Faculty of Engineering

Department of
Mechanical and Automobile Engineering

Syllabus for

M.Tech- Machine Design

(Applicable for 2019-20)

CHRIST (Deemed to be University) University, Bengaluru,

Karnataka, India

www.christuniversity.in

Syllabus for M.Tech- Machine Design 2019-20 prepared by the Department of Mechanical and Automobile Engineering, Faculty of Engineering and approved by the Academic Council, CHRIST(Deemed to be University), Bengaluru, India.

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1. INTRODUCTION

CHRIST- Deemed to be University blossomed out of the educational vision of the Carmelites of Mary Immaculate (CMI) congregation founded by St Kuriakose Elias Chavara. He was a visionary, an educationist and a social reformer of the nineteenth century who founded the Congregation in 1831 in South India.

CHRIST- Deemed to be University was established in July 1969 as Christ College. It was the first institution in Karnataka to be accredited by the National Assessment and Accreditation Council (NAAC). University Grants Commission (UGC) conferred Autonomy to the institution in 2004. It became the first College in South India to be reaccredited with A+ by NAAC in 2005. UGC identified it as an Institution with Potential for Excellence in 2006.Under Section 3 of the UGC Act, 1956, Ministry of Human Resources Development of the Union Government of India, vide Notification No. F. 9-34/2007-U.3 (A), declared Christ College as a Deemed to be University, in the name and style of CHRIST- Deemed to be University in July 2008. The University was accredited with 'A' Grade by NAAC in 2016.

CHRIST- Deemed to be University offers 46 Bachelor, 47 Master, 16 MPhil and 17 PhD Programs in Humanities, Social Sciences, Sciences, Commerce and Management, Education, Law and Engineering. The University which celebrates diversity has students from all the states of India and 58 countries across the globe.

CHRIST- Deemed to be University rooted in Gospel values, is committed to provide holistic education through the development of intellectual competence, personal skills, inter-personal skills and societal skills. The University welcomes to its fold students from all over the country and the world in an environment of religious harmony and secularism.

VISION

"EXCELLENCE AND SERVICE"

- CHRIST- Deemed to be University, a premier educational institution, is an academic fraternity of individuals dedicated to the motto of excellence and service. We strive to reach out to the star of perfection through an earnest academic pursuit for excellence and our efforts blossom into 'service' through our creative and empathetic involvement in the society to transform it.

- Education prepares one to face the challenges of life by bringing out the best in him/her. If this is well accepted, education should be relevant to the needs of the time and address the problems of the day. Being inspired by Blessed Kuriakose Elias Chavara, the founder of Carmelites of Mary Immaculate and the pioneer in innovative education, CHRIST-Deemed to be University was proactive to define and redefine its mission and strategies reading the signs of the time.

MISSION STATEMENT

"CHRIST- Deemed to be University is a nurturing ground for an individual's holistic development to make effective contribution to the society in a dynamic environment."

CORE VALUES

The values which guide us at CHRIST- Deemed to be University are:

Faith in God
Moral Uprightness
Love of Fellow Beings
Social Responsibility
Pursuit of Excellence

VISION OF DEPARTMENT

Develop Mechanical and Automobile engineering graduates to be successful in chosen professional career with innovative academic processes for the overall development

MISSION STATEMENT

1. To provide excellent academic ambience in curricular co-curricular and extracurricular initiatives, facilities and teaching-learning experience.
2. To nurture holistic development of individuals.
3. To imbibe professional ethics driven by a sense of moral responsibility committed to the service to society

PROGRAM EDUCATIONAL OBJECTIVES (PEO'S):

PEO 1: Fundamental Knowledge
Demonstrate fundamental knowledge in basic science and Mechanical Engineering, with critical and solution-oriented thinking for attaining professional excellence.

PEO 2: Industry Integration
Facilitate with industrial exposure within and outside the curriculum to integrate theoretical concepts with the latest industry practices.

PEO 3: Working in Team
Exhibit professional competence towards real-time problem solving by cross–disciplinary understanding and effective team-building skills.

PEO 4: Social Responsibility
Develop professionals with ethics, driven by a sense of social responsibility and service towards their peers, employers.

PROGRAM SPECIFIC OOTCOMES (PSO'S):

PSO 1: Design, Analyze and Evaluate Mechanical components through domain specific knowledge, experimentation and software tools.

PSO 2: Identify, Analyze and demonstrate the attributes of modern machining processes, tools and materials for manufacturing of mechanical systems and components.

PSO 3: Investigate thermal systems by modelling and analysis through modern simulation techniques and tools.

