	Demonstrate the ability to identify and address common simulation issues in ANSYS, and implement basic scenarios.					
5	Validate numerical solutions by comparing them with existing data in the literature.					
List of Experiments:						
Module 1: Introduction to CAE Tools & Simulation Work Flow						
1	Introduction to CAE tools					
2	Basics of Ansys FEA simulation software					
3	2D and 3D geometry creation, meshing, and model validation					
Module 2: Structural Analysis (FEA Applications)						
4	Static analysis of trusses					
5	Static analysis of beams					
6	Analysis of joints					
7	Modal analysis of beams					
8	Thermal analysis on components					
Module 3: Computational Fluid Dynamics (CFD Applications)						
9	Introduction to ANSYS Fluent for Fluid Flow Simulation					
10	Lid driven cavity flow					
11	Laminar pipe flow					
12	Steady flow past a cylinder					
LEARNING RESOURCES						
TEXT BOOKS:						
1	Daryl L Logan, "*A first course in the Finite element method*" by, Thomason,, Third Edition					
2	Hutton, "*Fundamentals of FEM"* ,- McGraw Hill, 2004					
3	H.K. Versteeg and W. Malalasekera, "Introduction to Computational Fluid Dynamics," Pearson, 2007					
REFERENCE BOOKS:						
1	George R. Buchanan, " *Finite Element Analysis",* Schaum Series					
2	J. Blazek, *"Computational Fluid Dynamics: Principles and Applications,"* Elsevier, 2015.					
3	ANSYS Inc*., "ANSYS Fluent 19.1: User's Guide,"* ANSYS Inc., 2019.					

ADDITIONAL REFERENCE MATERIAL	
1	https://confluence.cornell.edu/display/simulation/ansys+learning+modules
2	https://confluence.cornell.edu/display/SIMULATION/FLUENT+Learning+Modules
3	https://www.youtube.com/watch?v=78wU4h1dtVU&list=PLtj-yB-zGzytXzza6UPrcpsRjpreX_WIV
4	https://www.ansys.com/en-in/academic/learning-resources

R23MCSCL003 (EOEC-L3)	DATABASE MANAGEMENT SYSTEMS LAB (Common to all branches)					
	Total Contact Hours	42 (P)	**L**	**T**	**P**	**C**
	Pre-requisite	-	**0**	**0**	**3**	**2**

Course Objective

Students will gain exposure on ER model, R- Model to design the database, Data Retrieval using SQL and Procedural SQL. Students will be able to explore view level ofdata abstraction levels.

Course Outcomes

After completing this course, the students will be able to

1	Students will be able to design the database for the given client requirements using ER- Model and also be able to convert the ER design to R model by covering all sorts of constraints
2	Students will be able to retrieve the data for any given user constraints using SQL features group by, nested Queries and joins
3	Students will be able to design the different views and also able to identify the execution differences between a query and query as a view.
4	Students will be able to identify the importance of data and auditing.
List of Experiments	
1,2	Designing of ER model for the given constraints
3	Conversion of entities to relational tables with constraints using DDL statements (CREATE, ALTER, DROP)
4	Conversion of relations to relational tables with referential integrity constraint (using ON DELETE CASCADE and ON UPDATE CASCADE) and DML operations (INSERT, DELETE, UPDATE)
5	Querying the data using SELECT, WHERE, AND, BETWEEN, LIKE
6	Applying string, number and date functions while querying the data
7	Querying the data using set operations(UNION, UNION ALL, INRESECT, MINUS/EXCEPT) and GROUPBY, HAVING clauses
8	Querying the data using Nested Queries (Correlated Queries- EXISTS, NOT EXISTS, independent queries- IN, NOT IN, ANY, ALL, =, > and <).
9	Querying the data using JOINS and Handling NULL values using JOINS
10	Designing views for different user perspectives (updatable views and non-updatable views),
11	Designing of procedures and functions in PL/SQL
12	Design of Triggers
Additional experiments	
1	Sequence generation and its usage as primary key
2	Verifying DCL-grant, revoke
3	Verifying TCL commands- commit, roll back and save point.
Demonstration experiments	
1	Case study - Library Management system
2	Case study- E-commerce store management
3	Case Study**-** Hospital management

LEARNING RESOURCES	
TEXTBOOKS:	
1	Data base System Concepts, Silberschatz, Korth, McGraw hill, Sixth Edition. McGrawHill.
2	Data base Management Systems, Raghurama Krishnan, Johannes Gehrke
3	Learning SQL, Alan Beaulieu, O'Reilly Media, Inc., 3rd Edition,
ADDITIONAL REFERENCE MATERIAL	
1	https://docs.oracle.com/cd/B19306_01/server.102/b14200/toc.htm
2	https://dev.mysql.com/doc/refman/8.0/en/select.html

R23MCIVAT02	ENVIRONMENTAL STUDIES					
	Total Contact Hours	28 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	NIL	**2**	**0**	**0**	**0**

Course Objective

This course aims to impart a deep understanding of environmental processes, climate change, biodiversity, ecosystem functionality, and lifestyle impacts. Equipped with this knowledge, students will advocate for climate mitigation and combat climate change effectively.

Course Outcomes: After completing this course, the students will be able to

1	Develop comprehensive environmental management and conservation plans (**BL6**)
2	Create programs for energy, water conservation, and waste reduction. (**BL6**)
3	Formulate proposals for combating climate change (**BL6**)
4	Develop models to study climate dynamics and impacts (**BL6**)
5	Develop strategies to mitigate climate change impacts (**BL6**)

SYLLABUS

Unit I	**INTRODUCTION TO ENVIRONMENTAL STUDIES**	**5 hr**

Biodiversity and ecosystem functionality; Natural resources; Environmental pollution; Environmental episodes; Environmental legislation.

Unit II	**LIFE STYLE FOR ENVIRONMENT**	**5 hr**

Sustainability Challenges; Save Energy; Save Water; Reduce waste; Healthy Lifestyles.

Unit III	**INTRODUCTION TO CLIMATE CHANGE**	**5 hr**

Carbon cycle; Earth's Climate System; Weather and Climate; Understanding Microclimate; Policy initiatives to Combat Climate Change.

Unit IV	**SCIENCE BEHIND THE CLIMATE CHANGE – 1**	**5 hr**

Greenhouse gas effect; Paleoclimate; Energy Balance; Water Cycle; Atmospheric motion.

Unit V	**SCIENCE BEHIND THE CLIMATE CHANGE – 2**	**5 hr**

Ocean changes; Cryosphere dynamics; Volcanoes; Biosphere and climate regulation; Mitigation strategies.

LEARNING RESOURCES

TEXTBOOKS:

1	E. Bharucha, *Textbook of Environmental Studies for Undergraduate Courses*, 2nd ed. Hyderabad, India: Universities Press, 2012.
2	J.K. Arora, B.K. Tyagi, K.S. Bath, R. Bal, and S.S. Ladhar, *Activity Book on Climate Change*. Punjab State Council for Science & Technology, 2022.

REFERENCE BOOKS:

1	R. T. Wright and D. F. Boorse, *Environmental Science: Toward a Sustainable Future*, 13th ed. Boston, MA: Pearson, 2017.
2	United Nations Development Programme, *Climate Box. An interactive learning toolkit on climate change*. New York, NY, 2018.

ADDITIONAL REFERENCE MATERIAL	
1	https://missionlife-moefcc.nic.in/Download-Creatives-Save-Energy.php?id=MTE=
ONLINE COURSES	
1	https://enterprise.edx.org/APSCHE/program/df4909e1-a837-4c49-b575-a909c3990bf8/progress

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL6	X				
CO2	BL6		X			
CO3	BL6			X		
CO4	BL6				X	
CO5	BL6					X

VI Semester

R23MMECT014	HEAT TRANSFER					
	Total Contact Hours	42(L)	**L**	**T**	**P**	**C**
	Pre-requisite	Differential Equations, Physics, Engineering Thermodynamics, Fluid Mechanics and Hydraulic Machines	**3**	**0**	**0**	**3**

Course Objective

To equip students with a comprehensive understanding of the fundamental mechanisms of heat transfer including conduction, convection, radiation and to develop their ability to analyze and solve practical thermal management problems across various engineering applications.

Course Outcomes

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

1	Evaluate rate of heat transfer by conduction for one dimensional steady and transient heat flow through various geometries.(**BL5**)
2	Estimate heat transfer rates for both forced and free convection scenarios, applying correlations to various flow configurations and geometries.(**BL5**)
3	Evaluate the radiative heat exchange between different black and grey surfaces.(**BL5**)
4	Estimate heat transfer coefficients in pool boiling and condensation. (**BL5**)
5	Develop heat exchanger solutions using LMTD and NTU-effectiveness methods for different applications.(**BL6**)

SYLLABUS

Unit I	**CONDUCTION HEAT TRANSFER**	**8 hr**

Introduction to modes of heat transfer, physical laws and governing laws; Steady state heat conduction through plane walls, cylinders, and spheres; Steady state heat conduction through a composite wall, coaxial cylinders, and concentric spheres; Critical radius of insulation; Introduction to fins, steady state heat transfer through fins-Infinitely long fin, Insulated fin tip, convection at the end of the fin tip; Performance analysis of fins; Introduction to Transient heat conduction-Lumped heat analysis; Chart solutions for temperature distribution and heat flows with finite internal and surface resistances in -plane walls; long cylinders; solid spheres

Unit II	**CONVECTIVE HEAT TRANSFER**	**8 hr**

Introduction to convection-basic governing equations, velocity and thermal boundary layers; Significance of non-dimensional numbers in forced and free convection heat transfer; Estimation of heat transfer rates in forced convection for external flows; Estimation of heat transfer rate in forced convection for internal flow; Introduction to free convection and governing equations; Free convection on external flows-vertical plates and vertical cylinders; Free convection on Horizontal plates; Free convection on horizontal cylinders.

Unit III	**RADIATION HEAT TRANSFER**	**8 hr**

Introduction to radiation, surface emission properties and concept of black body; Laws of black body radiation and their applications; Radiation heat exchange between black surfaces; Radiation shape factor and rules; Radiation exchange between two black surfaces; Electrical network analogy for thermal radiation

systems; Estimation of Radiation exchange between two grey surfaces; Radiation shields.		
Unit IV	**BOILING AND CONDENSATION HEAT TRANSFER**	**8 hr**
Introduction to heat transfer in pool boiling; correlations related to pool boiling; Flow boiling regimes; Heat transfer correlations related to flow boiling; Fundamentals of Condensation Heat Transfer; Film wise Condensation – Theory and Analysis; Correlations related to filmwise condensation;Dropwise Condensation – Mechanism and Enhancement Techniques;		
Unit V	**HEAT EXCHANGERS**	**8 hr**
Introduction to heat exchangers, types, concept of overall heat transfer coefficient, fouling factor; LMTD method of heat exchanger analysis-parallel flow; LMTD method for counter flow; LMTD method for condensers, evaporators, and cross flow and multiple-pass heat exchangers; Effectiveness – NTU method for parallel flow heat exchangers; Effectiveness – NTU method for counter flow heat exchanger; Effectiveness – NTU method for condensers and evaporators; Effectiveness – NTU method for cross flow and multipass heat exchangers.		

LEARNING RESOURCES

TEXT BOOKS:	
1	R. C. Sachdev, *Fundamentals of Engineering Heat and Mass Transfer*, 6th edition, New age international, 2022.
2	J. P. Holman, *Heat Transfer*, 8th edition, McGraw-Hill Publishing Co. Ltd, 1996. 2011.
3	P. K. Nag, *Heat and Mass Transfer*, 3rd edition, McGraw-Hill Publishing Co. Ltd., 2011.
REFERENCE BOOKS:	
1	F. P. Incropera, and D.P. Dewitt, *Fundamentals of Heat and Mass Transfer*, 2nd edition, John Wiley, 2018.
2	Yunus A Cengel, *Heat Transfer: A Practical Approach*, 2nd edition, McGraw-Hill Publishing Co. Ltd, 2002.
3	M. Nicati Ozisik, *Heat Transfer - A Basic Approach*, 3rd edition, McGraw-Hill Publishing Co. Ltd, 1985.
ADDITIONAL REFERENCE MATERIAL	
1	https://archive.nptel.ac.in/courses/112/108/112108149/
2	https://pdhonline.com/courses/m211/HDBK-1012-Volume2.pdf
ONLINE COURSES	
1	https://nptel.ac.in/courses/112101097
2	https://www.cpp.edu/meonline/heat-transfer.shtml

Bloom's level – Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL5	×				
CO2	BL5		×			
CO3	BL5			×		
CO4	BL5				×	
CO5	BL6					×

R23MMECT015	OPERATIONS RESEARCH					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Matrices	**3**	**0**	**0**	**3**

COURSE OBJECTIVE

Student has to get the exposure towards the decision making in the industry and business aspects to achieve the best performance of the given system under the given circumstances like scarce resources

COURSE OUTCOMES

Students are able to

1	Analyze the concepts of linear programming to solve problems like optimization of fuel blend, product mix, production planning in the industry. **(BL4)**
2	Determine the optimum transportation and assignment schedules to minimize the cost of production and maximization of the profit in the industry. **(BL5)**
3	Develop the optimum strategies to be followed in business situations using the concept of game theory and to determine the optimum sequences to minimize the production times. **(BL6)**
4	Predict the behaviors of the customers in the queues and develop the optimum inventory strategies. **(BL6)**
5	Develop the optimum replacement policies using replacement models and estimate the optimum returns in capital budgeting, advertisement problems using dynamic programming techniques. **(BL6)**

SYLLABUS

UNIT I	INTRODUCTION TO OPERATIONS RESEARCH AND LINEAR PROGRAMMING	8 hr

Introduction to operations research, Models, Characteristics, Phases, Advantages and disadvantages, Applications; Introduction to Linear Programming, Formulation of LP problem; Graphical method to solve the LP problem; Simplex algorithm and solution of LP problem by simplex method; Artificial variable techniques – Big M method; Two-phase simplex method; Special cases like degeneracy, infeasibility and unbounded solutions; Duality principle, need of dual, conversion of primal to dual.

UNIT II	TRANSPORTATION AND ASSIGNMENT PROBLEMS	8 hr

Transportation problem, formulation, initial basic feasible solution, North-West corner method, least cost method, Vogels approximation method; optimization of transportation problem by U – V method; unbalanced transportation problems, degeneracy; problems with restricted cells, maximization transportation problem; Introduction to assignment problems and Hungarian method to solve assignment problems; Unbalanced assignment problems, maximization assignment problems; assignment problems with restrictions; travelling salesman problem.

UNIT III	GAME THEORY AND SEQUENCING	8 hr

Introduction to game theory, games with pure strategies, Nash equilibrium and mixed strategies, algebraic method to solve 2 × 2 games; principle of dominance and average dominance; graphical method to solve 2 × n and n × 2 games; method of matrices to solve 3 × 3 games; Introduction to sequencing and the solution of sequencing problems with n jobs processed on 2 machines; sequencing problems for n jobs processed on 3 machines; sequencing problems

with n jobs processed on m machines; sequence of problems with 2 jobs and m machines.		
UNIT IV	**INVENTORY AND QUEUING MODELS**	**8 hr**
Introduction to inventory, ABC and VED analysis; Inventory models with uniform rate and infinite production rates with and without shortages; Inventory model with uniform demand and finite production rates with and without shortages; Inventory models with price breaks; Introduction to queuing models, Kendall's notation for representing queuing models, classification of queuing models, assumptions and limitations of queuing models; Single channel models with infinite queue length; Single channel models with finite queue length; Multi channel models with infinite queue length.		
UNIT V	**DYNAMIC PROGRAMMING AND REPLACEMENT MODELS**	**8 hr**
Introduction to dynamic programming, Bellman's principle of optimality, Solution for shortest path problem; Employment smoothening and capital budgeting problems; Selection of advertising media and optimal subdivision problems; Solution of a linear programming problem using dynamic programming technique; Introduction to replacement, need for replacement, types of replacement models and applications; Replacement of items that deteriorate with time when money value is not considered; Replacement of items that deteriorate with time when money value is considered; Group replacement of items at fixed intervals of time		
LEARNING RESOURCES		
TEXT BOOKS:		
1	Prem Kumar Gupta, Hira D S, *Operations Research*, 3rd edition, S. Chand & Company Pvt. Ltd, 2018.	
2	Sharma S D, *Operations Research: Theory, Methods and Applications*, 7th edition, Kedar Nath Ram Nath, 2014.	
3	Sharma J K, *Operations Research: Problems and Solutions*, 3rd edition, Laxmi Publications, 2009.	
REFERENCE BOOKS:		
1	Sharma J K, *Operations Research: Theory and Applications*, 6th edition, MACIN, 2023.	
2	Taha H A, *Operations Research*, 10th edition, Prentice Hall of India, 2019.	
3	Hiller F S and Liberman G J, *Introduction to Operations Research*, 11th edition, Tata McGraw Hill, 2021.	
ONLINE COURSES		
1	https://nptel.ac.in/courses/110106062	
2	https://web.itu.edu.tr/topcuil/ya/OR.pdf	

BLOOM'SLEVEL - UNITSCATCHMENTARTICULATIONMATRIX

CO	Blooms Level	UNITI	UNITII	UNIT III	UNIT IV	UNIT V
CO1	BL4	**X**				
CO2	BL5		**X**			
CO3	BL6			**X**		
CO4	BL6				**X**	
CO5	BL6					**X**

R23MMECT016	MANUFACTURING SYSTEMS					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Prerequisite	Manufacturing Processes, Manufacturing Technology	**3**	**0**	**0**	**3**

Course Objective

This course aims to impart essential concepts in the design a CNC machine and selection of a suitable tooling system for machining. It also covers concepts on Group Technology, Cellular Manufacturing, Flexible Manufacturing System, Lean Manufacturing, Agile Manufacturing and Theory of Constraints .

Course Outcomes

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

1	Design (by selection) the major elements of a CNC machine tool.(**BL6**)
2	Plan and ensure overall operation of a CNC machine including selection of suitable tooling systems for machining a product. (**BL6**)
3	Evaluate a manufacturing system for sufficiency (**BL5**)
4	Design a simple lean manufacturing system for a production requirement (**BL6**)
5	Recommend interventions to improve an existing lean manufacturing system (**BL5**)

SYLLABUS

Unit I	**DESIGN OF CNC MACHINE**	**8 hr**

Concept of Numerical Control, Types of CNC Machines and Machine Operation; Principle of Operation (coordinate system, control loops); Construction of CNC Machine (structure, movement, drives, ATC/APC); Selection of motors and drives; Selection of ball screws; Ball screw mounting and bearing selection; Selection of LM guide; Overall schematic of machine LM guide system.

Unit II	**CNC MACHINE OPERATION**	**8 hr**

CNC Machine Electrical and Hydraulic Circuits; PLC Programming; Turning insert grades; Insert operating parameters; Turning tool holder selection for a component; Drill bit, collet and holder selection; End mill and holder selection; Milling cutter and holder selection.

Unit III	**MASS MANUFACTURING**	**8 hr**

Components and classification of manufacturing systems; Single station manufacturing cell; Analysis of single station cells; Group Technology: Parts classification and coding; Production flow analysis and cellular manufacturing; Quantitative analysis in cellular manufacturing; Flexible manufacturing systems; Components of FMS and implementation.

Unit IV	**THE LEAN PHILOSOPHY**	**8 hr**

The Emergence of Lean, House of Lean, Muda, Mura, Muri; 5S, Value Stream Mapping; Standardized Work; SMED, Jidoka, Poka-yoke; Kaizen, Hoshin Kanri, Lean Culture; JIT Production System;Flow Production, Kanban;Visual Control, Heijunka.

Unit V	**LEAN AND BEYOND**	**8 hr**

Total Productive Maintenance: Introduction; Overall Equipment Efficiency, Autonomous Maintenance, Fault Analysis; Total Quality Management - Introduction; TQM Tools and Techniques; Agile Manufacturing - Introduction; Implementing Agile; Theory of Constraints - Introduction; Implementing TOC.

LEARNING RESOURCES

TEXTBOOKS:

1	M. P. Groover —Automation, Production Systems and Computer Integrated Manufacturing‖ PHI Learning Pvt Ltd, New Delhi, 2016.

2	Dennis, Pascal., "Lean Production Simplified", Third Edition, CRC Press, Taylor and Francis Group, 2015.
3	Borris, Steven., "Total Productive Maintenance", McGraw-Hill, 2006.
4	Besterfield, Dale. H., Besterfield-Michna, Carol, Besterfield, Glen. H., Besterfield-Sacre, Mary., Urdhwareshe, Hemant., Urdhwareshe, Rashmi., "Total Quality Management", Revised Third Edition, Pearson, 2012.
5	S. R. Devadasan —Lean and Agile Manufacturing: Theoretical, Practical and Research Futurities, PHI Learning Pvt Ltd, New Delhi, 2012.
6	Eliyahu M Goldratt, "Theory of Constraints", North River Press, MA, USA, 1990.
REFERENCE BOOKS:	
1	Lonnie Wilson —How to Implement Lean Manufacturing‖, McGraw Hill, 2010.
2	Goal: A Process of On going Improvement Goldratt, Eliyahu M.,Cox, Jeff North River Press.1983.
ADDITIONAL REFERENCE MATERIAL	
1	https://www.youtube.com/watch?app=desktop&v=KcEoaesB6C8
ONLINE COURSES	
1	Course Era: The hidden value – Lean in manufacturing and services

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL6	X				
CO2	BL6		X			
CO3	BL5			X		
CO4	BL6				X	
CO5	BL5					X

R23MCSCT006 (EOEC-T6)	OOP WITH JAVA (for MEC, ECE, EEE, CIV and CHE)					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Data Structures	**3**	**0**	**0**	**3**

Course Objective

Students will have the ability to understand, design, integrate, and evaluate complex Java systems by combining object-oriented principles, multithreading, GUIs, exception handling, and collections to create efficient, scalable, and robust applications.

Course Outcomes

1	Students will be able to **apply** object-oriented concepts, Java programming constructs, and control structures.**(BL3)**
2	Students will be able to **analyze** and implement constructors, access control, static and final keywords, nested classes, and string handling. **(BL4)**
3	Students will be able to **apply** inheritance concepts, interfaces, access control, and Java standard libraries to develop modular and reusable Java programs. **(BL3)**
4	Students will be able to **Evaluate** and design robust Java applications by implementing effective exception handling, thread lifecycle management, multithreading, synchronization, and custom exception handling to ensure performance, stability, and efficient concurrency. **(BL5)**
5	Students will be able to **apply** the Delegation Event Model, AWT and Swing components, layout managers, and collections to create interactive Java applications with event handling and efficient data management. **(BL3)**
6	Students will be able to **design** and implement advanced Java applications by integrating OOPS principles, inheritance, polymorphism, exception handling, multithreading, GUIs, and collections for efficient problem-solving. **(BL6)**

SYLLABUS

Unit I	**BASICS OF JAVA**	**8 hr**

Deficiencies with Structured Programming in C, History and Evolution of Java; OOP Principles - abstraction, encapsulation, inheritance and polymorphism; Java virtual machine, features of java, A First Simple Java Program(Command lines,scanner class) Compilation, execution, CLASS PATH; Data Types, Literals, Variables; Type Conversion, Operators, Precedence, Associativity; Control Statements – Selection; Control Statements - Iteration statements; Arrays (One Dimensional, Multi-Dimensional);

Unit II	**CLASS FUNDAMENTALS**	**8 hr**

Class fundamentals, Declaring objects, Introducing Methods; Constructors, parameterized constructors; this keyword, garbage collection, returning objects, Access control; understanding static (static variable, static method, static block); final keyword, nested and inner classes; String Class, String Methods; String Buffer Class, Passing Arrays as parameters to methods; Method overloading, overloading constructors;

Unit III	**INHERITANCE, INTERFACES AND ABSTRACT CLASS**	**8 hr**

Inheritance Basics – Base class, sub class, types of inheritance; Member Access,

Method overriding; super keyword, Using final with inheritance; Abstract classes, Multiple inheritance issues; Interfaces – Defining an interface, implementing interfaces; Packages - Defining a Package, Finding Package with CLASSPATH, importing packages, Access Protection; Exploring java.util Package (Random, String Tokenizer, Scanner); Exploring java.io package (Byte and Character streams, File class);		
Unit IV	**EXCEPTION HANDLING AND MULTITHREADING**	**8 hr**
Exception Handling Fundamentals, Exception Types, Uncaught Exceptions; Using Try and Catch, Multiple Catch Clauses, Nested Try Statements; Throw, Throws and Finally; Handling of User Defined Exceptions; The Java Thread Model, Thread Life Cycle, Comparison of Thread and Process. The Main Thread; Creating a Thread: Implementing Runnable Interface, Extending Thread class; Creating Multiple Threads, isAlive () and join(); Synchronization (Keyword and Block), Thread Priorities;		
Unit V	**EVENT HANDLING, AWT, SWING**	**8 hr**
Delegation Event Model: Events, Event sources, Event Listeners; Event Classes, Event Listeners (Action Listener, Window Listener); Key Listener, keyboard events; Mouse Listeners, mouse events; AWT classes, AWT Controls (Button, Text Field, Label, Checkbox); Layout manager: BorderLayout, GridLayout, FlowLayout; Swings: JLabel, JButton, JTextField, JCheckbox; Collections: Array List, iterator;		
LEARNING RESOURCES		
TEXTBOOKS:		
1	Herbert Schildt, "Java The Complete Reference" 9th Edition, Oracle Press	
2	Paul Deitel and Harvey Deitel, "Java How to Program", 11th Edition, Pearson.	
REFERENCE BOOKS:		
1	Herbert Schildt, "Java: A Beginner's Guide", 9th Edition, McGraw Hill, 2022	
2	Bruce Eckel, "Thinking in Java", 9th Edition, Mind View, 2022.	
ADDITIONAL REFERENCE MATERIAL		
1	https://www.w3schools.com/java	
2	https://docs.oracle.com/javase/tutorial/	
3	https://www.geeksforgeeks.org/java/	
ONLINE COURSES		
1	https://www.udemy.com/courses/search/?q=java	
2	https://www.coursera.org/specializations/java-programming	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL3			X		
CO4	BL5				X	
CO5	BL3					X
CO6	BL6	X	X	X	X	X

R23MMECT019 DSC-E2	ADVANCED MANUFACTURING TECHNIQUES					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Manufacturing Technology	**3**	**0**	**0**	**3**

Course Objective

Students will be able to design, assess, and implement advanced machining and additive manufacturing processes to address complex engineering challenges, proposing innovative and effective solutions.

