KONGU ENGINEERING COLLEGE

(Autonomous Institution Affiliated to Anna University, Chennai)

PERUNDURAI ERODE – 638 060

TAMILNADU INDIA

REGULATIONS, CURRICULUM & SYLLABI - 2020

(CHOICE BASED CREDIT SYSTEM AND
OUTCOME BASED EDUCATION)
(For the students admitted during 2020 - 2021 and onwards)

MASTER OF ENGINEERING DEGREE
IN
ENGINEERING DESIGN

DEPARTMENT OF MECHANICAL ENGINEERING

KONGU
Assuring the Best

INDEX

KONGU ENGINEERING COLLEGE
PERUNDURAI ERODE – 638 060
(Autonomous)

INSTITUTE VISION

To be a centre of excellence for development and dissemination of knowledge in Applied Sciences, Technology, Engineering and Management for the Nation and beyond.

INSTITUTE MISSION

We are committed to value based Education, Research and Consultancy in Engineering and Management and to bring out technically competent, ethically strong and quality professionals to keep our Nation ahead in the competitive knowledge intensive world.

QUALITY POLICY

We are committed to

- Provide value based quality education for developing the student as a competent and responsible citizen.
- Contribute to the nation and beyond through the state-of-the-art technology.
- Continuously improve our services.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To be a centre of excellence for development and dissemination of knowledge in Mechanical Engineering for the Nation and beyond.

MISSION

Department of Mechanical Engineering is committed to:

MS1: Establish itself as an excellent academic centre through expert pedagogical methods and modern laboratories to produce world class mechanical engineers.

MS2: Disseminate knowledge through seminar, conferences and continuing education programs.

MS3: Make tie-ups with industries, research centres and renowned intuitions to synergize the benefit.

MS4: Contribute towards the upliftment of the society.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Graduates of M.E. Engineering Design will

PEO1: Practice Engineering Design in the general stems of design and development of engineering products.

PEO2: Habituate continuous learning and carryout research and development in science, engineering and technology that support career growth.

PEO3: Exhibit ethical code of conduct in a professional manner to solve real-time multidisciplinary engineering design problems.

PEO4: Demonstrate managerial and leadership capabilities that support economic development of firms as well as society.

MAPPING OF MISSION STATEMENTS (MS) WITH PEOs

MS\PEO	PEO1	PEO2	PEO3	PEO4
MS1	3	3	3	3
MS2	2	3	2	2
MS3	2	3	2	2
MS4	1	1	2	2

1 – Slight, 2 – Moderate, 3 – Substantial

PROGRAM OUTCOMES (POs)	
Engineering Post Graduates will be able to:	
PO1	carry out research /investigation and development work to solve practical problems.
PO2	write and present a substantial technical report/document.
PO3	use of modern engineering techniques, skills and tools for design and development of engineering products and services.

MAPPING OF PEOs WITH POs

PEO\PO	PO1	PO2	PO3
PEO1	3	3	3
PEO2	3	3	3
PEO3	3	2	2
PEO4	3	2	2

1 – Slight, 2 – Moderate, 3 – Substantial

KONGU ENGINEERING COLLEGE, PERUNDURAI, ERODE – 638060

(An Autonomous Institution Affiliated to Anna University)

REGULATIONS 2020

CHOICE BASED CREDIT SYSTEM AND OUTCOME BASED EDUCATION

MASTER OF ENGINEERING (ME) / MASTER OF TECHNOLOGY (MTech) DEGREE PROGRAMMES

These regulations are applicable to all candidates admitted into ME/MTech Degree programmes from the academic year 2020 – 2021 onwards.

1. DEFINITIONS AND NOMENCLATURE

In these Regulations, unless otherwise specified:

i. "University" means ANNA UNIVERSITY, Chennai.

ii. "College" means KONGU ENGINEERING COLLEGE.

iii. "Programme" means Master of Engineering (ME) / Master of Technology (MTech) Degree programme

iv. "Branch" means specialization or discipline of ME/MTech Degree programme, like Construction Engineering and Management, Information Technology, etc.

v. "Course" means a Theory / Theory cum Practical / Practical course that is normally studied in a semester like Engineering Design Methodology, Machine Learning Techniques, etc.

vi. "Credit" means a numerical value allocated to each course to describe the candidate's workload required per week.

vii. "Grade" means the letter grade assigned to each course based on the marks range specified.

viii. "Grade point" means a numerical value (0 to 10) allocated based on the grade assigned to each course.

ix. "Principal" means Chairman, Academic Council of the College.

x. "Controller of Examinations" means authorized person who is responsible for all examination related activities of the College.

xi. "Head of the Department" means Head of the Department concerned of the College.

2. PROGRAMMES AND BRANCHES OF STUDY

The following programmes and branches of study approved by Anna University, Chennai and All India Council for Technical Education, New Delhi are offered by the College.

Programme	Branch
ME	Construction Engineering and Management
	Structural Engineering
	Engineering Design
	Mechatronics Engineering
	VLSI Design
	Embedded Systems
	Power Electronics and Drives
	Control and Instrumentation Engineering
	Computer Science and Engineering
MTech	Information Technology
	Chemical Engineering
	Food Technology

3. ADMISSION REQUIREMENTS

Candidates seeking admission to the first semester of the ME/MTech Degree programme shall be required to have passed an appropriate qualifying Degree Examination of Anna University or any examination of any other University or authority accepted by the Anna University, Chennai as equivalent thereto, subject to amendments as may be made by the Anna University, Chennai from time to time. The candidates shall also be required to satisfy all other conditions of admission prescribed by the Anna University, Chennai and Directorate of Technical Education, Chennai from time to time.

4. STRUCTURE OF PROGRAMMES

4.1 Categorisation of Courses

The ME / MTech programme shall have a curriculum with syllabi comprising of theory, theory cum practical, practical courses in each semester and project work, internship,etc that have been approved by the respective Board of Studies and Academic Council of the College. All the programmes have well defined Programme Outcomes (PO) and Programme Educational Objectives (PEOs) as per Outcome Based Education (OBE). The content of each course is designed based on the Course Outcomes (CO). The courses shall be categorized as follows:

i. Foundation Courses (FC)

ii. Professional Core (PC) Courses

iii. Professional Elective (PE) Courses

iv. Open Elective (OE) Courses

v. Employability Enhancement Courses (EC) like Innovative Project, Internship cum Project work in Industry or elsewhere, Project Work

4.2 Credit Assignment

Each course is assigned certain number of credits as follows:

Contact period per week	Credits
1 Lecture / Tutorial Period	1
2 Practical Periods	1
2 Project Work Periods	1
40 Training /Internship Periods	1

The minimum number of credits to complete the ME/MTech programme is 72.

4.3 Employability Enhancement Courses

A candidate shall be offered with the employability enhancement courses like innovative project, internship cum project work and project work during the programme to gain/exhibit the knowledge/skills.

4.3.1 Innovative Project

A candidate shall earn two credits by successfully completing the project by using his/her innovations in second semester during his/her programme.

4.3.2 Internship cum Project Work

The curriculum enables a candidate to go for full time internship during the third semester and can earn credits through it for his/her academics vide clause 7.6 and clause 7.12. Such candidate shall earn the minimum number of credits as mentioned in the third semester of the curriculum other than internship by either fast track mode or through approved courses in online mode or by self study mode. Such candidate can earn the number of credits for the internship same as that of Project Work in the third semester. Assessment procedure is to be followed as specified in the guidelines approved by the Academic Council.

4.3.4 Project Work

A candidate shall earn nine credits by successfully completing the project work in fourth semester during the programme inside the campus or in industries.

4.4 Value Added Courses / Online Courses / Self Study Courses

The candidates may optionally undergo Value Added Courses / Online Courses / Self Study Courses as elective courses.

4.4.1 Value Added Courses: Value Added courses each with One / Two credits shall be offered by the college with the prior approval from respective Board of Studies. A candidate can earn a maximum of six credits through value added courses during the entire duration of the programme.

4.4.2 Online Courses: Candidates may be permitted to earn credits for online courses, offered by NPTEL / SWAYAM / a University / Other Agencies, approved by respective Board of Studies.

4.4.3 **Self Study Courses:** The Department may offer an elective course as a self study course. The syllabus of the course shall be approved by the respective Board of Studies. However, mode of assessment for a self study course will be the same as that used for other courses. The candidates shall study such courses on their own under the guidance of member of the faculty. Self study course is limited to one per semester.

4.4.4 The elective courses in the final year may be exempted if a candidate earns the required credits vide clause 4.4.1, 4.4.2 and 4.4.3 by registering the required number of courses in advance (up to second semester).

4.4.5 A candidate can earn a maximum of 15 credits through all value added courses, online courses and self study courses.

4.5 Flexibility to Add or Drop Courses

4.5.1 A candidate has to earn the total number of credits specified in the curriculum of the respective programme of study in order to be eligible to obtain the degree. However, if the candidate wishes, then the candidate is permitted to earn more than the total number of credits prescribed in the curriculum of the candidate's programme.

4.5.2 From the second to fourth semesters the candidates have the option of registering for additional elective/Honors courses or dropping of already registered additional elective/Honors courses within two weeks from the start of the semester. Add / Drop is only an option given to the candidates. Total number of credits of such courses during the entire programme of study cannot exceed six.

4.6 Maximum number of credits the candidate can enroll in a particular semester cannot exceed 30 credits.

4.7 The blend of different courses shall be so designed that the candidate at the end of the programme would have been trained not only in his / her relevant professional field but also would have developed to become a socially conscious human being.

4.8 The medium of instruction, examinations and project report shall be English.

5. DURATION OF THE PROGRAMME

5.1 A candidate is normally expected to complete the ME / MTech Degree programme in 4 consecutive semesters (2 Years), but in any case not more than 8 semesters (4 Years).

5.2 Each semester shall consist of a minimum of 90 working days including continuous assessment test period. The Head of the Department shall ensure that every teacher imparts instruction as per the number of periods specified in the syllabus for the course being taught.

5.3 The total duration for completion of the programme reckoned from the commencement of the first semester to which the candidate was admitted shall not exceed the maximum duration specified in clause 5.1 irrespective of the period of break of study (vide clause 11) or prevention (vide clause 9) in order that the candidate may be eligible for the award of the degree (vide clause 16). Extension beyond the prescribed period shall not be permitted.

6. COURSE REGISTRATION FOR THE EXAMINATION

6.1 Registration for the end semester examination is mandatory for courses in the current semester as well as for the arrear courses failing which the candidate will not be permitted to move on to the higher semester. This will not be applicable for the courses which do not have an end semester examination.

6.2 The candidates who need to reappear for the courses which have only continuous assessment shall enroll for the same in the subsequent semester, when offered next, and repeat the course. In this case, the candidate shall attend the classes, satisfy the attendance requirements (vide clause 8), earn continuous assessment marks. This will be considered as an attempt for the purpose of classification.

6.3 If a candidate is prevented from writing end semester examination of a course due to lack of attendance, the candidate has to attend the classes, when offered next, and fulfill the attendance requirements as per clause 8 and earn continuous assessment marks. If the course, in which the candidate has a lack of attendance, is an elective, the candidate may register for the same or any other elective course in the subsequent semesters and that will be considered as an attempt for the purpose of classification.

7. ASSESSMENT AND EXAMINATION PROCEDURE FOR AWARDING MARKS

7.1 The ME/MTech programmes consist of Theory Courses, Theory cum Practical courses, Practical courses, Innovative Project, Internship cum Project work and Project Work. Performance in each course of study shall be evaluated based on (i) Continuous Assessments (CA) throughout the semester and (ii) End Semester Examination (ESE) at the end of the semester except for the courses which are evaluated based on continuous assessment only. Each course shall be evaluated for a maximum of 100 marks as shown below:

<table>
<tr><th>Sl. No.</th><th>Category of Course</th><th>Continuous Assessment Marks</th><th>End Semester Examination</th></tr>
<tr><td>1.</td><td>Theory / Practical</td><td>50</td><td>50</td></tr>
<tr><td>2.</td><td>Theory cum Practical</td><td colspan="2">The distribution of marks shall be decided based on the credit weightage assigned to theory and practical components respectively.</td></tr>
<tr><td>3.</td><td>Innovative Project/ Project Work / Internship cum Project Work</td><td>50</td><td>50</td></tr>
<tr><td>4.</td><td>Value Added Course</td><td rowspan="2">The distribution of marks shall be decided based on the credit the credit weightage assigned</td><td rowspan="2">---</td></tr>
<tr><td>5.</td><td>All other Courses</td></tr>
</table>

7.2 Examiners for setting end semester examination question papers for theory courses, theory cum practical courses and practical courses and evaluating end semester examination answer scripts, project works, innovative project and internships shall be appointed by the Controller of Examinations after obtaining approval from the Principal.

7.3 Theory Courses

For all theory courses out of 100 marks, the continuous assessment shall be 50 marks and the end semester examination shall be for 50 marks. However, the end semester examinations shall be conducted for 100 marks and the marks obtained shall be reduced to 50. The continuous assessment tests shall be conducted as per the schedule laid down in the academic schedule. Three tests shall be conducted for 50 marks each and reduced to 30 marks each. The total of the continuous assessment marks and the end semester examination marks shall be rounded off to the nearest integer.

7.3.1 The assessment pattern for awarding continuous assessment marks shall be as follows:

Sl. No.	Type	Max. Marks	Remarks
1.	Test – I	30	Average o f best two
	Test – II	30	
	Test - III	30	
2.	Tutorial	15	Should be of Open Book/Objective Type. Average of best 4 (or more, depending on the nature of the course, as may be approved by Principal)
3.	Assignment / Paper Presentation in Conference / Seminar / Comprehension / Activity based learning / Class notes	05	To be assessed by the Course Teacher based on any one type.
	Total	50	Rounded off to the one decimal place

However, the assessment pattern for awarding the continuous assessment marks may be changed based on the nature of the course and is to be approved by the Principal.

7.3.2 A reassessment test or tutorial covering the respective test or tutorial portions may be conducted for those candidates who were absent with valid reasons (Sports or any other reason approved by the Principal).

7.3.3 The end semester examination for theory courses shall be for a duration of three hours and shall be conducted between November and January during odd semesters and between April and June during even semesters every year.

7.4 Theory cum Practical Courses

For courses involving theory and practical components, the evaluation pattern as per the clause 7.1 shall be followed. Depending on the nature of the course, the end semester examination shall be conducted for theory and the practical components. The apportionment of continuous assessment and end semester examination marks shall be decided based on the credit weightage assigned to theory and practical components approved by Principal.

7.5 Practical Courses

For all practical courses out of 100 marks, the continuous assessment shall be for 50 marks and the end semester examination shall be for 50 marks. Every exercise / experiment shall be evaluated based on the candidate's performance during the practical class and the candidate's records shall be maintained.

7.5.1 The assessment pattern for awarding continuous assessment marks for each course shall be decided by the course coordinator based on rubrics of that particular course, and shall be based on rubrics for each experiment.

7.6 Project Work

7.6.1 Project work shall becarried out individually. Candidates can opt for full time internship (vide clause 7.8) in lieu of project work in third semester. The project work is mandatory for all the candidates.

7.6.2 The Head of the Department shall constitute review committee for project work. There shall be two assessments by the review committee during the semester. The candidate shall make presentation on the progress made by him/her before the committee.

7.6.3 The continuous assessment and end semester examination marks for Project Work and the Viva-Voce Examination shall be distributed as below.

Continuous Assessment (Max. 50 Marks)						End Semester Examination (Max. 50 Marks)			
Review I (Max..10 Marks)		Review II (Max.. 20 Marks)		Review III (Max. 20 Marks)		Report Evaluation (Max. 20 Marks)	Viva - Voce (Max. 30 Marks)		
Rv. Com	Guide	Review Committee (excluding guide)	Guide	Review Committee (excluding guide)	Guide	Ext. Exr.	Guide	Exr. 1	Exr. 2
5	5	10	10	10	10	20	10	10	10

7.6.4 The Project Report prepared according to approved guidelines and duly signed by the Guide and Project Co-ordinator shall be submitted to Head of the Department. A candidate must submit the project report within the specified date as per the academic schedule of the semester. If the project report is not submitted within the specified date then the candidate is deemed to have failed in the Project Work and redo it in the subsequent semester. This applies to both Internship cum Project work and Project work.

7.6.5 If a candidate fails to secure 50% of the continuous assessment marks in the project work, he / she shall not be permitted to submit the report for that particular semester and shall have to redo it in the subsequent semester and satisfy attendance requirements.

7.6.6 Every candidate shall, based on his/her project work, publish a paper in a reputed journal or reputed conference in which full papers are published after usual review. A copy of the full paper accepted and proof for that shall be produced at the time of evaluation.

7.6.7 The project work shall be evaluated based on the project report submitted by the candidate in the respective semester and viva-voce examination by a committee consisting of two examiners and guide of the project work.

7.6.8 If a candidate fails to secure 50 % of the end semester examination marks in the project work, he / she shall be required to resubmit the project report within 30 days from the date of declaration of the results and a fresh viva-voce examination shall be conducted as per clause 7.6.7.

7.6.9 A copy of the approved project report after the successful completion of viva-voce examination shall be kept in the department library.

7.7 Innovative Project

The evaluation method shall be same as that of the Project Work as per clause 7.6 excluding clause 7.6.6.

7.8 Internship cum Project Work

Each candidate shall submit a brief report about the internship undergone and a certificate issued from the organization concerned at the time of Viva-voce examination to the review committee. The evaluation method shall be same as that of the Project Work as per clause 7.6 excluding 7.6.6.

7.9 Value Added Course

Two assessments shall be conducted during the value added course duration by the offering department concerned.

7.10 Online Course

The Board of Studies will provide methodology for the evaluation of the online courses. The Board can decide whether to evaluate the online courses through continuous assessment and end semester examination or through end semester examination only. In case of credits earned through online mode from NPTEL / SWAYAM / a University / Other Agencies approved by Chairman, Academic Council, the credits may be transferred and grades shall be assigned accordingly.

7.11 Self Study Course

The member of faculty approved by the Head of the Department shall be responsible for periodic monitoring and evaluation of the course. The course shall be evaluated through continuous assessment and end semester examination. The evaluation methodology shall be the same as that of a theory course.