PSO 4: Analyze the problems related to modern industries in the area of process planning, cost estimation and quality assurance

GRADUATE ATTRIBUTES:

1. Engineering Knowledge

2. Problem analysis

3. Design/development of solutions

4. Conduct investigations of complex problems

5. Modern tool usage

6. The Engineer and society

7. Environment and sustainability

8. Ethics

9. Individual and team work

10. Communication

11. Project management and finance

12. Life-long learning

PROGRAM OUTCOMES (PO'S)

At the end of graduation, the graduates of the Mechanical and Automobile Engineering Program are able to

1. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

2. PROGRAM OFFERED

- **Undergraduate Programmes** (B.Tech, 8 Semester Program)
    - Bachelor of Technology in Automobile Engineering (AE)
    - Bachelor of Technology in Civil Engineering(CIVIL)
    - Bachelor of Technology in Computer Science and Engineering (CSE)
    - Bachelor of Technology in Electronics and Communication Engineering (ECE)
    - Bachelor of Technology in Electrical and Electronics Engineering (EEE)
    - Bachelor of Technology in Information Technology (IT)

- Bachelor of Technology in Mechanical Engineering (ME)

- **Postgraduate Programmes (M. Tech, 4 Semester Program)**
  - Master of Technology in Computer Science and Engineering (CSE)
  - Master of Technology in Communication Systems(ECE)
  - Master of Technology in Information Technology(IT)
  - Master of Technology in Machine Design(MD)
  - Master of Technology in Power Systems(PS)
  - Master of Technology in Structural Engineering(SE)
- **Doctoral Programmes (Ph.D.) (Doctor of Philosophy)**
  - Doctor of Philosophy (Ph.D.) in Computer Science and Engineering
  - Doctor of Philosophy (Ph.D.) in Electronics and Communication Engineering
  - Doctor of Philosophy (Ph.D.) in Civil Engineering
  - Doctor of Philosophy (Ph.D.) in Electrical and Electronics Engineering
  - Doctor of Philosophy (Ph.D.) in Mechanical Engineering
  - Doctor of Philosophy (Ph.D.) in Information Technology

3. ELIGIBLITY CRITERIA

❖ **For Undergraduate Programmes**

A pass in PUC (10+2) or equivalent with 50% marks in aggregate with Mathematics, Physics and Chemistry is the minimum eligibility for admission.

Lateral Entry:

Candidates who have successfully completed 3 year diploma in Engineering are eligible to apply for lateral entry into:

- Automobile Engineering (AE)
- B.Tech Civil Engineering (CE)
- B.Tech Mechanical Engineering (ME)
- B.Tech Computer Science and Engineering (CSE)

- B.Tech Electronics & Communication Engineering (ECE)
- B.Tech Electrical and Electronics Engineering (EEE)
- B.Tech Information Technology (IT)

Candidates will be admitted to second year of the programme only after appearing the Christ deemed to be University selection process for engineering programmes.

❖ **For Postgraduate Programmes**:

- For Master of Technology in Computer Science and Engineering
  - A Pass in B.Tech/B.E or M.Sc with 55% aggregate.
- For Master of Technology in Communication Systems
  - A Pass in B.Tech/B.E or M.Sc in Electronics and VLSI Design with 55% aggregate.
- For Master of Technology in Civil Engineering
  - A Pass in BE/B.Tech or M.Sc in Civil and VLSI Design with 55% aggregate.
- For Master of Technology in Mechanical Engineering
  - A Pass in BE/B.Tech with 55% aggregate.

For Doctoral Programmes (Ph.D.):

- A pass with 55% marks in post graduation and equivalent in the relevant subject from any recognized university.
- A research proposal (Maximum 1500 words) has to be submitted along with the application.

5. SELECTION PROCESS

1) Candidates can process the admission based on the Undergraduate Entrance Test and Ranking by COMEDK.

OR

2) Christ Selection Process as given below:

Process	Particulars	Date	Venue/Centre

Entrance Test	Christ Entrance test for each candidate	As per the E-Admit Card	As per the E- Admit Card
Personal Interview	Personal interview for 15 minutes for each candidate by an expert panel	As per the E-Admit Card	As per the E- Admit Card
Academic Performance	Assessment of past performance in Class 10, Class 11/12 during the Personal Interview	As per the E-Admit Card	As per the E- Admit Card

6. ADMISSION PROCESS

Candidates will be intimated about the Selection status (Selected/Wait Listed/Not Selected) through the University Notice Board/on the "Application Status" link on University website. The Selection results will be declared within 24 hours of Personal Interview session.

The selected candidates must process admission at **Office of Admissions, Central Block, Christ deemed to be University within 3 working days of declaration of Selection Process results/as per the stipulated date and time mentioned by Office of Admissions.**

Selected candidates should collect the Fee Challan from the Office of Admissions and remit the Annual fee at the South Indian Bank, CHRIST- Deemed to be University Branch. The Offer of Admission will stand cancelled, if failing to remit the fee within the stipulated date and time.

Admission will not be processed without the presence of the candidate and the mandatory original documents mentioned below;

1. The Offer of Admission Card (E-Admission Card/Mail)

2. Class 10 Marks Statement

3. Class 11 Marks Statement, if Candidate is pursuing class 12 and appearing for final examination during March-April Month

4. Class 12 Marks Statement, if candidate has appeared and passed the Class 12 examination

The University ID card is a smart card, which is both an ID card as well as a South Indian Bank ATM card with a chip containing the student personal details. All transactions within the University campus after commencement of classes, including fees payment will be processed only through this card. It is also an access card for Library and other restricted places. Candidates are advised to collect the South Indian Bank account opening form along with fees challan and process it at the Bank branch within the University premises.

Candidates who fall under International student category (ISC), if selected, should register with the Foreigner Regional Registration Officer (FRRO/FRO) of the Local Police in Bangalore, India within 14 working days from the date of admission or arriving in Bangalore.