Course Outcomes

1	Critically evaluate the principles, classifications, and advancements in non-traditional machining methods to determine optimal processes for complex material applications. **(BL5)**
2	Appraise the applications, operational mechanisms, and comparative benefits of AJM, WJM, and AWJM, alongside an analytical assessment of Electron Beam and Laser Beam Machining.**(BL5)**
3	Evaluate the effectiveness of ECM techniques, focusing on process parameters, surface finish, and metal removal rates, and appraise their applications in ECG, ECH, and Chemical Machining processes.**(BL5)**
4	Assess the operational principles and critical process parameters in EDM and PAM, examining the effects on material removal rate, surface finish, and tool wear, and differentiate between various EDM types and applications of IBM and Electrostream Drilling.**(BL5)**
5	Analyze the evolution and categorization of Rapid Prototyping (RP) systems, discussing the key technologies such as Fused Deposition Modelling (FDM), Liquid-Based and Solid-Based RP methods, and 3D Printing (3DP) techniques, while exploring their applications in micro and nano fabrication. **(BL5)**
6	Evaluate and compare non-traditional machining methods, including AJM, WJM, ECM, EDM, PAM, and RP systems, focusing on their principles, process parameters, material removal rates, surface finish, and applications in advanced manufacturing and micro/nano fabrication. **(BL6)**

SYLLABUS

Unit I	**Introduction and mechanical energy domain processes**	**8 hr**

Introduction to Non-Traditional Machining; Classification of Modern Machining Processes; Merits and Demerits of Modern Machining; Considerations in Process Selection; Materials and Applications; Ultrasonic Machining (USM); Abrasive Finishing Processes; Recent Developments and applications of Non-Traditional Machining.

Unit II	**Mechanical and thermal energy domain processes**	**8 hr**

Abrasive Jet Machining (AJM); Water Jet Machining (WJM); Abrasive Water Jet Machining (AWJM); Application and difference between AJM,WJM and AWJM; Electron Beam Machining (EBM); Laser Beam Machining (LBM); Analysis and Comparison of LBM and EBM; Applications of EBM and LBM.

Unit III	**Chemical Energy Domain Material Removal Processes**	**8 hr**

Fundamentals of Electro-Chemical Machining (ECM); Process Parameters in ECM; Surface Finish and Metal Removal Rate (MRR) in ECM; Electro-Chemical Grinding (ECG); Electro-Chemical Honing (ECH); Shaped Tube Electrolytic Machining

(STEM); Chemical Machining Processes; Surface Finish, MRR, and Applications in Chemical Machining.		
Unit IV	**Electrical Energy Domain Material Removal Processes**	**8 hr**
Principle and Process Parameters of Electrical Discharge Machining (EDM); Types of Electrical Discharge Machining (EDM); Material Removal Rate (MRR), Surface Finish, and Tool Wear in EDM; Dielectric and Flushing Techniques in EDM; Applications and Power Control Circuits in EDM; Process Parameters and Principle of Plasma Arc Machining (PAM); Ion Beam Machining (IBM); Electrostream Drilling.		
Unit V	**Additive Manufacturing**	**8 hr**
Introduction to Rapid Prototyping (RP); Historical Development of Rapid Prototyping Systems; Classification of Rapid Prototyping (RP) Systems; Fused Deposition Modelling (FDM); Solid-Based and Powder-Based RP Methods; Liquid-Based Rapid Prototyping Methods; 3D Printing (3DP) Techniques; Micro and Nano Fabrication Technologies in RP.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	V. K. Jain Advanced machining processes. Allied publishers, 2009.V. K. Jain, *Advanced Machining Processes*. New Delhi: Allied Publishers, 2009.	
2	P. C. Pandey and H. S. Shan, *Modern Machining Processes*. New Delhi: Tata McGraw-Hill Education, 1980.	
3	I. Gibson, D. W. Rosen, B. Stucker, D. Rosen, B. Stucker, and M. Khorasani, *Additive Manufacturing Technologies*, vol. 17. Cham, Switzerland: Springer, 2021.	
REFERENCE BOOKS:		
1	Benedict, Gary F. Nontraditional manufacturing processes. CRC press, 2017.G. F. Benedict, *Nontraditional Manufacturing Processes*. CRC Press, 2017.	
2	R. Noorani, *Rapid Prototyping: Principles and Applications*. Wiley, 2006.	
ADDITIONAL REFERENCE MATERIAL		
1	https://home.iitk.ac.in/~nsinha/Non-traditional-machining.pdf	
2	https://www.cet.edu.in/noticefiles/261_MMP%20Lecture%20Notes-ilovepdf-compressed.pdf	
ONLINE COURSES		
1	https://onlinecourses.nptel.ac.in/noc24_me72/preview	
2	https://onlinecourses.nptel.ac.in/noc24_me39/preview	
3	https://onlinecourses.nptel.ac.in/noc24_me48/preview	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL5	X				
CO2	BL5		X			
CO3	BL5			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MMECT024 DSC-E2	FINITE ELEMENT ANALYSIS					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Mathematics & Strength of Materials	**3**	**0**	**0**	**3**

Course Objective

This course will enable students to apply FEM in practical engineering problems and develop computational models that help predict structural behaviours under various loading and boundary conditions.

Course Outcomes

After completing this course, the students will be able to

1	Apply FEM principles to model and solve one-dimensional structural problems **(BL3)**
2	Analyze and interpret results for beam and two-dimensional problems in structural engineering using FEM **(BL4)**
3	Evaluate and construct FEM models for axisymmetric solids and advanced two-dimensional elements**(BL5)**
4	Design FEM solutions for scalar field problems, such as steady-state heat conduction, and perform dynamic analysis for structural components**(BL6)**
5	Develop, implement, and critically evaluate FEM techniques in real-world engineering applications **(BL6)**

SYLLABUS

Unit I	**FUNDAMENTAL CONCEPTS & BASIC EQUATIONS OF ELASTICITY AND PROCEDURE**	**8 hr**

Fundamental concepts: A Brief History of FEM; Need and applications of FEM; Various methods of analysis; Classical method, Variational approach,Governing equation by variation approach and strength of materials approach for axially loaded bar; Governing equation by variational approach and strength of materials approach for beam bending, Rayleigh- Ritz Method; Weighted residual Method; Finite Difference Method.

Unit II	**ONE DIMENSIONAL PROBLEMS**	**8 hr**

Finite element modelling of bars; temperature effects on bars; Cubic shape function; formulation of stiffness matrix and load vector; Trusses: plane truss, local and global coordinate system, element stiffness matrix; stress in members, Truss with two members; truss with three members, truss with four members; temperature effects on trusses

Unit III	**BEAMS & TWO DIMENSIONAL PROBLEMS WITH CST**	**8 hr**

Beams: Potential energy approach;formulation of beam problem, load vector, simply supported beam subjected to point load; simply supported beam subjected to udl over half of the length; Two dimensional problems with CST: shape functions, Iso parametric representation; force terms, traction terms, Jacobian , strain displacement matrix, element stiffness; rectangular plate modelled with two elements; triangular plate modelled with single CST.

Unit IV	**AXISYMMETRIC SOLIDS & TWO DIMENSIONAL ISO PARAMETRIC ELEMENTS**	**8 hr**

Axisymmetric solids: Axisymmetric formulation, fem modelling triangular element; Jacobian, strain displacement matrix; stiffness matrix, body force,

surface traction; FEA of axisymmetric solid Two dimensional iso parametric elements: four node quadrilateral element: shape functions; jacobian, strain displacement relations, stiffness, Body force, Traction force; Higher order elements: Eight node quadrilateral element: shape functions; Numerical integration: one point formula, two point formula		
Unit V	**SCALAR FIELD PROBLEMS & DYNAMIC ANALYSIS**	**8 hrs**
Scalar field problems: steady state heat transfer: one dimensional heat conduction governing equation; shape function, thermal stiffness matrix of 1-D element; Application of 1-D heat transfer in composite wall; One dimensional heat transfer in thin fins. Dynamic Analysis: Hamilton's principle; mass matrix for bar, mass matrix for truss; lumped mass matrix, properties of Eigenvectors; Eigenvectors for stepped bar.		
LEARNING RESOURCES		
TEXTBOOKS:		
1	Triupathi R Chandrapla and Ashok D. Belegundu *Introduction to Finite Elements in Engineering*, Prentice Hall, 2002	
2	R.Dhanaraj, K. Prabhakrn nair *Finite Element method, Oxford University Press,2015*	
3	Singiresu S Rao, *The Finite Element Methods in Engineering*, Elsevier India, 2014	
REFERENCE BOOKS:		
1	JN Reddy, *An introduction to Finite Element Method,* McGraw-Hill, 2006	
2	Kenneth H.Huebner, Donald L. Dewhirst, DouglasE. Smith and TedG, *The Finite Element Method for Engineers*, John Wiley & sons, 2001	
3	Chennakesava Alavala, *Finite Element Method*s, PHI, 2008	
ADDITIONAL REFERENCE MATERIAL		
1	Hutton, D.V., "Fundamentals of Finite Element Analysis", McGraw-Hill, 2017	
ONLINE COURSES		
1	https://archive.nptel.ac.in/courses/112/106/112106180/	
2	https://ocw.mit.edu/courses/1-050-engineering-mechanics-i-fall-2007/	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X	X			
CO2	BL 4			X		
CO3	BL 5				X	
CO4	BL6					X
CO5	BL6	X	X	X	X	X

R23MMECT026 DSC-E2	HEATING, VENTILATION AND AIR CONDITIONING					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Engineering Thermodynamics	**3**	**0**	**0**	**3**

Course Objective

- This course provides a comprehensive understanding of the fundamentals of Refrigeration and Air Conditioning (R&AC), including the refrigeration cycle and key components.
- Differentiate between various air conditioning systems, perform load calculations, and design effective air distribution systems.
- Explores diverse applications of HVAC in residential, commercial, and industrial settings, emphasizing energy efficiency and indoor air quality.

Course Outcomes

Students are able

1	Apply the fundamental principles to distinguish different types of refrigeration systems. (**BL3)**
2	Use the psychrometric chart to determine psychrometric properties for various air conditions. (**BL3**)
3	Apply comparison techniques to identify differences among air conditioning systems and determine performance ratings. (**BL3**)
4	Analyze building load requirements, ventilation needs for indoor air quality (IAQ), and calculate parameters such as ESHF, ADP, and air flow rate (CFM). (**BL4**)
5	Evaluate design considerations and selection criteria for HVAC components and justify their appropriate applications. **(BL5)**
6	Design and develop optimized HVAC solutions using psychrometric, load analysis, and component selection to achieve performance and sustainability goals. **(BL6)**

SYLLABUS

Unit I	**FUNDAMENTALS OF REFRIGERATION**	**8 hr**

Carnot Refrigerator-Reversed Carnot cycle; COP of the cycle; Refrigerants-Types of refrigerants; properties of refrigerants; Vapor Compression Cycle; -Pressure – Enthalpy Chart; Factors affecting COP; sub cooling and superheating; working and COP of Vapour Absorption Refrigeration System
(NH_3-H_2O absorption refrigeration cycle).

Unit II	**PSYCHROMETRY OF AIR CONDITIONING PROCESS**	**8hr**

Review of psychrometry- Psychrometry; properties, relations and processes; Psychrometric chart; RSHF, GSHF; ERSHF, Bypass factor; Numerical based problems on psychrometric chart and Relations; sensible heating, sensible cooling; Cooling and Dehumidification, Heating and Humidification;

Unit III	**AIR-CONDITIONING SYSTEMS**	**8hr**

Types of air conditioning, Summer A/c; winter and year round air conditioning; working of Window A/C with Line Diagrams; Split A/C-Types; Working of Split A/C with Line Diagrams; duct type split A/c; Rating of air conditioning; Variable Refrigerant Flow (VRF);

Unit IV	**LOAD CALCULATIONS**	**8hr**

Survey of Building-Cooling Load Steps; Finding Temperature difference(ΔT)- Wall, Glass, Roof, Partition; Finding 'U' Factor-Wall, Glass, Roof, Partition; Finding Ventilation requirement for IAQ; Introduction to Load Calculations CLTD/CLF) and

the E-20 Form; Manual Calculation Techniques Using the E-20 Form; ESHF & ADP; Air Flow Rate (CFM)Calculation;		
Unit V	**AIR DISTRIBUTION, COMPONENTS AND APPLICATIONS OF HVAC SYSTEM**	**8 hr.**
Classification of ducts, duct material; pressure in ducts, Flow through ducts& pressure losses in duct; Types of fans used air conditioning applications; working of air cooled, and water cooled and evaporative condensers; Fittings used in the HVAC Piping System; Valves used in the HVAC; Applications of HVAC (ice plants, dairy and food processing plants; pharmaceutical industry and Hospitals etc.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	C. P. Arora, Refrigeration and Air Conditioning, New Delhi: McGraw Hill Education (India) (P) Limited, 2018.	
2	M. Prasad, Refrigeration and Air Conditioning, New Delhi: New Age International (P) Limited, 2019.	
Reference Books		
1	J. Dossat, Principles of Refrigeration, 4th ed., New Delhi: Pearson Education, 1996.	
2	ISHRAE, Air Conditioning Handbook, New Delhi: Indian Society of Heating, Refrigerating and Air Conditioning Engineers, 2017.	
ONLINE COURSES		
1	https://nptel.ac.in/courses/112/107/112107208/ - Refrigeration and Air Conditioning, IIT Roorkee	
2	https://nptel.ac.in/courses/112/105/112105128/ - Refrigeration and Air Conditioning, IIT Kharagpur	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL3		X	X	X	
CO3	BL3			X	X	X
CO4	BL4				X	X
CO5	BL5				X	X
CO6	BL6	X	X	X	X	X

R23MMECT020 DSC-E3	PRODUCT LIFECYCLE MANAGEMENT					
	Total Contact Hours	40 (L) + 2 (Introduction) + 6 (Case Discussion)	**L**	**T**	**P**	**C**
	Pre-requisite	Nil	**3**	**0**	**0**	**3**

Course Objective:

This course is aimed at helping students:

- To understand the philosophy and methodology of product design
- To understand the concept of lifecycle and its management
- To build an insight into the real world and the challenges related to product data management

Course Outcomes:

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

1	Apply engineering design methods and problem-solving techniques to develop practical solutions that meet technical and societal needs. **(BL3)**
2	Apply customer need analysis and market research tools, such as the Kano Model and Quality Function Deployment, to create products that satisfy user requirements. **(BL 3)**
3	Apply product lifecycle management tools like data models, workflows, and change management to support product documentation and collaboration. **(BL 3)**
4	Analyze design processes, standards, and organizational structures to improve product development and ensure compliance with regulations and societal expectations. **(BL 4)**
5	Evaluate PLM strategies, data, and workflows, and ways to improve efficiency, teamwork, and integration in engineering projects. **(BL 5)**
6	Create comprehensive product lifecycle strategies by integrating design principles, development processes, and PLM tools for efficient and innovative engineering solutions. (**BL 6)**

SYLLABUS

Unit I	**ENGINEERING DESIGN**	**8 hr**

4 C's of Engineering Design; Importance of the Engineering Design Process and Types of Design; Modelling Design Thought; Design as a Problem-solving Methodology; Considerations of a Good Design; The Design Process; Codes/Standards and Review; Societal Considerations in Engineering Design.

Unit II	**PRODUCT DEVELOPMENT**	**8 hr**

The Product Development Process; Factors for Success, Static/Dynamic Products, Variations on the Generic Process; Product and Process Cycles; Organisation for Product Development; Markets and Marketing; Identifying Customer's Needs; Kano Model, Quality Function Deployment; Design Specification and Product Architecture.

Unit III	**PRODUCT LIFECYCLE MANAGEMENT**	**8 hr**

Challenges and Emergence of PLM, Definition of PLM; PLM Model, Characteristics of PLM; Environment Driving PLM; PLM Elements; Developing PLM Strategy; Implementing PLM Strategy; PLM Readiness Assessment; Capability Maturity Model.

Unit IV	**PRODUCT IN PLM**	**8 hr**

Collaborative Product Development: Part 1; Collaborative Product Development: Part 2; Product Structure and Specifications; Bill of Material; Product Range, Instance, Identifier; Product Data and Metadata, Product Data Models; Types of Product Data in PLM; Product Data Issues		
Unit V	**PROCESS IN PLM**	**8 hr**
Overall Business Process Architecture, Managing BoM; Engineering Change Process; Workflow; Process Mapping and Modelling; Change Management; Variant and Version Management; Configuration Management; PLM Integration with Other Applications.		
*****		
LEARNING RESOURCES		
TEXT BOOKS:		
1	Dieter, George. E. and Schmidt, Linda. C., "Engineering Design", 4th Edition, McGraw-Hill, 2009	
2	Grieves, Michael, "Product Lifecycle Management", McGraw-Hill, 2006	
3	Antti Saaksvuori, Anselmi Immonen, "Product Lifecycle Management", 1st Edition, Springer-Verlag	
4	Sark, John, "Product Lifecycle Management: 21st Century Paradigm for Product Realisation", 2nd Edition, Springer-Verlag, 2011	
REFERENCE BOOKS:		
1	https://books.google.co.in/books?id=q9AdtdDeuPsC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false	
2	https://books.google.co.in/books?id=CiHbLm6twJMC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false	
ONLINE RESOURCES		
1	https://www.slideshare.net/anandsubramaniam/product-life-cycle-management	
2	http://productlifecyclestages.com/	
3	https://nxrev.com/2018/02/windchill-vs-enovia/	
4	https://www.cimdata.com/en/education/plm-basics-e-learning-course	
5	https://www.cimdata.com/en/education/plm-certificate-program	

Bloom's level - Units Catchment Articulation Matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X	X		X	
CO2	BL3		X	X	X	
CO3	BL3				X	X
CO4	BL4	X	X			
CO5	BL5			X	X	X
CO6	BL6	X	X	X	X	X

R23MMECT027 DSC-E3	COMPUTATIONAL FLUID DYNAMICS					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Differential Equations and Vector Calculus, Engineering Physics, Fluid Mechanics and Fluid Machines, Heat Transfer	**3**	**0**	**0**	**3**

Course Objective

Computational Fluid Dynamics (CFD) course is designed to give the fundamental concepts of the CFD methods and algorithms that enable students to develop their own CFD computer programs or use available public domain or commercial software and interpret the results.

Course Outcomes

After completing this course, the students will be able to

1	Develop a CFD procedure for different physical systems.(**BL5**)
2	Assess the formulation of mathematical models for steady and unsteady heat transfer and fluid flow systems. (**BL5**)
3	Evaluate finite difference equations using FDM. (**BL5**)
4	Assess the accuracy of finite volume discretization techniques for diffusion and convection-diffusion problems (FVM). (**BL5**)
5	Design a suitable CFD solution technique for solving heat transfer problems.(**BL6**)

SYLLABUS

Unit I	**CFD PROCEDURE**	**8 hr**

Introduction, Computational Fluid Dynamics as a Research and Design Tool; Applications of computational fluid dynamics; CFD frame work; Introduction to geometry and mesh generation; Selection of physics and fluid properties; Specification of boundary conditions; Numerical solution, result report and visualization; CFD procedure for different fluid flow and heat transfer problems.

Unit II	**CFD MODELLING**	**8 hr**

Navier-stokes equations and various forms; Conservative and non-conservative forms of governing equations; Non-dimensional form of continuity, Navier-stokes, and energy equations; Mathematical behavior of partial differential equations; Mathematical formulation for steady heat transfer systems; Mathematical formulation for steady fluid flow systems; Mathematical formulation for un-steady heat transfer systems; Mathematical formulation for un-steady fluid flow systems.

Unit III	**FINITE DIFFERENCE METHOD**	**8 hr**

Introduction to Finite difference method(FDM) Discretization, and Difference Equations; Higher order approximations; Explicit approach and implicit approaches for discretization of governing equations; Crank-Nicolson method; Dufort Frankel method; Lax Wendroff method; Application of FDM for one dimensional heat conduction; Application of FDM for unsteady heat conduction.

Unit IV	**FINITE VOLUME METHOD**	**8 hr**

Introduction to Finite Volume Method (FVM); Discretization of partial differential equations using FVM; Pressure Correction Methods –SIMPLE method; SIMPLER Method; Upwind differencing schemes; FVM for diffusion problems; Application of FVM for diffusion problems; FVM for convection-diffusion problems.

Unit V	**CFD SOLUTION METHODOLOGY**	**8 hr**

Direct solution method; TDMA; Application of TDMA; Iterative solution methods-Jacobi iteration;Gauss-Seidel iteration;Application of iterative solution methods; Relaxation methods; Application of relaxation methods.

LEARNING RESOURCES	
TEXTBOOKS:	
1	John. D. Anderson, *Computational fluid dynamics - Basics with applications*, McGraw Hill Education, 1997.
2	S. V. Patankar, *Numerical heat transfer and fluid flow.* Boca Raton: CRC Press, 1980.
REFERENCE BOOKS:	
1	T. J. Chung, *Computational fluid dynamics*, 2nd ed. Cambridge University Press, 2010.
2	H. K. Versteeg and W. Malalasekra, *An introduction to computational fluid dynamics: the finite volume method*, 2nd ed. Pearson, 2007.
ADDITIONAL REFERENCE MATERIAL	
1	https://www.cfd-online.com/Links/
2	https://www.cfd-online.com/Links/onlinedocs.html
ONLINE COURSES	
1	https://onlinecourses.nptel.ac.in/noc21_me126/preview
2	https://onlinecourses.nptel.ac.in/noc22_me101/preview

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL5	×				
CO2	BL5		×			
CO3	BL5			×		
CO4	BL5				×	
CO5	BL6					×

R23MMECL006	THERMAL ENGINEERING LAB					
	Total Contact Hours	42 (P)	**L**	**T**	**P**	**C**
	Prerequisite(s)	IC Engines, Applied thermodynamics, Heat Transfer	**0**	**0**	**3**	**2**

Course Objective

The objective of the thermal engineering laboratory is to provides hands-on experience in analyzing the performance evaluation of IC engines and thermal systems like fins, heat exchangers, air compressors and analyze the variations of thermal conductivity, heat transfer coefficients, and emissivity of different materials with temperature.