7.12 Audit Course

A candidate may be permitted to register for specific course not listed in his/her programme curriculum and without undergoing the rigors of getting a 'good' grade, as an Audit course, subject to the following conditions.

The candidate can register only one Audit course in a semester starting from second semester subject to a maximum of two courses during the entire programme of study. Such courses shall be indicated as 'Audit' during the time of Registration itself. Only courses currently offered for credit to the candidates of other branches can be audited.

A course appearing in the curriculum of a candidate cannot be considered as an audit course. However, if a candidate has already met the Professional Elective and Open Elective credit requirements as stipulated in the curriculum, then, a Professional Elective or an Open Elective course listed in the curriculum and not taken by the candidate for credit can be considered as an audit course.

Candidates registering for an audit course shall meet all the assessment and examination requirements (vide clause 7.3) applicable for a credit candidate of that course. Only if the candidate obtains a performance grade, the course will be listed in the semester Grade Sheet and in the Consolidated Grade Sheet along with the grade SF (Satisfactory). Performance grade will not be shown for the audit course.

Since an audit course has no grade points assigned, it will not be counted for the purpose of GPA and CGPA calculations.

8. REQUIREMENTS FOR COMPLETION OF A SEMESTER

8.1 A candidate who has fulfilled the following conditions shall be deemed to have satisfied the requirements for completion of a semester and permitted to appear for the examinations of that semester.

8.1.1 Ideally, every candidate is expected to attend all classes and secure 100 % attendance. However, a candidate shall secure not less than 80 % (after rounding off to the nearest integer) of the overall attendance taking into account the total number of working days in a semester.

8.1.2 A candidate who could not satisfy the attendance requirements as per clause 8.1.1 due to medical reasons (hospitalization / accident / specific illness) but has secured not less than 70 % in the current semester may be permitted to appear for the current semester examinations with the approval of the Principal on payment of a condonation fee as may be fixed by the authorities from time to time. The medical certificate needs to be submitted along with the leave application. A candidate can avail this provision only twice during the entire duration of the degree programme.

8.1.3 In addition to clause 8.1.1 or 8.1.2, a candidate shall secure not less than 60 % attendance in each course.

8.1.4 A candidate shall be deemed to have completed the requirements of study of any semester only if he/she has satisfied the attendance requirements (vide clause 8.1.1 to 8.1.3) and has registered for examination by paying the prescribed fee.

8.1.5 Candidate's progress is satisfactory.

8.1.6 Candidate's conduct is satisfactory and he/she was not involved in any indisciplined activities in the current semester.

8.2. The candidates who do not complete the semester as per clauses from 8.1.1 to 8.1.6 except 8.1.3 shall not be permitted to appear for the examinations at the end of the semester and not be permitted to go to the next semester. They have to repeat the incomplete semester in next academic year.

8.3 The candidates who satisfy the clause 8.1.1 or 8.1.2 but do not complete the course as per clause 8.1.3 shall not be permitted to appear for the end semester examination of that course alone. They have to repeat the incomplete course in the subsequent semester when it is offered next.

9. REQUIREMENTS FOR APPEARING FOR END SEMESTER EXAMINATION

9.1 A candidate shall normally be permitted to appear for end semester examination of the current semester if he/she has satisfied the semester completion requirements as per clause 8, and has registered for examination in all courses of that semester. Registration is mandatory for current semester examinations as well as for arrear examinations failing which the candidate shall not be permitted to move on to the higher semester.

9.2 When a candidate is deputed for a National / International Sports event during End Semester examination period, supplementary examination shall be conducted for such a candidate on return after participating in the event within a reasonable period of time. Such appearance shall be considered as first appearance.

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

10. PROVISION FOR WITHDRAWAL FROM EXAMINATIONS

10.1 A candidate may, for valid reasons, be granted permission to withdraw from appearing for the examination in any regular course or all regular courses registered in a particular semester. Application for withdrawal is permitted only once during the entire duration of the degree programme.

10.2 The withdrawal application shall be valid only if the candidate is otherwise eligible to write the examination (vide clause 9) and has applied to the Principal for permission prior to the last examination of that semester after duly recommended by the Head of the Department.

10.3 The withdrawal shall not be considered as an appearance for deciding the eligibility of a candidate for First Class with Distinction/First Class.

10.4 If a candidate withdraws a course or courses from writing end semester examinations, he/she shall register the same in the subsequent semester and write the end semester examinations. A final semester candidate who has withdrawn shall be permitted to appear for supplementary examination to be conducted within reasonable time as per clause 14.

10.5 The final semester candidate who has withdrawn from appearing for project viva-voce for genuine reasons shall be permitted to appear for supplementary viva-voce examination within reasonable time with proper application to Controller of Examinations and on payment of prescribed fee.

11. PROVISION FOR BREAK OF STUDY

11.1 A candidate is normally permitted to avail the authorised break of study under valid reasons (such as accident or hospitalization due to prolonged ill health or any other valid reasons) and to rejoin the programme in a later semester. He/She shall apply in advance to the Principal, through the Head of the Department, stating the reasons therefore, in any case, not later than the last date for registering for that semester examination. A candidate is permitted to avail the authorised break of study only once during the entire period of study for a maximum period of one year. However, in extraordinary situation the candidate may apply for additional break of study not exceeding another one year by paying prescribed fee for the break of study.

11.2 The candidates permitted to rejoin the programme after break of study / prevention due to lack of attendance shall be governed by the rules and regulations in force at the time of rejoining.

11.3 The candidates rejoining in new Regulations shall apply to the Principal in the prescribed format through Head of the Department at the beginning of the readmitted semester itself for prescribing additional/equivalent courses, if any, from any semester of the regulations in-force, so as to bridge the curriculum in-force and the old curriculum.

11.4 The total period of completion of the programme reckoned from the commencement of the semester to which the candidate was admitted shall not exceed the maximum period specified in clause 5 irrespective of the period of break of study in order to qualify for the award of the degree.

11.5 If any candidate is prevented for want of required attendance, the period of prevention shall not be considered as authorized break of study.

11.6 If a candidate has not reported to the college for a period of two consecutive semesters without any intimation, the name of the candidate shall be deleted permanently from the college enrollment. Such candidates are not entitled to seek readmission under any circumstances.

12. PASSING REQUIREMENTS

12.1 A candidate who secures not less than 50 % of total marks (continuous assessment and end semester examination put together) prescribed for the course with a minimum of 50 % of the marks prescribed for the end semester examination in all category of courses vide clause 7.1 except for the courses which are evaluated based on continuous assessment only shall be declared to have successfully passed the course in the examination.

12.2 A candidate who secures not less than 50 % in continuous assessment marks prescribed for the courses which are evaluated based on continuous assessment only shall be declared to have successfully passed the course. If a candidate secures less than 50% in the continuous assessment marks, he / she shall have to re-enroll for the same in the subsequent semester and satisfy the attendance requirements.

12.3 For a candidate who does not satisfy the clause 12.1, the continuous assessment marks secured by the candidate in the first attempt shall be retained and considered valid for subsequent attempts. However, from the fourth attempt onwards the marks scored in the end semester examinations alone shall be considered, in which case the candidate shall secure minimum 50 % marks in the end semester examinations to satisfy the passing requirements, but the grade awarded shall be only the lowest passing grade irrespective of the marks secured.

13. REVALUATION OF ANSWER SCRIPTS

A candidate shall apply for a photocopy of his / her semester examination answer script within a reasonable time from the declaration of results, on payment of a prescribed fee by submitting the proper application to the Controller of Examinations. The answer script shall be pursued and justified jointly by a faculty member who has handled the course and the course coordinator and recommended for revaluation. Based on the recommendation, the candidate can register for revaluation through proper application to the Controller of Examinations. The Controller of Examinations will arrange for revaluation and the results will be intimated to the candidate concerned. Revaluation is permitted only for Theory courses and Theory cum Practical courses where end semester examination is involved.

14. SUPPLEMENTARY EXAMINATION

If a candidate fails to clear all courses in the final semester after the announcement of final end semester examination results, he/she shall be allowed to take up supplementary examinations to be conducted within a reasonable time for the courses of final semester alone, so that he/she gets a chance to complete the programme.

15. AWARD OF LETTER GRADES

Range of % of Total Marks	Letter Grade	Grade Point
91 to 100	O (Outstanding)	10
81 to 90	A+ (Excellent)	9
71 to 80	A (Very Good)	8
61 to 70	B+ (Good)	7
50 to 60	B (Average)	6
Less than 50	RA (Reappear)	0
Satisfactory	SF	0
Withdrawal	W	-
Absent	AB	-
Shortage of Attendance in a course	SA	-

The Grade Point Average (GPA) is calculated using the formula:

$$GPA = \frac{\sum[(\text{course credits})\times(\text{grade points})] \text{ for all courses in the specific semester}}{\sum(\text{course credits}) \text{ for all courses in the specific semester}}$$

The Cumulative Grade Point Average (CGPA) is calculated from first semester (third semester for lateral entry candidates) to final semester using the formula

$$CGPA = \frac{\sum[(\text{course credits})\times(\text{grade points})] \text{ for all courses in all the semesters so far}}{\sum(\text{course credits}) \text{ for all courses in all the semesters so far}}$$

The GPA and CGPA are computed only for the candidates with a pass in all the courses.

The GPA and CGPA indicate the academic performance of a candidate at the end of a semester and at the end of successive semesters respectively.

A grade sheet for each semester shall be issued containing Grade obtained in each course, GPA and CGPA.

A duplicate copy, if required can be obtained on payment of a prescribed fee and satisfying other procedure requirements.

Withholding of Grades: The grades of a candidate may be withheld if he/she has not cleared his/her dues or if there is a disciplinary case pending against him/her or for any other reason.

16. ELIGIBILITY FOR THE AWARD OF DEGREE

A candidate shall be declared to be eligible for the award of the ME / MTech Degree provided the candidate has

i. Successfully completed all the courses under the different categories, as specified in the regulations.

ii. Successfully gained the required number of total credits as specified in the curriculum corresponding to the candidate's programme within the stipulated time (vide clause 5).

iii. Successfully passed any additional courses prescribed by the respective Board of Studies whenever readmitted under regulations other than R-2020 (vide clause 11.3)

iv. No disciplinary action pending against him / her.

17. CLASSIFICATION OF THE DEGREE AWARDED

17.1 First Class with Distinction:

17.1.1 A candidate who qualifies for the award of the degree (vide clause 16) and who satisfies the following conditions shall be declared to have passed the examination in First class with Distinction:

- Should have passed the examination in all the courses of all the four semesters in the **First Appearance** within four consecutive semesters excluding the authorized break of study (vide clause 11) after the commencement of his / her study.
- Withdrawal from examination (vide clause 10) shall not be considered as an appearance.
- Should have secured a CGPA of not less than 8.50

(OR)

17.1.2 A candidate who joins from other institutions on transfer or a candidate who gets readmitted and has to move from one regulation to another regulation and who qualifies for the award of the degree (vide clause 16) and satisfies the following conditions shall be declared to have passed the examination in First class with Distinction:

- Should have passed the examination in all the courses of all the four semesters in the **First Appearance** within four consecutive semesters excluding the authorized break of study (vide clause 11) after the commencement of his / her study.
- Submission of equivalent course list approved by the respective Board of studies.
- Withdrawal from examination (vide clause 10) shall not be considered as an appearance.
- Should have secured a CGPA of not less than 9.00

17.2 First Class:

A candidate who qualifies for the award of the degree (vide clause 16) and who satisfies the following conditions shall be declared to have passed the examination in First class:

- Should have passed the examination in all the courses of all four semesters within six consecutive semesters excluding authorized break of study (vide clause 11) after the commencement of his / her study.
- Withdrawal from the examination (vide clause 10) shall not be considered as an appearance.
- Should have secured a CGPA of not less than 7.00

17.3 Second Class:

All other candidates (not covered in clauses 17.1 and 17.2) who qualify for the award of the degree (vide clause 16) shall be declared to have passed the examination in Second Class.

17.4 A candidate who is absent for end semester examination in a course / project work after having registered for the same shall be considered to have appeared for that examination for the purpose of classification.

18. MALPRACTICES IN TESTS AND EXAMINATIONS

If a candidate indulges in malpractice in any of the tests or end semester examinations, he/she shall be liable for punitive action as per the examination rules prescribed by the college from time to time.

19. AMENDMENTS

Notwithstanding anything contained in this manual, the Kongu Engineering College through the Academic council of the Kongu Engineering College, reserves the right to modify/amend without notice, the Regulations, Curricula, Syllabi, Scheme of Examinations, procedures, requirements, and rules pertaining to its ME / MTech programme.

******

CURRICULUM BREAKDOWN STRUCTURE						
Summary of Credit Distribution						
Category	**Semester**				**Total number of credits**	**Curriculum Content (% of total number of credits of the program)**
	I	**II**	**III**	**IV**		
HS	**7**	**-**	**-**	**-**	**7**	**9.72**
PC	**13**	**14**	**-**	**-**	**27**	**37.50**
PE	**3**	**6**	**3**	**6**	**18**	**25.00**
EC		**2**	**9**	**9**	**20**	**27.78**
Semester wise Total	**23**	**22**	**12**	**15**	**72**	**100.00**

Category	**Abbreviation**
Lecture hours per week	**L**
Tutorial hours per week	**T**
Practical, Project work, Internship, Professional Skill Training, Industrial Training hours per week	**P**
Credits	**C**

CATEGORISATION OF COURSES							
FOUNDATION COURSES (FC)							
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Sem**
1.	20AMT12	Applied Mathematics for Electronics Engineers	3	1	0	4	1
2.	20GET11	Introduction to Research	2	1	0	3	1
Total Credits to be earned						7	

PROFESSIONAL CORE COURSES								
Sl. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Sem**	**Domain/ Stream**
1.	20EDT11	Finite Element Method	3	1	0	4	1	Design
2.	20EDT12	Advanced Strength of Materials	3	1	0	4	1	Design
3.	20EDT13	Engineering Design Methodology	3	0	0	3	1	Design
4.	20EDL11	Design and Analysis Laboratory	0	0	2	1	1	Design
5.	20EDL12	Advanced Mechanical Laboratory	0	0	2	1	1	Design
6.	20EDT21	Mechanism Design and Analysis	3	1	0	4	2	Design
7.	20EDT22	Applied Materials Engineering	3	0	0	3	2	Materials
8.	20EDT23	Mechanical Vibrations	3	0	0	3	2	Design
9.	20EDT24	Mechanical Behaviour of Materials	3	0	0	3	2	Design

10.	20EDL21	Mechanism Synthesis Laboratory	0	0	2	1	2	Design
Total Credits to be earned						27		

PROFESSIONAL ELECTIVE COURSES								
Sl.No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Sem**	**Domain/ Stream**
		Elective I						
1.	20EDE01	Mechanical Thermal Behaviour of Composite Materials	3	0	0	3	1	Materials
2.	20EDE02	Fracture Mechanics	3	0	0	3	1	Design
3.	20EDE03	Safety in Engineering Industry	3	0	0	3	1	Manufacturing
		Elective II						
4.	20EDE04	Optimization Techniques in Design and Manufacturing	3	0	0	3	2	Manufacturing
5.	20EDE05	Design of Material Handling Equipment	3	0	0	3	2	Design
6.	20EDE06	Fluid Power System Design	3	0	2	4	2	Design
		Elective III						
7.	20EDE07	Applied Finite Element Analysis	3	1	0	4	2	Design
8.	20EDE08	Tribology in Design	3	0	0	3	2	Design
9.	20EDE09	Design for Manufacture and Assembly	3	0	0	3	2	Manufacturing
		Elective IV						
10.	20EDE10	Vibration and Noise Control	3	1	0	4	3	Design
11.	20EDE11	Artificial Intelligence and Machine Learning	3	0	0	3	3	Manufacturing
12.	20EDE12	Machine Tool Control and Condition Monitoring	3	0	0	3	3	Manufacturing
		Elective V						
13.	20EDE13	Experimental Stress Analysis	3	1	0	4	4	Design
14.	20EDE14	Instrumentation and Measurements	3	0	0	3	4	Design
15.	20EDE15	Product Design and Development	3	0	0	3	4	Design
		Elective VI						
16.	20EDE16	Design of Heat Exchangers	3	0	0	3	4	Design
17.	20EDE17	Designing with Newer Materials	3	0	0	3	4	Materials
18.	20EDE18	Additive Manufacturing	3	0	0	3	4	Manufacturing
19.	20GET13	Innovation, Entrepreneurship and Venture Development	3	0	0	3	4	General
Total Credits to be earned						18		

EMPLOYABILITY ENHANCEMENT COURSES (EC)							
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Sem**
1.	20EDP21	Innovative project	0	0	4	2	2
2.	20EDP31	Internship cum Project Work	0	0	18	9	3
3.	20EDP41	Project Work	0	0	18	9	4
Total Credits to be earned						20	

KEC R2020: SCHEDULING OF COURSES – ME (Engineering Design) Total Credits : 72

Sem.	Course 1	Course 2	Course 3	Course 4	Course 5	Course 6	Course 7	Course 8	Credits
I	20AMT12 Advanced Mathematics (3-1-0-4)	20EDT11 Finite Element Method (3-1-0-4)	20EDT12 Advanced Strength of Materials (3-1-0-4)	20EDT13 Engineering Design Methodology (3-0-0-3)	20GET11 Introduction to Research (3-0-0-3)	Professional Elective I (3-0-0-3)	20EDL11 Design and Analysis Laboratory (0-0-2-1)	20EDT12 Advanced Mechanical Laboratory (0-0-2-1)	**23**
II	20EDT21 Mechanism Design and Analysis (3-1-0-4)	20EDT22 Applied Materials Engineering (3-0-0-3)	20EDT23 Mechanical Vibrations (3-0-0-3)	20EDT24 Mechanical Behaviour of Materials (3-0-0-3)	Professional Elective – II (3-0-0-3)	Professional Elective – III (3-0-0-3)	20EDL21 Mechanism Synthesis Laboratory (0-0-2-1)	20EDP21 Innovative Project (0-0-4-2)	**22**
III	Professional Elective – IV (3-0-0-3)	20EDP31 Internship cum Project Work (0-0-18-9)							**12**
IV	Professional Elective – V (3-0-0-3)	Professional Elective – VI (3-0-0-3)	20EDP41 Project work (0-0-18-9)						**15**