All International student category (ISC) candidates if studied in India should obtain an NOC from the previous qualifying institution.

7. GENERAL RULES

- There is a grading scheme for each paper and for all the courses.
- All marks will indicate the marks, percentage obtained, grade and grade point average.
- The grade point average will be calculated as follows: for each subject, multiply the grade point with the number of credits; divide the sum of product by the total number of credits.
- The CGPA [Cumulative GPA] is calculated by adding the total number of earned points [GP x Cr] for all semesters and dividing by the total number of credit hours for all semesters.

$$\mathbf{GPA} = \frac{\sum[\mathbf{GPA \times Cr}]}{\sum \mathbf{Cr}}$$

8. GRADING SCHEME FOR EACH PAPER: Undergraduate Courses

Percentage	Grade	Grade Point	Interpretation	Class
80 and above	A	4.0	Outstanding	First Class with Distinction
73-79	A-	3.67	Excellent	First Class
66-72	B+	3.33	Very Good	
60-65	B	3.0	Good	
55-59	B-	2.67	Average	Second Class
50-54	C+	2.33	Satisfactory	
45-49	C	2.00	Pass	Pass Class
40-44	D	1.0	Pass	
39 and below	F	0	Fails	Fail

9. GRADING SCHEME FOR EACH PAPER: Postgraduate Courses

Percentage	Grade	Grade Point	Interpretation	Class
80 and above	A+	4.0	Excellent	First Class with Distinction
70-79	A	3.5	Very Good	
65-69	B+	3.0	Good	First Class
60-64	B	2.5	Above Average	
55-59	C+	2.0	Average	Second Class
50-54	C	1.5	Satisfactory	
40-49	C-	1.0	Exempted if aggregate is more than 50%	Pass Class
39 and below	F	0	Fails	Fail

We believe that the student opportunities and experiences should lead to an appreciation of the holistic development of individual. We also try to pass to our students our passion for what we do, and to have the students comprehend that we also desire to continue to learn.

10. COURSE OVERVIEW

The Mechanical Engineering Department has well established facilities for carrying out the activities of basic mechanical engineering. It is equipped to meet the present day technological advances and to meet the industrial requirements matching with the global standards. The department has the state of the art laboratories to meet the demand for practical knowledge by the present day industrial applications.

One of the oldest, largest and diversified of all engineering disciplines is mechanical engineering. Rated as one of the most "evergreen" branches, students of mechanical engineering can look forward to an exciting and robust study in the field of Thermal, Design, Materials and Manufacturing Engineering. A Holistic blend of both theory and practicals ensure that students are ready to face the challenges of the industrial world.

11. COURSE OBJECTIVE

The goal of our program is to prepare our graduates for successful professional practice and advanced studies by providing a broad education in mechanical engineering and by offering

the opportunity to deepen their technical understanding in a particular concentration area of related technical electives. Following are the course objectives.

1. Join a technically sophisticated workforce as successful, practicing engineers in a wide range of mechanical engineering fields.
2. Continuously improve and expand their technical and professional skills through formal means as well as through informal self-study.
3. Pursue advanced degrees in engineering, business, or other professional fields.
4. Advance themselves professionally and personally by accepting responsibilities and pursuing leadership roles

12. TEACHING PEDAGOGY

Our teaching methodology ensures that students are being exposed to a holistic education experience in an active and dynamic learning environment, giving them the opportunity to identify and realize their potential, and to achieve excellence. In order to realize the objectives, a methodology based on the combination of the following will be adopted:

1. Team/Class room teaching.
2. PowerPoint presentations and handouts.
3. Simulated situations and role-plays.
4. Video films on actual situations.
5. Assignments.
6. Case Studies.
7. Exercises are solved hands on.
8. Seminars.
9. Industry / Field visits.
10. Information and Communication Technology.
11. Project work.
12. Learning Management System.

13. DETAILS OF CIA (Continuous Internal Assessment):

Assessment is based on the performance of the student throughout the semester.

Assessment of each paper

- Continuous Internal Assessment (CIA) for Theory papers: 50% (50 marks out of 100 marks)
- End Semester Examination(ESE) : 50% (50 marks out of 100 marks)

Components of the CIA

CIA I : Assignments/Open book test/Seminar	: 10 marks
CIA II : Mid Semester Examination (Theory)	: 25 marks
CIA III : Quizzes/Seminar/Case Studies/Project Work	: 10 marks
Attendance	: 05 marks
Total	**: 50 marks**

For subjects having practical as part of the subject

End semester practical examination	: 25 marks
Records	: 05 marks
Mid semester examination	: 10 marks
Class work	: 10 marks
Total	**: 50 marks**

14. ASSESSMENT RULES

- **Assessment of Project Work(Phase I)**
  - Continuous Internal Assessment:100 Marks
    - Presentation assessed by Panel Members
    - Assessment by the Guide
    - Project Progress Reports

- **Assessment of Project Work(Phase II) and Dissertation**
  - Continuous Internal Assessment:200 Marks
    - Presentation assessed by Panel Members
    - Assessment by the Guide
    - Project Progress Reports
    - Paper presentation in National/International conference or in Journal publications or at least acceptance letter is mandatory
  - End Semester Examination:100 Marks
    - Viva Voce
    - Demonstration
    - Project Report
  - Dissertation (Exclusive assessment of Project Report): 100 Marks
    - Internal Review : 50 Marks
    - External Review : 50 Marks

- **Assessment of Internship**

30 Internship days at Industry/Research Laboratories is mandatory and a report should be submitted with certificate before IV semester.