Course Outcomes

1.	Conduct the experiments on IC engines and evaluate the performance and emission parameters.
2.	Evaluate the density and calorific value of the fuel and Prepare heat balance sheet to analyse how the heat is distributed to various components.
3.	Analyze the performance of two stage reciprocating air compressors.
4.	Conduct the experiment and determine heat transfer coefficient in forced convection.
5.	Estimate the thermal conductivity metals and critical heat flux.
6.	Estimate the emissivity and analyze the variation of emissivity with temperature.
7.	Analyze the performance of fins and heat exchangers.

List of Experiments

1.	Performance test on Four Stroke Single Cylinder Petrol Engine.
2.	Heat Balance Sheet on High-speed Diesel Engine.
3.	Determination of the density and calorific value of the given fuel.
4.	Determination of Exhaust emission of a VCR Diesel Engine.
5.	Performance test on Two Stage Reciprocating Air Compressor.
6.	Determination of performance characteristics of a Vapour compression refrigeration system.
7.	Determination of the thermal conductivity of a given metal.
8.	Determination of the convective heat transfer coefficient air in forced convection.
9.	Determination of the emissivity of a grey body.
10.	Determination of critical heat flux between the water and Nichrome wire.
11.	Determination of efficiency and effectiveness of pin fin.
12.	Determination of performance of parallel and counter flow heat exchanger.

Additional Experiments

1.	Valve and Port Timing Diagrams of IC engine.
2.	Motoring test on 4- stroke Petrol engine.

LEARNING RESOURCES

TEXTBOOKS:

1.	Ganesan, V., ***Internal Combustion Engines***, 4th Ed., McGraw-Hill Education, 2012.
2.	Gupta, Hari N.,***Fundamentals of internal combustion engines***, 2nd edition, PHI Learning Pvt. Ltd., 2012.

REFERENCE BOOKS:

1.	Gilles, Tim. ***Automotive service: inspection, maintenance, repair***, 6th Ed, Cengage Learning, 2020.

<table>
<tr><td rowspan="3">R23MCSCL004
EOEC-L4</td><td colspan="6">OOP WITH JAVA LAB
(for MEC, ECE, EEE, CIV and CHE)</td></tr>
<tr><td>Total Contact Hours</td><td>42 (P)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Pre-requisite</td><td>-</td><td>0</td><td>0</td><td>3</td><td>2</td></tr>
<tr><td colspan="7">Course Objective</td></tr>
<tr><td colspan="7">Students will have the ability to apply object-oriented programming concepts in Java to develop and implement modular and reusable software solutions.</td></tr>
<tr><td colspan="7">Course Outcomes</td></tr>
<tr><td>1</td><td colspan="6">Students will be able to implement object-oriented programming concepts such as classes, inheritance, polymorphism, and exception handling to build modular Java applications.</td></tr>
<tr><td>2</td><td colspan="6">Students will be able to examine and debug Java programs to identify and resolve logical errors, ensuring correctness and efficiency.</td></tr>
<tr><td>3</td><td colspan="6">Students will be able to assess the design and performance of Java applications, optimizing for scalability, maintainability, and resource management.</td></tr>
<tr><td>4</td><td colspan="6">Students will be able to design and develop advanced Java applications by integrating OOP principles, multithreading, GUIs, and data structures to solve real-world problems.</td></tr>
<tr><td colspan="7">List of Experiments</td></tr>
<tr><td>1</td><td colspan="6">Week 1: Introduction to Java and Structured Programming
1. Write a simple Java program that prints "Hello, World!" to the console.
2. Write a Java program that takes user input using the Scanner class.
3. Write a Java program to demonstrate all primitive data types.
4. Implement a Java program that converts a floating-point number to an integer.
5. Create a Java program that uses the final keyword to define constants.</td></tr>
<tr><td>2</td><td colspan="6">Week 2: Operators, Control Statements - Selection
1. Implement a Java program that uses arithmetic, relational, and logical operators.
2. Write a Java program to find the largest of three numbers using if-else statements.
3. Use the ternary operator to implement a simple conditional check.</td></tr>
<tr><td>3</td><td colspan="6">Week 3: Control Statements - Iteration
1. Write a Java program that prints all even numbers between 1 and 100 using a for loop.
2. Create a Java program that calculates the factorial of a given number using a while loop.
3. Write a JAVA program to display the Fibonacci sequence.
4. Implement a menu-driven program using a do-while loop.</td></tr>
<tr><td>4</td><td colspan="6">Week 4: Arrays
1. Write a Java program to reverse a one-dimensional array of integers.
2. Write a Java program to search for an element in an array.</td></tr>
</table>

	3. Implement a Java program to find matrix multiplication using two-dimensional arrays.
5	**Week 5: Classes and Methods** 1. Create a class with fields and methods, then instantiate and use it. 2. Implement a method to calculate the area of a rectangle (accepting length and width as parameters). 3. Create a program that returns the area of different shapes (circle, square, rectangle) using method overloading.
6	**Week 6: Constructors, this Keyword, and Garbage Collection** 1. Implement a class with parameterized constructors and demonstrate object initialization. 2. Use 'this' keyword to resolve variable shadowing within methods and constructors. 3. Write a program that simulates garbage collection using System.gc() and observe the results.
7	**Week 7: Inheritance and Polymorphism** 1. Create a superclass and subclass to demonstrate basic inheritance. 2. Override a method in the subclass and call it from the main method. 3. Use the super keyword to call the parent class constructor and method.
8	**Week 8: Abstract Classes and Interfaces** 1. Write an abstract class with an abstract method and a concrete method. 2. Implement an interface and demonstrate how to implement it in a class. 3. Create a scenario where interfaces solve the multiple inheritance problem.
9	**Week 9: Exception Handling** 1. Write a program that demonstrates basic exception handling using try-catch blocks. 2. Implement a program that handles multiple exceptions using multiple catch clauses. 3. Create a custom exception class and use it to handle a specific error in a program.
10	**Week 10: Multithreading** 1. Implement a thread by extending the Thread class and demonstrate thread execution. 2. Create a program that demonstrates thread life cycle and state transitions. 3. Implement thread synchronization to avoid race conditions in a multi-threaded environment.
11	**Week 11: Event Handling, AWT** 1. Create a simple AWT program that displays a window with a button, text field, and label. 2. Implement mouse and keyboard event listeners in an AWT program.

12	**Week 12: Swings** 1. Create a Swing-based GUI with a JFrame, JButton, and JLabel, demonstrating layout managers like FlowLayout or BorderLayout. 2. Write a Java program that works as a simple calculator. Use a grid layout to arrange buttons for the digits and for the +, -,*, % operations. Add a text field to display the result.
LEARNING RESOURCES	
TEXTBOOKS:	
1	Herbert Schildt, "Java The Complete Reference" 9th Edition, Oracle Press
2	Paul Deitel and Harvey Deitel, "Java How to Program", 11th Edition, Pearson.
REFERENCE BOOKS:	
1	Herbert Schildt, "Java: A Beginner's Guide", 9th Edition, McGraw Hill, 2022
2	Bruce Eckel, "Thinking in Java", 9th Edition, Mind View, 2022.
ADDITIONAL REFERENCE MATERIAL	
1	https://www.w3schools.com/java
2	https://docs.oracle.com/javase/tutorial/
3	https://www.geeksforgeeks.org/java/
4	https://www.javatpoint.com/java-tutorial
5	https://www.udemy.com/courses/search/?q=java
6	https://www.coursera.org/specializations/java-programming
7	https://www.freecodecamp.org/news/tag/java/
8	https://www.tutorialspoint.com/java/index.htm

R23MMATT007	QUANTITATIVE PROBLEM-SOLVING TECHNIQUES					
	Total Contact Hours	28(L)	**L**	**T**	**P**	**C**
	Pre-requisite	NIL	**2**	**0**	**0**	**2**

Course Objective

The course aims to equip the students with standard concepts and techniques of arithmetic and logical thinking to handle various real-world problems and their applications.

Course Outcomes: After completing this course, the students will be able to

1	Enhance the aptitude and reasoning round clearing ability.
2	Solve real-time problems for performing job functions easily.
3	Improve individual decision–making abilities, how to think critically, and logically and analyze information as corporate company-based decisions.
4	Acquire satisfactory competency in the use of VERBAL REASONING as well as LOGICAL REASONING.
5	Develop knowledge, skills, and judgment around human communication that facilitate their ability to work collaboratively with others.

SYLLABUS

Unit I	**ARITHMETIC ABILITY**	**5 hr**

Number System and LCM & HCF; Ratio & Proportion; Percentages; Profit & Loss; Mixture and Allegation.

Unit II	**ALGEBRAIC ANALYSIS**	**5 hr**

Quadratic & Linear eq's; Inequalities; Speed, Time and Distance; Time and Work; Simple Interest & Compound Interest.

Unit III	**ADVANCED MATHS**	**5 hr**

Circles, lines, angles & Co-ordinate geometry; Triangles, quadrilaterals & polygons; Areas & perimeter-2D; Surface area & volumes-3D; Trigonometry.

Unit IV	**MODERN MATHS**	**5 hr**

Probability; Permutation and Combination; Surds, indices & set theory; Functions; Logarithms.

Unit V	**DATA INTERPRETATION & ELEMENTARY STATISTICS**	**5 hr**

Tables, charts & pie-diagrams; Venn diagrams; Data sufficiency; Mean, median & mode; Standard deviation ,variance & Case studies.

LEARNING RESOURCES

TEXTBOOKS:

1	ARIHANT Publications - RAJESH VERMA Fast Track Objective Arithmetic (Revised Edition)
2	MC GRAW HILL Education- ABHIJIT GUHA Quantitative aptitude (6th edition)
3	ARIHANT Publications - B.S. SIJWALI & INDU SIJWALI Verbal, Non-verbal & Analytical reasoning
4	ARIHANT SERIES - JAI KISHAN & PREM KISHAN Verbal, Non-verbal & Analytical reasoning
5	R. S. Aggarwal - S. Chand Publications Quantitative Aptitude for

	Competitive Examinations
REFERENCE BOOKS	
1	A SURE SHOT GUIDE TO CRACK SSB: YES, YOU HAVE IT IN YOU(MAJ GEN VPS BHAKUNI (Author), VSM (Author), KAVITA MODI (Author))
2	Excel in Quantitative Aptitude: Chapter-wise Maths 10 Years Previous Solved Papers (PYQ) of SSC CGL, IBPS PO & Clerk, SBI PO, & RRB NTPC Tier I & II | Mathematics for SSC, Banking, Railways Exams 2024 (Arun Sharma (Author)) https://amzn.in/d/3OTZ5uI
3	Ace Reasoning Ability for Banking and Insurance Book 2024 (Third English Edition)(Adda247 Publications (Author))
4	Ultimate Guide to SSC CGL - Combined Graduate Level - Tier I & Tier II Exam with Previous Year Questions & 5 Online Practice Sets 9th Edition | Combined Graduate Level Prelims & Mains| (Disha Experts (Author))
5	Excel in Quantitative Aptitude: Chapter-wise Maths 10 Years Previous Solved Papers (PYQ) of SSC CGL, IBPS PO & Clerk, SBI PO, & RRB NTPC Tier I & II | Mathematics for SSC, Banking, Railways Exams 2024 (Arun Sharma (Author))
6	Quantitative Aptitude for CAT 2025 | 11th Edition (Latest) | Quant | CAT Preparation Exam Book with Solved Previous Years Papers (PYQ) | McGraw Hill edge Access: Mock Tests, Expert Sessions & Strategies (Arun Sharma (Author))
7	Ace Reasoning Ability for Banking and Insurance Book 2024 (Third English Edition) (Adda247 Publications (Author))

VII Semester

R23MMECT017	LOGISTICS AND SUPPLY CHAIN MANAGEMENT					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Nil	**3**	**0**	**0**	**3**

Course Objective

- To understand the role of logistics in the supply chain and its impact on overall operations.
- To identify and analyze key issues in logistics, operations, marketing, procurement, and warehousing.
- To explore the integration of information technology in optimizing logistics and supply chain management.

Course Outcomes

1	Evaluate and integrate advanced SCM concepts to design strategies that improve coordination with suppliers and customers, driving corporate success through sustainable and innovative solutions. (**BL 5)**
2	Develop and propose SCM strategies that align with organizational goals, critically assessing procurement, production planning, logistics, and sales to ensure smooth execution across the supply chain. (**BL 5)**
3	Design and justify strategies for vendor selection, network optimization, layout design, and process re-engineering, evaluating their impact on supply chain performance and organizational goals. (**BL 5)**
4	Adequately skilled in selecting the right model for vehicle routing and scheduling to rise up to the expectations of firms. (**BL 5)**
5	Differentiate, comprehend and leveragethe type of organizational structures and implement process frame work. (**BL 5)**
6	Develop an understanding of the practices, Operational activities, Re-Design, Optimize, Transportation and Organisational structure in SCM. (**BL 6)**

SYLLABUS

Unit I	**INTRODUCTION**	**8 hr**

Business Logistics; Supply Chain Overview; Objectives of Business Logistics; Drivers of Supply Chain Management, Strategic Planning; Performance Measurement in Logistics; Role of Information Technology (IT) in Logistics; Supply Chain Risk Management; Ethical Considerations in Supply Chain

Unit II	**MANAGING FLOWS**	**8 hr**

Network Planning and Decision Making; Distribution Network Design and Design Tree; Inventory Management Objectives; Probabilistic Inventory Model, Multi-Echelon Inventory Management; Supply chain network optimisation models; Logistics information system; Role of IT in Supply chain; Framework for IT adoption

Unit III	**INVENTORY AND WAREHOUSING**	**8 hr**

Inventory Objectives and Control; Bullwhip Effect in Supply Chains; Probabilistic Inventory Models; Risk Pooling Strategies, Vendor-Managed Inventory (VMI); Multi-Echelon Inventory Management; Warehousing Functions and Types; Site Selection for Warehousing; Warehouse Decision Model, Layout, and Costing, Virtual Warehouse

Unit IV	**TRANSPORTATION AND PACKAGING**	**8 hr**

Organizational Structure in Logistics; Organizational Choices and Positioning; Interfunctional Management; Inter-organisational Management, Control Processes in Logistics; Continuous Improvement in Logistics; Supply Chain Visibility and

Collaboration; Strategic Alignment of Logistics and Business Goals; Adapting to Changing Business Environments		
Unit V	**ORGANISATION AND CONTROL**	**8 hr**
Organizational Structure: Need and Development; Organizational Choices; Orientation and Positioning in Organizations; Inter functional Management in Logistics, Inter organisational Management: Alliances and Partnerships; Control Processes in Logistics; Process Framework for Control; System Details in Control; Information, Measurement, and Interpretation in Control.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	S. Chopra and P. Meindl, *Supply Chain Management – Strategy, Planning, and Operation*, 4th ed. New Delhi, India: PHI, 2010.	
2	J. D. Wisner, K.-C. Leong, and K.-C. Tan, *Principles of Supply Chain Management: A Balanced Approach*. Mason, OH, USA: Thomson Press, 2005.	
3	Coyle, Bardi, Longley, THE MANAGEMENT OF BUSINESS LOGISTICS – A SUPPLY CHAIN PERSPECTIVE, Thomson Press, 2006.J. J. Coyle, E. J. Bardi, and C. J. Langley Jr., *The Management of Business Logistics: A Supply Chain Perspective*. Mason, OH, USA: Thomson Press, 2006.	
REFERENCE BOOKS:		
1	R. Monczka, R. Handfield, L. Giunipero, and J. Patterson, *Purchasing and Supply Chain Management*. Boston, MA, USA: Cengage Learning, 2020.	
2.	J. F. Shapiro, *Modeling the Supply Chain*. Belmont, CA, USA: Thomson Duxbury, 2002.	
3	A. Harrison and R. Van Hoek, *Logistics Management and Strategy: Competing through the Supply Chain*. 4th ed. Harlow, England: Pearson Education, 2014.	
4	F. R. Jacobs, W. Berry, D. C. Whybark, and T. Vollmann, *Manufacturing Planning and Control for Supply Chain Management*. 6th ed. New York: McGraw-Hill, 2011.	
ADDITIONAL REFERENCE MATERIAL		
1	Purchasing and Supply Chain Management: Analysis, Strategy, Planning and Practice by Arjan J. Van WA. J. Van Weele, *Purchasing and Supply Chain Management: Analysis, Strategy, Planning and Practice*. 6th ed. Andover, UK: Cengage Learning, 2010.	
2	S. Cohen and J. Roussel, *Strategic Supply Chain Management: The Five Core Disciplines for Top Performance*. New York: McGraw-Hill, 2005.	
3	D. Bowersox, D. Closs, and M. Bixby Cooper, *Supply Chain Logistics Management*. 4th ed. New York: McGraw-Hill, 2013.	
ONLINE COURSES		
1	https://onlinecourses.nptel.ac.in/noc21_mg79/preview	
2	https://www.careers360.co m/courses-certifications/swayam-logistics-and-supply-chain-management-courses	
3	https://onlinecourses.swayam2.ac.in/ugc19_hs51/previeiw	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL5	x				
CO2	BL5		x			
CO3	BL5			x		
CO4	BL5				x	
CO5	BL5					x
CO6	BL6	x	x	x	x	x

R23MMECT021 DSC-E4	SIX SIGMA					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Nil	**3**	**0**	**0**	**3**

Course Objective:
The course on Six Sigma will focus on strategic and operational issues of process improvement and variation reduction. To understand the Six Sigma methodology. To build an appreciation for implementation of a statistical approach to quality management.

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

1	Define a Six Sigma project **(BL6)**
2	Assess data requirements and process capability **(BL5)**
3	Evaluate a process for variables and relationships **(BL5)**
4	Design a quality improvement process **(BL6)**
5	Evaluate how controlled a given process is **(BL5)**

SYLLABUS

Unit I	**INTRODUCTION AND DESIGN PHASE**	**8 hr**

Quality Management: Basics and Key Concepts; Cost of quality, Voice of customer; Quality Function Deployment (QFD); Management and Planning Tools; Six Sigma Project Identification, Selection and Definition; Project Charter and Monitoring; Process Characteristics and Analysis; Process Tracking.

Unit II	**MEASURE**	**8 hr**

Process Characteristics; Data Collection and Summarization; Measurement Systems: Fundamentals; Measurement Systems Analysis: Gage R&R Study; Fundamentals of Statistics; Probability Theory; Process Capability Analysis: Key Concepts; Process Capability Analysis: Measures and Indices.

Unit III	**ANALYSE**	**8 hr**

Hypothesis testing: Fundamentals; Hypothesis Testing: Single Population Test; Hypothesis Testing: Two Population Test; Correlation and Regression Analysis; One-Way ANOVA; Two-Way ANOVA; Multi-vari Analysis; Failure Mode Effect Analysis (FMEA).

Unit IV	**IMPROVE**	**8 hr**

Introduction to Design of Experiment; Design Principles 1; Design Principles 2; Planning Experiments; Randomized Block Design; Factorial Design; Fractional Factorial Design; Taguchi Method: Key Concepts.

Unit V	**CONTROL**	**8 hr**

Statistical Process Control: Key Concepts; Control Charts for Variables; Control Charts for Attributes; Analysis of Control Charts; Acceptance Sampling: Key Concepts; Design of Acceptance Sampling Plans for Variables; Maintain Controls; Sustain Improvements.

LEARNING RESOURCES

TEXT BOOKS

1	Munro, Roderick. A., Govindarajan Ramu and Zrymiak, Daniel. J., "The Certified Six Sigma Green Belt Handbook", Second Edition, ASQ Quality Press, 2015.

2	Besterfield, Dale. H., Besterfield-Michna, Carol, Besterfield, Glen. H., Besterfield-Sacre, Mary., Urdhwareshe, Hemant., Urdhwareshe, Rashmi., "Total Quality Management", Revised Third Edition, Pearson, 2012.
3	Kubiak, T. M., Benbow, D. W., "The Certified Six Sigma Black Belt Handbook", Second Edition, Perason, 2017.
REFERENCE BOOKS:	
1	koncepce a příklady pro řízení bez chyb**,** Armin Töpfer, "Six Sigma"Praxe Manazera Press, 2008
2	Greg Brue,"Design for Six Sigma",Tata Mc-Graw Hill.
ADDITIONAL REFERENCE BOOKS:	
1	Council for Six Sigma certification (C.S.S.C) Six Sigma: A complete Step by Step guide
2	Graeme Knowles, Six Sigma,2011.
ONLINE RESOURCES	
1	https://my.uopeople.edu/pluginfile.php/57436/mod_book/chapter/39150/SixSigma.pdf
2	http://brharnetc.edu.in/br/wp-content/uploads/2018/11/8.pdf

Bloom's level - Units Catchment Articulation Matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL5	**X**				
CO2	BL5		**X**			
CO3	BL5			**X**		
CO4	BL5				**X**	
CO5	BL5					**X**

R23MMECT028 DSC-E4	ENERGY MANAGEMENT AND AUDIT					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Heat transfer; Thermal engineering	**3**	**0**	**0**	**3**

Course Objective

This course provides a foundational understanding of energy management, conservation, and auditing. The course covers energy forms, consumption patterns, regulatory frameworks, audit methodologies, and optimization techniques. The students gain insights into monitoring tools, data analysis, financial assessment, and the environmental impact of energy use. Emphasis is placed on renewable energy and developing sustainable energy policies.

Course Outcomes

At the end of the course student should be able to

1	Develop innovative approaches for integrating various forms of energy into sustainable systems, addressing real-world consumption patterns, and ensuring energy security and conservation. (**BL5**)
2	Assess the effectiveness and limitations of existing energy management frameworks and recommend improvements based on policy integration. (**BL5**)
3	Construct advanced energy audit methodologies and create optimized energy performance models through benchmarking and innovative techniques. (**BL5**)
4	Formulate and implement comprehensive energy policies, incorporating project techniques, financial analyses, and risk management strategies to ensure long-term sustainable energy management. (**BL5**)
5	Evaluate and design renewable energy-based solutions to address global environmental issues, such as climate change and global warming, by assessing their sustainability and potential for reducing carbon footprints. (**BL5**)
6	Design innovative and sustainable energy management strategies by synthesizing energy fundamentals, policies, auditing, financial analysis, and renewable energy systems. (**BL6**)

SYLLABUS

Unit I	**FUNDAMENTALS OF ENERGY AND ENERGY CONSERVATION**	**8 hr**

Introduction to Energy Concepts; Types of Energy; Global and National Energy Scenarios; Energy Consumption Patterns; Energy Security; Energy Conservation Principles; Fundamentals of Energy Units; Role of Sustainability in Energy Use.

Unit II	**REGULATORY FRAMEWORK AND POLICIES**	**8 hr**

Basics of Electricity and Thermal Energy; Electricity Act 2003;Energy Conservation Act and BEE Schemes; National Action Plan on Climate Change; Integrated Energy Policy; International Climate Agreements; Climate Change and Energy; Policy Implementation Challenges.

Unit III	**ENERGY MANAGEMENT AND AUDIT**	**8 hr**

Introduction to Energy Management; Types of Energy Audits; Energy Performance Assessment; Energy Benchmarking; Energy Optimization Techniques; Substitution of Energy Sources; Instruments and Tools for Energy Auditing; Monitoring and Targeting Energy Use.