MAPPING OF COURSES WITH POs

Sem.	Course Code	Course Title	PO1	PO2	PO3
I	20AMT12	Advanced Mathematics	✓		
I	20EDT11	Finite Element Method	✓	✓	✓
I	20EDT12	Advanced Strength of Materials	✓	✓	✓
I	20EDT13	Engineering Design Methodology	✓	✓	✓
I	20GET11	Introduction to Research	✓	✓	✓
I	20EDL11	Design and Analysis Laboratory	✓	✓	✓
I	20EDL12	Advanced Mechanical Laboratory	✓	✓	✓
II	20EDT21	Mechanism Design and Analysis	✓	✓	✓
II	20EDT22	Applied Materials Engineering	✓	✓	✓
II	20EDT23	Mechanical Vibrations	✓	✓	✓
II	20EDT24	Mechanical Behaviour of Materials	✓	✓	✓
II	20EDL21	Mechanism Synthesis Laboratory	✓	✓	✓
II	20EDP21	Innovative Project	✓	✓	✓
III	20EDP31	Internship cum Project Work	✓	✓	✓
IV	20EDP41	Project Work	✓	✓	✓
		Professional Elective			
I	20EDE01	Mechanical Thermal Behaviour of Composite Materials	✓	✓	✓
I	20EDE02	Fracture Mechanics	✓	✓	✓
I	20EDE03	Safety in Engineering Industry	✓	✓	✓
II	20EDE04	Optimization Techniques in Design and Manufacturing	✓	✓	✓
II	20EDE05	Design of Material Handling Equipment	✓	✓	✓
II	20EDE06	Fluid Power System Design	✓	✓	✓
II	20EDE07	Applied Finite Element Analysis	✓	✓	✓

II	20EDE08	Tribology in Design	✓	✓	✓
II	20EDE09	Design for Manufacture and Assembly	✓	✓	✓
III	20EDE10	Vibration and Noise Control	✓	✓	✓
III	20EDE11	Artificial Intelligence and Machine Learning	✓	✓	✓
III	20EDE12	Machine Tool Control and Condition Monitoring	✓	✓	✓
IV	20EDE13	Experimental Stress Analysis	✓	✓	✓
IV	20EDE14	Instrumentation and Measurements	✓	✓	✓
IV	20EDE15	Product Design and Development	✓	✓	✓
IV	20EDE16	Design of Heat Exchangers	✓	✓	✓
IV	20EDE17	Designing with Newer Materials	✓	✓	✓
IV	20EDE18	Additive Manufacturing	✓	✓	✓
IV	20GET13	Innovation Entrepreneurship and Venture Development	✓	✓	✓

M.E. ENGINEERING DESIGN CURRICULUM – R2020

SEMESTER – I									
Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
20AMT12	Advanced Mathematics	3	1	0	4	50	50	100	FC
20GET11	Introduction to Research	2	1	0	3	50	50	100	FC
20EDT11	Finite Element Method	3	1	0	4	50	50	100	PC
20EDT12	Advanced Strength of Materials	3	1	0	4	50	50	100	PC
20EDT13	Engineering Design Methodology	3	0	0	3	50	50	100	PC
	Professional Elective I	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20EDL11	Design and Analysis Laboratory	0	0	2	1	50	50	100	PC
20EDL12	Advanced Mechanical Laboratory	0	0	2	1	50	50	100	PC
Total Credits to be earned					**23**				

SEMESTER – II									
Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
20EDT21	Mechanism Design and Analysis	3	1	0	4	50	50	100	PC
20EDT22	Applied Materials Engineering	3	0	0	3	50	50	100	PC
20EDT23	Mechanical Vibrations	3	0	0	3	50	50	100	PC
20EDT24	Mechanical Behaviour of Materials	3	0	0	3	50	50	100	PC
	Professional Elective - II	3	0	0	3	50	50	100	PE
	Professional Elective – III	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20EDL21	Mechanism Synthesis Laboratory	0	0	2	1	50	50	100	PC
20EDP21	Innovative Project	0	0	4	2	50	50	100	EC
Total Credits to be earned					**22**				

M.E. ENGINEERING DESIGN CURRICULUM – R2020

SEMESTER – III									
Course Code	**Course Title**	**Hours / Week**			**Credit**	**Maximum Marks**			**Category**
		L	**T**	**P**		**CA**	**ESE**	**Total**	
Theory/Theory with Practical									
	Professional Elective - IV	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20EDP31	Internship cum Project Work	0	0	18	9	50	50	100	EC
Total Credits to be earned					**12**				

SEMESTER – IV									
Course Code	**Course Title**	**Hours / Week**			**Credit**	**Maximum Marks**			**Category**
		L	**T**	**P**		**CA**	**ESE**	**Total**	
Theory/Theory with Practical									
	Professional Elective - V	3	0	0	3	50	50	100	PE
	Professional Elective - VI	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20EDP41	Project Work	0	0	18	9	50	50	100	EC
Total Credits to be earned					**15**				

LIST OF PROFESSIONAL ELECTIVES						
Course Code	**Course Title**	**Hours/Week**			**Credit**	**CBS**
		L	**T**	**P**		
	Semester I					
	Elective I					
20EDE01	Mechanical Thermal Behaviour of Composite Materials	3	0	0	3	PE
20EDE02	Fracture Mechanics	3	0	0	3	PE
20EDE03	Safety in Engineering Industry	3	0	0	3	PE
	Semester II					
	Elective II					
20EDE04	Optimization Techniques in Design and Manufacturing	3	0	0	3	PE
20EDE05	Design of Material Handling Equipment	3	0	0	3	PE
20EDE06	Fluid Power System Design	3	0	2	4	PE
	Elective III					
20EDE07	Applied Finite Element Analysis	3	1	0	4	PE
20EDE08	Tribology in Design	3	0	0	3	PE
20EDE09	Design for Manufacture and Assembly	3	0	0	3	PE
	Semester III					
	Elective IV					
20EDE10	Vibration and Noise Control	3	1	0	4	PE
20EDE11	Artificial Intelligence and Machine Learning	3	0	0	3	PE
20EDE12	Machine Tool Control and Condition Monitoring	3	0	0	3	PE
	Semester IV					
	Elective V					
20EDE13	Experimental Stress Analysis	3	1	0	4	PE
20EDE14	Instrumentation and Measurements	3	0	0	3	PE
20EDE15	Product Design and Development	3	0	0	3	PE
	Elective VI					
20EDE16	Design of Heat Exchangers	3	0	0	3	PE
20EDE17	Designing with Newer Materials	3	0	0	3	PE
20EDE18	Additive Manufacturing	3	0	0	3	PE
20GET13	Innovation Entrepreneurship and Venture Development	3	0	0	3	PE

20AMT12 - ADVANCED MATHEMATICS
(Common to Engineering Design and Mechatronics branches)

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	FC	3	1	0	4

Preamble	This course will help the students to develop knowledge to identify and formulate problems in mechanical engineering using mathematical tools such as probability, calculus of variations and solve ordinary and partial differential equations by employing transform and numerical techniques.	
Unit - I	**Random Variables and Probability Distributions**	**9 + 3**
Random Variables and Probability Distributions: Random variable – Probability mass function – Probability density function – Moments – Moment generating functions – Discrete distributions – Binomial distribution – Poisson distribution – Geometric distribution – Continuous distributions - Uniform distribution – Exponential distribution – Normal distribution.		
Unit - II	**Calculus Of Variations**	**9 + 3**
Calculus Of Variations: Concept of variation and its properties – Euler's equation – Functional dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – Isoperimetric problems - Direct methods : Ritz and Kantorovich methods.		
Unit - III	**Transform Methods**	**9 + 3**
Transform Methods: Laplace transform methods: Solution of one-dimensional wave equation - Solution of one-dimensional heat equation – Fourier transform methods: Solution of Diffusion equation – Solution of one-dimensional wave equation – Solution of Laplace equation.		
Unit - IV	**Numerical solution of Ordinary differential equations**	**9 + 3**
Numerical solution of Ordinary differential equations: Runge - Kutta methods for system of IVPs – Numerical stability of Runge - Kutta method – Adams - Bashforth multistep method – Shooting method –Solution of BVP : Finite difference method – Collocation method and orthogonal collocation method.		
Unit - V	**Numerical Solution of Partial Differential Equations**	**9 + 3**
Numerical Solution of Partial Differential Equations: Solution of one dimensional wave equation – Solution of diffusion equation – Explicit and implicit methods – Solution of Elliptic equation: Solution of Laplace equation – Solution of Poisson equation.		

Lecture: 45, Tutorial: 15, Total: 60

REFERENCES:

1.	Richard Johnson, Miller & Freund's, "Probability and Statistics for Engineers", Seventh Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2007.
2.	Gupta, A.S., "Calculus of Variations with Applications", Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
3.	Sankara Rao K, "Introduction to Partial Differential Equations", PHI Learning Pvt. Ltd, Third edition, 2011.
4.	Smith, G. D., "Numerical Solutions of Partial Differential Equations: Finite Difference Methods", Clarendon Press, 1985.
5.	Curtis F. Gerald, Patrick O.Wheatley, "Applied Numerical Analysis", Seventh Edition, Pearson Education India, 2009.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	handle engineering problems involving discrete and continuous random variables.	Applying (K3)
CO2	solve problems involving functional, that occur in various branches of engineering disciplines.	Applying (K3)
CO3	apply Laplace and Fourier transforms solve to initial value, initial–boundary value and boundary value problems in Partial Differential Equations.	Applying (K3)
CO4	solve ordinary differential equations using finite difference and finite element methods.	Applying (K3)
CO5	solve elliptic partial differential equations by using finite difference methods.	Applying (K3)

Mapping of COs with POs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	1		
CO2	1		
CO3	3		
CO4	3		
CO5	3		
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	20	70				100
CAT2	10	20	70				100
CAT3	10	20	70				100
ESE	10	20	70				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20GET11 INTRODUCTION TO RESEARCH

(Common to all ME / MTech Engineering and Technology Branches)

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	PC	2	1	0	3

Preamble	This course will familiarize the fundamental concepts/techniques adopted in research, problem formulation and patenting. Also will disseminate the process involved in collection, consolidation of published literature and rewriting them in a presentable form using latest tools.	
Unit - I	**Concept of Research:**	**6+3**
Meaning and Significance of Research: Skills, Habits and Attitudes for Research - Time Management - Status of Research in India. Why, How and What a Research is? - Types and Process of Research - Outcome of Research - Sources of Research Problem - Characteristics of a Good Research Problem - Errors in Selecting a Research Problem - Importance of Keywords - Literature Collection – Analysis - Citation Study - Gap Analysis - Problem Formulation Techniques.		
Unit - II	**Research Methods and Journals:**	**6+3**
Interdisciplinary Research - Need for Experimental Investigations - Data Collection Methods - Appropriate Choice of Algorithms / Methodologies / Methods - Measurement and Result Analysis - Investigation of Solutions for Research Problem - Interpretation - Research Limitations. Journals in Science/Engineering - Indexing and Impact factor of Journals - Citations - h Index - i10 Index - Journal Policies - How to Read a Published Paper - Ethical issues Related to Publishing - Plagiarism and Self-Plagiarism.		
Unit - III	**Paper Writing and Research Tools:**	**6+3**
Types of Research Papers - Original Article/Review Paper/Short Communication/Case Study - When and Where to Publish? - Journal Selection Methods. Layout of a Research Paper - Guidelines for Submitting the Research Paper - Review Process - Addressing Reviewer Comments. Use of tools / Techniques for Research - Hands on Training related to Reference Management Software - EndNote, Software for Paper Formatting like LaTeX/MS Office. Introduction to Origin, SPSS, ANOVA etc., Software for detection of Plagiarism.		
Unit - IV	**Effective Technical Thesis Writing/Presentation:**	**6+3**
How to Write a Report - Language and Style - Format of Project Report - Use of Quotations - Method of Transcription Special Elements: Title Page - Abstract - Table of Contents - Headings and Sub-Headings - Footnotes - Tables and Figures - Appendix - Bibliography etc. - Different Reference Formats. Presentation using PPTs.		
Unit - V	**Nature of Intellectual Property:**	**6+3**
Patents - Designs - Trade and Copyright. Process of Patenting and Development: Technological research - innovation - patenting - development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents.		

Lecture: 30, Tutorial:15, Total:45

REFERENCES:

1.	DePoy, Elizabeth, and Laura N. Gitlin, “Introduction to Research-E-Book: Understanding and Applying Multiple Strategies”, Elsevier Health Sciences, 2015.
2.	Walliman, Nicholas, “Research Methods: The basics”,Routledge, 2017.
3.	Bettig Ronald V., “Copyrighting culture: The political economy of intellectual property”,Routledge, 2018.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	list the various stages in research and categorize the quality of journals	Analyzing (K4)
CO2;	formulate a research problem from published literature/journal papers	Evaluating (K5)
CO3:	write, present a journal paper/ project report in proper format	Creating (K6)
CO4:	select suitable journal and submit a research paper	Applying (K3)
CO5:	compile a research report and the presentation	Applying (K3)

Mapping of COs with POs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	2	1
CO2	3	2	3
CO3	3	3	1
CO4	3	2	1
CO5	3	2	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1		30	40	30			100
CAT2		30	40	30			100
CAT3			30	40	30		100
ESE		30	40	30			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDT11- FINITE ELEMENT METHOD

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Strength of Materials	**1**	**PC**	**3**	**1**	**0**	**4**

Preamble	The course familiarizes the fundamental concepts of finite element analysis with the principles involved in discretization and to assemble stiffness matrices and force vectors for simple/advanced elements. It also focuses on iso parametric elements, numerical integration and structural dynamic problem for various applications.	
Unit - I	**One Dimensional Applications**	**9 + 3**
One Dimensional Applications: Historical Background - Weighted Residual Methods - Basic Concept of FEM - Variational Formulation - Ritz Method - Finite Element Modelling - Element Equations - Linear and Quadratic Shape Functions - Bar and Beam Elements - Galerkin's Method - Application of Structural Bar and Heat Transfer.		
Unit - II	**Two Dimensional Scalar Variable Applications**	**9 + 3**
Two Dimensional Scalar Variable Applications: Basic Boundary Value Problems in Two Dimensions - Constant Strain Triangular Element - Higher Order elements – Poisson's and Laplace's Equation - Weak Formulation - Element Matrices and Vectors - Load consideration: Point load and Pressure - Plane stress and Plane Strain Conditions. Two Dimensional Heat Transfer: Finite Element Equation - Potential Energy Approach - Conduction - Side and Face Convection - Internal Heat Generation. Application of Structural and Heat Transfer		
Unit - III	**Two Dimensional Vector Variable Problems**	**9 + 3**
Two Dimensional Vector Variable Problems: Introduction to Axi-Symmetric Formulation – Linear Element – Elemental Element Matrices and Vectors – Load Consideration – Application of Structural and Heat Transfer Problems – Application of Plane Trusses.		
Unit - IV	**Isoparametric Formulation**	**9 + 3**
Isoparametric Formulation: Natural Co-ordinate Systems - Lagrangian Interpolation Polynomials - Isoparametric Elements - Formulation - Numerical Integration - Gauss Quadrature - One and Two dimensional Integration - Rectangular Elements - Serendipity Elements - Finite Element Modeling - Illustrative Examples.		
Unit - V	**Structural Dynamics and Refinements**	**9 + 3**
Structural Dynamics and Refinements: Dynamic Analysis - Equation of Motion – Mass and Damping Matrices - Free Vibration Analysis - Natural Frequencies of Longitudinal, Transverse and Torsional Vibration - Introduction to Transient Field Problems. Refinement Techniques - h and p Elements.		

Lecture: 45, Tutorial: 15, Total: 60

REFERENCES:

1. Rao Singiresu S. “The Finite Element Method in Engineering”. 6th Edition, Butterworth-Heinemann, USA, 2017.
2. Reddy J.N. “An Introduction to the Finite Element Method”. 4th Edition, McGraw Hill, INDIA, 2018.
3. Logan D.L. “A First Course in the Finite Element Method”. 6th Edition, Cengage Learning, UK, 2018.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	comprehend the finite element concepts and derive the element matrix equation for solving one dimensional structural problems used for designing engineering components	Analyzing (K4)
CO2	compute the results for a 3D domain using simple two dimensional assumptions for different applications	Analyzing (K4)
CO3	solve and analyze the engineering problems using axisymmetric assumptions	Analyzing (K4)
CO4	comprehend the effective usage of isoparametric elements and numerical integration techniques used in FEM	Analyzing (K4)
CO5	solve the structural dynamic problems in various applications	Analyzing (K4)

Mapping of COs with POs			
COs/Pos	**PO1**	**PO2**	**PO3**
CO1	3	1	3
CO2	3	1	2
CO3	3	1	2
CO4	3	1	2
CO5	3	1	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	30	50	10			100
CAT2		30	50	20			100
CAT3		30	50	20			100
ESE	10	20	50	20			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDT12 - ADVANCED STRENGTH OF MATERIALS

(Approved Data book may be permitted)

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Engineering Mechanics, Strength of Materials	**1**	**PC**	**3**	**1**	**0**	**4**

Preamble	The course imparts knowledge on three-dimensional theory of elasticity, Stress and strain relations and Compatibility equations. It also covers the Shear center estimation, Unsymmetrical bending, stress analysis on Curved beams, torsion on non-Circular members and membrane stresses in shells, rotating discs, buckling of plates, and the contact stresses.	
Unit - I	**Elasticity**	**9 + 3**
Elasticity: Stress - Strain Relation and General Equation of Elasticity in Cartesian - Polar - Cylindrical and Spherical Coordinates - Differential Equation of Equilibrium - Compatibility Equation - Boundary Conditions - Representations of Three Dimensional Stress in Tension - Generalized Hooke's law - St.Vennant's Principle - Plane Strain, plane Stress - Airy's Stress Function.		
Unit - II	**Unsymmetrical Bending and Shear Centre**	**9 + 3**
Unsymmetrical Bending: Stresses and Deflection in Beams Subjected to Unsymmetrical Loading - Kern of a Section. Shear Centre: Location of shear Centre for Various Sections - Shear Flow.		
Unit - III	**Curved Beams**	**9 + 3**
Curved Beams: Curved Flexural Members - Circumferential and Radial Stresses - Deflection and Radial Curved Beam with Re-Strained ends - Closed Ring Subjected to Concentrated Load and Uniform Load - Chain Link and Crane Hooks.		
Unit - IV	**Stresses due to Rotation and Contact Stresses**	**9 + 3**
Stresses due to Rotation: Stresses due to Rotation - Radial and Tangential Stresses in Solid Disc and Ring of Uniform Thickness and Varying Thickness - Allowable Speed. Contact Stresses: Hertz Equation for Contact Stresses - Applications to Rolling Contact Elements.		
Unit - V	**Stresses in Flat Plates and Torsion of Non Circular Sections**	**9 + 3**
Stresses in Flat Plates: Stresses in circular and rectangular plates due to various types of loading and end conditions - Buckling of plates. Torsion of Non Circular Sections: Torsion of rectangular cross section - St.Vennant Theory – Elastic Membrane analogy - Tensional stresses in hollow thin walled tubes.		