15. QUESTION PAPER PATTERN:

End Semester Examination (ESE):

Theory Papers:

The ESE is conducted for 100 marks of 3 hours duration.

The syllabus for the theory papers is divided into FIVE units and each unit carries equal weightage in terms of marks distribution.

Question paper pattern is as follows.

Two full questions with either or choice, will be drawn from each unit. Each question carries 20 marks. There could be a maximum of three sub divisions in a question. The emphasis on the questions is broadly based on the following criteria:

50 % - To test the objectiveness of the concept

30 % - To test the analytical skill of the concept

20 % - To test the application skill of the concept

Laboratory / Practical Papers:

The ESE is conducted for 50 marks of 3 hours duration. Writing, Execution and Viva – voce will carry weightage of 20, 20 and 10 respectively.

Mid Semester Examination (MSE):

Theory Papers:

- The MSE is conducted for 50 marks of 2 hours duration.
- Question paper pattern; Five out of Six questions have to be answered. Each question carries 10 marks.

Laboratory / Practical Papers:

The MSE is conducted for 50 marks of 2 hours duration. Writing, Execution and Viva – voce will carry weightage of 20, 20 and 10 respectively.

Holistic Education:

End Semester Examination	25 Marks
Participation	25 Marks
Total	**50 Marks**

16. COURSE STRUCTURE:

I Semester								
Sl.No	**Course Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**Hrs/ Week**	**Credits**
1	Core 1	MTME131	Experimental Stress Analysis	3	0	0	3	3
2	Core 2	MTME132	Theory of Applied Stress	3	0	0	3	3
3	Program Elective 1	MTME133E	1. Advanced Engineering Material 2. Mathematical Methods in Engineering 3. Computer Aided Design	3	0	0	3	3
4	Program Elective 2	MTME134E	1. Advanced Design of Mechanical System 2.Robotics 3.Optimization Techniques in Design	3	0	0	3	3
5	Core Lab 1	MTME151	Advanced CAD Laboratory	0	0	4	4	2
6	Core Lab 2	MTME152	Simulation Laboratory	0	0	4	4	2
7	MLC	MTME135	Research Methodology and IPR	2	0	0	2	2
8	Audit 1	Audit	Audit-I	2	0	0	2	0
9		HE171	Holistic Education - I	1	0	0	1	1
			Total	**17**	**0**	**8**	**19**	**19**

II Semester								
Sl.No	**Course Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**Hrs/ Week**	**Credits**
1	Core 3	MTME231	Advanced Finite Element method	3	0	0	3	3
2	Core 4	MTME232	Advanced Theory of Vibrations	3	0	0	3	3
4	Program Elective 3	MTME233E	1.Tribology in Bearing Design 2.Condition Based Monitoring 3.Theory of Plates and shells	3	0	0	3	3
5	Program Elective 4	MTME234E	1.Design for Manufacturing 2.Analysis and Synthesis of Mechanism 3.Multi body Dynamics	3	0	0	3	3
6	Core Lab 3	MTME251	Advanced Design Laboratory	0	0	4	4	2
7	Core Lab 4	MTME252	Analysis Laboratory	0	0	4	4	2
8	Core	MTME271	Mini Project	0	0	4	4	2
9	Audit 2	Audit	Audit-II	2	0	0	2	0
10		HE271	Holistic Education - II	1	0	0	1	1
			Total	**15**	**0**	**12**	**27**	**19**

III Semester								
Sl.No	**Course Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**Hrs/ Week**	**Credits**
1	Program Elective-3	MTME331E	1. Design for Manufacture 2. Rotor Dynamics 3. Robust Design 4. Research Methodology	3	0	0	3	3
2	Program Elective-4	MTME332E	1.Advanced Theory of 2.Vibration 3.Optimum Design Vehicle Dynamics	3	0	0	3	3
3	Program Elective-5	MTME333E	1.Tribology and Bearing Design 2.Theory of Plates and Shells 3.Advanced Mechanisms Design and Simulation	3	0	0	3	3
4	Project	MTME371	Project Work (Phase-I)	0	0	3	18	3
5		MTME373	Internship (Industry/Research Lab)	0	0	4	-	2
6		MTCY01	Cyber Security	2	0	0	2	2
			Total	**09**	**0**	**11**	**29**	**16**

IV Semester								
Sl.No	**Course Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**Hrs/ Week**	**Credits**
1	Dissertation	MTME471	Dissertation Phase-II	0	0	32	32	9
			Total	**0**	**0**	**32**	**32**	**9**

Audit Course 1 and 2

1. English for Research Paper writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality development through Life Enlightenment Skills

17.DETAILED SYLLABUS

Course Name: EXPERIMENTAL STRESS ANALYSIS					
Course Code : MTME131					
	L	**T**	**P**	Category	**PCC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives:

- Describe variety of strain gauges, mounting techniques and strain gauge circuits.
- Understand the fundamental concepts of photo elasticity and experimental techniques.
- Explain the two and three dimensional photo elasticity concept on the practical problems.
- Explain different types of coatings, test strain data using brittle coating and Birefringent coating.
- Understand the Moire fringe method, analysis and its applications.