Unit IV	**IMPLEMENTATION AND FINANCIAL ANALYSIS**	**8 hr**

Energy Policy Planning; Project Development Techniques; Implementation of Energy Policies; Budgeting for Energy Projects; Verification and Measurement;

Financial Analysis for Energy Projects; Risk and Sensitivity Analysis; Tools for Effective Implementation.		
Unit V	**RENEWABLE ENERGY AND ENVIRONMENTAL IMPACT**	**8 hr**
Introduction to Renewable Energy; Solar Energy Fundamentals; Wind Energy Principles; Hydropower and Biomass Energy; Wave, Tidal, and Geothermal Energy; Fuel Cells and Waste-to-Energy; Environmental Impacts of Energy Use; Sustainable Development and Climate Change.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	W. C. Turner, Energy Management Handbook, 7th ed. Lilburn, GA, USA: Fairmont Press, 2007.	
2	Y. P. Abbi and S. Jain, Handbook on Energy Audit and Environment Management. New Delhi, India: TERI Press, 2006.	
3	United Nations Industrial Development Organization (UNIDO), Energy Efficiency Guide for Industry in Asia. UNIDO, 2006.	
4	P. W. O'Callaghan, Energy Management. New York, NY, USA: McGraw Hill Education, 1993.	
REFERENCE BOOKS:		
1	A. Thumann and D. P. Mehta, Fundamentals of Energy Engineering, 2nd ed. Lilburn, GA, USA: Fairmont Press, 2008.	
2	B. L. Capehart, W. C. Turner, and W. J. Kennedy, Guide to Energy Management, 6th ed. Boca Raton, FL, USA: CRC Press, 2008.	
3	Bureau of Energy Efficiency (BEE), Guidebooks.	
ADDITIONAL REFERENCE MATERIAL		
1	R. Zmeureanu and C. Marceau, Improving Energy Efficiency in Buildings. Hoboken, NJ, USA: Wiley, 2002.	
2	I. G. C. Dryden, Efficient Use of Energy. Oxford, UK: Butterworth-Heinemann, 1982.	
3	F. Kreith and J. F. Kreider, Principles of Sustainable Energy, 2nd ed. Boca Raton, FL, USA: CRC Press, 2011.	
4	T. D. Eastop and D. R. Croft, Energy Efficiency for Engineers and Technologists. Harlow, UK: Longman Scientific & Technical, 1990.	
5	C. Beggs, Energy: Management, Supply, and Conservation, 2nd ed. Oxford, UK: Butterworth-Heinemann, 2009.	
6	M. A. Rosen and I. Dincer, Exergy: Energy, Environment and Sustainable Development, 2nd ed. Amsterdam, Netherlands: Elsevier, 2017.	
ONLINE COURSES		
1	https://archive.nptel.ac.in/courses/108/106/108106022/?utm_source	
2	https://onlinecourses.nptel.ac.in/noc22_hs105/preview?utm_source	
3	https://onlinecourses.swayam2.ac.in/nou23_es05/preview?utm_source	

Bloom's level – Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL5	×				
CO2	BL5		×			
CO3	BL5			×		
CO4	BL5				×	
CO5	BL5					×
CO6	BL6	×	×	×	×	×

R23MMECT022 DSC-E5	NON DESTRUCTIVE TESTING					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Material science, Manufacturing Processes	**3**	**0**	**0**	**3**

Course Objective

To provide knowledge and practical skills in various non-destructive testing methods, enabling individuals to evaluate the integrity of materials, detect defects, and ensure safety and quality without causing damage.

Course Outcomes

1	Apply NDT knowledge to assess material properties **(BL3)**.
2	Evaluate ultrasonic testing methods to assess and interpret imperfections in components **(BL6)**.
3	Analyze radiographic testing methods to detect imperfections and implement safety precautions effectively **(BL4)**.
4	Evaluate and apply surface NDE techniques to conduct inspections in accordance with established procedures **(BL6)**.
5	Apply acoustic emission and thermal testing methods to assess integrity and monitor conditions **(BL3)**.
6	Evaluate defective samples after inspection to identify causes and propose corrective actions**(BL6)**.

SYLLABUS

Unit I	**OVERVIEW OF NDT&VISUAL EXAMINATION METHOD**	**8 hr**

Introduction to destructive and non-destructive testing, Historical disasters that affected the development of NDT; The birth of Codes and Standards, NDT Qualification and Certification; Significance of testing materials, properties of engineering materials; scope, characteristics and Limitations of NDT;Types of visual examination; Different visual examination aids; factors affecting visual testing; applications, advantages and limitations.

Unit II	**VOLUMETRIC EXAMINATION METHODS**	**8 hr**

Ultrasonic Equipment and Variables Affecting Ultrasonic Test; Principle of Wave Propagation, Reflection, Refraction, Diffraction; Mode Conversion and Attenuation; Ultrasonic Transducers and their Characteristics;Types of probes, ultrasonic inspection methods; ultrasonic data presentation techniques; Ultrasonic Testing Interpretations and Guidelines for Acceptance, Rejection; applications, advantages and Limitations of Ultrasonic Testing.

Unit III	**VOLUMETRIC EXAMINATION METHODS**	**8 hr**

Principle of radiography test**;** Types of RT sources**;** Sources of X and Gamma Rays and their interaction with Matter, properties X-rays and Gamma rays; Radiographic Image Quality indicators; Safety Aspects of Industrial Radiography; applications, advantages and limitations; Interpretation of Volumetric Examination Method:Interpretation for welds, castings etc.,; applications, various case studies, Inspection standards applicable codes, standards and specifications (ASME, ASTM, AWS, BS, IBR etc.).

Unit IV	**SURFACE EXAMINATIONS METHODS**	**8 hr**

Dye penetrant testing principle; Types of dye and methods of application; Developer application and Inspection, advantages and limitations; Magnetic Particle Inspection principle Basic theory of magnetism; Magnetization methods;

Field indicators, Particle application, Inspection;Eddy current testing; Basic principle, Faraday's law Inductance, Lenz's law; Self and Mutual Inductance, Impedance plane, Inspection system and probes, advantages and limitations.		
Unit V	**INTEGRITY EXAMINATION &CONDITION MONITORING METHOD**	**8 hr**
Introduction to Acoustic Emission Testing; Acoustic Emission Equipmentand Data display, Sources of acoustic emission;Kaiser-Felicity theory,applications, advantages and limitations. Introduction and fundamentals to infrared and thermal testing; radiation laws; Active and passive techniques, factors affecting the thermal measurement; Types of thermographic cameras, Lock in and pulse thermography, Contact and non-contact thermal inspection methods; advantages, limitations and applications.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	Non-Destructive Examination and Quality Control, ASM International, Vol.17, 9th edition, 1989.	
2	J. Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGra Hill Education, 2nd edition, 2011.	
3	B. Raj, T. Jayakumar and M. Thavasimuthu, Practical Non Destructive Testing, Alpha Science International Limited, 3rd edition, 2002.	
4	T. Tangachari, J. Prasad and B.N.S. Murthy, Treatise on non-destructive testing and evaluation, Navbharath Enterprises, Vol.3, 1983.	
REFERENCE BOOKS:		
1	C. Hellier, Handbook of Nondestructive Evaluation, McGraw-Hill Professional, 1st edition, 2001.	
2	J. Thomas Schmidt, K. Skeie and P. MacIntire, ASNT Non Destructive Testing Handbook: Magnetic Particle Testing, American Society for Nondestructive Testing, American Society for Metals, 2nd edition, 1989.	
3	V. S. Cecco, G. V. Drunen and F. L. Sharp, Eddy current Manual: Test method, Vol.1, Chalk River Nuclear Laboratories, 1983.	
ONLINE COURSES		
1	https://www.nde-ed.org	
2	https://www.youtube.com/watch?v=5cNWF61Tmj0&list=PLyAZSyX8Qy5AePdV6vbGP4OJQOpbga-0Q	

Bloom's level – Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL6		X			
CO3	BL4			X		
CO4	BL6				X	
CO5	BL3					X
CO6	BL6	X	X	X	X	X

R23MMECT029 DSC-E5	SUSTAINABLE DESIGN OF BUILDINGS					
	Total Contact Hours	42(L)	**L**	**T**	**P**	**C**
	Pre-requisite	Heat transfer, Thermal engineering	**3**	**0**	**0**	**3**

Course Objective

The objective of the course is to equips students with skills to design energy-efficient, environmentally responsible buildings. It covers sustainable design principles, renewable energy, green building technologies, and the use of materials that minimize environmental impact. Students will explore energy modeling, resource efficiency, and green building standards like LEED to develop solutions that reduce the carbon footprint and enhance occupant comfort.

Course Outcomes

1	To evaluate real-world challenges by applying fundamental concepts and strategies of sustainable building design, including energy efficiency, resource conservation, and environmental impact reduction, to recommend effective solutions. (**BL5**)
2	To design building solutions incorporating eco-friendly materials and construction methods that optimize energy efficiency and minimize environmental impact. (**BL5**)
3	To evaluate the effectiveness of proposed solutions to reduce energy consumption in buildings and recommend improvements. (**BL5**)
4	To evaluate the compliance of building designs with green building standards such as LEED and BREEAM to ensure environmental sustainability, occupant health, and regulatory adherence. (**BL5**)
5	To designand integrate renewable energy systems into building layouts to decrease reliance on non-renewable energy sources while meeting project-specific requirements. (**BL5**)
6	To create a comprehensive sustainable building proposal that integrates sustainability principles, reduces environmental impacts, optimizes energy efficiency, ensures occupant comfort, and adheres to green building standards. (**BL6**)

SYLLABUS

Unit I	**INTRODUCTION TO SUSTAINABILITY**	**8 hr**

Definition and principles of sustainability; Historical development of sustainable practices; Role of early civilizations in shaping sustainability concepts; Industrial Revolution's impact on the environment; Evolution of modern sustainability frameworks; Key contributions of pioneers like Rachel Carson and Gro Harlem Brundtland; Link between sustainability and economic growth; Global initiatives.

Unit II	**ENVIRONMENTAL IMPACTS**	**8 hr**

Pollution types: water, soil, and air contamination; Impacts of deforestation and urbanization on land; Depletion of freshwater resources and its effects on ecosystems; Air quality deterioration and its influence on human health; Greenhouse gas emissions and climate change; Biodiversity loss due to environmental degradation; Economic consequences of resource overexploitation; Social disparities resulting from environmental crises and resource scarcity.

Unit III	SUSTAINABLE DESIGN PRINCIPLES	8 hr
Key definitions of sustainable design and green building; The role of energy efficiency in design; Water conservation strategies in sustainable buildings; Materials selection based on sustainability; Indoor environmental quality for occupant health; Design for longevity and minimal environmental impact; Green building rating systems (e.g., LEED, BREEAM); The integration of renewable energy sources in buildings.		
Unit IV	**COMFORT AND CLIMATE**	**8 hr**
Thermal comfort factors; Strategies for natural ventilation and passive cooling; The impact of building orientation on temperature regulation; Visual comfort and lighting strategies for energy efficiency; Daylighting techniques to reduce artificial lighting needs; Acoustic comfort considerations in building design; Use of soundproofing materials for noise control; Integration of climate-responsive design features for overall comfort.		
Unit V	**SUSTAINABLE SITES AND RESOURCES**	**8 hr**
Principles of sustainable site selection and planning; Water conservation strategies; Choosing sustainable, low-impact building materials; Design techniques to maximize energy efficiency; Energy modeling and simulation for performance optimization; Use of renewable energy sources; Green roofs and sustainable landscaping; Performance evaluation metrics		
LEARNING RESOURCES		
TEXT BOOKS:		
1	C. J. Kibert, Sustainable Construction: Green Building Design and Delivery, 4th ed. Hoboken, NJ, USA: Wiley, 2016.	
2	A. Roth, Sustainable Design for the Built Environment: A Guide to Green Building, 2nd ed. London, UK: Routledge, 2013.	
3	P. Jones and J. A. de la Hoz, Sustainable Building Design: Principles and Practice, 2nd ed. Hoboken, NJ, USA: Wiley, 2017.	
REFERENCE BOOKS:		
1	N. Baker and K. Steemers, Energy and Environment in Architecture: A Technical Design Guide. London, UK: Routledge, 2000.	
2	P. Sassi, Strategies for Sustainable Architecture. Abingdon, UK: Taylor & Francis, 2006.	
3	A. D. Little and J. F. Foster, The Green Building Revolution: Sustainable Architecture for the 21st Century. New York, NY, USA: McGraw-Hill, 2005.	
ADDITIONAL REFERENCE MATERIAL		
1	T. Liptan, Sustainable Building Systems and Construction for Designers. Lilburn, GA, USA: Fairmont Press, 2013.	
2	J. C. Dyer, Introduction to Green Building: Sustainable Design and Construction. Upper Saddle River, NJ, USA: Pearson, 2014.	
3	F. D. K. Ching and M. Juroszek, Building Construction Illustrated, 5th ed. Hoboken, NJ, USA: Wiley, 2012.	
4	J. M. Harris, Environmental and Energy Efficient Building Design: A Guide for Sustainable Architecture. New York, NY, USA: McGraw-Hill, 2010.	
5	L. Wang and M. Xu, Green Building: Design and Construction. Cham, Switzerland: Springer, 2016.	

6	B. Gething, The Green Building Handbook: Volume 1 & 2. Abingdon, UK: Routledge, 2014.
ONLINE COURSES	
1	https://onlinecourses.nptel.ac.in/noc20_ar01/preview?utm_source
2	https://onlinecourses.nptel.ac.in/noc23_ce51/preview?utm_source
3	https://onlinecourses.nptel.ac.in/noc19_ce40/preview?utm_source

Bloom's level – Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL5	×				
CO2	BL5		×			
CO3	BL5			×		
CO4	BL5				×	
CO5	BL5					**×**
CO6	BL6	**×**	**×**	**×**	**×**	**×**

VIII Semester

EOEC-E1(Self-Study/MOOCs)

R23MCSCT007 EOEC-E1	**COMPUTER NETWORKS (Common to all Branches)**					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisites	DLD, CAO	**3**	**0**	**0**	**3**

Course Objective

Students will gain an ability to identify and design network architecture and apply the essence of various protocols.

Course Outcomes

1	Students will be able to analyse and **apply** key concepts of data communication, including network topologies, layering, and protocols; the OSI and TCP/IP reference models in order to design and evaluate efficient communication systems. **(BL3**)
2	Students will be able to **describe**, **demonstrate**, and **analyse** various data link layer techniques and apply this knowledge to design and evaluate reliable data communication systems. (**BL4**)
3	Students will be able to **identify**, **explain**, and **apply** random access methods and assess their impact on the performance and evolution of network communication systems.(**BL3**)
4	Students will be able to **describe**, **compare**, and **apply** the roles of connecting devices (switches, hubs, routers, bridges, gateways), **analyze** and **evaluate** various routing algorithms and **assess** the effectiveness of flooding in network communication.(**BL5**)
5	Students will be able to **compare**, and **apply** the TCP and UDP datagram formats, congestion control techniques and flow control methods and their roles in Internet communication.(**BL4**)
6	Students will be able to design and evaluate efficient, reliable and effective network communication systems.(**BL6**)

SYLLABUS

Unit I	**OVERVIEW OF DATACOMMUNICATION AND NETWORKING**	**8 hr**

Introduction to Data Communication**;** Network Topologies, Layering and Protocols; Reference-Model: OSI & TCP/IP Reference Model, Addressing; Physical Layer-Different types of Transmission Media-Guided; Different types of Transmission Media-Unguided; Multiplexing-TDM,FDM,WDM; Line Encoding (NRZ,NRZI,Manchester,AMI,4B/5B); Switching and Taxonomy: Circuit Switched, Packet Switched.

Unit II	**DATALINK LAYER : ERROR CONTROL & FLOW CONTROL**	**8 hr**

Error Detection: CRC, Checksum; Error Correction: Hamming Distance, Linear Block Codes Framing: Bit and Byte Stuffing ; Flow Control: Noiseless-Simplest, Stop and Wait; Noisy: Stop and wait ARQ; Go Back N, Selective repeat; PPP, HDLC; Random Access: Aloha: Pure and Slotted;

Unit III	**DATALINK LAYER**	**8 hr**

Random Access: CSMA, CSMA/CD; Random Access: CSMA/CA; Controlled

Access-Reservation, Polling and Token passing; Channelization-FDMA; TDMA and CDMA; Standard Ethernet-MAC; Standard Ethernet-Physical Layer; Changes in the Standard- Fast Ethernet; Gigabit Ethernet,10 Gigabit Ethernet.		
Unit IV	**NETWORK LAYER**	**8 hr**
ConnectingDevices-Switches,Hubs,Routers,Bridges,Gateways;IPv4addressing-Classful,Classless; IPv4 Datagram Format,IPv6 Datagram Format; Address Mapping: ARP; RARP,BOOTP, DHCP; Routing: Routing table, Optimization, Distance Vector Routing ; Link State Routing, Path Vector Routing;		
Unit V	**TRANSPORT LAYER AND APPLICATION LAYER**	**8 hr**
TRANSPORT LAYER: TCP Datagram Format; UDP Datagram Format; Congestion Control: Data Traffic, Open Loop, Closed Loop; Quality of Service: Flow characteristics, Scheduling ; Flow Control: Leaky Bucket and Token Bucket; **REMOTE LOGIN & APPLICATION LAYER:** Telnet, Electronic Mail; DNS, Distribution of Name Space, DNS in the Internet; WWW and HTTP.		
LEARNING RESOURCES		
TEXTBOOKS:		
1	Data Communications and Networking, Behrouz Forouzan ,4th Edition,McGrawHill.	
REFERENCE BOOKS:		
1	Computer Networks –Andrew S Tanenbaum,4th Edition, Pearson Education/PHI.	
2	Computer Networking: *A Top Down Approach-James F Kurose and Keith W Ross,* 6th Edition, Pearson Education.	
ADDITIONAL REFERENCE MATERIAL		
1	https://www.geeksforgeeks.org/computer-network-tutorials	
2	https://www.javatpoint.com/computer-network-tutorial	
3	https://www.tutorialspoint.com/data_communication_computer_network	
ONLINE COURSES		
1	https://onlinecourses.nptel.ac.in/noc22_cs19	
2	https://www.coursera.org/learn/illinois-tech-computer-networking	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL3			X		
CO4	BL5				X	
CO5	BL4					X
CO6	BL6	X	X	X	X	X

EOEC-E1 (Self-Study/MOOCs)

R23MCSCT003	ARTIFICIAL INTELLIGENCE: PRINCIPLES AND TECHNIQUES (for MEC, ECE, EEE, CIV and CHE)					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Data Structures	**3**	**0**	**0**	**3**

Course Objective

This course aims to help students conversant with the theoretical concepts and algorithm approaches that can be applied to the design of AI applications and students will gain insights into foundational principles, algorithms, and theoretical frameworks underlying Machine Learning.

Course Outcomes

After completing this course, the students will be able to

1	Apply AI Search Algorithms and Backtracking Techniques to Solve Constraint Satisfaction Problems. (**BL3**)
2	Analyze and Compare the Applications and Limitations of Propositional Logic and First-Order Logic in Knowledge Representation and Reasoning. (**BL4**)
3	Apply Machine Learning Techniques and Neural Network Models to Solve Real-World Problems Across Various Domains. (**BL3**)
4	Analyze and Compare the Effectiveness of the Find-S and Candidate Elimination Algorithms in Designing a Learning System, Focusing on Version Spaces and Their Applications. (**BL4**)
5	Evaluate the Effectiveness and Applicability of Decision Tree Learning and Single and Multi-Layer Perceptrons in Solving Classification Problems Across Various Domains. (**BL5**)
6	Design and Develop an Integrated Intelligent System that Utilizes AI Search Algorithms, Knowledge Representation, and Machine Learning Techniques, Including Decision Trees and Neural Networks, to Solve Complex Real-World Problems. (**BL6**)

SYLLABUS

Unit I	**INTRODUCTION TO ARTIFICIAL INTELLIGENCE**	**8 hr**

Introduction to Artificial Intelligence (AI), machine learning, deep learning, Types of AI, Advantages and Applications of AI; Agents in Artificial Intelligence, Types of agents; State Space Search: Uninformed search: (Iterative Deepening, Bidirectional search); Informed search: Best First Search; A* Algorithm; Hill Climbing Algorithms in Artificial Intelligence (Simple and Steepest Ascent); Constraint satisfaction problems (Constraint propagation: Arc Consistency), Backtracking Algorithm for CSP's; Knowledge-Based Agent (KBA): Architecture and Various level of KBA.

Unit II	**KNOWLEDGE REPRESENTATION AND REASONING**	**8 hr**

Knowledge representation (KR), Approaches to KR, Techniques of KR; Propositional Logic, Logical Connective and Equivalence; Rules of Inference; PEAS description of Wumpus world; First Order Logic in AI, Inference in First-Order Logic; Knowledge Engineering in First-order logic; Forward Chaining and backward chaining in AI; Reasoning in Artificial intelligence;

Unit III	**BASICS AND TYPES OF MACHINE LEARNING**	**8 hr**

Conceptual introduction to Machine Learning and Neural Networks: Biological

Neural Networks and Artificial Neural Networks; Supervised Learning: (Linear and Non-Linear regression); Logistic Regression; Classification: Decision Tree and Support Vector Machines; Unsupervised Learning (clustering approach); Association; Semi-Supervised Learning; Reinforcement Learning		
Unit IV	**MACHINE LEARNING TRAINING EXAMPLES**	**8 hr**
Well Posed Learning Problems, Designing A Learning System, Perspectives and Issues in Machine Learning; Introduction to Concept Learning: A Concept Learning as a Task; Concept Learning as Search; Find-S: Finding a Maximally Specific Hypothesis; Version Spaces Representation: The List-Then-Eliminate Algorithm, Compact Representation for Version Spaces; Candidate Elimination Algorithm and Example; Remarks on Version Spaces and Candidate-Elimination: Converge, Order of Training Examples, Usage of Partially Learned Concepts; Inductive Bias		
Unit V	**DECISION TREE LEARNING AND SINGLE AND MULTI-LAYER PERCEPTRON**	**8 hr**
Introduction, Decision Tree Representation and Appropriate Problems for Decision Tree Learning;ID3 Algorithm: An Illustrative Example; Hypothesis Space Search and Inductive Bias in Decision Tree Learning; Neural Network Representation, Appropriate Problems for Neural Network Learning; Perceptrons - Representational Power of Perceptrons, The Perceptron Training Rule; Gradient Descent and The Delta Rule, Stochastic Approximation to Gradient Descent; Multilayer Networks and The Back Propagation Algorithm - A Differentiable Threshold Unit; The Back Propagation Algorithm		
LEARNING RESOURCES		
TEXTBOOKS:		
1	Tom M. Mitchell "Machine Learning", Indian Edition.	
2	Stuart J. Russell and Peter Norvig, "Artificial Intelligence A Modern Approach", Third Edition.	
3	Kevin Knight, Elaine Rich, B. Nair, "Artificial Intelligence", Tata McGraw-Hill Education, 3rd Edition, 2010.	
REFERENCE BOOKS:		
1	Christopher M. Bishop, "Pattern recognition and machine learning", Springer,2007.	
2	Ethem Alpaydin, "Introduction to Machine Learning", PHI, Third edition, 2015.	
ADDITIONAL REFERENCE MATERIAL		
1	https://www.javatpoint.com/artificial-intelligence-ai/	
2	https://www.geeksforgeeks.org/machine-learning/	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL3			X		
CO4	BL4				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

EOEC-E1(Self-Study/MOOCs)

R23MCSCT009	OOAD AND DESIGN PATTERNS (Common to all Branches)					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Prerequisite	Object Oriented Programming	**3**	**0**	**0**	**3**

Course Objectives

1. Understand the importance and basic concepts of object oriented modeling,
2. Specify, analyze and design the requirements for a system and model the state of the set of objects and their implementation specifications.
3. Identify, Analyze the subsystems, various components and collaborate them interchangeably.
4. Describe the design patterns that are common in software applications
5. Design a module structure to solve a problem, and evaluate alternatives

Course Outcomes

On the successful completion of this course, Students will be able to

1	Examine the Object Oriented Models required for Software development through use case driven approach. (**BL4**)
2	Categorize and model the structural and behavioural concepts of the software system. (**BL4**)
3	Develop and explore the transformation of conceptual models into various scenarios and real time applications. (**BL4**)
4	Construct a design consisting of a collection of modules using creational and structural design patterns.(**BL5**)
5	Identify appropriate behavioral patterns to demonstrate the dynamic aspects of a given software model during execution.(**BL5**)
6	Design a Small-Scale Application with Unified Models and Integrated Design Patterns.(**BL6**)

SYLLABUS

Unit I	**INTRODUCTION TO UNIFIED MODELING LANGUAGE**	**8 hr**
Introduction to UML, Importance of Modeling; Principles of Modeling; Object oriented modeling; Conceptual model of UML: Basic building blocks; Conceptual model of UML: Rules; Conceptual model of UML: Common Mechanisms; Architecture; Software Development life cycle		
Unit II	**STRUCTURAL MODELING**	**8 hr**
Basic Structural Modeling: Classes ; Relationships; Common Mechanisms; Diagrams; Advanced Structural Modeling: Advanced classes; Advanced Relationships; Interfaces, Types and Roles**;** Packages & Instances**;**		
Unit III	**ARCHITECTURAL MODELING & UML 2.0**	**8 hr**
Usecase Diagrams**;** Interactions : Sequence & Collaboration Diagrams**;** Activity Diagrams**;** State Diagrams; Component Diagrams; Deployment Diagrams; Updations in UML 2.0: Interaction overview diagram and Timing diagrams; Unified Process Models in Software Engineering;		
Unit IV	**DESIGN PATTERNS-1**	**8 hr**
Introduction to Design patterns; Creational Design Patterns : Factory Method & Abstract Factory; Builder; Prototype; Singleton; Case study on Creational Design Patterns ; Structural Patterns: Adapter ; Bridge;		
Unit V	**DESIGN PATTERNS-2**	**8 hrs**

Composite; FlyWeight; Case study on Structural Patterns; Behavioral Patterns: Chain of Responsibility; Iterator; Memento ; Observer ; Case study on Behavioral Patterns	
LEARNING RESOURCES	
TEXTBOOKS:	
1	Grady Booch, James Rumbaugh, Ivar Jacobson: The Unified Modeling Language User Guide, Pearson Education.
2	Design Patterns By Erich Gamma, Pearson Education.
3	Hans-Erik Eriksson, Magnus Penker, Brian Lyons, David Fado: UML 2 Toolkit, WILEY-Dreamtech India Pvt. Ltd.
REFERENCE BOOKS:	
1	https://www.ibm.com/developerworks/rational/library/769.html
2	https://www.visual-paradigm.com/tutorials/uml-class-diagram-in-diff-programming-languages.jsp
3	https://www.uml-diagrams.org/index-examples.html
4	https://www.tutorialspoint.com/design_pattern/
5	http://www.oodesign.com/
6	https://praveenthomasln.wordpress.com/2012/03/03/interfaces-types-and-roles-s8-cs/
7	https://www.uml-diagrams.org/uml-25-diagrams.html
8	https://www.tutorialspoint.com/uml/uml_2_overview.htm#:~:text=UML%202.0%20offers%20four%20interaction,of%20interactions%20as%20interaction%20occurrences.
ONLINE COURSES	
1	NPTEL :: Computer Science and Engineering - NOC: Object-Oriented Analysis and Design
2	https://onlinecourses.nptel.ac.in/noc22_cs99/preview

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL4	X				
CO2	BL4		X			
CO3	BL4			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

HONORS COURSES

Thread-I: Manufacturing Sector

S.No	Course Code	Course Title	L	T	P	Credits	Sem
1	**R23MMECHT01**	Project Management	3	0	0	3	VI
2	**R23MMECHT02**	Nanotechnology	3	0	0	3	VI
3	**R23MMECHT03**	Additive Manufacturing	3	0	0	3	VII
4	**R23MMECHT04**	Design for Manufacturing and Assembly	3	0	0	3	VII
5	**R23MMECHT05**	Material Characterization Techniques	3	0	0	3	VIII
6	**R23MMECHT06**	Surface Engineering	3	0	0	3	VIII
Total Credits						**18**	

R23MMECHT01	PROJECT MANAGEMENT					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Prerequisite		**3**	**0**	**0**	**3**

Course Objective

Equip students with a comprehensive understanding of project management principles, tools, and techniques necessary for successful project initiation, planning, execution, monitoring, control, and closure.