Lecture: 45, Tutorial: 15, Total: 60

REFERENCES:

1. Sadhu Singh. "Applied Stress Analysis". 4th Edition, Khanna Publishers, New Delhi, 1978.
2. Timoshenko S. "Strength of Materials, Part 2". 3rd Edition, CPS Publishers, New Delhi, 2002.
3. Timoshenko and Goodler "Theory of Elasticity". 3rd Edition, McGraw-Hill, New Delhi, 2002
4. Den Hartog J.P. "Advanced Strength of Materials". 1 st Edition, Dover Publications, New York, 1987.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	calculate the stresses and strains at a point in three dimensional load	Analyzing (K4)
CO2	calculate analytically the shear center and stresses in unsymmetrical bending	Analyzing (K4)
CO3	determine the stresses and deflections in curved beams, chains and links	Analyzing (K4)
CO4	determine the stresses due to rotation and contact stresses	Analyzing (K4)
CO5	estimate the stresses & deflection in plates and the torsion in noncircular members	Analyzing (K4)

Mapping of COs with POs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	2	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	20	50	10			100
CAT2	20	20	50	10			100
CAT3	20	20	50	10			100
ESE	20	20	40	20			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDT13 - ENGINEERING DESIGN METHODOLOGY

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Quality Engineering, Total Quality Management, Fundamentals of Design and Manufacturing	1	PC	3	0	0	3

Preamble	The course enrich the knowledge on product design process with fundamental concepts to arrive design solutions with the use of advanced computer aided technology, selection of suitable engineering materials with the understanding of their performance, design of tooling for various manufacturing process with consideration for quality, safety, environment, reliability, legal and ethical aspects.	
Unit - I	**The Product Design Process**	**9**
The Product Design Process: Importance of Product Design - Design Process - Consideration of a Good Design - Morphology of Design - Concurrent Engineering - CAD & CAM - Product and Process Cycle - Need identification - Identifying Customer Needs – Benchmarking - Customer Requirements.		
Unit - II	**Tools in Engineering Design and Modelling**	**9**
Tools in Engineering Design: Concept Generation – Creativity and Problem solving - Creative Methods. Embodiment Design - Product Architecture - Configuration Design - Parametric Design - Design Guidelines - Industrial Design - Human Factors in Design. Modelling: Role of Models in Engineering Design - Mathematical Modeling - Geometric Modeling - Finite Element Modeling - Rapid Prototyping.		
Unit - III	**Material Selection and Materials in Design**	**9**
Material Selection: Relation of Material Selection to Design - Performance Characteristics of Materials - Material Selection Process - Value Analysis, Recycling. Materials in Design: Design for Brittle Fracture - Design for Fatigue Failure - Design for Corrosion Resistance - Design with Plastics.		
Unit - IV	**Material Processing and Design for Processes**	**9**
Material Processing: Classification of Manufacturing Processes and their Role in Design - Factors Determining the Process Selection. Design for Processes: Design for Manufacturing - Design for Casting - Design for Forging - Design for Sheet Metal Forming - Design for Machining - Design for Welding - Design for Heat Treatment - Design for Plastic Processing.		
Unit - V	**Design Engineering and Quality Engineering**	**9**
Design Engineering: Legal and Ethical Issues in Design- Design for environment - Design for Reliability - Design for Safety. Quality Engineering: Quality Design – Optimisation Methods - The origin of laws – Contracts – Liability - Tort Law - Product Liability - Protecting Intellectual Property - Legal and Ethical Domains - Codes of Ethics - Solving Ethical Conflicts.		

Lecture: 45

REFERENCES:

1. Dieter George. E, “Engineering Design: A Materials and Processing Approach”. 3rd Edition, McGraw-Hill, International Edition, Singapore, 2000.
2. Ulrich Karl T. and Eppinger Steven D. “Product design and Development”. 5th Edition, McGraw-Hill, International Edition, New York, 2011.
3. Gerhard Pahl and Beitz W. “Engineering Design: A Systematic Approach”. 3rd Edition, Springer - Verlag, NY, 2007.
4. Ray M.S. “Elements of Engineering Design”, Prentice Hall Inc, USA, 1985.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply the knowledge on various design process and methods for product design.	Applying (K3)
CO2	implement the various design modelling, design methods and optimization tools for tool design.	Applying (K3)
CO3	apply the knowledge on the material selection process by considering the various design factors.	Applying (K3)
CO4	implement the various manufacturing process with design of materials for various applications.	Analyzing (K4)
CO5	implement the knowledge on legal aspect, environmental, quality and safety aspect for designing of materials.	Applying (K3)

Mapping of COs with POs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	3	2
CO2	3	3	2
CO3	3	3	2
CO4	3	3	2
CO5	3	3	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	25	25	50				100
CAT2	25	25	50				100
CAT3	15	15	50	20			100
ESE	15	15	40	30			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDL11 - DESIGN AND ANALYSIS LABORATORY

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Strength of Materials, Design of Machine Elements	**1**	**PC**	**0**	**0**	**2**	**1**

Preamble:	Design and analysis laboratory is the use of computer systems to aid in the creation, Modification, analysis, or optimization of a design. It is used to increase the productivity, improve the quality, communications and create a database for manufacturing.
List of Exercises / Experiments:	
1.	Modeling and Assembly of component using Creo.
2.	Modeling a component using Creo, Importing to ANSYS and Meshing.
3.	Plotting the shear Force and Bending Moment diagram using ANSYS APDL.
4.	Meshing a component using ANSYS WORKBENCH.
5.	Structural Analysis using ANSYS WORKBENCH.
6.	Non-Linear structural contact analysis of a component using ANSYS.
7.	Thermal Analysis of a component using ANSYS APDL.
8.	Modal Analysis of a structure using ANSYS APDL.
9.	Harmonic Analysis using ANSYS APDL.
10.	Coupled Field Analysis using ANSYS APDL.

Practical: 30, Total: 30

REFERENCES/MANUAL/SOFTWARE:

1.	Laboratory Manual.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	analyze the problem boundary conditions with various fields using analysis software	Analyzing (K3) Manipulation (S2)
CO2	model and analyze the structural members with external load for different applications	Analyzing (K3) Precision(S3)
CO3	analyze the non-linear structural, thermal and coupled field problems for various applications	Analyzing (K3) Precision(S3)
CO4	analyze the mode shape and critical frequency of the structural component	Analyzing (K3) Precision(S3)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	3	3	3
CO2	3	3	3
CO3	3	3	3
CO4	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

20EDL12 – ADVANCED MECHANICAL LABORATORY

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Applied Physics, Engineering Thermodynamics, Strength of Materials, Engineering Materials and Metallurgy,	1	PC	0	0	2	1

Preamble:	To expose the students to handle various measuring instrument for various measuring quantities.
List of Exercises / Experiments:	
1.	Analyse the dimensional properties of the components using Coordinate measuring machine (CMM).
2.	Study the surface profile of the machined components using surface roughness testing machine.
3.	Analyze the tensile stress distribution of the given components using Electronic Tenso meter setup.
4.	Analysis of pressure distribution around aerofoil templates in Wind tunnel.
5.	Study the effect of variation in tilt angle on solar photovoltaic module output power.
6.	Study the effect of shading on solar photovoltaic module output power.
7.	Evaluation of overall heat loss coefficient, heat removal factor and efficiency of solar flat plate collector.
8.	Thermal analysis of machining processes using Thermal Imager
9.	Determine the micro structure of aluminum alloys.
10.	Determine the Micro structure of copper alloys.
11.	Determine the Micro structure of Grey cast iron and SG iron.
12.	Hardness Measurement- Vickers hardness, Rockwell hardness and Birnell hardness.

Practical: 30, Total: 30

REFERENCES/MANUAL/SOFTWARE:

1.	Laboratory Manual.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	analyze the dimensions of a component, stress distribution, pressure distribution and Thermal analysis using various measuring instruments.	Analyze (K4) Manipulation (S2)
CO2	estimate the performance of solar PV module and flat plat collector	Analyze (K4) Manipulation (S2)
CO3	understand the different micro structures of alloys	Analyze (K4) Manipulation (S2)
CO4	Carry out the hardness measurements tests	Analyze (K4) Manipulation (S2)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	3	1	2
CO2	3	2	3
CO3	3	1	2
CO4	3	1	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

20EDT21 - MECHANISM DESIGN AND ANALYSIS

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Kinematic of Machinery, Engineering Mechanics	**2**	**PC**	**3**	**1**	**0**	**4**

Preamble	This course provide knowledge on analysing the displacement, velocity and acceleration of various complex mechanisms through various acceleration methods and to develop the various mechanisms through design, analysis and simulation with an ability to use the various mechanisms in real life problems effectively.	
Unit - I	**Fundamental of Kinematics**	**9+3**
Fundamental of Kinematics: Review of Fundamentals of kinematics - Mobility Analysis – Formation of one D.O.F of Complex Mechanism - Kinematic Inversion. Position Analysis – Vector Loop Equations for Four Bar- Slider crank-Inverted Slider Crank-Geared Five Bar and Six bar Linkages.		
Unit - II	**Kinematic Analysis**	**9+3**
Kinematic Analysis: The velocity and Acceleration Analysis– Simple Four Bar Linkage Mechanism and Plane Complex Mechanism – Normal Acceleration-Goodman's Indirect Method- Auxiliary Point Method.		
Unit - III	**Path Curvature Theory**	**9+3**
Path Curvature Theory: Fixed and Moving Centrodes- Inflection Points and Inflection Circle- Euler Savary Equation- Graphical Constructions – Cubic of Stationary Curvature – Bobillier Theorem.		
Unit - IV	**Synthesis of Mechanisms**	**9+3**
Synthesis of Mechanisms: Type Synthesis – Number Synthesis – Associated Linkage Concept. Dimensional Synthesis – Function Generation- Path Generation- Motion Generation- Two-Three and Four Position Synthesis-Graphical Methods- Cognate Linkages - Coupler Curve Synthesis-Bloch's Method of Synthesis- Design of Six-Bar Mechanisms.		
Unit - V	**Dynamics and Spatial Mechanism Analysis**	**9+3**
Dynamics and Spatial Mechanism Analysis: Static Force and Inertia Force Analysis of Simple Mechanism - Graphical Method. Mobility of Four Bar Spatial Linkage – Wobble Plate Mechanism - Kinematic Analysis of Spatial RSSR Mechanism – Denavit – Hartenberg Parameters- Forward and Inverse kinematics of Robotic Manipulators.		

Lecture:45, Tutorial:15, Total: 60

REFERENCES:

1.	Shigley J.E., Pennock G.R. and Uicker J.J. "Theory of Machines and Mechanisms". 4th Edition, McGraw Hill, New York, 2016.
2.	Rattan S.S. "Theory of Machines". 3rd Edition, Tata McGraw Hill Education, New York, 2014.
3.	Ghosh Amitabha and Mallik Asok Kumar. "Theory of Mechanism and Machines". 3rd Edition, East West Press, New Delhi, 2015.
4.	Nortron R.L. "Design of Machinery". 3rd Edition, Tata McGraw Hill, New Delhi, 2005.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	construct the one D.O.F of the complex mechanism by changing the links and find out the position of links in various mechanisms	Analyzing (K4)
CO2	analyze the velocity and acceleration of the various plane complex mechanisms by using various methods	Analyzing (K4)
CO3	determine the path of curvature of the various plane mechanisms	Analyzing (K4)
CO4	synthesis the various mechanism links by different synthesis methods	Analyzing (K4)
CO5	analyze the static and dynamics force of the mechanism and different spatial robotics mechanisms	Analyzing (K4)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	3	3	2
CO2	3	2	3
CO3	3	2	1
CO4	3	2	1
CO5	3	2	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	20	30	30			100
CAT2	20	20	25	35			100
CAT3	20	20	25	35			100
ESE	20	20	30	30			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDT22 - APPLIED MATERIALS ENGINEERING

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Engineering Materials and Metallurgy	**2**	**PC**	**3**	**0**	**0**	**3**

Preamble	The course deals with the study on structure –property relationship of ferrous metals, analysis on their morphological and technical characteristics, purpose of heat treatment and related techniques.	
Unit - I	**Introduction of Physical Metallurgy**	**9**
Introduction of Physical Metallurgy: Concept of Phase Diagram - Phases and Micro Constituents in Steels and Cast Irons - Equilibrium and Non-Equilibrium Cooling of Various Fe-C alloys - Effects of Alloying Elements and Cooling Rate on Structure and Properties of Steels and Cast Irons.		
Unit - II	**Introduction to Heat Treatment and Specifications**	**9**
Introduction to Heat Treatment and Specifications: Time Temperature Transformation (TTT) Diagram and Continuous Cooling Transformation (CCT) diagram - Hardenability Measurement - Annealing - Normalizing - Hardening and tempering - Heat treatment furnaces - Atmospheres - Quenching media - Case hardening techniques. Types of steels - Plain carbon steels - Alloy steels - Tool steels - Stainless steels - Types of cast iron – Compositions - Properties and Applications.		
Unit - III	**Characterization of Materials**	**9**
Characterization of Materials: Stereographic Projections - X-ray diffraction - Crystal Structure and Phase Identification - Residual Stress Measurement and Other Applications. Scanning Electron Microscopy (SEM) – Optics and Performance of SEM - Image Interpretation - Crystallographic Information - Analytical Microscopy. Transmission Electron Microscopy (TEM) - Construction and Operation of TEM - Electron Diffraction - Image Interpretation.		
Unit - IV	**Corrosion Engineering**	**9**
Corrosion Engineering: Degradation of Materials - Oxidation - Corrosion and Wear. Basics of Thermodynamics and kinetics of Oxidation and Corrosion - Pourbaix Diagram – Polarization - Different Types of Corrosion – Atmospheric – Galvanic – Pitting - Crevice Corrosion- Intergranular and De-alloying - Stress Corrosion Cracking - Season Cracking - Hydrogen Damage and Radiation Damage - Hydrogen Embrittlement - Corrosion Rate Measurement.		
Unit - V	**Metallurgical Failure Analysis and Plastic Deformation**	**9**
Metallurgical Failure Analysis and Plastic Deformation: Stages of Failure Analysis - Classification and Identification of Various Types of Fracture. Overview of Fracture Mechanics - Characteristics of Ductile and Brittle Fracture - General concepts - Fracture Characteristics Revealed by Microscopy - Factors Affecting Fatigue Life – Creep - Stress Rupture - Elevated Temperature Fatigue - Metallurgical Instabilities - Environmental Induced Failure - Some Case Studies on Failures - Basics of Plastic Deformation - Mohr"s circle - Yield theories - Plastic stress - Strain relationship - Mechanical working - Work hardening.		

Lecture: 45

REFERENCES:

1. Avner, S. H. “Introduction to Physical Metallurgy”. 2nd Edition, McGraw Hill, New Delhi, 2017.
2. Philips V. A. “Modern Metallographic Techniques and their Applications”. 1st Edition, Wiley Interscience, New York, 1972.
3. Fontana. M.G. “Corrosion Engineering”. 3rd Edition, Tata McGraw Hill, New Delhi, 2005.
4. Hosford W.F. and Caddell R.M. “Metal Forming Mechanics and Metallurgy”. 4th Edition, Printice Hall, United Kingdom, 2014.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	demonstrate the microstructures of steels and cast irons	Applying (K3)
CO2	apply heat treatment processes for various applications	Applying (K3)
CO3	determine the microstructure for utilizing the material characterization	Applying (K3)
CO4	analyze the causes and impacts of corrosion	Analyzing (K4)
CO5	solve the problems in plastic deformation of materials and to analyse the failures	Analyzing (K4)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	1	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	3	3
CO5	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	40				100
CAT2	20	40	20	20			100
CAT3	20	40	20	20			100
ESE	10	26	32	32			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDT23 - MECHANICAL VIBRATIONS

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Strength of Materials, Engineering Mechanics, Dynamics of Machinery	2	PC	3	0	0	3

Preamble	The course gives the knowledge of vibrations, solving single, two, multi degree of freedom system and continuous systems. It also emphasis on vibration tests for various applications	
Unit - I	**Fundamentals of Vibration and Single Degree of Freedom System**	**9**
Fundamentals of Vibration and Single Degree of Freedom System: Review of Single Degree Freedom Systems – Response to Arbitrary Periodic, Excitations- Duhamel"s Integral – Impulse Response Function – Virtual Work – Lagrange"s Equation – Single Degree Freedom Forced Vibration with Elastically Coupled Viscous Dampers – System Identification from Frequency Response – Transient Vibration.		
Unit - II	**Two Degree Freedom System**	**9**
Two Degree Freedom System: Free Vibration of Spring-Coupled System – Mass Coupled System – Vibration of Two Degree Freedom System – Forced Vibration – Vibration Absorber – Vibration Isolation.		
Unit - III	**Multi-Degree Freedom System**	**9**
Multi-Degree Freedom System: Normal Mode of Vibration – Flexibility Matrix and Stiffness matrix – Eigen Values and Eigen Vectors – Orthogonal Properties – Modal Matrix-Modal Analysis – Forced Vibration by Matrix Inversion – Modal Damping in Forced Vibration – Numerical Methods for Fundamental Frequencies.		
Unit - IV	**Vibration of Continuous Systems**	**9**
Vibration of Continuous Systems: Systems Governed by Wave Equations – Vibration of Strings – Vibration of Rods – Euler Equation for Beams – Effect of Rotary Inertia and Shear Deformation – Vibration of Plates.		
Unit - V	**Experimental Methods in Vibration Analysis**	**9**
Experimental Methods in Vibration Analysis: Vibration Instruments – Vibration Exciters Measuring Devices – Analysis – Vibration Tests – Free and Forced Vibration Tests. Examples of Vibration Tests – Industrial, Case Studies.		