Prerequisites: Strength of Materials , Mechanics of Materials and Mechatronics

Units	**Teaching Hours**
Unit-1	
ELECTRICAL RESISTANCE STRAIN GAUGES: Strain sensitivity of gage metals, Gage construction, Gage sensitivity and gage factor, Performance characteristics, Environmental effects Strain, gage circuits, Potentiometer, Wheat Stone's bridges, Constant current circuits. **STRAIN ANALYSIS METHODS:** Two element and three element, rectangular and delta rosettes, Correction for transverse strains effects, stress gage - plane shear gage, Stress intensity factor gage.	10
Unit-2	
PHOTOELASTICITY: Nature of light, - wave theory of light,- optical interference - Polariscopes stress optic law - effect of stressed model in plane and circuclar Polariscopes, Isoclinics Isochromatics fringe order determination - Fringe multiplication techniques - Calibration Photoelastic model materials. **TWO DIMENSIONAL PHOTOELASTICITY STRESS ANALYSIS:** Separation methods shear difference method, Analytical separation methods, Model to prototype scaling.	08
Unit-3	
THREE DIMENSIONAL PHOTOELASTICITY : Stress freezing method, General slice, Effective stresses, Stresses separation, Shear deference method, Oblique incidence method Secondary principals stresses, Scattered light photoelasticity, Principals, Polariscope and stress data analyses.	09

Unit-4	
COATING METHODS a) Photoelastic Coating Method: Birefringence coating techniques Sensitivity Reinforcing and thickness effects - data reduction - Stress separation techniques Photoelastic strain gauges b) Brittle Coatings Method: Brittle coating technique Principles data analysis - coating materials, Coating techniques.	09
Unit-5	
MOIRE TECHNIQUE: Geometrical approach, Displacement approach-sensitivity of Moire data data reduction, In plane and out plane Moire methods, Moire photography, Moire grid production. **HOLOGRAPHY:** Introduction, Equation for plane waves and spherical waves, Intensity, Coherence, Spherical radiator as an object (record process), Hurter, Driffeld curves, Reconstruction process, Holograpic interferometry, Real-time. and double exposure methods, Displacement measurement, Isopachics.	09
Self Study : Nil	
Site/Industrial Visits : Nil	
Course outcomes: CO1: To be able to describe the Sensitivity & the construction of strain gauges. {L1,L2,L3}{PO1,2,3,4,7} CO2: To elucidate the isoclinics & Fringe multiplication techniques. {L1,L2,L3}{PO1,2,3,4,5} CO3: To be able to explain the stress separation methods of 3D Photoelasticity. {L1,L2,L3}{PO1,2,3,4,5} CO4: To describe the Birefringence coating techniques. {L1,L2,L3,L4}{PO1,2,3,7,9} CO5: To be able to describe the Moire's Techniques. {L1,L2,L3}{PO1,2,3,4,5,6,7}	
Text Books: T1.Dally and Riley, "Experimental Stress Analysis", McGraw Hill, 3rd revised Edition, 1991. T2.Sadhu Singh, "Experimental Stress Analysis", Khanna publisher, 4th revised Edition, 2009. T3.Srinath L.S, "Experimental stress Analysis", Tata Mc Graw Hill, 1984.	
Reference Books: R1. M.M.Frocht, "Photoelasticity, Vol I and Vol II", John Wiley & sons, 4th Revised Edition, 2003. R2. Perry and Lissner, "Strain Gauge Primer", Mc Graw Hill, 2nd Revised Edition, 1962. R3.Kuske, Albrecht & Robertson, "Photo Elastic Stress Analysis", John Wiley & Sons, 4th Revised Edition, 2003. R4.Dave and Adam, "Motion Measurement and Stress Analysis", Merrill; First Edition, 1964	
Online Resources: W1. https://apm.iitm.ac.in/smlab/kramesh/book_5.htm W2.http://www.ifsc.usp.br/~lavfis/images/BDApostilas/ApEfFotoelastico/photoelasticity.pdf. W3. http://textofvideo.nptel.ac.in/112106068/lec24.pdf. W4. http://textofvideo.nptel.ac.in/112106247/lec23.pdf W5. https://apps.dtic.mil/dtic/tr/fulltext/u2/a255686.pdf W6. https://depts.washington.edu/mictech/optics/me557/moire_a.pdf	

Course Name: THEORY OF APPLIED STRESS					
Course Code : MTME132					
	L	**T**	**P**	Category	**PCC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives:

- To obtain the stress strain relation for engineering materials.
- To know Yield criteria for ductile metal.
- To understand the plastic stress-strain relations.
- To learn Upper and lower bound theorems and corollaries.
- To solve problems of tension compression, torsion and combined loading.