Course Outcomes

1	Evaluate project management concepts, tools, and techniques to develop strategic project selection, risk assessment, and recommend optimal project management approaches tailored to contemporary organizational needs.(**BL5**)
2	Assess organizational concepts, feasibility studies, and project planning techniques to develop comprehensive project management strategies, conflict resolution approaches for effective project execution.(**BL5**)
3	Evaluate financial appraisal techniques, project budgeting methods, and project control processes to develop informed decision and to integrate earned value analysis within a computerized project management information system.(**BL5**)
4	Analyze advanced scheduling techniques, including PERT, CPM, and Critical Chain, to optimize project timelines and resource allocation, demonstrating the ability to develop strategic solutions for multi-project scheduling, risk management, and constrained resource scenarios.(B**L5**)
5	Evaluate project auditing processes, termination strategies, and final reporting frameworks to synthesize comprehensive project completion strategies, including considerations for software project management.(**BL5**)
6	Design and develop innovative, data-driven project management frameworks by integrating advanced tools, techniques, and financial appraisal methods to optimize project selection, scheduling methodologies, and project auditing processes to contemporary organizational and technological needs. (**BL6**)

SYLLABUS

Unit I	**INTRODUCTION TO PROJECTMANAGEMENT**	**8 hr**

Concept of a Project Meaning; classification, Characteristic features; Project considerations, Project Management and Tools and techniques for project management; Role of project Managers, Projects in Contemporary Organization; Project Initiation: Strategic Management; Project Selection & Evaluation; Organization and project considerations; Risk Management, Portfolio Process and Project portfolio management system.

Unit II	**PROJECT ORGANIZATION**	**8 hr**

Organizational concepts in PM; Project feasibility studies; Project life cycle; Project constraints and Project Planning; Systems integration and WBS; Responsibility Charts; Interface coordination; Conflict and Negotiation in PM.

Unit III	**PROJECT EVALUATION UNDER CERTAINTY**	**8 hr**

Net Present Value, Benefit cost ratio; Internal rate of return, & payback period; Accounting rate of return, Estimating Project Budgets; Project evaluation under uncertainty: Methodology, commercial vs. National

profitability; Commercial or national profitability & social profitability; Information Needs & Reporting Process, Earned Value Analysis & Computerized PMIS; Project Control process: Need for Project Control, control issues, Types; Design of Control Systems, Control of Creative Activities.		
Unit IV	**PROJECT IMPLEMENTATION AND SCHEDULING**	**8 hr**
Scheduling: Background, Network Techniques: PERT; CPM; Risk Analysis; Crashing a Project and Resource Allocation; Resource Loading and Levelling; Constrained Resource Scheduling; Multi- project Scheduling & Resource Allocation; Goldratt's Critical Chain.		
Unit V	**PROJECT TERMINATION**	**8 hr**
Project Auditing, System Goals; Project Audit & Audit Report; Project Audit Life Cycle; Project Termination; Varieties of Project Termination & Termination Process; Final Report, Project Completion; Review and Future Directions; Introduction to software project management.		
LEARNING RESOURCES		
TEXTBOOKS:		
1	Clifford F. Gray and Erik W. Larson*, Project management – The Managerial Process,* Tata McGraw Hill, 2014.	
2	Prasanna Chandra, *Project Planning, Analysis, Selection, Implementation and review,* Tata McGraw Hill,2009.	
3	Harold R. Kerzner,Project Management: A Systems Approach to Planning, Scheduling, and *Controlling 10th Edition, 2012.*	
REFERENCE BOOKS:		
1	Moder, J., C. Phillips and E. Davis, "*Project Management with CPM, PERT and Precedence Diagramming*", Van Nostrand Reinhold Company, Third Edition, 2003.	
2	*United Nations Industrial Development Organization (UNIDO) Manual for the preparation of Industrial Feasibility Studies", (IDSI Reproduction) Bombay, 2007.*	
ADDITIONAL REFERENCE MATERIAL		
1	*A Guide to the Project Management Body of Knowledge (PMBOK® Guide) — Fifth Edition.*	
ONLINE COURSES		
1	https://onlinecourses.nptel.ac.in/noc19_mg30/preview	
2	https://onlinecourses.nptel.ac.in/noc22_mg71/preview	
3	https://onlinecourses.nptel.ac.in/noc24_mg01/preview	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL5	X				
CO2	BL5		X			
CO3	BL5			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MMECHT02	NANO TECHNOLOGY					
	Total Contact Hours		**L**	**T**	**P**	**C**
	Pre-requisite	Engineering Physics and Material Science	**3**	**0**	**0**	**3**

Course Objective

Students will gain a comprehensive understanding of nanoscale phenomena and the interdisciplinary nature of nanotechnology.

Course Outcomes

1	Acquire understanding of the basics of nanotechnology and diverse approaches to synthesis methods. (**BL 3**)
2	Identify the properties of nanomaterials for intended applications. (**BL 3**)
3	Contrast the distinct properties of carbon-based nanomaterials, metals, and polymers in the context of energy and electronic applications. (**BL 5**)
4	Classify various nano devices along with their respective applications. (**BL 4**)
5	Demonstrate the instrumental techniques for characterization of nanomaterials. (**BL 5**)
6	Suggest appropriate nanomaterials considering their characteristics and fabrication techniques for intricate nano devices, and recommend applications. (**BL6**)

SYLLABUS

Unit I	**FOUNDATIONS OF NANOTECHNOLOGY AND FABRICATION METHODS**	**8 hr.**

Introduction to Nanotechnology; Historical Perspective and Milestones; Physical Methods: Physical Vapour Deposition (PVD); Arc discharge, DC sputtering; Ion sputtering, RF & Magnetron sputtering; Ball Milling; Chemical Methods: Sol-gel, micro and macro emulsions; Chemical vapour deposition.

Unit II	**PROPERTIES OF NANO MATERIALS**	**8 hr.**

Fundamentals of Di-electrical properties of bulk materials; Di-electrical properties of nano structured materials; Fundamentals of magnetic Properties(magnetics dipole and domain structure); Magnetic properties of nano structured materials (super para magnetism); Optical Properties (Gold , ZnO, quantum dots); Optical Properties on nano structured materials; Impact of nano scale on mechanical properties; Creep properties of nano structured materials.

Unit III	**NANOMATERIALS**	**8 hr.**

Carbon-based Nanomaterials (Fullerenes); Carbon-based Nanomaterials (Graphene, Carbon Nanotubes); Metal and metal oxide nanowires; Metal and Semiconductor Nanoparticles; Polymeric Nanomaterials; Nano toxicology and Biocompatibility; Nanomaterials for electronic Applications. (Nano lithography, Data storage);
Nanomaterials for electronic Applications:Nano capacitors;

Unit IV	**NANO DEVICES AND APPLICATIONS**	**8 hr.**

Nano sensors and Nano probes; Nano medicine and Drug Delivery; Nanotechnology in Energy Harvesting; Nano fluids; Nanorobotics: Current State and Future Prospects;Nano-catalysts andRe-chargeable batteries;

Nanotechnology in Hydrogen storage; Nanotechnology in Space Exploration.		
Unit V	**NANOSCALE CHARACTERIZATION TECHNIQUES**	**8 hr.**
Scanning Electron Microscopy;Scanning Tunneling Microscopy;Transmission Electron Microscopy (TEM); X-ray Diffraction (XRD) at the Nanoscale; Atomic Force Microscopy (AFM) Applications;Nanoscale Mechanical Testing; Fourier Transform Infrared Spectroscopy; Raman Spectroscopy.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	Charles P. Poole Jr. and Frank J. Owens:Poole Jr., C. P., & Owens, F. J.*Introduction to Nanotechnology*" John Wiley & Sons. (2003).	
2	Ben Rogers, Sumita Pennathur, and Jesse Adams: Rogers, B., Pennathur, S., & Adams, J. *"Nanotechnology: Understanding Small Systems*" CRC Press. (2012).	
3	A.S. Edelstein and R.C. Cammarata: Edelstein, A. S., & Cammarata, R. C. "*Nanomaterials: Synthesis, Properties, and Applications*" CRC Press. (1996).	
REFERENCE BOOKS:		
1	Mohan Sundara Rajan, *Nano the next revolution*, National Book Trust, India, 2004	
2	Mauro Sardela, *Practical Materials Characterization*, Springer, 2014.	
ADDITIONAL REFERENCE MATERIAL		
1	https://www.kth.se/social/upload/54062f97f2765416cecdfd74/HT14-IM2655_Lecture%201.pdf	
2	https://www.uc.edu/content/dam/refresh/cont-ed-62/olli/olli_docs/nano-meta-materials.pdf	
3	https://www.sathyabama.ac.in/sites/default/files/course-material/2020-10/note_1519281428.pdf	
4	https://ia801001.us.archive.org/34/items/2011.06.28.nanotechnologyanintroduction2011/2011.06.28.%20Nanotechnology%20%20An%20Introduction%20%282011%29.pdf	
ONLINE COURSES		
1	https://nptel.ac.in/courses/118102003	
2	https://archive.nptel.ac.in/courses/113/106/113106093/	
3	https://nptel.ac.in/courses/118104008	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL 3	X				
CO2	BL 3		X			
CO3	BL 5			X		
CO4	BL 4				X	
CO5	BL 5					X
CO6	BL 6	X	X	X	X	X

R23MMECHT03	ADDITIVE MANUFACTURING					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Prerequisite	Manufacturing Technology and Processes.	**3**	**0**	**0**	**3**

Course Objective

Students will Comprehend the Evolution, Functionalities, and Comparative Analysis of Additive Manufacturing (AM) Processes, Assessing Prototyping Techniques, Tooling Methods, Software, and Diverse Applications.

Course Outcomes

1	Assess Additive Manufacturing Processes, and Liquid-Based Systems by Critical Analysis and Comparative Assessment. (**BL5**)
2	Assess Solid-Based AM Systems, Assess LOM, FDM Applications and Analyzing Powder-Based Systems for Strategic Decision-Making in Advanced Manufacturing.(**BL5**)
3	Assess the Rapid Tooling's necessity, diverse methods, and advanced techniques, enabling informed comparative assessments and strategic application perspectives.(**BL5**)
4	Elaborate diverse file formats, and conduct comprehensive assessments of Additive Manufacturing software, while predicting emerging trends for strategic adoption.(**BL5**)
5	Assess AM Evolution and its Role in Industries, and Futuristic Trends. Enable Strategic Comparison between Manufacturing and Prototyping for Advanced Applications.(**BL5**)
6	Integrate Critical Analyses, Comparative Assessments, and Strategic Decision-Making across AM Processes, Tools, Software, Industry Applications, and Future Trends to Innovate Advanced Manufacturing Practices.(**BL6**)

SYLLABUS

Unit I	**LIQUID BASE AM PROCESSES**	**8 hr**

Prototyping Fundamentals; Advantages and Challenges of Rapid Prototyping; Digital Manufacturing Classification; Liquid-Based Additive Manufacturing Technologies; Layering Techniques in Additive Manufacturing; Laser Applications in Additive Manufacturing; Principles of Stereolithography (SLA) and Solid Ground Curing (SGC); Comparative Analysis of Liquid-Based and Solid-Based AM Systems.

Unit II	**SOLID BASE AND POWDER BASED AM PROCESSES**	**8 hr**

Overview of Solid and Powder-Based Digital Manufacturing Systems; Laminated Object Manufacturing (LOM) Process and Working Principle; Fused Deposition Modeling (FDM) Operation and Insights; Applications of LOM and FDM in Manufacturing; Advantages LOM Technology and FDM Technology; Limitations and Challenges of LOM and FDM Systems; Selective Laser Sintering (SLS); 3D Printing (3DP) in Powder-Based Manufacturing.

Unit III	**RAPID TOOLING**	**8 hr**

Fundamentals and Importance of Rapid Tooling (RT); Need, Significance, and Applications of RT; Indirect Rapid Tooling Methods and Casting Techniques; 3D Kel-Tool Process: Principles and Applications; Direct Rapid Tooling Techniques and Processes; EOS Direct Tool Process: Overview and Benefits; Direct Metal Tooling Using 3D Printing (3DP); Comparative Analysis of RT Methods and Their Application Scope.

Unit IV	SOFTWARES AND FORMATS	8 hr
Understanding the STL Format and Its Role in Rapid Prototyping; STL File Issues: Common Problems and Repair Techniques; Alternative File Formats for Digital Manufacturing; Introduction to Digital Manufacturing Software; Utilizing STL View for Enhanced Digital Manufacturing; Applications of 3Data Expert in Digital Manufacturing; Using 3D Doctor for Model Repair and Preparation in Digital Manufacturing; Comparative Analysis of Digital Manufacturing Software and Emerging Trends.		
Unit V	**ENGINEERING APPLICATIONS OF AM**	**8 hr**
Digital Manufacturing Applications in Aerospace and Automotive Industries; Digital Manufacturing in Jewelry, Coin Production, Geo spatial and GIS; Role of Digital Manufacturing in Arts and Architectural Design; Medical and Bioengineering Innovations Through Digital Manufacturing; Principles and Applications of Direct Digital Manufacturing (DDM); Comparative Evolution of Additive Manufacturing Technologies; Future Trends in Additive Manufacturing; Strategic Importance of Digital Manufacturing for Industry Advancements.		
LEARNING RESOURCES		
TEXTBOOKS:		
1	C. K. Chua, K. F. Leong, and C. S. Lim, *Rapid Prototyping: Principles and Applications*, 3rd ed. Singapore: World Scientific Publishing Company, Jan. 2010.	
2	D. Pham and S. S. Dimov, *Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling*. London, U.K.: Springer Science & Business Media, Dec. 2012.	
3	T. Wohlers, *Wohlers Report 2000: Rapid Prototyping*. Fort Collins, CO, USA: Wohlers Associates, 2000.	
REFERENCE BOOKS:		
1	R. P. Jackson, *Rapid Prototyping & Manufacturing*. New York, NY, USA: ASME Press, 2020.	
2	F. W. Liou, *Rapid Prototyping and Engineering Applications*. Boca Raton, FL, USA: CRC Press.	
3	A. Ghosh, *Introduction to Rapid Prototyping*. New Delhi, India: North-West Publication.	
ADDITIONAL REFERENCE MATERIAL		
1	D. T. Flham and S. S. Dinjoy, *Rapid Manufacturing*. London, U.K.: Verlog, 2001.	
2	L. Wood, *Rapid Automated*. New York, NY, USA: Indus Press.	
ONLINE COURSES		
1	https://archive.nptel.ac.in/courses/112/103/112103306/	
2	https://onlinecourses.nptel.ac.in/noc22_me130/preview	
3	https://onlinecourses.nptel.ac.in/noc22_me74/preview	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL5	X				
CO2	BL5		X			
CO3	BL5			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MMECHT04	DESIGN FOR MANUFACTURING AND ASSEMBLY					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Prerequisite	Manufacturing Processes, Manufacturing Technology	**3**	**0**	**0**	**3**

Course Objective

To address the challenges for manufacturing and assembly of product even though the desired it is well designed.

Course Outcomes

After completing this course, the student will be able to

1	Understand the steps involved in DFMA and its advantages of applying DFMA during product design.(**BL4**)
2	Select suitable material and shapes for a given component.(**BL5**)
3	Understand different manufacturing processes and select suitable material and right technique for component to be produced. (**BL5**)
4	Understand different types joints and select suitable joint for given application. (**BL6**)
5	Analyze different modes of failure and steps involved in optimizing design.(**BL6**)

SYLLABUS

Unit I		**8 hr**

Introduction to DFMA: Steps for applying DFMA during product design; Steps for applying DFMA during product design; Advantages & Disadvantages of applying DFMA during product design;Need Identification in DFMA; Problem Definition; Concept Generation ;Embodiment Design.

Unit II	**SELECTION OF MATERIALS AND SHAPES**	**8 hr**

Fundamentals on selection of Materials, Properties of Engineering Materials; Case Study-1 (Machine tool industries); Case study-2 (Automobile Sector); Case study-3(Energy Sector); Selection of Shapes for foundry; Selection of Shapes for die forging; Co-selection of Materials and Shapes; Case Study-3.

Unit III	**SELECTION OF MANUFACTURING PROCESSES**	**8 hr**

Review of Manufacturing Processes; Design for Casting; Design for Bulk Deformation (Rolling, Extrusion, Tube drawing and wire drawing); Design for Sheet Metal Forming Processes; Design for Machining; Design for Powder Metallurgy; Design for Polymer Processing; Case-Studies.

Unit IV	**DESIGN FOR ASSEMBLY**	**8 hr**

Review of Assembly Processes; Design for Welding(Fusion); Design for Welding(Solid); Design for Brazing; Design for Soldering; Design for Adhesive Bonding; Design for Joining of Polymers; Case-Studies.

Unit V	**DESIGN FOR RELIABILITY AND QUALITY**	**8 hr**

Failure Mode and Effect Analysis; Design for Quality; Design for Reliability; Case study-1; Approach to Robust Design; Implementing Agile; Design of Experimentation fundamentals; Case studies.

LEARNING RESOURCES

TEXTBOOKS:

1	M F Ashby and K Johnson, Materials and Design - the art and science of material selection in product design, Butterworth-Heinemann, 2003.
2	G Boothroyd, P Dewhurst and W Knight, Product design for manufacture and assembly, Third Edition, CRC press, Taylor & Francis, Florida,USA, 2010. Revised Third Edition, Pearson, 2012

REFERENCE BOOKS:	
1	J G Bralla, Handbook for Product Design for Manufacture, McGraw Hill,2020
2	K G Swift and J D Booker, Process selection: from design to manufacture, London: Arnold, 1997.
3	G Dieter, Engineering Design – A materials and processing approach, McGraw Hill, NY, 2000.

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL6	X				
CO2	BL6		X			
CO3	BL5			X		
CO4	BL6				X	
CO5	BL5					X

R23MMECHT05	MATERIAL CHARACTERIZATION TECHNIQUES					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Materials Science and Engineering, Solid State Physics, Chemistry	**3**	**0**	**0**	**3**

Course Objective

To familiarize the various microscopic, spectroscopic, x-ray diffraction and thermal analysis techniques used for material characterization.

Course Outcomes

1	Analyze and evaluate material characterization techniques, defects, and microscopy methods. (**BL5**)
2	Analyze SEM techniques, specimen preparation, and detectors.(**BL5**)
3	Design and critically assess X-ray diffraction patterns for phase identification and stress analysis.(**BL6**)
4	Interpret and analyze TEM imaging techniques and spectroscopic methods.(**BL4**)
5	Analyze and interpret thermal and microscopy techniques for material analysis.(**BL5**)
6	Design, evaluate, and synthesize advanced material characterization and analysis techniques.(**BL6**)

SYLLABUS

Unit I	**INTRODUCTION TO MCT**	**8 hr**

Scope of MCT, Classification of different techniques; Macro and Micro characterization; Defects in materials; Bulk average techniques; Specimen preparation techniques for optical microscopy; Principles of optical microscopy, bright and dark field illumination; polarized and interference contrast microscopy; quantitative metallography.

Unit II	**SCANNING ELECTRON MICROSCOPY**	**8 hr**

Construction and working of SEM; Interaction of electron beam with materials; Specimen preparation techniques for SEM, various imaging techniques; EDS; WDS; EPMA; Different detectors used in SEM.

Unit III	**X-RAY AND DIFFRACTION**	**8 hr**

X-ray diffraction construction and operation of diffractometer; diffraction pattern; uses of diffraction pattern in powder method; identification of crystal structure; estimation of relative amount of phases; order-disorder transformation; determination of solvus line, estimation of crystallite size and strain; residual stress measurement.

Unit IV	**TRANSMISSION ELECTRON MICROSCOPY**	**8 hr**

TEM construction; bright and dark field imaging and diffraction techniques; specimen preparation for TEM; different components & their functions;
Introduction to spectroscopic techniques: Optical emission spectroscopy (OES), atomic absorption spectroscopy (AAS), Raman spectroscopy, Introduction to XPS, XRF.

Unit V	**THERMAL ANALYTICAL TECHNIQUES**	**8 hr**

Introduction to thermal analytical techniques and other characterization techniques; Differential Thermal analysis (DTA); differential scanning calorimetry (DSC); thermogravimetric analysis(TGA); Scanning probe microscopy; Atomic force microscopy (AFM); scanning tunneling microscope (STM); Field ion microscopy.

LEARNING RESOURCES	
TEXT BOOKS:	
1	B.D. Cullity, S.R. Stock, Elements of X-ray Diffraction, 3rd Ed, Pearson, 2001.
2	P.J. Goodhew, J. Humphreys, R. Beanland, Electron Microscopy and Analysis, 3rd Ed, Taylor & Francis, New York, 2001.
3	Vander Voort, G.F., Metallography: Principle and practice, ASM International, 1999.
REFERENCE BOOKS:	
1	P.C. Angelo, Material Characterization, 1st Ed, Cengage learning, 2016.
2	Leng, Y., Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd, Singapore, 2008.
ONLINE COURSES	
1	https://onlinecourses.nptel.ac.in/noc22_mm14/preview
2	https://www.udemy.com/course/advanced-materials-characterization-techniques-analytical/?couponCode=ST10MT30325G2
3	https://www.classcentral.com/course/swayam-material-characterization-13029
4	https://cmti.res.in/trainingprogramme/advanced-materials-characterization-techniques/
5	https://onlinecourses.nptel.ac.in/noc22_mm37/preview

Bloom'slevel - Unitscatchmentarticulationmatrix

CO	Blooms Level	UnitI	UnitII	Unit III	UnitIV	UnitV
CO1	BL5	X				
CO2	BL5		X			
CO3	BL6			X		
CO4	BL4				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MMECHT06	SURFACE ENGINEERING					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Materials Science and Engineering, Electrochemistry	**3**	**0**	**0**	**3**

Course Objective

To analyze surface engineering techniques, including coatings, electroplating, and plasma treatments, to enhance material performance and corrosion resistance.