Lecture: 45

REFERENCES:

1. Singh V.P. “Mechanical Vibrations”. 3rd Edition, Dhanpat Rai & Co. Ltd., New Delhi, 2014.
2. Den Hartog J.P. “Mechanical Vibrations”. 3rd Edition, Crastre Press, Newyork, 2013.
3. Rao S.S. “Mechanical Vibrations”. 5th Edition, New delhi, 2004.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	solve and identify the frequency response of single degree of freedom system	Analyzing (K4)
CO2	solve and design vibration absorber and the two degrees of freedom system	Analyzing (K4)
CO3	solve and determine the natural frequency of Multi degrees of freedom system	Analyzing (K4)
CO4	solve and analyse the vibration characteristics of continuous system	Analyzing (K4)
CO5	analyse and understand the vibration measuring instruments and machine signature	Analyzing (K4)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	1	3	1
CO2	1	3	2
CO3	1	3	2
CO4	1	3	1
CO5	1	3	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	10	40	40			100
CAT2	10	10	40	40			100
CAT3	10	10	40	40			100
ESE	10	10	40	40			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDT24 - MECHANICAL BEHAVIOUR OF MATERIALS

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Fundamentals of Material Sciences, Fundamental of Physical Properties of the Materials, Engineering Materials and Metallurgy	2	PC	3	0	0	3

Preamble	The course impart the knowledge on analysis of stress – strain components in three dimensions, plane stress, plane strain problems, theory of plasticity fracture and their mechanics in design	
Unit - I	**Elasticity of the Materials**	**9**
Elasticity of the Materials: Analysis of Stress - Definition and Notation of Stress - Equation of Equilibrium -Description of Stress at a Point - Principal Stresses - Two and Three Dimensional Mohr's Circles Diagram - Boundary Condition in Terms of Surface Forces - Analysis of Stress-Strain Components - Description of Strain at a Point - Compatibility Equations of Elasticity - Generalized Hooke's law - Formulations of Elastic Problems - Two and Three Dimensional Mohr's Circles Diagram - Strain Energy.		
Unit - II	**Plane Stress and Plane Strain Problems**	**9**
Plane Stress and Plane Strain Problems: The Governing Differential Equations - Bending of Narrow Cantilever Beam of Rectangular Cross Section Under an End Load - General Equations in Cylindrical Co-ordinates – Effect of Small Circular Holes in Strained Plates - Stress Concentration.		
Unit - III	**Elements of the Theory of Plasticity**	**9**
Elements of the Theory of Plasticity: Introduction - Flow Curves - Tensile Test - True Stress/True Strain - Yield Criteria for Ductile Metals - Plastic Stress-Strain Relations - Creep Definition - Creep Tests and Properties of Creep - Theories of Failure.		
Unit - IV	**Fracture**	**9**
Fracture: Overview of Problem of Fracture and Fatigue in Structures - Stress Analysis for Members with Cracks - Stress Intensity Equations - Relationship Between Stress Intensity Factor and Fracture Toughness - Experimental Determination - K_{IC} and Kc Values - Effect of Temperature - Loading Rate and Plate Thickness on Fracture Toughness.		
Unit - V	**Fracture Mechanics Design**	**9**
Fracture Mechanics Design: Fatigue Crack Initiation - Fatigue Crack Propagation Under Constant Load and Variable Load - Fatigue Damage Tolerance - Elastic - Plastic Fracture Mechanics.		

Lecture: 45

REFERENCES:

1. George E. Dieter. "Mechanical Metallurgy". 3rd Edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 2013.
2. Wang C.T. "Applied Elasticity". 1st Edition, McGraw-Hill, New York, 1953.
3. Barsom M. John and Rolfe T. Stanley. "Fracture and Fatigue Control in Structures". 3rd Edition, Butterworth-Heinemann, Woburn, USA, 1999.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	analyze the elastic behaviours of the materials.	Analyzing (K4)
CO2	analyze the problems of plane stress and strain conditions.	Applying (K3)
CO3	understand the plastic behaviours of the materials.	Understanding (K2)
CO4	implement the various fracture stress analysis under various conditions.	Applying (K3)
CO5	implement the fracture mechanics and the design under various conditions	Applying (K3)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	3	2	2
CO2	3	2	2
CO3	3	2	2
CO4	3	2	2
CO5	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	20	50	10			100
CAT2	20	20	50	10			100
CAT3	20	20	50	10			100
ESE	20	20	50	10			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDL21 - MECHANISM SYNTHESIS LABORATORY

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Engineering Mechanics, Kinematics of Machinery, Strength of Materials, Fundamental of Analyzing Software.	**2**	**PC**	**0**	**0**	**2**	**1**

Preamble:	The aim of this course is to design, synthesis and simulate the various mechanisms using analysis tools.
List of Exercises / Experiments:	
1.	Static force analysis of simple mechanisms using ANSYS.
2.	Static force analysis of plane complex mechanism using ANSYS.
3.	Kinematic analysis of slider crank using ADAMS.
4.	Kinematic analysis of four bar mechanism using ADAMS.
5.	Kinematic analysis of one degree of freedom of pendulum using ADAMS.
6.	Kinematic Analysis of the press mechanism using ADAMS.
7.	Kinematic Analysis of lift mechanism using ADAMS.
8.	Kinematic Analysis of the Atkinson mechanism using ADAMS.

Practical: 30, Total: 30

REFERENCES/MANUAL/SOFTWARE:

1.	Laboratory Manual.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	analyze the static force distribution in simple and complex mechanism	Evaluating (K5), Manipulation (S2)
CO2	analyze the kinematics parameters in simple and complex mechanisms for improving the output motions	Evaluating (K5), Manipulation (S2)
CO3	analyze the velocity and acceleration of simple and complex mechanisms	Analyzing (K4), Manipulation (S2)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	2	2	3
CO2	3	2	3
CO3	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

20EDP21 - INNOVATIVE PROJECT

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	2	EC	0	0	4	2

Total: 60

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	identify the problem and formulate a problem statement	Applying (K3)
CO2	summarize the literature review	Understanding (K2)
CO3	develop a suitable methodology	Applying (K3
CO4	carry out experimental and/or theoretical work as per the specified methodology / design and prepare detailed drawing for various structural components using computer software	Creating (K6)
CO5	prepare and present the project report	Applying (K3)

Mapping of COs with POs and PSOs					
COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	2	2
CO2	3	3	3	2	2
CO3	3	3	3	2	2
CO4	3	3	3	2	2
CO5	3	3	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

20EDP31 – INTERNSHIP CUM PROJECT WORK

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	3	EC	0	0	18	9

Total: 270

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	identify the problem and formulate a problem statement	Applying (K3)
CO2	summarize the literature review	Understanding (K2)
CO3	develop a suitable methodology	Applying (K3
CO4	carry out experimental and/or theoretical work as per the specified methodology / design and prepare detailed drawing for various structural components using computer software	Creating (K6)
CO5	prepare and present the project report	Applying (K3)

Mapping of COs with POs and PSOs					
COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

20EDP41 - PROJECT WORK

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	NIL	4	EC	0	0	18	9

Total : 270

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	identify the problem and formulate a problem statement	Applying (K3)
CO2	summarize the literature review	Understanding (K2)
CO3	develop a suitable methodology	Applying (K3
CO4	carry out experimental and/or theoretical work as per the specified methodology / design and prepare detailed drawing for various structural components using computer software	Creating (K6)
CO5	prepare and present the project report	Applying (K3)

Mapping of COs with POs and PSOs					
COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

20EDE01 – MECHANICAL THERMAL BEHAVIOUR OF COMPOSITE MATERIALS

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Advanced Strength of Materials, Materials Characterization, Manufacturing Process	1	PE	3	0	0	3

Preamble	The course deals with the fundamental concepts of fibres, particulates, matrices and manufacturing techniques of composite materials. The key aspects of this course covers the mechanical and thermal behaviour of fibre reinforced composites.	
Unit - I	**Basics of Composites, Matrices and Manufacturing**	**9**
Basics of Composites: Basics of Fibers- Matrices and Composites- Definition – Need – General Characteristics- Applications- Fibers – Glass- Carbon- Ceramic and Aramid Fibers. Matrices: Polymer-Ceramic and Metal Matrices – Characteristics of Fibers and Matrices- Fiber Surface Treatments. Manufacturing: Bag Moulding – Compression Moulding – Pultrusion – Filament Winding.		
Unit - II	**Performance**	**9**
Performance: Static Mechanical Properties – Fatigue and Impact Properties – Environmental effects– Long term properties- Fracture Behavior and Damage Tolerance – Quality Inspection Methods.		
Unit - III	**Mechanics**	**9**
Mechanics: Rule of mixture -Volume and Mass Fractions – Density - Void Content, Evaluation of Four Elastic Moduli Based on Strength of Materials Approach and Semi-Empirical Model-Longitudinal Young's Modulus-Transverse Young's modulus–Major Poisson's Ratio-In-plane Shear Modulus- Ultimate Strengths of a Unidirectional Lamina - Characteristics of Fiber reinforced Lamina–Laminates– Lamination Theory.		
Unit - IV	**Design Analysis and Thermal Behaviour**	**9**
Design Analysis and Thermal Behaviour: Failure Predictions, Laminate Design Consideration-design Criteria-Design Allowable - Design Guidelines- Joint Design-Bolted and Bonded Joints- Design Examples-Design of a Tension Member – Design of a Compression Member – Design of a Beam-Design of a Torsional member- Application of Finite Element Method (FEM) for Design and Analysis of Laminated Composites. Assumption of Constant Coefficient of Thermal Expansion. Modification of Hooke's law- Orthotropic Lamina Co-efficient of Thermal Expansion (C.T.E)'s- efficient of Thermal Expansion (C.T.E)'s for special laminate configurations- Zero Co-efficient of Thermal Expansion (C.T.E) laminates.		
Unit - V	**Particulate Based Metal Matrix Composite (MMC) and Polymer Matrix Composite (PMC)**	**9**
Particlates: Basics of Graphite- Carbon Nanotube- Nanoclay- Nanosilica. Metal Matrix Composite (MMC): Processing - Diffusion Bonding – Stir Casting – Squeeze Casting. Polymer Matrix Composite (PMC): Processing- Interactions- Morphological- Rheological- Mechanical Properties.		

Lecture: 45

REFERENCES:

1. Mallick P.K. "Fiber Reinforced Composites: Materials, Manufacturing and Design". 3rd Edition, CRC Press, Taylor & Francis, USA, 2007.
2. Autar K. Kaw. "Mechanics of Composite Materials". 2nd Edition, CRC Press, Taylor & Francis, USA, 2006.
3. Agarwal B.D. and Broutman L.J. "Analysis and Performance of Fiber Composites". 4th Edition, John Wiley & Sons, New York, 1990.
4. Gibson Ronal. "Principles of Composite Material Mechanics". 4th Edition, CRC Press, Taylor & Francis, USA, 2016.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	demonstrate the knowledge on the fundamentals and manufacturing of composites	Applying (K3)
CO2	understand the performance of fiber reinforced composites	Applying (K3)
CO3	understand and solve problems related to the mechanics of composite materials	Analyzing (K4)
CO4	understand the design concepts and thermal behaviour of composite materials	Analyzing (K4)
CO5	demonstrate the knowledge on the fundamentals of particulate reinforced composite	Applying (K3)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	3	1	2
CO2	3	1	2
CO3	3	2	2
CO4	3	2	3
CO5	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	40	50				100
CAT2	10	10	50	30			100
CAT3	10	10	50	30			100
ESE	10	20	40	30			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE02 - FRACTURE MECHANICS

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Strength of Materials, Applied Materials Engineering	**1**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course aims to deliver the concepts of fracture mechanics with respect to design and safety.	
Unit - I	**Elements of Solid Mechanics**	**9**
Elements of Solid Mechanics: The Geometry of Stress and Strain - Elastic Deformation - Plastic and Elasto-Plastic Deformation - Limit Analysis - Theory of Elasticity - Stress – Strain Relations - Equilibrium Equations – Compatibility - Stress Functions.		
Unit - II	**Stationary Crack under Static Loading**	**9**
Stationary Crack under Static Loading: Two Dimensional Elastic Fields – Analytical Solutions Yielding Near a Crack Front – Irwin's Approximation - Plastic Zone Size – Dugdaale Model – J Integral and its relation to Crack Opening Displacement.		
Unit - III	**Energy Balance and Crack Growth**	**9**
Energy Balance and Crack Growth: Griffith Analysis – Linear Fracture Mechanics-Crack Opening Displacement – Dynamic Energy Balance – Crack Arrest.		
Unit - IV	**Fatigue Crack Growth Curve**	**9**
Fatigue Crack Growth Curve: Empirical Relation Describing Crack Growth by Fatigue – Life Calculations for a given Load Amplitude – Effects of Changing the load Spectrum – Effects of Calculations for a Given load Amplitude – Effects of Changing Environment.		
Unit - V	**Elements of Applied Fracture Mechanics**	**9**
Elements of Applied Fracture Mechanics: Examples of Cracks - Growth Analysis for Cyclic LOADING - Leak before Break – Crack Initiation Under Large Scale Yielding – Thickness as a Design Parameter – Crack Instability in Thermal or Residual Stress Fields.		

Lecture: 45

REFERENCES:

1.	George E. Dieter. "Mechanical Metallurgy". 3rd Edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 2013.
2.	Hellan Kare. "Introduction of Fracture Mechanics". 1st Edition, Tata McGraw-Hill Book Company, New Delhi, 1985.
3.	Prashant Kumar. "Elements of Fracture Mechanics". 1st Edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 2009.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	analyze the behaviour of material under varying load conditions	Analyzing (K4)
CO2	model and analyze crack propagation under static loading	Analyzing (K4)
CO3	perform energy balance modelling	Evaluating (K5)
CO4	predict fatigue crack growth under various loads	Applying (K3)
CO5	analyze crack installing and report the result	Applying (K3)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	3	3	3
CO2	3	3	
CO3	3	3	
CO4	3	3	3
CO5	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	15	15	30	40			100
CAT2	10	10	25	25	30		100
CAT3	20	20	60				100
ESE	15	15	25	25	20		100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE03 - SAFETY IN ENGINEERING INDUSTRY

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Manufacturing Technology, Material Removal Processes, Thermal Engineering.	1	PE	3	0	0	3

Preamble	The course deals with the study of hazards, safety precautions and guidelines to be followed during several machining operations. It also emphasize on adoption of safety devices to perform operations in industrial equipments and explore the different types of machine guarding system.	
Unit - I	**Safety in Metal Working Machinery and Wood Working Machines**	**9**
Safety in Metal Working Machinery and Wood Working Machines: General safety rules - Principles - Maintenance - Inspections of Turning Machines - Boring Machines - Milling Machine - Planning Machine And Grinding Machines - CNC Machines - Wood Working Machinery - Types - Safety Principles - Electrical Guards - Work Area - Material Handling - Inspection - Standards and Codes- Saws - Types - Hazards.		
Unit - II	**Principles of Machine Guarding and Selection and suitability**	**9**
Principles of Machine Guarding: Guarding during maintenance - Zero Mechanical State (ZMS) - Definition - Policy for ZMS – Guarding of Hazards - Point of Operation Protective Devices - Machine Guarding - Types - Fixed Guard - Interlock Guard - Automatic Guard - Trip Guard - Electron Eye - Positional Control Guard - Fixed Guard Fencing- Guard Construction- Guard Opening. Selection and suitability: Lathe-Drilling-Boring-Milling-Grinding-Shaping-Sawing-Shearing-Presses- Forge Hammer – Flywheels - Shafts Couplings-Gears-Sprockets Wheels and Chains- Pulleys and Belts-Authorized Entry to Hazardous Installations-Benefits of Good Guarding Systems.		
Unit - III	**Safety in Welding and Gas Cutting**	**9**
Safety in Welding and Gas Cutting: Gas Welding and Oxygen Cutting - Resistances Welding - Arc Welding and Cutting - Common Hazards - Personal Protective Equipment - Training - Safety Precautions in Brazing - Soldering and Metalizing – Explosive Welding - Selection - Care and Maintenance Of The Associated Equipment and Instruments – Safety in Generation - Distribution and Handling of Industrial Gases - Colour Coding – Flashback Arrestor – Leak Detection - Pipe Line Safety - Storage and Handling of Gas Cylinders.		
Unit - IV	**Safety in Cold Forming and Hot Working of Metals**	**9**
Safety in Cold Forming and Hot Working of Metals: Cold Working - Power Presses - Point of Operation Safe Guarding - Auxiliary Mechanisms - Feeding and Cutting Mechanism - Hand or Foot-Operated Presses - Power Press Electric Controls - Power Press Set Up and Die Removal - Inspection and Maintenance-Metal Sheers-Press Brakes - Hot Working Safety in Forging - Hot Rolling Mill Operation - Safe Guards in Hot Rolling Mills – Hot Bending of Pipes - Hazards and Control Measures- Safety in Gas Furnace Operation - Cupola - Crucibles - Ovens - Foundry Health Hazards - Work Environment - Material Handling in Foundries - Foundry Production Cleaning and Finishing Foundry Processes.		
Unit - V	**Safety in Finishing and Inspection and Testing**	**9**
Safety in Finishing and Inspection and Testing: Heat Treatment Operations - Electro Plating - Paint Shops - Sand and Shot Lasting - Safety in Inspection and Testing - Dynamic Balancing - Hydro Testing - Valves - Boiler Drums and Headers - Pressure Vessels - Air Leak Test - Steam Testing - Safety in Radiography - Personal Monitoring Devices - Radiation Hazards - Engineering and Administrative Controls - Indian Boilers Regulation. Health and Welfare Measures in Engineering Industry-Pollution Control in Engineering Industry- Industrial Waste Disposal.		