Prerequisites: Mechanics of Materials, Design of Machine Elements, Finite Element Methods

Units	**Teaching Hours**
Unit-1	
INTRODUCTION STRESS: Definition and Notation for forces and stresses. Components of stresses, equations of Equilibrium, Specification of stress at a point. Principal stresses and Mohr's diagram in three dimensions. Boundary conditions. INTRODUCTION TO STRAIN: Deformation, Strain Displacement relations, Strain components, The state of strain at a point, Principal strain, Strain transformation, Compatibility equations, Cubical dilatation.	09
Unit-2	
STRESS-STRAIN RELATIONS AND THE GENERAL EQUATIONS OF ELASTICITY: Generalized Hooke's law in terms of engineering constants. Formulation of. elasticity Problems. Existence and uniqueness of solution, Saint -Venant's principle, Principle of super position and reciprocal theorem. Idealised stress-strain diagrams for different material models, Engineering and natural strains, Mathematical relationships between true stress and true strains,	09
Unit-3	
TWO DIMENSIONAL PROBLEMS IN CARTESIAN CO-ORDINATES: Airy's stress function, investigation for simple beam problems. Bending of a narrow cantilever beam under end load, simply supported beam with uniform load, Use of Fourier series to solve two dimensional problems. TWO DIMENSIONAL PROBLEMS IN POLAR CO-ORDINATES: General equations, stress distribution symmetrical about an axis, Pure bending of curved bar, Strain components in polar co-ordinates, Rotating disk and cylinder, Concentrated force on semi-infinite plane, Stress concentration around a circular hole in an infinite plate	09

Unit-4	
Yield criteria for ductile metal, Von Mises, Tresca, Yield surface for Isotropic Plastic materials, Stress space, Experimental verification of Yield criteria, Yield criteria for an anisotropic material. Stress - Strain Relations, Plastic stress-strain relations, PrandtlRoeuss Saint Venant, Levy - Von Mises, Experimental verification of the Prandtl-Rouss equation, Yield locus, Symmetry convexity, Normality rule., Upper and lower bound theorems and corollaries.	09
Unit-5	
Application to problems: Uniaxial tension and compression, bending of beams, Torsion of rods and tubes, Simple forms of indentation problems using upper bounds. Problems of metal forming I: Extrusion, and Drawing. Problems of metal forming II: Rolling and Forging. Slip line theory, Introduction, Basic equations for incompressible two-dimensional flows, continuity equations, Stresses in conditions of plain strain convention for slip-lines, Geometry of slip lines, Properties of slip lines.	09
Self-study : Nil	
Site/Industrial Visits : Nil	
Course outcomes: CO1: To Understand the concepts of stress and strain. {L1, L2} {PO1, PO2} CO2: To demonstrate Idealized stress-strain diagrams for different material models. {L1, L2} {PO1, PO2, PO3} CO3: To be able to formulate general stress-strain equations in cartesian and polar coordinate system. {L2, L3, L4} {PO1, PO2, PO3, PO4} CO4: To understand the concept of yield criterion. {L1, L2} {PO1, PO2, PO3} CO5: To be able to solve Problems of uniaxial tension, compression, bending of beams and torsion. {L2, L3, L5} {PO1, PO2 PO3, PO4}	
Text Books: T1. Timoshenko and Goodier, "Theory of Elasticity", McGraw Hill, 1982. T2. R.A.C..Slater, "Engineering Plasticity - Theory and Application to Metal Forming Process", McMillan Press Ltd.2016. T3. Sadhu Singh," Theory of Elasticity", Khanna publishers, Delhi, 2003. T4. Sadhu Singh, "Theory of Plasticity and Metal forming Process", 8th Edition, Khanna Publishers, Delhi, 2015.	
Reference Books: R1. L S Srinath, "Advanced Mechanics of Solids ", Tata Mcgraw-Hill, 2008. R2. Phillips, Durelli and Tsao, " Introduction to the Theoretical and Experimental Analysis of Stress and Strain ", McGraw-Hill, 1st Edition,1958. R3. W. & Mellor and P.B. Johnson, "Plasticity for Mechanical Engineers", 1st Edition, D.Van Nostrand Company Inc., 1962. R4. Oscar Hoffman and George Sachs, "Introduction to the Theory of Plasticity for Engineers", 1st Edition, Literary Licensing, LLC., 2012. R5. Chakraborty,"Theory of plasticity" 3rd Edition, Oxford: Elsevier Butterworth-Heinemann, 2007.	
Online Resources: W1. https://nptel.ac.in/downloads/112105125/ W2. https://nptel.ac.in/syllabus/112106137/ W3. https://onlinecourses.nptel.ac.in/noc18_ce18/preview	

Course Name: Advanced Engineering Materials					
Course Code : MTME133E1					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives:

- Enable Students to recognize the conventional methods for processing of advanced composite materials
- Enable Students to distinguish between the available reinforcing fibre performance
- Enable Students to recognize the conventional thermo set and thermoplastic polymers
- Enable Students to describe the mechanical properties of a collimated fiber, polymer composite as an anisotropic medium Introduce test methods required to characterize anisotropic medium