Course Outcomes

1	Analyze the importance of surface engineering and corrosion in various industrial applications. (**BL6**)
2	Analyze the basic mechanisms involved in thermal spray coatings and electroplating processes and their impact on material properties. (**BL6**)
3	Distinguish between overlay and diffusion coatings, analyzing their advantages and limitations.(**BL4**)
4	Analyze the role of plasma-assisted surface treatments in enhancing material performance. (**BL6**)
5	Analyze the significance of thin film coatings and their applications across diverse industries.(**BL6**)
6	Design advanced surface engineering strategies to optimize material performance and corrosion resistance. (**BL6**)

SYLLABUS

Unit I	**INTRODUCTION TO CORROSION AND SURFACE ENGINEERING**	**8 hr**

Importance and need of Surface Engineering; Classification of surface engineering processes; substrate and pre-treatments; Introduction to Corrosion, cost of corrosion; different forms of Corrosion; Galvanic, Intergranular; Crevice, Pitting; Erosion Corrosion, Stress corrosion cracking;

Unit II	**OVERLAY COATINGS & ELECTROCHEMICAL COATINGS**	**8 hr**

Thermal Sprayed coatings; Plasma spraying; Flame spraying; High Velocity Oxy Fuel coatings; Electroplating (Cu, Ni, Cr, Zn); Electro-less nickel plating and anodizing; Precious metal coatings; Functional and decorative electroplated coatings with Tin and Tin Alloys;

Unit III	**DIFFUSION COATINGS**	**8 hr**

Difference between diffusion coatings and overlay coatings; Coating medium-Coating forming elements; Carburizing Overview of pack, liquid, and gas carburizing; Nitriding – Overview of gas and liquid nitriding; Carbonitriding and Nitrocarburising; Boronizing; Aluminized coatings; Chromized and Siliconized coatings;

Unit IV	**PLASMA PROCESSES**	**8 hr**

Plasma carburizing; Plasma nitriding; Plasma immersed ion implantation; Plasma enhanced physical vapour deposition; Plasma enhanced chemical vapour deposition; Note on different vacuum pumps; Coating on plastics; advantages and Industrial applications of plasma process

Unit V	**THIN FILM COATING TECHNOLOGY**	**8 hr**

Chemical vapour deposition (CVD); Physical vapour deposition (PVD); Electron beam evaporation; Magnetron sputtering; Diamond like carbon coating technology; Thermal Barrier coatings on Turbine blades to improve durability and efficiency; Present and future aspects of thin film coatings; advantages and

Industrial applications of Tin film coating technology	
LEARNING RESOURCES	
TEXT BOOKS:	
1	Fontana, Mars G. "Perspectives on corrosion of materials." Metallurgical Transactions 1, no. 12 (1970): 3251-3266.
2	Budinski, Kenneth G. "Surface engineering for wear resistance." (No Title) (1988).
3	Davis, Joseph R., ed. Surface engineering for corrosion and wear resistance. ASM international, 2001.
REFERENCE BOOKS:	
1	Bhushan, Bharat. "3.15 Micro/Nanotribology." The CRC handbook of mechanical engineering (2005): 222.
2	Ohring, Milton. Materials science of thin films: depositon and structure. Academic press, 2002.
ONLINE COURSES	
1	https://www.princeton.edu/~maelabs/mae324/12/electrochemical.htm
2	http://www.materials.unsw.edu.au/tutorials/online-tutorials/1-what-corrosion
3	https://metallisation.com/applications/thermal-spray-engineering-applications
4	http://www.precisioncoatings.com/what-is-thermal-spray.html
5	https://www.sharrettsplating.com/about/what-electroplating
6	https://chem.libretexts.org/Core/Analytical_Chemistry/Electrochemistry/Electrolytic_Cells/Electroplating
7	http://www.iisc.ernet.in/currsci/aug102002/237.pdf

Bloom'slevel - Unitscatchmentarticulationmatrix

CO	Blooms Level	UnitI	UnitII	Unit III	UnitIV	UnitV
CO1	BL6	X				
CO2	BL6		X			
CO3	BL4			X		
CO4	BL6				X	
CO5	BL6					X
CO6	BL6	X	X	X	X	X

Automotive and Aerospace Sector

S.No	Course Code	Course Title	L	T	P	Credits	Sem
1	**R23MMECHT07**	Mechanical Vibrations and Condition Monitoring	3	0	0	3	VI
2	**R23MMECHT08**	Advanced Strength of Materials	3	0	0	3	VI
3	**R23MMECHT09**	Design of Power Transmission Elements	3	0	0	3	VII
4	**R23MMECHT04**	Design for Manufacturing and Assembly	3	0	0	3	VII
5	**R23MMECHT10**	Mechanics of Composite Materials	3	0	0	3	VIII
6	**R23MMECHT11**	Product Design	3	0	0	3	VIII
Total Credits						**18**	

R23MMECHT07	MECHANICAL VIBRATIONS AND CONDITION MONITORING					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Differential Equations and Vector Calculus, Engineering Mechanics	**3**	**0**	**0**	**3**

Course Objective

The primary objective of the Mechanical Vibrations and Condition Monitoring course is to equip students with the knowledge and skills to analyze, understand, and manage mechanical vibrations in engineering systems. This includes studying the dynamic behavior of mechanical components, machinery, and structures to ensure their safe and efficient operation. Additionally, the course aims to introduce students to techniques and methods for monitoring the condition of machinery to prevent failures and optimize maintenance practices.

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

1	Apply basic vibration concepts to assess the performance of mechanical systems with one, two, or more degrees of freedom under various conditions. (**BL3**)
2	Evaluate complex mechanical systems in the context of vibrations by employing analytical and numerical methods. (**BL5**)
3	Develop solutions for complex vibratory systems. (**BL6**)
4	Apply fundamental knowledge in maintenance engineering by utilizing various maintenance strategies, conducting equipment failure analysis, and implementing condition monitoring techniques. (**BL3**)
5	Analyze and propose solutions for maintenance challenges, equipment failures, and condition monitoring. (**BL4**)
6	Develop solutions for difficult maintenance situations and condition monitoring applications. (**BL6**)

SYLLABUS

Unit I	**FREE VIBRATIONS OF SINGLE DEGREE FREEDOM SYSTEMS**	**8 hr**

Fundamentals of Vibration: Basic Concepts of Vibration, Classification of Vibration, Spring Elements, Damping Elements, Harmonic Motion; Free Vibration of Single-Degree-of-Freedom Systems; Free vibration of an undamped translational system; Free vibration of an undamped torsional system; Newton 's second law method; Rayleigh 's energy method; Free vibration with viscous damping; Free vibration with coulomb damping.

Unit II	**FORCED VIBRATIONS OF SINGLE AND TWO DEGREE FREEDOM SYSTEMS**	**8 hr**

Harmonically Excited Vibration: Response of an undamped system under harmonic force, Response of a damped system under harmonic force; Response of a damped system under the harmonic motion of the base; Response of a damped system under rotating unbalance, Vibration isolation and transmissibility;

Two-Degree of- Freedom Systems: Equations of motion for free and forced vibration; Free- vibration analysis of an undamped system; Torsional system; Free-vibration analysis of a damped system; Forced-vibration analysis of an undamped system.

Unit III	**MULTI DEGREE FREEDOM VIBRATORY SYSTEMS**	**8 hr**

Multi-degree-of- Freedom Systems: Exact Analysis: Modeling of continuous systems as multi- degree-of-freedom systems using Newton 's second law to derive equations of motion; influence coefficients, the Eigenvalue problem; normal modes

and their properties, free and forced vibration of undamped systems using modal analysis. Multi-degree-of- Freedom Systems: Numerical Methods - Rayleigh's Method; Dunkerley 's Formula; Matrix Iteration Method; Stodola 's Method; and Holzer 's Methods.		
Unit IV	**TYPES OF MAINTENANCE SYSTEMS**	**8 hr**
Maintenance: Importance of maintenance, Objectives of maintenance, Types of maintenance, Maintenance systems; Planned and unplanned maintenance, breakdown maintenance, corrective maintenance; opportunistic maintenance, routine maintenance; preventive maintenance, predictive maintenance; Condition based maintenance; design-out maintenance, challenges in maintenance;Equipment Failure, Equipment Failure Rate and Patterns; Failure Management Strategy.		
Unit V	**CONDITION MONITORING**	**8 hr**
Condition Monitoring Maintenance categories - Temperature Measurements, Dynamic Monitoring; Oil Analysis, Corrosion Monitoring; Nondestructive Testing, Electrical Testing; Observation and Surveillance. Commonly witnessed machinery faults diagnosed by vibration analysis – Unbalance, Bent shaft; Eccentricity, Misalignment, Looseness, Belt drive problems; Gear defects, Bearing defects; Electrical faults, Oil whip/whirl, Cavitation, Shaft cracks.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	G.K. Groover, *Mechanical Vibrations*, Nem Chand And Bross, 8th edition, 2018.	
2	Singiresu S. Rao, *Mechanical Vibrations*, Prentice Hall, 5th edition, 2011.	
3	Collacot R.A., *Mechanical fault diagnosis and condition monitoring*, Springer Science & Business Media.	
REFERENCE BOOKS:		
1	Alan Davies, *Handbook of condition monitoring: Techniques and Methodology*, Chapman & Hall, 1998.	
2	John S Mitchell, *Introduction to Machinery Analysis and Monitoring*, PennWell Books, PennWell Publishing Company, 2nd edition, 1993.	
ONLINE COURSES		
1	https://www.udemy.com/course/complete-mechanical-vibration-online-course-	
2	https://onlinecourses.nptel.ac.in/noc22_me76/preview	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X	X	X		
CO2	BL5	X	X	X		
CO3	BL6	X	X	X		
CO4	BL3				X	X
CO5	BL4				X	X
CO6	BL6				X	X

R23MMECHT08	ADVANCED STRENGTH OF MATERIALS					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Engineering Mechanics & Strength of Materials	**3**	**0**	**0**	**3**

Course Objective

Students will gain understanding of the concepts of advancedstrength of materials in view of analysing the behavior of material under various loading conditions associated with real-world engineering scenarios.

Course Outcomes

1	Apply mathematical relations for finding stresses and strains of members under various loading conditions (**BL3**)
2	Analyze the modes of failure and deflections of beams. (**BL4**)
3	Distinguish symmetric and unsymmetrical bending (**BL4**)
4	Design curved beams (**BL6**)
5	Determine the stresses in non-circular shafts subjected to torsion (**BL5**)
6	Adapt the concepts of advanced strength of materials for analysing the mechanical components (**BL6**)

SYLLABUS

Unit I	**CONCEPT OF STRESS AND STRAIN**	**8 hr**

Definition of stress at a point, stress notation, stress array; normal and shear stress on an oblique plane; Principal Stresses; Strain theory, Principal strains and strain of a volume element; small displacement theory; Elastic and non-Elastic response of solids; 1st law of Thermodynamics;Hooke's Law-Anisotropic and Isotropic elasticity.

Unit II	**FAILURE CRITERIA AND DEFLECTION OF BEAMS**	**8 hr**

Modes of Failure; Failure by Excessive deflections and Yield initiation; Failure by fracture, Progressive fracture; Castigliano's theorem on deflections, Castigliano's theorem on deflections for linear load deflection relations; Strain energy for axial loading and bending; Strain energy due to shear and torsion; Deflections of statically determinate structures; Deflections of statically indeterminate structures.

Unit III	**BENDING OF STRAIGHT BEAMS AND CURVED BEAM THEORY**	**8 hr**

Review ofSymmetric bending; Bending stresses in beams subjected to Non symmetrical bending; Equations of equilibrium, geometry of deformation and stress strain relations; Deflection of straight beams due to Non symmetrical bending; Winkler Bach formula for circumferential stress&limitations; Radial stresses in curved beams;Stresses in crane hook;Stresses in closed rings.

Unit IV	**CONTACT STRESSES**	**8 hr**

Introduction to contact stresses;Problem of determining contact stresses and assumptions on which a solution for contact stresses is based;Expressions for principal stresses; Method of computing contact stresses; Deflection of bodies in point contact; Stresses for two bodies in line contact-Loads normal and tangent to contact area;Estimation of contact stresses in bearings; Estimation of contact stresses in locomotive wheels and track.

Unit V	**TORSION**	**8 hr**

Torsion of prismatic bar of circular cross section; Linear elastic solution: elliptical cross section; Linear elastic solution: Equilateral triangle cross section; Prandtl elastic membrane (Soap-Film) Analogy; Narrow rectangular cross Section; Cross

sections made up of long narrow rectangles; Rectangular cross section; Hollow thin wall torsion members.	
LEARNING RESOURCES	
TEXT BOOKS:	
1	Arthur P. Boresi, Richard J. Schmidt, *Advanced Mechanics of materials,*6ed, An Indian Adaptaion, Wiely International, 2018.
2	Egor P Popov, *Mechanics of Materials*, 2nd edn, Pearson, December 2015.
3	Dr.Sadhu Singh, *Strength of materials,* Khanna publishers, 2024.
REFERENCE BOOKS:	
1	Den HortogJ.P, *Advanced strength of materials,* Dover publications, 1987.
2	Timoshenko, *Theory of plates,* McGraw-Hill, 1984.
3	L.S Srinath, *Advanced Mechanics of Solids,*McGraw-Hill, July 2017.
ADDITIONAL REFERENCE MATERIAL	
1	Timoshenko, *Strength of Materials,3rd Part, Advanced Theory And Problems,*January 2002
ONLINE COURSES	
1	http://www.digimat.in/nptel/courses/video/112101095/L01.html
2	https://archive.nptel.ac.in/courses/105/105/105105108/

Bloom's level – Units catchment articulation matrix

CO	Blooms Level	UnitI	UnitII	Unit III	UnitIV	UnitV
CO1	BL3	×		×		×
CO2	BL 4		×	×		
CO3	BL 4			×		
CO4	BL6			×		
CO5	BL5					×
CO6	BL6	×	×	×	×	×

R23MMECHT09	DESIGN OF POWER TRANSMISSION ELEMENTS					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Strength of Materials and Design of Machine Elements	**3**	**0**	**0**	**3**

Course Objective

Students will gain understanding of the concepts of stress analysis, failure criteria and material to analyze, design and/or select commonly used power transmission elements.

Course Outcomes

1	Apply concepts of helical and bevel gears in the analysis for power transmission applications. (**BL3**)
2	Evaluate the failure criteria of the helical and bevel gears for power transmission applications. (**BL5**)
3	Analyse flexible power transmission elements like ropes, chains and power screws (**BL4**)
4	Design flexible power transmission elements (**BL 6**)
5	Apply the design concepts of engine parts such as cylinder, piston, connecting rod and gear box analysis of engine (**BL3**)
6	Analyse the engine parts such as cylinder, piston, connecting rod and gear box. (**BL4**)
7	Design the power transmission systems and IC engine components to meet desired needs within realistic conditions. (**BL6**)

SYLLABUS

Unit I	**INTRODUCTION TO GEAR TRANSMISSION AND DESIGN OF HELICAL GEARS**	**8 hr**

Gear transmission: Speed ratios and number of teeth on gears;Force analysis on gears; Determination of tooth stresses, Dynamic effects; fatigue strength, on gear design, Factor safety, gear materials for gear design;

Design of helical gears: Force Components on a Tooth of Helical Gear**;** Equivalent number of teeth and forces for helical gears; Design of helical gears based on strength; Design of helical gears based on wear considerations.

Unit II	**DESIGN OF BEVEL AND WORM GEARS**	**8 hr**

Straight bevel gear: Tooth terminology, tooth forces of bevel gears; Determination of Stresses of bevel gears; Calculate the equivalent number of teeth; Estimating the dimensions of a pair of straight bevel gears.

Worm gear: Merits & Demerits, terminology of worm gear; materials, forces & stresses; Temperature Rise of Lubricating Oil; Beam and Wear Strengths of Worm Wheel Set.

Unit III	**DESIGN OF ROPES, CHAINS AND POWER SCREWS**	**8 hr**

Flexible transmission elements, Design of chains and sprockets: Design of rope drives; Selection of hoisting wire ropes and pulleys; Terms Used in Chain Drive, Classification of Chains; Selection of chains and design of chains;

Design of power screws: Types of power screws, Stresses in power screws; design of power screws, Differential and Compound Screws; Screw jack: parts of screw jack, stresses in screw jack; Design of screw jack;

Unit IV	**DESIGN OF PISTON, CYLINDER AND CONNECTING ROD**	**8 hr**

Engine parts: Piston and cylinder: Pistons, forces acting on piston-construction; Design and proportions of piston; Design of cylinder; Design of cylinder liners;

Connecting Rod: Thrust in connecting rod – stress due to whipping action on connecting rod; Design of connecting rod. (Dimensions of cross-section of the connecting rod); Design of connecting rod. (Dimensions of the crankpin at the big end and the piston pin at the small end); Design of connecting rod. (Size of bolts for securing the big end cap);		
Unit V	**DESIGN OF CRANK SHAFTS AND GEAR BOX**	**8 hr**
Crankshaft: Materials and selection of crankshaft; Design of centre crankshaft. (Maximum bending moment); Design of centre crankshaft. (Maximum twisting moment); Design of overhang crankshaft. **Gear box:** Geometric progression, standard step ratio, Ray diagram, kinematics layout; Design of sliding mesh gear box; Design of multi-speed gearbox for machine tool applications;Variable speed gearbox (Torque converters for automotive applications).		
LEARNING RESOURCES		
TEXT BOOKS:		
1	V. B. Bhandari, *Design of Machine Elements*, 5th ed. New Delhi, India: McGraw Hill Education (India) Pvt Ltd., 2020.	
2	N. C. Pandya and C. S. Shah, *Machine Design*, 20th ed. Anand, India: Charotar Publishing House, Pvt. Ltd., 2015.	
3	K. Mahadevan and K. Balaveera Reddy, *Design Data Handbook*. New Delhi, India: CBS Publishers, 2022.	
REFERENCE BOOKS:		
1	U. C. Jindal, *Machine Design: Design of Transmission System*. Dorling Kindersley, 2010.	
2	J. E. Shigley, C. R. Mischke, R. G. Budynas, and K. J. Nisbett, *Mechanical Engineering Design*, 10th ed. New Delhi, India: Tata McGraw Hill, 2017.	
ADDITIONAL REFERENCE MATERIAL		
1	https://www.asme.org/codes-standards/find-codes-standards/y14-7-1-gear-drawing-standards-parts-1-spur-helical-double-helical-rack/1971/drm-enabled-pdf	
2	https://www.astm.org/f2571-15r20.html	
3	https://standards.globalspec.com/std/3804236/astm-d6593-01	
ONLINE COURSES		
1	https://archive.nptel.ac.in/courses/112/106/112106137/	
2	https://www.youtube.com/watch?v=HVliu7ab87Y&list=PLOiT2XTdTTBeAu9GtyY8Yn8fEVPHPCg0k	
3	https://www.youtube.com/watch?v=hRexymJSf-U&list=PLOiT2XTdTTBeHMfMrUlfDZRyDoK4Hw2vW	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X	X			
CO2	BL5	X	X			
CO3	BL4			X		
CO4	BL6			X		
CO5	BL3				X	X
CO6	BL4				X	X
CO7	BL6	X	X	X	X	X

R23MMECHT04	DESIGN FOR MANUFACTURING AND ASSEMBLY					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Prerequisite	Manufacturing Processes, Manufacturing Technology	**3**	**0**	**0**	**3**

Course Objective

To address the challenges for manufacturing and assembly of product even though the desired it is well designed.

Course Outcomes

After completing this course, the student will be able to

1	Understand the steps involved in DFMA and its advantages of applying DFMA during product design.(**BL4**)
2	Select suitable material and shapes for a given component.(**BL5**)
3	Understand different manufacturing processes and select suitable material and right technique for component to be produced. (**BL5**)
4	Understand different types joints and select suitable joint for given application. (**BL6**)
5	Analyze different modes of failure and steps involved in optimizing design.(**BL6**)

SYLLABUS

Unit I		**8 hr**

Introduction to DFMA: Steps for applying DFMA during product design; Steps for applying DFMA during product design; Advantages & Disadvantages of applying DFMA during product design;Need Identification in DFMA; Problem Definition; Concept Generation ;Embodiment Design.

Unit II	**SELECTION OF MATERIALS AND SHAPES**	**8 hr**

Fundamentals on selection of Materials, Properties of Engineering Materials; Case Study-1 (Machine tool industries); Case study-2 (Automobile Sector); Case study-3(Energy Sector); Selection of Shapes for foundry; Selection of Shapes for die forging; Co-selection of Materials and Shapes; Case Study-3.

Unit III	**SELECTION OF MANUFACTURING PROCESSES**	**8 hr**

Review of Manufacturing Processes; Design for Casting; Design for Bulk Deformation (Rolling, Extrusion, Tube drawing and wire drawing); Design for Sheet Metal Forming Processes; Design for Machining; Design for Powder Metallurgy; Design for Polymer Processing; Case-Studies.

Unit IV	**DESIGN FOR ASSEMBLY**	**8 hr**

Review of Assembly Processes; Design for Welding(Fusion); Design for Welding(Solid); Design for Brazing; Design for Soldering; Design for Adhesive Bonding; Design for Joining of Polymers; Case-Studies.

Unit V	**DESIGN FOR RELIABILITY AND QUALITY**	**8 hr**

Failure Mode and Effect Analysis; Design for Quality; Design for Reliability; Case study-1; Approach to Robust Design; Implementing Agile; Design of Experimentation fundamentals; Case studies.

LEARNING RESOURCES

TEXTBOOKS:

1	M F Ashby and K Johnson, Materials and Design - the art and science of material selection in product design, Butterworth-Heinemann, 2003.
2	G Boothroyd, P Dewhurst and W Knight, Product design for manufacture and assembly, Third Edition, CRC press, Taylor & Francis, Florida,USA, 2010. Revised Third Edition, Pearson, 2012

REFERENCE BOOKS:	
1	J G Bralla, Handbook for Product Design for Manufacture, McGraw Hill,2020
2	K G Swift and J D Booker, Process selection: from design to manufacture, London: Arnold, 1997.
3	G Dieter, Engineering Design – A materials and processing approach, McGraw Hill, NY, 2000.

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL6	X				
CO2	BL6		X			
CO3	BL5			X		
CO4	BL6				X	
CO5	BL5					X

R23MMECHT10	MECHANICS OF COMPOSITE MATERIALS					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Material Science, Engineering Mechanics.	**3**	**0**	**0**	**3**

Course Objective:

The objective of Mechanics of Composite Materials is to provide students with a fundamental understanding of the behaviour, analysis, and design of composite materials used in engineering applications.

Course Outcomes:

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

1	Classify composites, types of reinforcement and matrix phases. (**BL4**)
2	Determine stress and strain, elastic constants of composites. (**BL3**)
3	Explain different fabrication methods to prepare composite materials. (**BL2**)
4	Evaluate the strength of composites and describe methods to characterize composite properties. (**BL5**)
5	Analyze different types of composite laminates using thin plate theory. (**BL4**)

SYLLABUS

Unit I	**INTRODUCTION TO COMPOSITE MATERIALS**	**8 hr**

Introduction: Definition of composite material, classification based on matrix and topology; constituents of composites, interfaces and interphases, distribution of constituents; mechanical behavior of composite materials; Polymer matrix composites, metal matrix and ceramic matrix composites.

Raw materials: Resins- polyester, epoxy, metal matrices; Reinforcement- lass fibers, boron fibers, silicon carbide, carbon and graphite fibers, Kevlar, sisal and other vegetable fibers; whiskers, fillers and parting agents; Applications of composites.