Lecture: 45

REFERENCES:

1. John V. Grimaldi and Rollin H. Simonds. “Safety Management”. 5th Edition, Richard D. Irwin, Inc. Publisher, Homewood, 1994.
2. Krishnan N.V. “Safety Management in Industry”. 1st, Jaico Publishers, Mumbai, 1996.
3. Jane Blunt - Nigel C. Balchin. “Health and Safety in Welding and Allied Processes”. 5th Edition, Woodhead Publishing Ltd., U.K., 2002.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	infer safety in metal and wood working machines	Applying (K3)
CO2	identify proper guarding for different applications	Applying (K3)
CO3	describe safety in welding and allied process	Applying (K3)
CO4	apply safety principles in cold and hot working of metals	Applying (K3)
CO5	handle safety testing and inspection instruments	Analyzing (K4)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	3	1	2
CO2	3	1	1
CO3	3	1	2
CO4	3	1	2
CO5	3	1	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	40				100
CAT2	20	40	40				100
CAT3	10	30	30	30			100
ESE	10	40	30	20			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE04 - OPTIMIZATION TECHNIQUES IN DESIGN AND MANUFACTURING

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Fundamentals of Operation Research and Mathematics.	**2**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course emphasis the application of optimization techniques, tools and methods in the field of Engineering. It exploits to design the engineering mechanisms and their systems with high effectiveness.	
Unit - I	**Introduction**	**9**
Introduction: Introduction to Optimum Design-Global and Local – Problems - General Characteristics of Mechanical Elements-Adequate and Optimum Design-General Principles of Optimization - Formulation of Objective Function - Design Constraints – Classification of Optimization Problem -Saddle Point-Single Variable Optimization-Multi Variable Optimization with no Constraints.		
Unit - II	**Unconstrained Optimization Techniques**	**9**
Unconstrained Optimization Techniques: Single Variable and Multivariable Optimization with Constraints, Techniques of Unconstrained Minimization -Golden Section-Pattern and Gradient Search Methods -Interpolation Methods -Quadratic Function Method.		
Unit - III	**Constrained and Advanced Optimization Techniques**	**9**
Constrained Optimization Techniques: Optimization with Equality and Inequality Constraints - Indirect Methods using Penalty Functions-Lagrange Multipliers- Geometric Programming- Constrained-Mixed Inequality and Unconstrained Minimization. Advanced Optimization Techniques - GA, SA and NN based on optimization - Fuzzy Systems - Taguchi Technique - Parallel Processing.		
Unit - IV	**Static Applications**	**9**
Static Applications: Structural Applications – Design of Simple Truss Members-Reanalysis Techniques Design Applications - Design of Simple Axial- Transverse Loaded Members for Minimum Cost- Maximum Weight -Design of Shafts and Torsionally Loaded Members – Design of Springs.		
Unit - V	**Dynamic Applications**	**9**
Dynamic Applications: Optimum Design of Single and Two Degree of Freedom Systems, Vibration Absorbers. Optimum Design of Simple Linkage Mechanisms. Case Study: Optimization of Process Parameters in Production Operation.		

Lecture: 45

REFERENCES:

1. Rao Singaresu S. “Engineering Optimization – Theory and Practice”. 4th Edition, New Age International Pvt. Ltd., New Delhi, 2015.
2. Kalyanamoy Deb. “Optimization for Engineering Design Algorithms and Examples”. 3nd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2013.
3. Goldberg D.E. “Genetic Algorithms in Search, Optimization and Machine”. 4th Edition, Barnen, Addison Wesley, New York, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	build an optimization problems for design and manufacturing applications	Evaluating (K5)
CO2	compute the optimum value for unconstrained optimization problem	Evaluating (K5)
CO3	solve the optimization problem by various techniques	Evaluating (K5)
CO4	design the stress members and shafts using reanalysis techniques	Applying (K3)
CO5	optimize the influencing parameters for linkages and vibratory systems	Evaluating (K5)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	2	2	3
CO4	3	2	3
CO5	2	3	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	25	25	20	20		100
CAT2	10	15	15	30	30		100
CAT3	10	15	15	30	30		100
ESE	10	15	25	20	30		100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE05 - DESIGN OF MATERIAL HANDLING EQUIPMENT

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Fundamentals of Material Handling Equipment. Knowledge on Machine Element and Transmission System.	**2**	**PE**	**3**	**0**	**0**	**3**

Preamble	The course impart the design knowledge on different material handling equipments, Flexible hoisting equipments, load handling equipments, overhead and surface transportation, elevating equipment and conveying equipments.	
Unit - I	**Flexible Hoisting Appliances**	**9**
Flexible Hoisting Appliances: Type-Selection and Applications of Material Handling Equipment's-Choice of Material Handling Equipment- Hoisting Equipment- Components and Theory of Hoisting Equipment- Chain and Ropes- Selection of Ropes- Pulleys- Pulley Systems-Sprockets and Drums.		
Unit - II	**Load Handling Equipments and Brakes**	**9**
Load Handling Equipments and Brakes: Forged Standard Hooks- Forged Ram Shorn Hooks- Solid Triangular Eye Hooks- Crane Grabs-Electric Lifting Magnetic- Grabbing Attachments for Loose Materials-Arresting Gear-Brakes- Shoe-Band and Cone Types- Elements of Shoe Brakes- Thermal Calculation in Shoe Brakes.		
Unit - III	**Surface and Overhead Transportation Equipment**	**9**
Surface and Overhead Transportation Equipment: Hand Operated Trucks- Powered Trucks- Tractors- Electronically Controlled Tractors- Hand Truck on Rails- Industrial railroad Equipment's- Locomotives- Winches- Capstans- Turntables- Monorail Conveyors- Pipe Rail Systems-Flat Bar Monorails- Rail Travelling Mechanism- Cantilever and Monorail Cranes-Cogwheel Drive-Monocable Tramways-Reversible Tramways.		
Unit - IV	**Elevating Equipment**	**9**
Elevating Equipment: Continuous-Motion Vertical Conveyors- Reciprocating-Motion Vertical Conveyors- Stackers-Work Levellers and Tail Gates- Industrial Lifts- Passenger Lifts- Freight Elevators- Mast Type Elevators- Vertical Skip Hoist Elevators-Bucket Elevators- Design-Loading and Bucket Arrangements.		
Unit - V	**Conveying Equipment**	**9**
Conveying Equipment: Belt Conveyors-Chain Conveyors-Apron Conveyors-Escalators-Flight Conveyors-Roller Conveyors- Oscillating Conveyors- Design of Belt Conveyors-Screw Conveyors and Pneumatic Conveyors.		

Lecture: 45

REFERENCES:

1. Rudenko N. "Materials Handling Equipment". 2nd Edition, MIR Publishers, Moscow, 1970.
2. Spivakovsky A.O. and Dyachkov V.K. "Conveying Machines". Volume I & II, 1st Edition, MIR Publishers, Moscow, 1985.
3. Lingaiah K. "Machine Design Data Book". 2nd Edition, McGraw Hill, New York, 2003.
4. Chowdary R.B. and Tagore G.R.N. "Materials Handling Equipment". 2nd Edition, Khanna Publishers, New Delhi, 2003.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	understand the basic concepts of flexible hoisting equipment	Applying (K3)
CO2	demonstrate the basic concepts and design the braking system for load handling equipment	Applying (K3)
CO3	solve the problems in surface and overhead transportation equipment	Analyzing (K4)
CO4	solve the problems and understanding the basic of elevators	Analyzing (K4)
CO5	recognize the concepts and solve the problems of conveying equipment	Analyzing (K4)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	2	1	3
CO2	2	1	3
CO3	3	1	3
CO4	3	1	2
CO5	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	15	45	40				
CAT2	15	20	30	35			
CAT3	15	15	40	40			
ESE	10	15	50	25			

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE06 FLUID POWER SYSTEM DESIGN

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PE	3	0	2	4

Preamble	This course deals with the design of a system which generate, control and transmission of power using pressurized fluids.	
Unit - I	**Fundamentals and Power Source of Hydraulic System**	**9**
Fundamentals and Power Source of Hydraulic System: Basics, Types and structure of fluid power systems – Pascal's Law and its application –Fluid properties – Losses in pipes, valves and fittings – Advantages and applications of Fluid power systems. Fluid power symbols – Hydraulic pumps: Gear, Vane and Piston pumps, Pump Performance, Characteristics and Selection – Sizing of hydraulic pumps.		
Unit - II	**Control Components of Hydraulic System**	**9**
Control Components of Hydraulic System: Direction control valves: Three-way valve, Four way valve, Check valve and shuttle valve – Actuation mechanism of DCV – Pressure control valves: Pressure relief, Pressure Reducing, Counter balance, Sequencing and Unloading Valves – Flow control valves and its types – Proportional Valves – Servo valves and its types.		
Unit - III	**Fundamentals of Pneumatic System**	**9**
Fundamentals of Pneumatic System: Perfect Gas laws – Compressors: piston, screw and vane compressor – Fluid conditioning Elements: Filter, Regulator and Lubricator unit, Pneumatic silencers, After coolers, Air dryers – Air control valves – Fluid power actuators: Linear and Rotary actuators – types – Cushioning mechanism in cylinders – Sizing of Actuators.		
Unit - IV	**Fluid Power Circuit Design**	**9**
Fluid Power Circuit Design: Circuit design methods: Cascade method, Step counter method and KV Map method (two / three-cylinder circuits) – Basic pneumatic circuits – Electrical components and electrical controls for Fluid power circuits – Introduction to Fluid logic devices and applications – Accumulator: Types and application circuits – Pressure intensifier circuits – PLC applications in Fluid power circuit.		
Unit - V	**Industrial Circuits and Maintenance**	**9**
Industrial Circuits and Maintenance: Industrial circuits: Speed control circuits – Regenerative cylinder circuits – Pump unloading circuit – Double pump circuit – Counter balance valve circuit – Hydraulic cylinder sequencing circuit – Automatic cylinder reciprocating circuit – Cylinder synchronizing circuits – Fail safe circuits – Sealing devices: Types and materials – Installation, Maintenance and trouble shooting of Fluid Power systems.		

List of Exercises / Experiments :

1. Design and testing of speed control circuits (Meter in, Meter out and Bleed off circuits)
2. Design and testing of Electro-hydraulic circuit with pressure sequence valve
3. Design and testing of Sequential circuit with pneumatic control (with and without time delay)
4. Design and testing of Electro Pneumatic sequential circuit with limit switches
5. Design and testing of Pneumatic circuits with logic controls – AND valve and OR valve
6. Design and simulation of Sequential fluid power circuits using cascade method
7. Design and testing of Pneumatic circuit with vacuum cup and rod less cylinder
8. Design and testing of Hydraulic circuit with Proportional control of Pressure and Flow
9. Design and testing of sequential circuits using cascade method
10. Design, testing and simulation of electro pneumatic circuit with timers and counters

Lecture:45, Practical:30, Total: 75

REFERENCES:

1.	Esposito Anthony, "Fluid Power with Applications", 7th Edition, Pearson Higher Education, New York, 2015.
2.	Jegadeesa T., "Hydraulics and Pneumatics", 1st Edition, I.K International Publishing House Pvt. Ltd., New Delhi, 2015.
3.	Majumdar S.R., "Oil Hydraulic Systems – Principles and Maintenance", 2nd Edition, Tata McGraw-Hill, New Delhi, 2012.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	identify fluid power components and their symbols as used in industry and also select suitable pump for hydraulic power pack	Understanding (K2) Imitation (S1)
CO2	choose appropriate control valves for fluid power applications	Applying (K3) Manipulation (S2)
CO3	select pneumatic components and fluid power actuators for low cost automation	Analysing (K4) Precision (S3)
CO4	design and construct a fluid power circuits real time applications	Applying (K3) Manipulation (S2)
CO5	design, construct, test, install, maintain and trouble shoot fluid power circuits for engineering applications	Analysing (K4) Precision (S3)
CO6	Select the appropriate fluid power components and their symbols to design and simulate the industrial circuits	Applying (K3), Precision (S3)
CO7	design, construct and test fluid power circuits with Manual, Mechanical, hydraulic, pneumatic and electrical actuation methods for low cost automation	Applying (K3), Precision (S3)
CO8	develop and simulate fluid power circuits using simulation software for industrial applications	Applying (K3), Precision (S3)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1		2	
CO2	2		1
CO3	2		1
CO4		1	3
CO5	2	2	3
CO6	2	2	3
CO7	2	2	3
CO8	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	60	30				100
CAT2	10	55	35				100
CAT3	10	40	50				100
ESE	15	50	35				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE07 – APPLIED FINITE ELEMENT ANALYSIS

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Finite Element Method	**2**	**PE**	**3**	**1**	**0**	**4**

Preamble	The course offers advanced concepts of finite element analysis on the bending of plates, shells, Non linear problems, dynamic problems, fluid mechanics and het transfer analysis.	
Unit - I	**Bending of Plates and Shells**	**9+3**
Bending of Plates and Shells: Review of Elasticity Equations – Bending of Plates and Shells – Finite Element Formulation of Plate and Shell Elements – Conforming and Non-Conforming Elements – C0 and C1 Continuity Elements – Application and Examples.		
Unit - II	**Non-Linear Problems**	**9+3**
Non-Linear Problems: Introduction – Iterative Techniques – Material Non-linearity – Elasto Plasticity – Plasticity – Visco Plasticity – Geometric Non linearity – Large displacement formulation – Application in Metal Forming Process and Contact Problems.		
Unit - III	**Dynamic Problems**	**9+3**
Dynamic Problems: Direct Formulation – Free, Transient and Forced Response – Solution Procedures – Subspace Iterative Technique – Houbolt, Wilson, Newmark – Methods – Examples.		
Unit - IV	**Fluid Mechanics and Heat Transfer Analysis**	**9+3**
Fluid Mechanics and Heat Transfer Analysis: Governing Equations of Fluid Mechanics – Inviscid and Incompressible Flow – Potential Formulations – Slow Non-Newtonian Flow – Metal and Polymer Forming – Navier Stokes Equation – Steady and Transient Solution.		
Unit - V	**Error Estimates and Adaptive Refinement:**	**9+3**
Error Estimates and Adaptive Refinement: Error Norms and Convergence rates – H-Refinement with Adaptivity – Adaptive Refinement Techniques.		

Lecture:45, Tutorial:15, Total: 60

REFERENCES:

1. Bathe K.J. “Finite Element Procedures”. 2nd Edition , Prentice Hall, New Jersey, 2006.
2. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt , “Concepts and Applications of Finite Element Analysis”, 4th Edition, Wiley, John & Sons, United States, 2007.
3. Ramamurthy G. “Applied Finite Element Analysis”. 2nd Edition, I K International Publishing House, New Delhi, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	formulate and analyse the finite element equation using plate and shell elements for various applications	Applying (K3)
CO2	analyze the behaviour of non-linear materials	Analyzing (K4)
CO3	solve and compute the responses under dynamics conditions	Analyzing (K4)
CO4	calculate the fluid flow phenomena and heat transfer analysis of various applications	Analyzing (K4)
CO5	estimate the error and remesh the given structure for reducing the discretization error	Applying (K3)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	3	1	3
CO2	3		3
CO3	2		3
CO4	3		3
CO5	3		3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	20	30	30			100
CAT2	20	20	30	30			100
CAT3	20	20	30	30			100
ESE	20	20	30	30			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE08 – TRIBOLOGY IN DESIGN

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PE	3	0	0	3

Preamble	The course deals with the fundamental concepts of friction wear and lubrications. Surface effects in tribology, bearing design and contact mechanics will be the key aspects of this course which will improve the functionality and life of the components.	
Unit - I	**Introduction to Surfaces and Friction**	**9**
Introduction to Surfaces and Friction: Topography of Surfaces – Surface Features – Experimental Determinations of Surface Structures – Chemical Analysis of Surfaces – Surface Effects in Tribology – Analysis of Surface Roughness – Surface Topography Measurements. Surface Treatments, Surface Modifications and Surface Coating. Friction – Mechanism of Friction, Equations and Models of Friction, Friction Measurements, Friction Properties of Metallic and Non-Metallic Materials, Friction in Extreme Conditions.		
Unit - II	**Fundamentals of Wear and Lubrication**	**9**
Fundamentals of Wear and Lubrication: Wear – Types, Mechanism, Mapping, Measurements, Wear Resistance Materials – Lubricants – Selection Criteria – Lubrication Regimes. Hydrodynamic, Elasto and Plasto Hydrodynamic Lubrication, Basic Equations, Reynold's Equation, Boundary Lubrication, Boundary Lubricating Films and its Properties.		
Unit - III	**Design of Hydrodynamic Bearings**	**9**
Design of Hydrodynamic Bearings: Dynamic Analysis of Hydrodynamic Bearing Performance, Thrust and Journal Bearings– Full, Partial, Fixed and Pivoted – Mass Flow Rate, Friction, Power Loss, Heat and Temperature Difference, Dynamic Loads, Oil Film Thickness, Stiffness of Squeeze Film – Problems.		
Unit - IV	**Hydrostatic and Rolling Element Bearings**	**9**
Hydrostatic and Rolling Element Bearings: Hydrostatic Lubrication –Hydrostatic Bearing Design. Slider Bearings – Self-Acting Finite Bearings, Failure Modes, Materials for Rolling Element Bearings – Types, Bearing Geometry and Kinematics, Load Ratings and Life Prediction.		
Unit - V	**Contact Mechanics and Tribo Measurements**	**9**
Contact Mechanics and Tribo Measurements: Contact Mechanics, Analysis of Contacts, Elastic Plastic Contact of Frictionless Solids, Problems. Bearing Torque Calculation, Temperature Analysis, Endurance Testing and Failure Analysis, Bearing Performance Measurements, Bearing Vibration Measurements		

Lecture: 45

REFERENCES:

1. Bharat Bhushan. "Principles and Applications of Tribology". 2nd Edition, John Wiley & Sons, New York, 2013.
2. Williams J.A."Engineering Tribology". 2nd Edition, Oxford University Press, England, 2005.
3. Sahoo P. "Engineering Tribology". 3rd Edition, PHI Learning, India, 2013.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	comprehend the surface effects in tribology	Applying (K3)
CO2	apply the basic concepts of friction, wear and lubrication in industrial components	Evaluating (K5)
CO3	design the hydrodynamic bearings with realistic constraints	Analyzing (K4)
CO4	design the hydrostatic bearings with appropriate assumptions and basics about rolling element bearings	Analyzing (K4)
CO5	apply the principles of tribo measurement techniques and contact mechanics in industrial applications	Evaluating (K5)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	1	1	3
CO2	2	1	3
CO3	1	1	3
CO4	1	1	3
CO5	1	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	10	40	30	10		100
CAT2	10	10	35	35	10		100
CAT3	10	10	40	30	10		100
ESE	10	20	30	30	10		100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE09 – DESIGN FOR MANUFACTURE AND ASSEMBLY

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Engineering Drawing, Manufacturing Technology	**2**	**PE**	**3**	**0**	**0**	**3**

Preamble	The course provides the knowledge on design and manufacture of industrial components. So the design is to be modified as manufacture and assembly oriented. It also deals with the form design, machining consideration, casting process and design for environment.	
Unit - I	**DFMA Guidelines and Geometric Tolerance**	**9**
DFMA Guidelines and Geometric Tolerance: General Design Principles for Manufacturability – Design for Assembly – Strength and Mechanical Factors – Geometric Tolerances – Worst Case Method – Assembly Limits –Design and Manufacturing Datum – Conversion of Design Datum into Manufacturing Datum –Tolerance Stacks- Process Capability.		
Unit - II	**Form Design**	**9**
Form Design: Principal Materials – Selection of Materials and Processes – Mechanisms Selection – Possible Solutions – Evaluation Method – Influence of Materials on Form Design – Form Design of Grey Iron, Malleable Iron- Steel and Aluminium Castings- Welded Members and Forgings.		
Unit - III	**Machining Considerations**	**9**
Machining Considerations: Design Features to Facilitate Machining – Single Point and Multipoint Cutting Tools – Design for Turning Operation- Design for Machining Round Holes – Design for Parts Produced by Milling- Planning- Shaping and Slotting- Reduction of Machined Area- Simplification by Separation – Simplification by Amalgamation – Design for Machinability – Design for Economy – Design for Clampability – Design for Accessibility.		
Unit - IV	**Casting Considerations**	**9**
Casting Considerations: Redesign of Castings Based on Parting Line Considerations – Minimizing Core Requirements, Machined Holes – Design Rules for Sand Castings – Investment Casting: Introduction, Design Consideration of Investment Casting –The Die Casting Cycle, Determination of Number of Cavities and Appropriate Machine Size in Die Casting- Identification of Uneconomical Design – Modifying the Design – Computer Applications in DFMA.		
Unit - V	**Design for the Environment**	**9**
Design for the Environment: Environmental Objectives – Basic DFE Methods – Lifecycle Assessment –AT&T‟s Environmentally Responsible Product Assessment – Weighted Sum Assessment Method – Techniques to Reduce Environmental Impact – Design to Minimize Material Usage – Design for Recyclability – Design for Remanufacture – Design for Energy Efficiency – Design to Regulations and Standards.		

Lecture: 45

REFERENCES:

1. Boothroyd G. “Product Design for Manufacture and Assembly”. 3rd Edition, CRC Press, London, 2013.
2. Peck Harry. “Design For Manufacture”. 1st Edition, Pitman Publications, London 1983.
3. Otto Kevien and Wood Kristin. “Product Design”. 1st Edition, Pearson Publication, New Delhi, 2004.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	analyze the given component and identify the suitable geometrical tolerances for manufacturing oriented design	Analyzing (K4)
CO2	propose design guidelines for form design of castings, welded members and forgings	Applying (K3)
CO3	suggest suitable design modifications to facilitate machining of components	Applying (K3)
CO4	identify uneconomical design and modify component design for sand and die castings	Analyzing (K4)
CO5	perform the life cycle assessment for a component to achieve eco-friendly design	Applying (K3)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	3	2	2
CO2	3	2	2
CO3	3	2	2
CO4	3	2	2
CO5	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	20	30	30			100
CAT2	25	25	50	--			100
CAT3	20	20	30	30			100
ESE	20	20	30	30			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

Programme & Branch	**M.E. & Engineering Design**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	Fundamentals of Mathematics, Fundamentals of Dynamics of Machinery, Fundamentals of Strength of Materials.	**3**	**PE**	**3**	**1**	**0**	**4**

Preamble	The course gives the insight of basics of vibration and noise measurements, automotive noise control various noise sources and their control techniques.	
Unit - I	**Basics of Vibration**	**9+3**
Basics of Vibration: Introduction, Classification of Vibration-Free and Forced Vibration-Undamped and Damped Vibration. Linear and Non-linear Vibration-Response of Damped and Undamped Systems under Harmonic Force. Analysis of Single Degree and Two Degree of Freedom Systems-Torsional Vibration- Determination of Natural Frequencies.		
Unit - II	**Basics of Noise**	**9+3**
Basics of Noise: Introduction-Amplitude-Frequency-Wavelength and Sound Pressure Level-Addition- Subtraction. Averaging Decibel Levels-Noise Dose Level-Legislation. Measurement and Analysis of Noise- Measurement Environment-Equipment-Frequency Analysis-Tracking Analysis-Sound Quality Analysis.		
Unit - III	**Automotive Noise Sources**	**9+3**
Automotive Noise Sources: Noise – Characteristics of Engines-Engine Overall Noise Levels-Assessment of Combustion Noise-Assessment of Mechanical Noise-Engine Radiated Noise-Intake and Exhaust noise. Engine Accessory Contributed Noise-Transmission Noise-Aerodynamic Noise-Tyre Noise-Brake Noise.		
Unit - IV	**Control Techniques**	**9+3**
Control Techniques: Vibration Isolation-Tuned Absorbers-Untuned Viscous Dampers-Damping Treatments. Applications Dynamic Forces Generated by IC Engines-Engine Isolation-Crank Shaft Damping-Modal Analysis of the Mass Elastic Model Shock Absorbers.		
Unit - V	**Source of Noise and Control**	**9+3**
Source of Noise and Control: Methods for Control of Engine Noise-Combustion Noise-Mechanical Noise. Predictive Analysis-Palliative Treatments and Enclosures-Automotive Noise Control Principles-Sound in Enclosures-Sound Energy Absorption- Sound Transmission through Barriers.		

Lecture:45, Tutorial:15, Total: 60

REFERENCES:

1. Rao Singiresu S. “Mechanical Vibrations”. 5th Edition, Pearson Education, New Delhi, 2010.
2. Pujara Kewal. “Vibrations and Noise for Engineers”. 4th Edition, Dhanpat Rai & Sons, New Delhi, 2004.
3. Challen Bernard and Baranescu Rodica. “Diesel Engine Reference Book”. 2nd Edition, SAE International, Warrendale, 2006.
4. Happian-Smith, Julian. “An Introduction to Modern Vehicle Design”. 1st Edition, Butterworth-Heinemann, Boston, 2011.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	solve and identify the frequency response of the system	Applying (K3)
CO2	analyze the noise related parameters	Analyzing (K4)
CO3	solve and design the automobile related noise systems and their control	Analyzing (K4)
CO4	solve and analyze the vibration isolation and control systems	Analyzing (K4)
CO5	identify and analyze the sources of vibration, noise and their control	Analyzing (K4)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	3	2	2
CO2	3	2	1
CO3	3	2	1
CO4	3	3	3
CO5	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	10	40	40			100
CAT2	10	10	40	40			100
CAT3	10	10	40	40			100
ESE	10	10	40	40			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE11 ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisite	Nil	III	PC	3	0	0	3

Preamble:	This course provides basic knowledge about Artificial Intelligence and its applications and different types of machine learning and their implementation for real world problems	
UNIT – I	**Intelligent Agents:**	**9**
Concept of Rationality, Environments and Structure. Solving Problems by Searching: Problem-Solving Agents, Example, Searching for Solutions, Search Strategies and constraint Satisfaction Problems		
UNIT – II	**Logical Agents:**	**9**
Knowledge-Based Agents, Wumpus World, Propositional Logic, Propositional Theorem. **First-Order Logic:** Representation, Syntax and Semantics, Using First-Order Logic and Knowledge Engineering. **Inference in First-Order Logic:** Unification and Lifting, Forward and Backward Chaining, Resolution.		
UNIT – III	**Introduction to Machine Learning:**	**9**
Machine Learning Applications - Types of Machine learning **-Supervised Learning:** Building good training sets – Data Pre-processing - Decision tree learning. Bayesian Decision Theory: Introduction – Classification.		
UNIT – IV	**Artificial Neural Networks:**	**9**
Introduction – Representations – Problems – Perceptron – Multilayer network and Back Propagation Algorithm. **Unsupervised Learning:** K-Means clustering - Hierarchical clustering.		
UNIT – V	**Reinforcement Learning:**	**9**
Single state case – Elements – Model based learning –Temporal difference learning – Generalization.		

Total: 45

REFERENCES:

1. Stuart Russell and Peter Norvig, “Artificial Intelligence: A Modern Approach”, 3rd Edition, Pearson Education, 2016.
2. Ethem Alpaydin, “Introduction to Machine Learning”, 3rd Edition, Prentice Hall India, 2015.
3. Sebastian Raschka,”Python Machine Learning”, 3rd Edition, Packt Publishing, 2019.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	define intelligent agents and apply searching for solving problems	Understanding (K2)
CO2	apply propositional and first order logic in ai	Applying (K3)
CO3	utilize supervised learning methods to solve real world problems	Applying (K3)
CO4	design solutions for the given problem using artificial neural networks and unsupervised learning methods	Applying (K3)
CO5	recognize the need of reinforcement learning in ai applications	Understanding (K2)

Mapping of COs with POs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	2	2
CO2	3	3	3
CO3	3	3	3
CO4	3	3	3
CO5	3	2	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	50	30				100
CAT2	20	40	40				100
CAT3	10	40	50				100
ESE	20	50	30				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE12 MACHINE TOOL CONTROL AND CONDITION MONITORING

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisite	Nil	III	PC	3	0	0	3

Preamble:	This course impart the knowledge in machine tool control and condition monitoring in a mechatronics perspective.	
UNIT – I	**Overview of Automatic Control in Machine Tools**	**9**
Open loop and closed loop system in machine tools- process model formulation-transfer function. Control actions-block diagram representation of mechanical pneumatic and electrical systems. Process computer -Peripherals-Data logger-Direct digital control-Supervisory computer control.		
UNIT – II	**Adaptive Control and PLC**	**9**
Adaptive control-types – ACC, ACO, Real time parameter estimation, Applications- adaptive control for turning, milling, grinding and EDM. Programmable logic controller-Functions-Applications in machine tools-Macro programming for tool life monitoring and Management		
UNIT – III	**Condition Monitoring**	**9**
Introduction – Cost comparison with and without CM – On-load testing and offload testing – Methods and instruments for CM – Temperature sensitive tapes – Pistol thermometers – wear-debris analysis		
UNIT – IV	**Vibration, Acoustic Emission and Sound Monitoring**	**9**
Primary & Secondary signals, Online and Off -line monitoring. Fundamentals of Vibration, Sound, Acoustic Emission. Machine Tool Condition Monitoring through Vibration, Sound, Acoustic Emission, Case Studies.		
UNIT – V	**Condition Monitoring, Through Other Techniques**	**9**
Visual & temperature monitoring, Leakage monitoring, Lubricant monitoring, condition monitoring of Lube and Hydraulic systems, Thickness monitoring, Image processing techniques in condition monitoring.		

Total: 45

REFERENCES:

1. Mishra R.C., Pathak K., “Maintenance Engineering and Management”, 2nd Edition, Prentice Hall of India Pvt. Ltd., 2016
2. Mikell P. Groover, “Automation, Production Systems, and Computer-Integrated Manufacturing” Pearson Education India, 2016
3. Robert Bond Randall – Vibration-Based Condition Monitoring – Industrial, Aerospace and Automotive applications, John Wiley & Sons Ltd., 2011.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	summarize the concepts of automatic control in machine tools	Understanding (K2)
CO2	choose the type of adaptive control and PLC for machining operations	Applying (K3)
CO3	explain the concepts of condition monitoring techniques	Understanding (K2)
CO4	select the condition monitoring technique for the machine tool among vibration, acoustic emission and sound analysis	Applying (K3)
CO5	select appropriate condition monitoring technique for machine tool control applications	Applying (K3)

Mapping of COs with POs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	1	2
CO2	3	2	2
CO3	3	2	3
CO4	3	2	3
CO5	2	3	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	**10**	**70**	**10**				
CAT2	**10**	**60**	**20**				
CAT3	**10**	**50**	**40**				
ESE	**10**	**60**	**30**				

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE13 – EXPERIMENTAL STRESS ANALYSIS

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Stress and Strain Principles, Metal Coating Techniques, Metrology and Measurement Techniques	4	PE	3	1	0	4

Preamble	This course provides the physical principles and guidelines to select an experimental technique for a given application. It also explore two-dimensional photo elasticity, the frozen stress method and surface coating techniques, structural model analysis, and special instruments for dynamic stress analysis and analogue methods for dealing with stress problems.

Unit - I	**Strain Gauges and Circuits**	**9+3**

Strain Gauges and Circuits: Choice of Experimental Methods –Standards and Accuracy of Measurements – Principles of Modal Analysis- P1 Theorem Direct and Indirect Models. Mechanical- Optical – Acoustic and Pneumatic Strain Gauges – Electrical Strain Gauges – Gauge Factor Types of Resistance Gauges – Gauge Materials – Backing Materials Adhesives – Protective Coatings – Semiconductor Gauges- Introduction of Wheatstone bridge– Constant – Current Resistance Bridge Balancing –Reference Bridge – Potentiometer Circuit – Temperature Compensation Effects of Lead Wires.

Unit - II	**Strain Analysis Methods**	**9+3**

Strain Analysis Methods: Introduction – Two – Element Rectangular Rosette- Three- Element Rectangular Rosette – Three – Element Delta Rosette – Four –Element Rectangular Rosette and Tee Delta Rosette – Correction for Transverse Strain Effects, Stress Gauge, Plane Shear Gauge, Stress Intensity Factor Gauge.

Unit - III	**Brittle Coating Method Bi-Refringent Coating Techniques**	**9+3**

Brittle Coating Method Bi-Refringent Coating Techniques: Introduction –Relation between the state of Stress in Coating and that on Model –Isostatics and Isoentacties – Types of Brittle Coating Materials Relative Merits of Stress – Coat and all – Temp Coatings – Crack Detection Techniques –Variables Influencing Accuracy of Brittle Coating Application-model – Surface Preparation and Application of Coating Calibration of Brittle Coating Materials – Brittle Coatings Technique applied to a Specific Problem. Reflection Plariscope – Sensitivity of the Method Principle Stress – Separation – Comparison of Brittle Coating and bi-Refringent Coating Techniques.

Unit - IV	**Photo Elasticity**	**9+3**

Photo Elasticity: Background Optics – Plane and Circular Polarization –Stress Optic Law Photo Elastic Materials – Casting and Modeling Techniques – Calibration Methods –Isoclinic- Isochromatic and Stress Trajectories –Stress Separation Methods-Fringe Sharpening-Stress Freezing-Three Dimensional Analysis from Models Slicing –Axisymmetric Stress –Torsion Problem Plane and Spherical Waves –Coherence.

Unit - V	**Morie Methods**	**9+3**

Morie Methods: Moire Fringes Produced by Mechanical Interference –Geometrical Approach – Displacement Field Approach to Moire Fringe Analysis-Out of Plane Displacement Measurements-Out of Plane Slope Measurements-Applications and Advantages-Holography and Thermography.

Lecture:45, Tutorial:15, Total: 60

REFERENCES:

1. Srinath L.S., Raghavan M.R., Lingaiah K., Gargesa G., Pant B., and Ramachandra K. “Experimental Stress Analysis”. 1st Edition, Tata McGraw Hill, New Delhi, 1984.
2. Dally J.W. and Riley W.F. “Experimental Stress Analysis”. 3rd Edition, McGraw-Hill, New York, 1991.
3. Sadhu Singh. “Experimental Stress Analysis”. 2nd Edition, Khanna Publishers, New Delhi , 2009.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	measure strain by different methods for various applications	Analysing (K4)
CO2	analyse the strain analysis of various mechanical systems	Analysing (K4)
CO3	identify, calibrate and recommend the coating techniques	Analysing (K4)
CO4	measure the Stress trajectories and stress separation using photo elasticity	Analysing (K4)
CO5	measure the different experiment to measure the thermo elastic stress	Analysing (K4)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	3	3	1
CO2	3	3	1
CO3	3	3	1
CO4	3	3	1
CO5	3	3	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	15	20	35	30			100
CAT2	15	20	35	30			100
CAT3	15	20	35	30			100
ESE	15	20	35	30			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE14 – INSTRUMENTATION AND MEASUREMENTS

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Applied Physics, Instrumentation and Control	**4**	**PE**	**3**	**0**	**0**	**3**

Preamble	The course deals with various measuring instruments and their characteristics suited for industry and academic research.	
Unit - I	**Introduction to Measurement System**	**9**
Introduction to Measurement System: Introduction-Definition of Instrumentation-General concepts and terminology of measurement systems-Static characteristics-Dynamic Characteristics-Types of errors and statistical analysis of errors-Calibration and Standards-Uncertainties.		
Unit - II	**Transducer Elements**	**9**
Transducer Elements: Introduction-principle-construction and design of various active and passive transducers-Design of signal conditioning circuits for various Resistive-Capacitive and Inductive transducers-photoelectric and piezoelectric transducer. Displacement, velocity and acceleration measurements- Force- Load and Torque Measurement.		
Unit - III	**Analytical Instrumentation**	**9**
Analytical Instrumentation: Measurement techniques for water quality parameters: conductivity - temperature - turbidity. Measurement techniques for chemical pollutants: chloride - sulphides - nitrates and nitrites - phosphates - fluoride - phenolic compounds. Measurement techniques for particulate matter in air. Measurement of oxides of Sulphur-oxides of nitrogen unburnt hydrocarbons- carbon- monoxide, dust mist and fog.		
Unit - IV	**Industrial Instrumentation**	**9**
Industrial Instrumentation: Temperature measurement - Introduction to temperature measurements, Thermocouple, Resistance Temperature Detector, Thermistor and its measuring circuits, Radiation pyrometers and thermal imaging. Pressure measurement - Introduction, definition and units, Mechanical, Electro-mechanical and electronic pressure measuring instruments. Low pressure measurement. Flow measurement - Introduction, definition and units, classification of flow meters, differential pressure and variable area flow meters, Positive displacement flow meters, Electro Magnetic flow meters. Hot wire anemometer, laser Doppler anemometer and measurement of mass flow rate.		
Unit - V	**Automotive and Medical Instrumentation**	**9**
Automotive and Medical Instrumentation : Engine Management System – Basic Sensor Arrangement – Types of Sensors - Throttle Angle – Temperature – Typical Coolant – Knock- Fuel Quantity-Oil Pressure – Vehicle Speed. Bioelectric Potential and Cardiovascular Measurements: Measurement of Blood Pressure using Sphygmomanometer instrument Based on Korotkoff Sound – Indirect measurement of Blood Pressure – Heart Sound Measurement: Stethoscope – Phonocardiograph – ECG.		