Units	**Teaching Hours**
Unit-1	
Introduction, Atomic Structure, Interatomic Bonding and Structure of Crystalline Solids: Historical perspective of Materials Science. Why study properties of materials? Classification of materials. Advanced Materials, Future materials and modern materials, Atomicstructure. Atomic bonding in solids, Crystal structures, Crystalline and noncrystalline materials. Miller indices. Anisotropic elasticity. Elastic behaviour of composites. Structure and properties of polymers. Structure and properties of ceramics.	9
Unit-2	
Imperfections in Solids and Mechanical Properties of Metals, Diffusion, Dislocations and Strengthening Mechanisms: Point defects. Theoretical yield point. Line defects and dislocations. Interfacial defects. Bulk or volume defects. Atomic vibrations; Elastic deformation. Plastic deformation. Interpretation of tensile stress-strain curves Yielding under multiaxial stress. Yield criteria and macroscopic aspects of plastic deformation. Property variability and design factors, Diffusion mechanisms. Steady and non-steady state diffusion. Factors that influence diffusion. Non-equilibrium transformation and microstructure, Dislocation and plastic deformation. Mechanisms of strengthening in metals. Recovery, recrystallization and grain growth. Strengthening by second phase particles. Optimum distribution of particles. Lattice resistance to dislocation motion.	9
Unit-3	
Phase Diagrams Equilibrium phase diagrams. Particle strengthening by precipitation. Precipitation reactions. Kinetics of nucleation and growth. The iron-carbon system. Phase transformations. Transformation rate effects and TTT diagrams. Microstructure and property changes in ironT carbon system	9

Unit-4	
Failure: Fracture. Ductile and brittle fracture. Fracture mechanics. Impact fracture. Ductile brittle transition. Fatigue. Crack initiation and propagation. Crack propagation rate. Creep. Generalized creep behaviour. Stress and temperature effects	9
Unit-5	
Applications and Processing of Metals and Alloys, Polymers, Ceramics, and composites: Types of metals and alloys. Fabrication of metals. Thermal processing of metals. Heat treatment. Precipitation hardening. Types and applications of ceramics. Fabrication and processing of ceramics, Mechanicalbehaviour of polymers. Mechanisms of deformation and strengthening of polymers. Crystallization, melting and glass transition. Polymer types. Polymer synthesis and processing, Particle reinforced composites. Fibre reinforced composites. Structural composites	9
Self-study : Nil	
Site/Industrial Visits : Nil	
Course outcomes: **CO1.** Demonstarte an understanding of mechanics, physical and chemical properties of materials including metals, ceramics, polymers and composites(L1,3,4) (PO1,2) **CO2.** Understand existence of imperfections and their effects on mechanical properties of materials and cause of failure (L1,3,4) (PO1,2) **CO3.** Demonstrate understanding of phase diagrams and their use in predicting phase transformation and microstructure (L1,3,4) (PO1,2,3) **CO4**. Understand and predict various types of failures using concept of fracture mechanics, creep and effect of impact (L1,3,4) (PO1,2) **CO5**. Know Electrical, Thermal, Optical and Magnetic Properties of metals, ceramics, polymers and composites (L1,2,3) (PO1,2,4)	
Text Books: **T1**. Materials Science and Engineering, William D. Callister, Jr, John Wiley & sons, 07	
Reference Books: **R1**. Modern Physical Metallurgy and Material Engineering, Science, Process, application, Smallman R.E., Bishop R J, Butterworth Heinemann, Sixth Ed., 1999.	

Course Name: Mathematical Methods in Engineering					
Course Code : MTME133E2					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives: This course is outlined to those who intend to apply the subject at the proper place and time, while keeping him/her aware to the needs of the society where he/she can lend his/her expert service, and also to those who can be useful to the community without even going through the formal process of drilling through rigorous treatment of Mathematics.

Units	**Teaching Hours**
Unit-1	
Introduction to Probability Theory: Probability Theory and Sampling Distributions. Basic probability theory along with examples. Standard discrete and continuous distributions like Binomial, Poisson, Normal, Exponential etc. Central Limit Theorem and its Significance. Some sampling distributions like □2, t, F	9
Unit-2	
Testing of Statistical Hypothesis: Testing a statistical hypothesis, tests on single sample and two samples concerning means and variances. ANOVA: One – way, Two – way with/without interactions.	9
Unit-3	
Ordinary Differential Equations: Ordinary linear differential equations solvable by direct solution methods; solvable nonlinear ODE's.	9
Unit-4	
Partial Differential Equations and Concepts in Solution to Boundary Value: First and second order partial differential equations; canonical forms	9
Unit-5	
Major Equation Types Encountered in Engineering and Physical Sciences: Solution methods for wave equation, D'Alembert solution, potential equation, properties of harmonic functions, maximum principle, solution by variable separation method	9
Self-study : Nil	
Site/Industrial Visits : Nil	

Course outcomes:

CO1. Apply statistical techniques to analyze multivariate functions(L1,3,4) (PO1,2)

CO2. Identify and solve engineering problems by applying the knowledge of ordinary and partial differential equations (L1,3,4) (PO1,2)

CO3. Identify nature of a given wave equation and solve by applying D'Alembert solution and/or method of solution of method of separation of variables (L1,3,4) (PO1,2,3)

CO4. Apply mathematical and computational methods to a range of problems in science and engineering (L1,3,4) (PO1,2)

CO5. Implement basic operations in Fourier series and Laplace transforms (L1,2,3) (PO1,2,4)

CO6. Evaluate partial derivatives of multivariate functions (L1,3,4) (PO1,2,3)

Text Books:

T1. Ronald E, Walpole, Sharon L. Myers, Keying Ye, Probability and Statistics for Engineers and Scientists (8th Edition), Pearson Prentice Hall, 07 (for Units I & II)