Unit II	**MANUFACTURING OF COMPOSITE MATERIALS**	**8 hr**

Fabrication methods: Hand lay-up, bag molding,;mating molds, spray up molding, matched - die molding; preform molding, filament winding, winding patterns; winding machines, pultrusion, liquid composite molding.

Manufacturing of Metal and Ceramic Matrix Composites: Casting, solid state diffusion technique; cladding, hot isostatic pressing; Liquid metal infiltration; liquid phase sintering, properties and applications.

Unit III	**MICROMECHANICAL BEHAVIOR OF A LAMINA**	**8 hr**

Introduction, weight and volume fractions; properties of lamina, Micromechanical behaviour of Lamina; Stress- strain relation for anisotropic materials; stiffness matrix;

compliances matrix; Engineering constants; restriction on engineering constants; stress strain relation for plane stress in orthotropic materials.

Unit IV	**MACRO-MECHANICAL BEHAVIOUR OF LAMINATES AND PLATE THEORIES**	**8 hr**

Stress-strain relations for anisotropic materials; stiffnesses and compliances, for orthotropic materials; engineering constants for orthotropic materials; stress-strain relations for plane stress in an orthotropic material;

classical laminate theory; special cases of laminate stiffness; strength of laminates; inter laminar stresses.

Unit V	**TESTING OF COMPOSITE MATERIALS**	**8 hr**

Strength of unidirectional lamina: Micromechanics of failure, failure

mechanisms, strength of an orthotropic lamina; strength of a lamina under tension and shear, maximum stress and strain criterion. **Fiber composites:** Tensile and compressive strength of unidirectional fiber composites, **fracture modes in composites:** single and multiple fracture, de-bonding, fiber pull out and de-lamination failure; fatigue of laminate composites, the failure envelope. **Testing of Composites:**Mechanical testing of composites, tensile testing, Compressive testing, Intralaminar shear testing; Inter-laminar shear testing, Fracture testing; Impact testing and Hardness Testing.	
LEARNING RESOURCES	
TEXT BOOKS:	
1	A. Ghosal, Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2006
2	J. L. Meriam, and L. G. Kraige, Engineering Mechanics: Dynamics, Wiley, 2013/7th Edition
3	G. F. Franklin, J. D. Powell, and A. Emami-Naeini, Feedback Control of Dynamic Systems, Pearson, 2006/5th edition
REFERENCE BOOKS:	
1	Isaac and M Daniel, Engineering Mechanics of Composite Materials, Oxford University Press, 1994.
2	Autar K. Kaw, Mechanics of Composite Materials, CRC Publishers,1997.
ONLINE COURSES	
1	https://www.openlearning.com/courses/mechanics-of-composite-materials/?cl=1
2	https://onlinecourses.nptel.ac.in/noc22_me40/preview
3	https://ep.jhu.edu/courses/535720-mechanics-of-composite-materials-and-structures/

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL 4	X				
CO2	BL 3		X			
CO3	BL 2			X		
CO4	BL 5				X	
CO5	BL 4					X

R23MMECHT11	PRODUCT DESIGN					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Engineering Fundamentals	**3**	**0**	**0**	**3**

Course Objective This course aims to equip students with a comprehensive understanding of product design principles, practices, and their applications in various industries. The objectives are structured to foster a holistic development of knowledge, skills, and critical thinking in the field of product design

Course Outcomes

1	Develop innovative product design strategies by applying principles of innovation, evolution, and essential factors. (**BL3**)
2	Able to analyze and develop industry-relevant product design strategies.(**BL4**)
3	Evaluate economic factors influencing product design.(**BL5**)
4	Estimate a value analysis job plan, applying creativity in problem-solving, and conducting value analysis tests.(**BL5**)
5	Analyze and apply principles of product management, demonstrating the ability to define products based on nature and demand. (**BL4**)
6	Develop comprehensive product management strategies, integrating elements such as defining products, formulating new product strategies, and effectively managing product life cycles. (**BL6**)

SYLLABUS

Unit I	**INTRODUCTION TO PRODUCT DESIGN**	**8 hr.**

Design by innovation, evolution; essential factors of product design, production consumption cycle (pcc);flow and value addition in pcc; morphology of design; feasibility study, preliminary design; detailed design ; role of allowances, process capability; tolerances in design and assembly

Unit II	**APPLICATION OF PRODUCT DESIGN IN INDUSTRY**	**8 hr.**

Product design strategies in industry; time to market analysis of the market; standardization, simplification, specialization; designer and his role, myth and reality; basic design considerations; Industrial design considerations; procedures, problems, types of models; role of aesthetics, functional design practices

Unit III	**ECONOMIC FACTORS AND HUMAN ENGINEERING CONSIDERATIONS IN PRODUCT DESIGN**	**8 hr.**

product value, Design for safety, reliability and economic considerations; economic analysis; profit, competitiveness, break even analysis; economics of new product design; human being as applicator of forces; man as occupant of space; design of controls and display; man/ machine information exchange.

Unit IV	**VALUE ENGINEERING AND QUALITY ASSURANCE IN PRODUCT DESIGN**	**8 hr.**

Value, value analysis job plan; creativity; steps to problem-solving and value analysis; value analysis tests, cost reduction through value engineering. Quality and design spiral, theory of sampling inspection; monitoring of quality; quality of performance; six sigma.

Unit V	**PRODUCT MANAGEMENT MODERN APPROACHES TO PRODUCT DESIGN**	**8 hr.**

Defining product by nature and demand; New product strategy; product

classification, product development & management; managing product life cycle; Concurrent engineering; rapid prototyping; reverse engineering; Quality function deployment.	
LEARNING RESOURCES	
TEXT BOOKS:	
1	K. Chitale and R. C. Gupta, Product Design and Manufacturing, PHI Publication, seventh edition ,2023
2	P. Kumar, Product Design, Creativity, Concepts and Usability, PHI Learning Pvt. Ltd., New Delhi, 2012
REFERENCE BOOKS:	
1	K. T. Ulrich and S. Eppinger, Product Design and Development, 5th ed. McGraw-Hill Education, 2011.
2	R. E. Y. Inetoviez, New Product Development: Design & Analysis, John Wiley and Sons Inc., N.Y., 1990.
3	B. Hollins and S. Pugh, Successful Product Design, Butterworth, London, 1990.
ONLINE COURSES	
1	https://onlinecourses.nptel.ac.in/noc21_me83/preview
2	https://www.digimat.in/nptel/courses/video/112104230/L06.html
3	http://digimat.in/nptel/courses/video/107103082/L03.html

Bloom'slevel - Unitscatchmentarticulationmatrix

CO	Blooms Level	UnitI	UnitII	Unit III	UnitIV	UnitV
CO1	BL3	X				
CO2	BL4		X			
CO3	BL5			X		
CO4	BL5				X	
CO5	BL4					X
CO6	BL6	X	X	X	X	X

Thread-III: Energy Sector

S.No	Course Code	Course Title	L	T	P	Credits	Sem
1	**R23MMECHT12**	Advanced Thermodynamics	3	0	0	3	VI
2	**R23MMECHT13**	Energy Storage Systems	3	0	0	3	VI
3	**R23MMECHT14**	Thermal Management of Electronics	3	0	0	3	VII
4	**R23MMECHT15**	Measurement Techniques in Fluid Flow and Heat Transfer	3	0	0	3	VII
5	**R23MMECHT16**	Design of Heat Exchangers	3	0	0	3	VIII
6	**R23MMECHT17**	Fuel Cells and Hydrogen Storage technologies	3	0	0	3	VIII
Total Credits						**18**	

R23MMECHT12	ADVANCED THERMODYNAMICS					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Engineering Thermodynamics	**3**	**0**	**0**	**3**

Course Objective

- Develop an in-depth understanding of advanced thermodynamic concepts, including:
  Exergy analysis, Real gas behavior, Chemical equilibrium, Combustion thermodynamics
- Apply fundamental thermodynamic laws to analyze and solve complex engineering system problems.
- Integrate industry-relevant applications to build practical problem-solving skills for engineering challenges.

Course Outcomes

Students are able

1	Explain the advanced principles of thermodynamics and their significance in engineering applications. (**BL3**)
2	Analyze energy availability, exergy destruction, and irreversibilities in thermodynamic systems. (**BL5**)
3	Apply thermodynamic property relations to evaluate real gas behavior and phase equilibria. (**BL5**)
4	Evaluate chemical equilibrium, combustion processes, and their impact on system performance. (**BL6**)
5	Assess thermodynamic cycles and their modifications for efficiency enhancement in power and refrigeration systems. (**BL6**)

SYLLABUS

Unit I	**FUNDAMENTAL CONCEPTS AND LAWS OF THERMODYNAMICS**	**8 hr**

Review of thermodynamic laws and principles; Energy, entropy, and exergy concepts; Availability and irreversibility analysis; Generalized thermodynamic property relations; Maxwell's equations and their applications; Clapeyron equation and phase equilibrium; Joule-Thomson coefficient and throttling processes; Helmholtz and Gibbs free energy functions.

Unit II	**EXERGY ANALYSIS AND REAL GAS BEHAVIOR**	**8hr**

Exergy balance for closed and open systems; Second law efficiency and entropy generation minimization; Thermodynamic property relations for real gases; Generalized compressibility charts; Equations of state: van der Waals, Redlich-Kwong, Peng-Robinson; Fugacity and activity coefficients; Phase equilibrium and Gibbs phase rule; Real gas mixtures and their behavior

Unit III	**CHEMICAL EQUILIBRIUM AND COMBUSTION**	**8hr**

Chemical potential and equilibrium criteria; Law of mass action and equilibrium constant; Gibbs free energy minimization; Combustion reactions and stoichiometry; Enthalpy of formation and heating values; Adiabatic flame temperature calculations; Equilibrium combustion analysis; Emission and environmental impact of combustion

Unit IV	**POWER AND REFRIGERATION CYCLES**	**8hr**

Advanced Rankine cycle and its modifications; Regeneration and reheat cycles; Combined gas-vapor cycles; Brayton cycle with reheating and intercooling; Advanced refrigeration cycles; Absorption refrigeration systems; Thermoelectric refrigeration principles; Thermodynamic analysis of cryogenic systems

Unit V	THERMODYNAMICS OF IRREVERSIBLE PROCESSES AND INDUSTRY APPLICATIONS	8 hr
Introduction to irreversible thermodynamics; Onsager's reciprocal relations; Thermodynamics of steady-state flow processes; Applications in fuel cells and energy storage systems; Thermodynamic modelling of energy conversion devices ;Solar thermal energy systems and heat pumps; Industrial case studies in power and refrigeration; Future trends in thermodynamic research.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	Yunus A. Cengel and Michael A. Boles, "Thermodynamics: An Engineering Approach," McGraw-Hill Education, 9th Edition, 2019.	
2	Richard E. Sonntag, Claus Borgnakke, and Gordon J. Van Wylen, "Fundamentals of Thermodynamics," Wiley, 8th Edition, 2019.	
Reference Books		
1	Adrian Bejan, "Advanced Engineering Thermodynamics," Wiley, 4th Edition, 2016.	
2	Kenneth Wark Jr., "Advanced Thermodynamics for Engineers," McGraw-Hill, 1995.	
ONLINE COURSES		
1	NPTEL Course - Advanced Thermodynamics, IIT Kharagpur	
2	MIT OpenCourseWare - Thermodynamics & Kinetics	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL5		X			
CO3	BL5			X		
CO4	BL6			X	X	
CO5	BL6				X	X

R23MMECHT 13	Energy Storage Systems					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Thermal Engineering, Heat transfer	**3**	**0**	**0**	**3**

Course Objective

students will be well-equipped to design, analyze, and apply energy storage solutions in various sectors, including renewable energy, transportation, and industrial applications.

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

1	Apply fundamental concepts of energy storage technologies to analyze their role in sustainable energy systems. (**BL3**)
2	Analyze the working principles, advantages, and limitations of different energy storage methods, including mechanical, thermal, chemical, and electrochemical storage.**(BL4)**
3	Evaluate the performance parameters of various energy storage systems based on efficiency, energy density, and cost-effectiveness.**(BL5)**
4	Design and develop innovative energy storage solutions by integrating different storage technologies to enhance system reliability and efficiency. **(BL6)**
5	Examine the environmental, economic, and technical challenges associated with large-scale energy storage deployment.**(BL4)**
6	Design and develop innovative energy storage strategies to enhance renewable energy integration, improve grid stability, and optimize load management for sustainable energy solutions **(BL6)**

SYLLABUS

Unit I	**INTRODUCTION TO ENERGY STORAGE SYSTEMS**	**8 hr**

Importance of energy storage in modern energy systems; Classification of energy storage technologies; Key performance metrics: Energy density, power density, and efficiency; Role of energy storage in renewable energy integration; Cost and economic feasibility of different storage methods; Comparison of short-term vs. long-term energy storage; Grid stability and load management using energy storage; Environmental impacts of energy storage technologies.

Unit II	**MECHANICAL AND THERMAL ENERGY STORAGE**	**8 hr**

Principles of mechanical energy storage systems; Working of pumped hydro storage (PHS) systems; Design and efficiency of compressed air energy storage (CAES); Applications of flywheel energy storage in grid and transport; Fundamentals of thermal energy storage (TES); Comparison of sensible heat, latent heat, and thermochemical storage; Applications of molten salts in concentrated solar power (CSP); Phase change materials (PCMs) for thermal storage and thermochemical energy storage mechanisms.

Unit III	**ELECTROCHEMICAL ENERGY STORAGE**	**8 hr**

Basics of electrochemical energy storage systems; Working principles of different battery chemistries; Comparison of lead-acid, lithium-ion, sodium-ion, and flow batteries; Importance of anode, cathode, and electrolyte materials; Battery degradation and strategies for life-cycle extension; Charge storage mechanisms and advantages; Applications of batteries in electric vehicles (EVs); Role of Battery Management Systems (BMS) in safety and efficiency.

Unit IV	SUPERCAPACITORS AND SUPERCONDUCTING MAGNETIC ENERGY STORAGE	8 hr
Fundamentals of Supercapacitors; Supercapacitor Materials and Design; Charge Storage Mechanisms in Supercapacitors; Applications of Supercapacitors; Introduction to Superconducting Magnetic Energy Storage; Materials and Cryogenic Cooling in SMES; Advantages and Challenges of SMES; Applications of SMES in Energy Systems.		
Unit V	**ENERGY STORAGE SYSTEM INTEGRATION AND APPLICATIONS**	**8 hr**
Role of energy storage in smart grids and decentralized energy systems; Grid-scale energy storage for frequency regulation and peak shaving; Demand-side management using energy storage technologies; Integration of energy storage in renewable energy micro grids; Energy storage applications in electric vehicles (EVs) and hybrid systems; Life cycle assessment (LCA) of energy storage technologies; Cybersecurity and digitalization of energy storage systems; Case studies of successful energy storage projects worldwide.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	Huggins, R. A., Energy Storage. Springer, 2016.	
2	Ibrahim Dincer and Marc A. Rosen, Thermal Energy Storage: Systems and Applications, 2nd ed. Wiley, 2011.	
3	J. Yan, Handbook of Clean Energy Systems, Wiley, 2015.	
REFERENCE BOOKS:		
1	B. E. Conway, Electrochemical Supercapacitors: Scientific Fundamentals and Technological Applications, 1st ed. New York, NY, USA: Springer, 1999.	
2	I. Hadjipaschalis, A. Poullikkas, and V. Efthimiou, Overview of Current and Future Energy Storage Technologies for Renewable Energy Systems, 1st ed. New York, NY, USA: Nova Science Publishers, 2018.	
ONLINE COURSES		
1	https://onlinecourses.nptel.ac.in/noc21_mm34/preview?utm_source	
2	https://online.stanford.edu/courses/xeiet139-energy-storage?utm_source	
3	https://www.futurelearn.com/courses/energy-storage?utm_source	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL5			X		
CO4	BL6				X	
CO5	BL3					X
CO6	BL6					X

R23MMECHT 14	THERMAL MANAGEMENT OF ELECTRONICS					
	Total Contact Hours	42(L)	**L**	**T**	**P**	**C**
	Pre-requisite	Differential Equations and Vector Calculus, Engineering Physics, Fluid Mechanics and Fluid Machines, Heat Transfer	**3**	**0**	**0**	**3**

Course Objective

The objective of this course is to equip students with fundamental and practical knowledge of thermal management in electronic systems. Students will learn to analyze heat generation, transfer, and dissipation methods for effective thermal design. The course aims to enable students to design efficient thermal solutions for electronic and power devices.

Course Outcomes

After completing this course, the students will be able to

1	Estimate the importance of thermal management in electronic systems and identify the sources of heat generation in various electronic components.(**BL5**)
2	Analyze thermal modelling techniques, including lumped element models and thermal resistance, to calculate heat dissipation in electronic systems.(**BL5**)
3	Evaluate different cooling techniques, including active and passive methods, heat sinks, and thermoelectric devices, to select the most effective solution for electronic systems.(**BL5**)
4	Analyze the thermal management strategies for integrated circuits and printed circuit boards, focusing on power dissipation and cooling techniques.(**BL5**)
5	Design advanced thermal management systems for integrated circuits and printed board circuits, and (**BL5**)
6	Design and integrate efficient thermal management solutions for electronic devices and power systems, synthesizing heat transfer principles, modeling, cooling methods, and future trends to optimize performance and reliability. (**BL6**)

SYLLABUS

Unit I	**INTRODUCTION TO THERMAL MANAGEMENT AND HEAT TRANSFER**	**8 hr**

Overview of Thermal Management in Electronics, Importance of Effective Thermal Management; Heat Generation in Electronic Components; Heat Transfer in electronics; Modes of Heat Transfer in electronic systems, Thermal Resistance and Conductance; Heat Transfer in Solids, Liquids, and Gases in electronic systems; Thermal Conductivity and Material Selection; Effect of Temperature on Electronic Performance; Introduction to Thermal Design Guidelines.

Unit II	**THERMAL MODELING AND ANALYSIS**	**8 hr**

Introduction to Thermal Modeling, Lumped Element Thermal Model; Thermal Resistance and Conductance; Basic Thermal Circuit Representation; Steady-State Thermal Analysis; Transient Thermal Response; Thermal Time Constant; Thermal Simulation Tools; Thermal Capacitance and Its Role, practical Applications of Thermal Modeling.

Unit III	**HEAT DISSIPATION AND COOLING TECHNIQUES**	**8 hr**

Active vs. Passive Cooling Methods; Heat Sink Design and Functionality; Fans and Forced Air Cooling Systems; Liquid Cooling Techniques and Applications;

Thermoelectric Cooling (TEC) and Peltier Devices; Heat Pipes and Vapor Chambers; Thermal Interface Materials (TIMs); Microchannel Heat Exchangers.		
Unit IV	**THERMAL MANAGEMENT IN INTEGRATED CIRCUITS AND PCBS**	**8 hr**
Thermal Management in Integrated Circuits (ICs); Power Dissipation and Thermal Effects in ICs; On-Chip Heat Dissipation Methods; Thermal Packaging of Integrated Circuits; Thermal Management in Printed Circuit Boards (PCBs);Thermal Via Design and PCB Material Selection; Thermal Design Guidelines for High-Density PCBs; Thermal Simulation Tools for PCB Designs; Case Studies in IC and PCB Thermal Management; Thermal Reliability in Multilayer PCBs.		
Unit V	**ADVANCED THERMAL MANAGEMENT SOLUTIONS AND FUTURE TRENDS**	**8 hr**
Nanoelectronics and Thermal Challenges; Thermal Management for 3D ICs and Advanced Packaging; Smart Thermal Management Systems; Thermal Management in Flexible and Wearable Electronics; Sustainable and Green Solutions for Thermal Management; Thermal Management in Electric Vehicles (EVs); Integration of Thermal Management with Energy Harvesting; Future Trends in Thermal Management of Electronics.		
LEARNING RESOURCES		
TEXTBOOKS:		
1	Y. Shabany, *Heat Transfer: Thermal Management of Electronics*, CRC Press, 2009.	
2	D. S. Steinberg, *Cooling techniques for electronic equipment*, 2. ed. in A Wiley-Interscience publication. New York: Wiley, 1991.	
REFERENCE BOOKS:		
1	R. Kandasamy and A. S. Mujumdar, *Thermal management of electronic components: phase change material based hybrid thermal management of electronic components and systems / monograph.* Saarbrücken: LAP Lambert Academic Publishing, 2010.	
2	J. E. Sergent and A. Krum, *Thermal management handbook: for electronic assemblies*. in Electronic packaging and interconnection series. New York, NY: McGraw-Hill, 1998.	
3	S. Kakaç, H. Yüncü, and K. Hijikata, Eds., *Cooling of Electronic Systems*. Dordrecht: Springer Netherlands, 1994.	
ADDITIONAL REFERENCE MATERIAL		
1	https://web.iitd.ac.in/~pmvs/course_mcl348.php	
2	https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1319&context=coolingpubs	
3	https://www.sameskydevices.com/catalog/resource/the-complete-guide-to-thermal-management-ebook.pdf?srsltid=AfmBOorYJUqeJEibVQCCQ8wz_vhptSvKz3aXoib4YIhnYcIHU8G0Smxv	
ONLINE COURSES		
1	https://archive.nptel.ac.in/courses/108/108/108108110/	
2	https://archive.nptel.ac.in/courses/112/105/112105267/	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL5	×				
CO2	BL5		×			
CO3	BL5			×		
CO4	BL5				×	
CO5	BL5					×
CO6	BL6	×	×	×	×	×

R23MMECHT15	MEASUREMENT TECHNIQUES IN FLUID FLOW AND HEAT TRANSFER					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Engineering mathematics, Fluid mechanics, Heat transfer	**3**	**0**	**0**	**3**

Course Objective

Students will get exposure about basic measurement techniques of fluid flow and heat transfer and how to apply them to real time industrial applications.