Lecture: 45

REFERENCES:

1. Semyon G. Rabinovich. “Measurement Errors and Uncertainties – Theory and Practice”. 3rd Edition, Springer Publication, USA, 2005.
2. John P. Bentley. “Principles of Measurement system”. 4th Edition, Pearson Education, New Delhi, 2005.
3. Ewing,G.W. “Instrumental Methods of Analysis”, 5th Edition, McGraw Hill, Singapore,1992.
4. Ernest. O.Doebelin and Dhanesh.N.Manik, Doebelin’s. “Measurement Systems”, McGraw Hill Education, 7th Edition, India, 2019.
5. A. K. Sawhney. PuneetSawney “A course in Mechanical Measurements and Instrumentation”, Dhanpat Rai & Co, 2005.
6. William B Ribbens” Understanding Automotive Electronics”,7th Edition, Elsevier, USA, 2012
7. Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer, “Biomedical Instrumentation and Measurements”, Prentice Hall of India, 2nd Edition, 2014.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	carryout characteristic analysis of instrument	Analyzing (K4)
CO2	select transducers at different stages of a measurement system and relate them to manipulation and presentation devices	Applying (K3)
CO3	analyse the water and air pollutants	Applying (K4)
CO4	plan and use pressure, flow and temperature measuring instruments in day to day and modern application	Analyzing (K4)
CO5	analyse the biomedical and Engine management devices.	Analyzing (K4)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	3	1	1
CO2	3	1	1
CO3	3	1	1
CO4	3	1	1
CO5	3	1	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	15	20	35	30			100
CAT2	15	20	35	30			100
CAT3	15	20	35	30			100
ESE	15	20	35	30			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE15 PRODUCT DESIGN AND DEVELOPMENT

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	IV	PE	3	0	0	3

Preamble:	This course provides knowledge on new product planning, concept development, industrial design and prototype development	
UNIT – I	**Development Processes and Organizations**:	**9**
Introduction to New Product and Product design- Characteristics of successful product – The challenges in product development - Product development process – adapting generic product development process- Product development process flows –product development organizations.		
UNIT – II	**Opportunity Identification and Product Planning**:	**9**
Types of opportunities- Structure of Opportunity Identification – Opportunity identification process; Product Planning Process - Four types of product development projects – Steps in Product Planning- - Identifying Customer needs.		
UNIT – III	**Product specifications and Concept development:**	**9**
Product Specifications – Target and final specifications. Concept generation: Five step method- Concept selection- Concept screening – Concept scoring – concept testing.		
UNIT – IV	**Product architecture and Industrial Design**:	**9**
Implications of the architecture – Establishing the architecture – Delayed differentiation – Platform Planning – System level design issues. Industrial Design – Assessing the Need for Industrial Design and its impact - Industrial design process and management – Assessing the quality of Industrial Design.		
UNIT – V	**Design considerations and prototyping:**	**9**
Design for environment – Design for manufacturing and assembly; Prototyping – Principles – Technologies – planning for prototypes -Robust design – process flow.		

Total: 45

REFERENCES:

1. Eppinger, S.D. and Ulrich, K.T. " Product design and development", 6th edition, McGraw-Hill Higher Education, 2016
2. Devdas Shetty, "Product Design For Engineers", Cengage Learning, 2015.
3. Maddock M. and Uriarte L., "Brand New: Solving the Innovation Paradox – How Great Brands Invent and Launch New Products, Services and Business Models", John Wiley & Sons, Inc., Hoboken, New Jersey, 2011.
4. Roozenburg, N. F., & Eekels, J., "Product design: fundamentals and methods", John Wiley & Sons Inc, 1995.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	infer the basic need for new product design and development process	Understanding (K2)
CO2	identify opportunities and customer needs for new product development	Applying (K3)
CO3	arrive at product specification and develop concepts for new product	Analysing (K4)
CO4	establish the overall product architecture and assess its industrial design	Analyzing (K4)
CO5	assess the design from environmental, manufacturing and assembly perspective and develop prototypes	Analyzing (K4)

Mapping of COs with POs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	1	2
CO2	3	1	2
CO3	3	1	2
CO4	3	1	2
CO5	3	1	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	30	30	30			100
CAT2	10	30	30	30			100
CAT3	10	30	30	30			100
ESE	10	30	30	30			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE16 - DESIGN OF HEAT EXCHANGERS
(*Usage of approved Heat Exchanger design data book is permitted for end semester examination*)

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Heat and Mass Transfer	**4**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course intends to build design skills in the field of heat exchangers among the Post Graduate Students of Engineering Design.	
Unit - I	**Heat Exchangers**	**9**
Heat Exchangers: Classification - Parallel Flow - Counter Flow - Cross Flow - Shell and Tube - Plate Type - Single Pass - Multi Pass - Once through Steam Generators - Analysis of Heat Exchangers – LMTD and NTU Methods.		
Unit - II	**Process Design of Heat Exchangers**	**9**
Process Design of Heat Exchangers: Heat Transfer Correlations - Overall Heat Transfer Coefficient - Effect of Baffles - Effect of Turbulence - Sizing of Finned Tube Heat Exchangers - Fouling Factors - Pressure Drop Calculations.		
Unit - III	**Mechanical Design of Shell and Tube Heat Exchangers**	**9**
Mechanical Design of Shell and Tube Heat Exchangers: Thickness Calculations - Tube Sheet Design using TEMA Formula - Flow Induced Vibration Risks including Acoustic Issue and Remedies - Tube to Tube Sheet Joint Design - Buckling of Tubes - Thermal Stresses.		
Unit - IV	**Compact Heat Exchangers and Plate Heat Exchangers**	**9**
Compact Heat Exchangers: Types – Merits and Demerits – Design of Compact heat exchangers. Plate heat exchangers: Performance Influencing Parameters - Limitations.		
Unit - V	**Condensers and Cooling Towers**	**9**
Condensers: Design -Surface Condensers - Evaporative Condensers. Cooling Towers: Design – Approach - Range - Performance Characteristics.		

Lecture: 45

REFERENCES:

1. Kuppan Thulukkanam. “Heat Exchanger Design Handbook”. 2nd Edition, CRC Press (Taylor & Francis Group), USA, 2013.
2. Ray Sinnot, Gavin Towler. “Chemical Engineering Design”. 6th Edition, Coulson & Richardson"s Chemical Engineering Series, Elsevier, UK, 2019.
3. Ramesh K. Shah, DuŠan P. Sekulic. “Fundamentals of Heat Exchanger Design”. 1st Edition, John Wiley & Sons Inc., USA, 2003.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	recognize the type of heat exchanger and also design and analyze the heat exchanger using LMTD and NTU methods	Analyzing (K4)
CO2	design a heat exchanger by considering the effects of baffles, turbulence, finned tubes, fouling and pressure drop	Evaluating (K5)
CO3	apply TEMA standards for designing shell and tube heat exchanger mechanically	Applying (K3)
CO4	classify the compact and plate heat exchangers and also design and evaluate the same	Evaluating (K5)
CO5	design and evaluate the condensers and cooling towers with appropriate procedures	Evaluating (K5)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	3	1	1
CO2	3	1	1
CO3	3	2	1
CO4	3	2	2
CO5	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	5	10	35	25	25		100
CAT2	5	10	35	25	25		100
CAT3	5	10	35	25	25		100
ESE	5	10	35	25	25		100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE17 - DESIGNING WITH NEWER MATERIALS

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisites	Engineering Materials and Metallurgy	**4**	**PE**	**3**	**0**	**0**	**3**

Preamble	The course deals with the study on structure – property relationship of non-metals, processing techniques involved in fabrication of components and related applications.	
Unit - I	**Modern Materials in Design and Plastics**	**9**
Modern Materials in Design and Plastics: Modern Materials in Design Plastics Composites and Smart Materials Polymers - Classification - Thermoplastics and Thermosetting Plastics – Structure Property Relationship- Thermoforming Processes - Compression and Transfer Molding - Injection Molding - Extrusion - Blow Molding - Calendaring - Lamination and Pultrusion - Design consideration in manufacturing of plastic components.		
Unit - II	**Rubber**	**9**
Rubber: Rubber - Additives – Applications- Stages in Raw Rubber and Latex Rubber Technology – Structure Property Relationship -Processing of Rubbers –Manufacturing Techniques - Tyres - Belts - Hoses - Foot wears - Cellular products – Cables - Manufacturing of latex based Products.		
Unit - III	**Glass**	**9**
Glass: Glass - Characteristics - Application - Glass making - Glass Forming Machines - Hollow Wares - Flat Glasses - Fiber Glass - Bulbs - Bottles - Heat Absorbing Glasses- Amber glass and their Manufacturing Methods - General Plant Layouts for Manufacture of Different Types of Glasses.		
Unit - IV	**Ceramics**	**9**
Ceramics: Ceramics - Classification - Traditional Ceramics - Structural Ceramics - Fine Ceramics - Bioceramics - Ceramic Super Conductors. Ceramic Processing Techniques - Hot Pressing - Hot Isostatic Pressing (HIP) - Sintering - Injection molding - Slip Casting - Tape casting - Gel Casting – Extrusion.		
Unit - V	**Composites**	**9**
Composites: Composites - Requirements of Reinforcement and Matrix - Manufacturing of Composites -Casting - Solid State Diffusion - Cladding – Hot Isostaic Pressing - Liquid Metal Infiltration - Liquid Phase Sintering - Preparation of Molding Compounds and Prepregs - Hand Layup Method - Autoclave Method - Filament Winding Method – Functionally Graded Materials - Features-Processing Methods - Applications		

Lecture: 45

REFERENCES:

1. Brydson J. A. and Newnes-Butterwarths. “Plastic Materials”, 8th Edition, Newnes-Butterworths, London, 2016.
2. Barsoum M.W. “Fundamentals of Ceramics”. 1st Edition, CRC Press, United States, 2002.
3. George Lubin. “Handbook of Composites”. 2nd Edition, Springer, Germany, 1982.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	demonstrate the manufacturing and design aspects of plastics	Applying (K3)
CO2	present processing properties and applications of rubber products	Applying (K3)
CO3	demonstrate processing and applications of glasses	Applying (K3)
CO4	demonstrate processing and applications of ceramics	Applying (K3)
CO5	demonstrate processing and applications of composites	Applying (K3)

Mapping of COs with POs			
COs/POs	PO1	PO2	PO3
CO1	3	1	3
CO2	3	1	3
CO3	3	1	2
CO4	3	1	3
CO5	3	2	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	40				100
CAT2	20	40	40				100
CAT3	20	40	40				100
ESE	10	45	45				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20EDE18 ADDITIVE MANUFACTURING

Programme & Branch	M.E. & Engineering Design	Sem.	Category	L	T	P	Credit
Prerequisite	Nil	IV	PE	3	0	0	3

Preamble	This course provides scientific as well as technological aspects of various additive, and formative rapid manufacturing processes. Variety of applications also be covered ranging from rapid prototyping, rapid manufacturing to mass customization.	
UNIT – I	**Introduction to Additive Manufacturing:**	**9**
Evolution, fundamental fabrication processes, CAD for RPT, product design and rapid product development - Need for time compression in product development - Conceptual design - Detail design, Prototype fundamentals - Fundamentals of RP systems – RP process chain - 3D modelling -3D solid modeling software and their role in RPT - Data format - STL files- History of RP systems - Classification of RP systems - Benefits of RPT.		
UNIT – II	**Liquid based RP systems**:	**9**
Stereo Lithography Apparatus (SLA): Principle, Photo polymers, Post processes, Process parameters, Machine details, Advantages. Solid Ground Curing (SGC): Principle, Process parameters, Process details, Machine details, Limitations. Solid Creation System (SCS): Principle, Process parameters, Process details, Machine details, Applications.		
UNIT – III	**Solid based RP systems**:	**9**
Fusion Deposition Modeling (FDM): Principle, Raw materials, BASS, Water soluble support system, Process parameters, Machine details, Advantages and limitations. Laminated Object Manufacturing (LOM): Principle, Process parameters, Process details, Advantages and limitations. Solid Deposition Manufacturing (SDM): Principle, Process parameters, Process details, Machine details, Applications.		
UNIT – IV	**Powder based RP systems**:	**9**
Selective Laser Sintering (SLS): Principle, Process parameters, Process details, Machine details, Advantages and applications. 3-Dimensional Printers (3DP): Principle, Process parameters, Process details, Machine details, Advantages and limitations. Laser Engineered Net Shaping (LENS): Principle, Process details, Advantages and applications.		
UNIT – V	**Rapid Tooling and Applications of RP:**	**9**
Direct Rapid Tooling, Indirect Rapid Tooling: Soft tooling and Hard tooling. Applications of RP in Product design, Automotive industry, and Medical field – Conversion of CT/MRI scan data - Customized implant - Case studies -Reverse engineering.		

Total : 45

REFERENCES:

1. Chua.C.K., Leong K.F. and Lim C.S., “Rapid prototyping: Principles and Applications”, World scientific, Newjersy, 2010.
2. Pham D.T. and Dimov S.S, “Rapid Manufacturing”, Springer -Verlag, London, 2011.
3. Amitabha Ghosh, “Rapid Manufacturing a brief Introduction”, Affiliated East West Press, New Delhi, 2011.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	apply the concepts of rapid prototyping in product design and development	Applying (K3)
CO2:	Select the suitable liquid based rapid prototyping system for a specific application	Applying (K3)
CO3:	select the suitable solid based rapid prototyping system for a specific application	Applying (K3)
CO4:	select the suitable powder based rapid prototyping system for a specific application	Applying (K3)
CO5:	apply the concepts of rapid prototyping in product design and development	Applying (K3)

Mapping of COs with POs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	2	2
CO2	3	2	2
CO3	3	2	2
CO4	3	2	2
CO5	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20				100
CAT2	30	40	30				100
CAT3	30	45	25				100
ESE	30	40	30				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20GET13 - INNOVATION, ENTREPRENEURSHIP AND VENTURE DEVELOPMENT

Programme & Branch	All ME/MTech, MCA Programmes	Sem.	Category	L	T	P	Credit
Prerequisite	Nil	4	PE	3	0	0	3

Preamble	This course will direct the students on how to employ their innovations towards a successful entrepreneurial venture development.	
UNIT – I	**Innovation and Entrepreneurship:**	**9**
Creativity and Innovation – Types of innovation – challenges in innovation- steps in innovation management- Meaning and concept of entrepreneurship - Role of Entrepreneurship in Economic Development - Factors affecting Entrepreneurship – Entrepreneurship vs Intrapreneurship		
UNIT – II	**Design Thinking and Product Design:**	**9**
Design Thinking and Entrepreneurship – Design Thinking Stages: Empathize – Define – Ideate – Prototype – Test. Design thinking tools: Analogies – Brainstorming – Mind mapping. Techniques and tools for concept generation, concept evaluation – Product architecture –Minimum Viable Product (MVP)- Product prototyping – tools and techniques– overview of processes and materials – evaluation tools and techniques for user-product interaction		
UNIT – III	**Business Model Canvas (BMC) and Business Plan Preparation:**	**9**
Lean Canvas and BMC - difference and building blocks- BMC: Patterns – Design – Strategy – Process–Business model failures: Reasons and remedies. Objectives of a Business Plan - Business Planning Process and Preparation		
UNIT – IV	**IPR and Commercialization:**	**9**
Need for Intellectual Property- Basic concepts - Different Types of IPs: Copy Rights, Trademarks, Patents, Geographical Indications, Trade Secrets and Industrial Design– Patent Licensing - Technology Commercialization – Innovation Marketing		
UNIT – V	**Venture Planning and Means of Finance:**	**9**
Startup Stages - Forms of Business Ownership - Sources of Finance – Idea Grant – Seed Fund – Angel & Venture Fund – Institutional Support to Entrepreneurs – Bank and Institutional Finance to Entrepreneurs		

Total : 45

REFERENCES:

1.	Gordon E. & Natarajan K., "Entrepreneurship Development", 6th Edition, Himalaya Publishing House, Mumbai, 2017.
2.	Sangeeta Sharma, "Entrepreneurship Development", 1st Edition, PHI Learning Pvt. Ltd., New Delhi, 2017.
3.	Charantimath Poornima M., "Entrepreneurship Development and Small Business Enterprises", 3rd Edition, Pearson Education, Noida, 2018.
4.	Robert D. Hisrich, Michael P. Peters & Dean A. Shepherd, "Entrepreneurship", 10th Edition, McGraw Hill, Noida, 2018.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	understand the relationship between innovation and entrepreneurship	Understanding (K2)
CO2:	understand and employ design thinking process during product design and development	Analysing (K4)
CO3:	develop suitable business models as per the requirement of the customers	Analysing (K4)
CO4:	Practice the procedures for protection of their ideas' IPR	Applying (K3)
CO5:	understand and plan for suitable type of venture and modes of finances	Applying (K3)

Mapping of COs with POs and PSOs

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

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	40	40	20				100
CAT2	30	40	30				100
CAT3	30	45	25				100
ESE	30	40	30				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**