Course Outcomes

Students are able to

1	Apply the basic concepts of general measuring techniques for flow and heat transfer measuring devices. (**BL3**)
2	Apply various measurement techniques for fluid flow, including the selection, calibration, and operation of different flowmeters. (**BL3**)
3	Apply various measurement techniques for heat flow, including the selection, calibration, and operation of different flowmeters. (**BL3**)
4	Choose the appropriate signal conditioning techniques and implementation of amplification strategies to enhance weak signals will be acquired. (**BL4**)
5	Develop proficiency in calibrating instruments and assessing measurement uncertainties. (**BL4**)
6	Adapt advanced knowledge and practical skills in multiphase flow measurement, non-intrusive techniques, computational fluid dynamics, and data analysis methods for fluid and heat transfer measuring devices. (**BL6**)

SYLLABUS

Unit I	**INTRODUCTION OF MEASUREMENT**	**8 hr**

Measurement Systems and Signal Flow; Errors in Measurement and Uncertainty Analysis; Statistical Analysis of Experimental Data; Displacement and Pressure Transducers; Special Transducers and Sensors; Thermal and Flow Measurement Sensors; Transient Response Sensors and Time Constant Analysis; Sensitivity Analysis and Calibration Techniques

Unit II	**FLOW MEASUREMENT TECHNIQUES**	**8 hr**

Introduction to Flow Measurement;Differential Pressure Flowmeters;Velocity and Positive Displacement Flowmeters;Mass Flow Measurement Techniques;Ultrasonic and Magnetic Flow Measurement;Flow Measurement in Open Channels;Calibration Procedures for Flowmeters;Sensitivity Analysis and Performance Evaluation

Unit III	**HEAT TRANSFER MEASUREMENT TECHNIQUES**	**8 hr**

Importance of Heat Transfer Measurement; Types and Characteristics of Heat Exchangers; Temperature Measurement Techniques; Heat Flux Measurement Methods; Heat Transfer Coefficient Measurement; Experimental Techniques for Heat Transfer Analysis; Practical Considerations in Heat Transfer Measurement; Applications and Future Trends in Heat Transfer Measurement

Unit IV	**INSTRUMENTATION AND DATA ACQUISITION**	**8 hr**

Instrumentation in Measurement Systems; Types and Characteristics of Sensors; Signal Conditioning Techniques; Amplification of Weak Signals; Components of Data Acquisition Systems; Sampling Rates and Resolution in Data Acquisition; Calibration Procedures for Instruments; Error Analysis and Uncertainty

Estimation in Measurements		
Unit V	**ADVANCEMENTS AND APPLICATIONS OF FLOW AND HEAT TRANSFER MEASUREMENTS**	**8 hr**
Advanced Techniques for Multiphase Flow Measurement; Non-Intrusive Measurement Techniques; Integration of Computational Fluid Dynamics (CFD) in Flow Measurement; Role of Data Extraction Tools for Flow and Heat Measuring Devices; Fast Fourier Transform (FFT) Methods for Flow and Heat Transfer Measurement; Industrial Case Studies in Flow and Heat Transfer Measurement; Challenges in Industrial Flow and Heat Transfer Measurement; Recent Developments and Future Trends in Flow and Heat Transfer Measurement		
LEARNING RESOURCES		
TEXT BOOKS:		
1	Beckwith, T. G., Marangoni, R. D., & Lienhard, J. H. Mechanical measurements. Pearson,6TH Edition,2013	
2	Doebelin, E. O., & Manik, D. N. (2007). Measurement systems: application and design.Tata McGraw-Hill Eductation,5th Edition,2007.	
REFERENCE BOOKS:		
1	Holman, J. P., & Gajda, W. J. Experimental methods for engineers (Vol. 2). New York: McGraw-Hill,2001.	
ADDITIONAL REFERENCE MATERIAL		
1	Introduction to Instrumentation - Open Textbook Library (umn.edu)	
ONLINE COURSES		
1	NPTEL ::Measurement Technique in Multiphase Flows	
2	NPTEL :: Experimental Methods in Fluid Mechanics	
3	NPTEL :: Mechanical Measurement System	

Bloom's level – Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL3		X			
CO3	BL3			X		
CO4	BL4				X	
CO5	BL4					X
CO6	BL6	X	X	X	X	X

R23MMECHT16	DESIGN OF HEAT EXCHANGERS					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Heat Transfer, Fluid Mechanics	**3**	**0**	**0**	**3**

COURSE OBJECTIVE

Students will get exposure to the design of different types of heat exchangers, their construction, applications and analyze the performance of the heat exchangers as per the required conditions and requirements

COURSE OUTCOMES

Students are able to

1	Analyze different types of heat exchangers for different pressure drops and different temperatures with different fluids.**(BL4)**
2	Design different types of evaporators for the use in power plants and chemical industries.**(BL6)**
3	Design the condensers for single component and multi component mixtures in different industries.**(BL6)**
4	Analyze the cooling towers for different process conditions and prepare the heat balance sheet.**(BL4)**
5	Optimize the shape, size of the fins and spacing between the fins on the surface of the heat exchanger to enhance the heat transfer rates.**(BL6)**

SYLLABUS

UNIT I	**BASICS, PARALLEL, COUNTER FLOW AND SHELL AND TUBE HEAT EXCHANGERS**	**8 hr**

Introduction to the design of heat exchangers, design considerations, assumptions; Analysis of parallel and counter flow heat exchangers; Analysis of shell and tube heat exchangers; Analysis of performance of 1 – 2 heat exchangers; Double pipe heat exchangers with series and parallel heat exchangers; Heat exchangers with steam as heating medium, 1 – 2 exchangers without baffles; Heat recovery in 1 – 2 heat exchangers; Efficiency and other performance parameters of heat exchangers exchanger.

UNIT II	**EVAPORATORS**	**8 hr**

Vaporization coefficient, effect of pressure on vaporization coefficient, classification of vaporization equipment;Design and analysis of power plant evaporators; Analysis of chemical evaporators; Design of forced circulation evaporators;Analysis of thermocompression sugar evaporators; Natural circulation vaporizing exchangers; Pressure drop calculations in the evaporator tubes; Effect of hydrostatic head, optimum number of effects, thermos compression.

UNIT III	**CONDENSERS**	**8 hr**

Condensation of single vapors, condensation on surfaces – Nusselt theory;Design and analysis of horizontal condensers and vertical condensers;Condensation of superheated vapor and surface condensers;Condensation of mixed vapors and condensation of a binary mixtures;Condensation of mixture of miscible components; Condensation of mixture of immiscible components; Condensationfrom a mixture of water and non-condensable gas; Calculations of operating pressure of a condenser and condensing curve.

UNIT IV	**COOLING TOWERS**	**8 hr**

Introduction to cooling towers and design of natural draught cooling towers;Design of forced draught cooling towers; Analysis of counter flow cooling towers; Structural design of cooling towers; Heat balance, simultaneous diffusion and convection; Selection and sizing of cooling towers; Analysis of cooling tower

requirements, cooling tower process conditions; Performance of cooling towers, influence of process conditions on the design.		
UNIT V	**EXTENDED SURFACES**	**8 hr**
Introduction, fin efficiency and weighted fin efficiency curve;Longitudinal fin double pipe heat exchangers and pressure drops;Analysis of double pipe heat exchangers with extended surfaces;Design of shell and tube heat exchangers with extended surfaces;Calculation of thermal efficiency in different arrangements;Pressure drop calculations in different fin arrangements; Analysis of temperature differences in crossflow arrangements;Calculations of optimum spacing between fins.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	Donald Q Kern, *Process Heat Transfer*, 2nd edition, McGraw-Hill International Book Company, 2016.	
2	Ramesh K Shah, Dusan P Sekulic, *Fundamentals of heat exchanger design*, 3rd edition, JOHN WILEY & SONS, INC, 2003	
REFERENCE BOOKS:		
1	Kuppan Thulukkanam, *Heat Exchangers Design Handbook*, 2nd edition, CRC Press, 2013.	
2	M.Nitsche and R O Gbadamosi, *Heat Exchangers Design Guide*, 2nd edition, Butterworth-Heinemann, 2016.	
3	Sadik Kakaç, Hongtan Liu, Anchasa Pramuanjaroenkij, *Heat Exchangers - Selection, Rating, and Thermal Design*, 4th edition, CRC Press, 2020	
ONLINE COURSES		
1	https://archive.nptel.ac.in/courses/112/105/112105248/	
2	https://archive.nptel.ac.in/content/storage2/courses/103103027/pdf/mod1.pdf	
3	https://www.youtube.com/watch?v=qh9OzgxrwJc	

Bloom'slevel – Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL4	X				
CO2	BL6		X			
CO3	BL6			X		
CO4	BL4				X	
CO5	BL6					X

R23MMECHT 17	FUEL CELLS &HYDROGEN STORAGE TECHNOLOGIES					
	Total Contact Hours	42 (L)	L	T	P	C
	Pre-requisite	Thermodynamics, Fluid mechanics, Chemistry	3	0	0	3

Course Objective

To impart fundamental knowledge on hydrogen production, storage technologies, and fuel cells, along with their design, performance, and applications for sustainable energy systems

Course Outcomes

Students are able

1	Analyse various methods of hydrogen production, including traditional and advanced techniques **(BL4)**
2	Evaluate different hydrogen storage methods, including compression, liquefaction, and absorption **(BL5)**
3	Explain the Principles of Absorption-Based Hydrogen Storage Using Metal Hydrides. **(BL5)**
4	Explain the principles, components, types, and applications of fuel cells with physical and chemical phenomena. **(BL5)**
5	Analyze performance, overpotentials, and water management in DMFC and PEMFC systems. **(BL4)**
6	Design and evaluate hydrogen storage and fuel cell systems based on thermodynamics, mass flow rates, and water management. **(BL6)**

SYLLABUS

Unit I	INTRODUCTION TO HYDROGEN AND HYDROGEN PRODUCTION	8 hr

Introduction to Hydrogen Economy; Thermochemical Methods; Electrochemical Methods; Photochemical Methods; Recent Advancements in Hydrogen Generation Technologies; Global Hydrogen Production Roadmap and Policies; Environmental Impact of Various Hydrogen Production Methods; Global Hydrogen Production Roadmap and Policies.

Unit II	HYDROGEN STORAGE	8 hr

Introduction to Hydrogen Storage; Underground Hydrogen Storage; Fundamentals of Hydrogen Compression and Expansion; Mechanical Hydrogen Compressors; Reciprocating Compressors and Centrifugal Compressors; Screw Compressors and Compressed Hydrogen Tank Types; Hydrogen Liquefaction and Storage.

Unit III	ABSORPTION-BASED HYDROGEN STORAGE AND TRANSPORTATION SYSTEMS	8 hr

Fundamentals of Absorption-Based Hydrogen Storage; Thermodynamics of Absorption-Based Hydrogen Storage; Metal Hydrides and Types of Metal Hydrides; Metal Hydride-Based System Design; Novel Materials for Solid-State Hydrogen Storage and Hydrogen Transportation Technologies; Hydrogen Adsorption-Based Storage Systems; Thermal Management in Solid-State Storage Systems; Hydrogen Leak Detection and Safety Systems.

Unit IV	INTRODUCTION TO FUEL CELLS	8 hr

Fundamentals of Fuel Cells; Applications, Advantages and Disadvantages of Fuel Cells; Types of fuel cells; Working of PEMFC; Theoretical electrical work and Theoretical fuel cell efficiency; Voltage losses; Cell components and materials;

Operating parameters on the PEMFC.		
Unit V	**FUEL CELL DESIGN AND PERFORMANCE**	**8 hr**
DMFC and its working; Design considerations of PEMFC and DMFC; PEMFC and DMFC stack; Water management; Thermal management; Problems on work and efficiency calculations; Performance Characteristics of Fuel Cells; Degradation and Lifetime of Fuel Cells.		
LEARNING RESOURCES		
TEXT BOOKS:		
1	ByAbbas Tcharkhtchi, Hamid Reza Vanaei, Albert Lucas, Sedigheh Farzaneh, Hydrogen Production, Storage, and Utilization,CRC Press,Taylor-Francis, 2024.	
2	Fano Barbir,PEM Fuel cells,2nd Edition,Elseveir, 2012.	
3	Trygve Riisand Elisabet F. Hagen,Preben J. S. Vie,Hydrogen production and storage,International Energy agency,January 2006.	
REFERENCE BOOKS:		
1	Michael Hirscher, "Handbook of Hydrogen Storage", Wiley-VCH, 2010.	
ONLINE COURSES		
1	NPTEL:Hydrogen Energy,Production,Storage,transporation,safety	
2	NPTEL:Cryogenic hydrogen Technology	
3	NPTEL:Fuel cell Technology	

Bloom'slevel – Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL4	X				
CO2	BL5		X			
CO3	BL5			X		
CO4	BL5				X	
CO5	BL4					X
CO6	BL6	X	X	X	X	X

R23MCSCT007	**COMPUTER NETWORKS (Common to all Branches)**					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisites	DLD,CAO	**3**	**0**	**0**	**3**

Course Objective

Students will gain an ability to identify and design network architecture and apply the essence of various protocols.

Course Outcomes

1	Students will be able to analyse and **apply** key concepts of data communication, including network topologies, layering, and protocols; the OSI and TCP/IP reference models in order to design and evaluate efficient communication systems. **(BL3)**
2	Students will be able to **describe**, **demonstrate**, and **analyse** various data link layer techniques and apply this knowledge to design and evaluate reliable data communication systems. **(BL4)**
3	Students will be able to **identify**, **explain**, and **apply** random access methods and assess their impact on the performance and evolution of network communication systems. **(BL3)**
4	Students will be able to **describe**, **compare**, and **apply** the roles of connecting devices (switches, hubs, routers, bridges, gateways), **analyze** and **evaluate** various routing algorithms and **assess** the effectiveness of flooding in network communication. **(BL5)**
5	Students will be able to **compare**, and **apply** the TCP and UDP datagram formats, congestion control techniques and flow control methods and their roles in Internet communication. **(BL4)**
6	Students will be able to design and evaluate efficient, reliable and effective network communication systems. **(BL6)**

SYLLABUS

Unit I	**OVERVIEW OF DATACOMMUNICATION AND NETWORKING**	**8 hr**

Introduction to Data Communication**;** Network Topologies, Layering and Protocols; Reference-Model: OSI & TCP/IP Reference Model, Addressing; Physical Layer-Different types of Transmission Media-Guided; Different types of Transmission Media-Unguided; Multiplexing-TDM,FDM,WDM; Line Encoding (NRZ,NRZI,Manchester,AMI,4B/5B); Switching and Taxonomy: Circuit Switched, Packet Switched.

Unit II	**DATALINK LAYER : ERROR CONTROL & FLOW CONTROL**	**8 hr**

Error Detection: CRC, Checksum; Error Correction: Hamming Distance, Linear Block Codes Framing: Bit and Byte Stuffing ; Flow Control: Noiseless-Simplest, Stop and Wait; Noisy: Stop and wait ARQ; Go Back N, Selective repeat; PPP, HDLC; Random Access: Aloha: Pure and Slotted;

Unit III	**DATALINK LAYER**	**8 hr**

Random Access: CSMA, CSMA/CD; Random Access: CSMA/CA; Controlled Access-Reservation, Polling and Token passing; Channelization-FDMA; TDMA and CDMA; Standard Ethernet-MAC; Standard Ethernet-Physical Layer; Changes in the Standard- Fast Ethernet; Gigabit Ethernet,10 Gigabit Ethernet.

Unit IV	**NETWORK LAYER**	**8 hr**

ConnectingDevices-Switches,Hubs,Routers,Bridges,Gateways;IPv4addressing-

Classful,Classless; IPv4 Datagram Format,IPv6 Datagram Format; Address Mapping: ARP; RARP,BOOTP, DHCP; Routing: Routing table, Optimization, Distance Vector Routing ; Link State Routing, Path Vector Routing;		
Unit V	**TRANSPORT LAYER AND APPLICATION LAYER**	**8 hr**
TRANSPORT LAYER: TCP Datagram Format; UDP Datagram Format; Congestion Control: Data Traffic, Open Loop, Closed Loop; Quality of Service: Flow characteristics, Scheduling ; Flow Control: Leaky Bucket and Token Bucket; **REMOTE LOGIN & APPLICATION LAYER:** Telnet, Electronic Mail; DNS, Distribution of Name Space, DNS in the Internet; WWW and HTTP.		
LEARNING RESOURCES		
TEXTBOOKS:		
1	Data Communications and Networking, Behrouz Forouzan ,4th Edition,McGrawHill.	
REFERENCE BOOKS:		
1	Computer Networks –Andrew S Tanenbaum,4th Edition, Pearson Education/PHI.	
2	Computer Networking: *A Top Down Approach-James F Kurose and Keith W Ross,* 6th Edition, Pearson Education.	
ADDITIONAL REFERENCE MATERIAL		
1	https://www.geeksforgeeks.org/computer-network-tutorials	
2	https://www.javatpoint.com/computer-network-tutorial	
3	https://www.tutorialspoint.com/data_communication_computer_network	
ONLINE COURSES		
1	https://onlinecourses.nptel.ac.in/noc22_cs19	
2	https://www.coursera.org/learn/illinois-tech-computer-networking	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL3			X		
CO4	BL5				X	
CO5	BL4					X
CO6	BL6	X	X	X	X	X

R23MCSCT008	ARTIFICIAL INTELLIGENCE: PRINCIPLES AND TECHNIQUES (for MEC, ECE, EEE, CIV and CHE)					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Pre-requisite	Data Structures	**3**	**0**	**0**	**3**

Course Objective

This course aims to help students conversant with the theoretical concepts and algorithm approaches that can be applied to the design of AI applications and students will gain insights into foundational principles, algorithms, and theoretical frameworks underlying Machine Learning.

Course Outcomes

After completing this course, the students will be able to

1	Apply AI Search Algorithms and Backtracking Techniques to Solve Constraint Satisfaction Problems and Design Adversarial Search Strategies in Real-World Scenarios. (**BL3**)
2	Analyze and Compare the Applications and Limitations of Propositional Logic and First-Order Logic in Knowledge Representation and Reasoning. (**BL4**)
3	Apply Machine Learning Techniques and Neural Network Models to Solve Real-World Problems Across Various Domains. (**BL3**)
4	Analyze and Compare the Effectiveness of the Find-S and Candidate Elimination Algorithms in Designing a Learning System, Focusing on Version Spaces and Their Applications. (**BL4**)
5	Evaluate the Effectiveness and Applicability of Decision Tree Learning and Single and Multi-Layer Perceptrons in Solving Classification Problems Across Various Domains. (**BL5**)
6	Design and Develop an Integrated Intelligent System that Utilizes AI Search Algorithms, Knowledge Representation, and Machine Learning Techniques, Including Decision Trees and Neural Networks, to Solve Complex Real-World Problems. (**BL6**)

SYLLABUS

Unit I	**INTRODUCTION TO ARTIFICIAL INTELLIGENCE**	**8 hr**

Introduction to Artificial Intelligence (AI), machine learning, deep learning, Types of AI, Advantages and Applications of AI; Agents in Artificial Intelligence, Types of agents; State Space Search: Uninformed search: (Iterative Deepening, Bidirectional search); Informed search: Best First Search; A* Algorithm; Hill Climbing Algorithms in Artificial Intelligence (Simple and Steepest Ascent); Constraint satisfaction problems (Constraint propagation: Arc Consistency), Backtracking Algorithm for CSP's; Knowledge-Based Agent (KBA): Architecture and Various level of KBA.

Unit II	**KNOWLEDGE REPRESENTATION AND REASONING**	**8 hr**

Knowledge representation (KR), Approaches to KR, Techniques of KR; Propositional Logic, Logical Connective and Equivalence; Rules of Inference; PEAS description of Wumpus world; First Order Logic in AI, Inference in First-Order Logic; Knowledge Engineering in First-order logic; Forward Chaining and backward chaining in AI; Reasoning in Artificial intelligence;

Unit III	**BASICS AND TYPES OF MACHINE LEARNING**	**8 hr**

Conceptual introduction to Machine Learning and Neural Networks: Biological Neural Networks and Artificial Neural Networks; Supervised Learning: (Linear and Non-Linear regression); Logistic Regression; Classification: Decision Tree

and Support Vector Machines; Unsupervised Learning (clustering approach); Association; Semi-Supervised Learning; Reinforcement Learning		
Unit IV	**MACHINE LEARNING TRAINING EXAMPLES**	**8 hr**
Well Posed Learning Problems, Designing A Learning System, Perspectives and Issues in Machine Learning; Introduction to Concept Learning: A Concept Learning as a Task; Concept Learning as Search; Find-S: Finding a Maximally Specific Hypothesis; Version Spaces Representation: The List-Then-Eliminate Algorithm, Compact Representation for Version Spaces; Candidate Elimination Algorithm and Example; Remarks on Version Spaces and Candidate-Elimination: Converge, Order of Training Examples, Usage of Partially Learned Concepts; Inductive Bias		
Unit V	**DECISION TREE LEARNING AND SINGLE AND MULTI-LAYER PERCEPTRON**	**8 hr**
Introduction, Decision Tree Representation and Appropriate Problems for Decision Tree Learning;ID3 Algorithm: An Illustrative Example; Hypothesis Space Search and Inductive Bias in Decision Tree Learning; Neural Network Representation, Appropriate Problems for Neural Network Learning; Perceptrons - Representational Power of Perceptrons, The Perceptron Training Rule; Gradient Descent and The Delta Rule, Stochastic Approximation to Gradient Descent; Multilayer Networks and The Back Propagation Algorithm - A Differentiable Threshold Unit; The Back Propagation Algorithm		
LEARNING RESOURCES		
TEXTBOOKS:		
1	Tom M. Mitchell "Machine Learning", Indian Edition.	
2	Stuart J. Russell and Peter Norvig, "Artificial Intelligence A Modern Approach", Third Edition.	
3	Kevin Knight, Elaine Rich, B. Nair, "Artificial Intelligence", Tata McGraw-Hill Education, 3rd Edition, 2010.	
REFERENCE BOOKS:		
1	Christopher M. Bishop, "Pattern recognition and machine learning", Springer,2007.	
2	Ethem Alpaydin, "Introduction to Machine Learning", PHI, Third edition, 2015.	
ADDITIONAL REFERENCE MATERIAL		
1	https://www.javatpoint.com/artificial-intelligence-ai/	
2	https://www.geeksforgeeks.org/machine-learning/	

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL3	X				
CO2	BL4		X			
CO3	BL3			X		
CO4	BL4				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X

R23MSCST009	OOAD AND DESIGN PATTERNS (Common to all Branches)					
	Total Contact Hours	42 (L)	**L**	**T**	**P**	**C**
	Prerequisite	Object Oriented Programming	**3**	**0**	**0**	**3**

Course Objectives

1. Understand the importance and basic concepts of object oriented modeling,
2. Specify, analyze and design the requirements for a system and model the state of the set of objects and their implementation specifications.
3. Identify, Analyze the subsystems, various components and collaborate them interchangeably.
4. Describe the design patterns that are common in software applications
5. Design a module structure to solve a problem, and evaluate alternatives

Course Outcomes

On the successful completion of this course, Students will be able to

1	Examine the Object Oriented Models required for Software development through use case driven approach (**BL4**)
2	Categorize and model the structural and behavioural concepts of the software system. (**BL4**)
3	Develop and explore the transformation of conceptual models into various scenarios and real time applications. (**BL4**)
4	Construct a design consisting of a collection of modules using creational and structural design patterns.(**BL5**)
5	Identify appropriate behavioral patterns to demonstrate the dynamic aspects of a given software model during execution.(**BL5**)
6	Design a Small-Scale Application with Unified Models and Integrated Design Patterns.(**BL6**)

SYLLABUS

Unit I	**INTRODUCTION TO UNIFIED MODELING LANGUAGE**	**8 hr**

Introduction to UML, Importance of Modeling; Principles of Modeling; Object oriented modeling; Conceptual model of UML: Basic building blocks; Conceptual model of UML: Rules; Conceptual model of UML: Common Mechanisms; Architecture; Software Development life cycle.

Unit II	**STRUCTURAL MODELING**	**8 hr**

Basic Structural Modeling: Classes ; Relationships; Common Mechanisms; Diagrams; Advanced Structural Modeling: Advanced classes; Advanced Relationships; Interfaces, Types and Roles**;** Packages & Instances**;**

Unit III	**ARCHITECTURAL MODELING & UML 2.0**	**8 hr**

Usecase Diagrams**;** Interactions : Sequence & Collaboration Diagrams**;** Activity Diagrams**;** State Diagrams; Component Diagrams; Deployment Diagrams; Updations in UML 2.0: Interaction overview diagram and Timing diagrams; Unified Process Models in Software Engineering;

Unit IV	**DESIGN PATTERNS-1**	**8 hr**

Introduction to Design patterns; Creational Design Patterns : Factory Method & Abstract Factory; Builder; Prototype; Singleton; Case study on Creational Design Patterns ; Structural Patterns: Adapter ; Bridge;

Unit V	**DESIGN PATTERNS-2**	**8 hr**

Composite; FlyWeight; Case study on Structural Patterns; Behavioral Patterns: Chain of Responsibility; Iterator; Memento ; Observer ; Case study on Behavioral Patterns	
LEARNING RESOURCES	
TEXTBOOKS:	
1	Grady Booch, James Rumbaugh, Ivar Jacobson: The Unified Modeling Language User Guide, Pearson Education.
2	Design Patterns By Erich Gamma, Pearson Education.
3	Hans-Erik Eriksson, Magnus Penker, Brian Lyons, David Fado: UML 2 Toolkit, WILEY-Dreamtech India Pvt. Ltd.
REFERENCE BOOKS:	
1	https://www.ibm.com/developerworks/rational/library/769.html
2	https://www.visual-paradigm.com/tutorials/uml-class-diagram-in-diff-programming-languages.jsp
3	https://www.uml-diagrams.org/index-examples.html
4	https://www.tutorialspoint.com/design_pattern/
5	http://www.oodesign.com/
6	https://praveenthomasln.wordpress.com/2012/03/03/interfaces-types-and-roles-s8-cs/
7	https://www.uml-diagrams.org/uml-25-diagrams.html
8	https://www.tutorialspoint.com/uml/uml_2_overview.htm#:~:text=UML%202.0%20offers%20four%20interaction,of%20interactions%20as%20interaction%20occurrences.
ONLINE COURSES	
1	NPTEL :: Computer Science and Engineering - NOC: Object-Oriented Analysis and Design
2	https://onlinecourses.nptel.ac.in/noc22_cs99/preview

Bloom's level - Units catchment articulation matrix

CO	Blooms Level	Unit I	Unit II	Unit III	Unit IV	Unit V
CO1	BL4	X				
CO2	BL4		X			
CO3	BL4			X		
CO4	BL5				X	
CO5	BL5					X
CO6	BL6	X	X	X	X	X