T2. J. B. Doshi, Differential Equations for Scientists and Engineers, Narosa, New Delhi, 10 (for Units III & IV)

Reference Books:

R1. Douglas C. Montgomery, *Design and Analysis of Experiments* (7th Edition), Wiley Student Edition, 09.
R2. S. P. Gupta, *Statistical Methods*, S. Chand & Sons, 37th revised edition, 08
R3. William W. Hines, Douglas C. Montgomery, David M. Goldsman, *Probability and Statistics for Engineering*, (4th Edition), Willey Student edition, 06.
R4. Advanced Engineering Mathematics (9th Edition), Erwin Kreyszig, Wiley India (13)

Course Name: Computer Aided Design
Course Code : MTME133E3

	L	T	P	Category	PEC
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

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

- Have a conceptual understanding of the principles of CAD systems, the implementation of these principles, and its connections to CAM and CAE systems.
- Understand 2D, 3D transformations and projection transformations
- Get knowledge of various approaches of geometric modeling
- Understand mathematical representation of 2D and 3D entities
- Understand basic fundamentals of FEM
- Integrate principles of related fields into the use of CAD software.

Units	**Teaching Hours**
Unit-1	
Introduction: CAD Hardware and Software, Types of systems and system considerations, input and output devices, hardware integration and networking, hardware trends, Software modules	9
Unit-2	
Networks: Computer Communications, Principle of networking, classification networks, network wring, methods, transmission media and interfaces, network operating systems.	9
Unit-3	
Computer Graphics Introduction: Computer Graphics Introduction, transformation of geometric models: translation, scaling, reflection, rotation, homogeneous representation, concatenated transformations; mappings of geometric models, translational mapping rotational mapping, general mapping, n mappings as changes of coordinate system; inverse transformations and mapping	9
Unit-4	
Geometric Modeling: Projections of geometric models, orthographic projections, Geometric Modeling, curve representation: Parametric representation of analytic curves, parametric representation of synthetic curves, curve manipulations. Surface representation,	9
Unit-5	
Fundamentals of solid modeling: Fundamentals of solid modeling, boundary representation (B-rep), Constructive Solid Geometry (CSF), sweep representation, Analytic Solid Modeling (ASM), other representations; solid manipulations, solid modeling based applications: mass properties calculations, mechanical	9
Self-study : Nil	
Site/Industrial Visits : Nil	

Course outcomes:

CO1. Have a conceptual understanding of the principles of CAD systems, the implementation of these principles, and its connections to CAM and CAE systems. {L1,2}{CO1,2,3}

CO2. Understand 2D, 3D transformations and projection transformations {L2,3}{CO1,2,3,4}

CO3. Get knowledge of various approaches of geometric modeling {L2,3}{CO1,2,3,4}

CO4. Understand mathematical representation of 2D and 3D entities. {L3,4}{CO1,2,3,4}

CO5. Understand basic fundamentals of FEM. {L3,5}{CO2,3,4}

CO6. Integrate principles of related fields into the use of CAD software. {L4}{CO2,4}

Text Books:

T1. Ibrahbim Zeid, "CAD / CAM Theory and Practice".

T2. Jim Browne, "Computer Aided Engineering and Design".

T3. P. Radhakrishnan / V. Raju / S. Subramanyam, "CAD / CAM / CIM"

T4: P.N. Rao, "CAD / CAM principles and applications", Tata Mcraw-Hill, 02

Reference Books:

R1. Rogers / Adams, "Mathematical Elements for Computer Graphics".

R2. Rooney and Steadman, "Principles of Computer Aided Design", Aug. 1993.

R3. Jerry Banks / John Carson / Barry Nelson / David Nicol, "Discrete-Event System Simulation"

Course Name: Advanced Design of Mechanical System					
Course Code : MTME134E1					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives:

- To facilitate the students to appreciate the design function in machine elements and understand the role of failure prevention analysis in mechanical design.
- To be able to estimate the fatigue life estimation using stress-life approach and strain life approach.
- To understand the significance of statistical aspects in fatigue, LEFM, fatigue from variable amplitude loading etc.
- To impart the knowledge on various aspects of surface failure and dynamic contact stresses.
- The course aims at enumerating the theoretical and practical aspects of design process.

Prerequisites: Strength of Materials, Design of Machine Elements

Units	**Teaching Hours**
Unit-1	
INTRODUCTION: Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples. **FATIGUE OF MATERIALS**: Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features.	9
Unit-2	
STRESS-LIFE (S-N) APPROACH: S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behavior, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach. **STRAIN-LIFE(E-N)APPROACH:** Monotonic stress-strain behavior ,Strain controlled test methods ,Cyclic stress-strain behavior ,Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach.	9
Unit-3	
LEFM APPROACH: LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation. **STATISTICAL ASPECTS OF FATIGUE:** Definitions and quantification of data scatter, Probability distributions, Tolerance limits, Regression analysis of fatigue data, Reliability analysis, Problems using the Weibull distribution.	9

Unit-4	
FATIGUE FROM VARIABLE AMPLITUDE LOADING: Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach.	9
Unit-5	
SURFACE FAILURE: Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength.	9
Self-study : Nil	
Site/Industrial Visits : Nil	
Course outcomes: **CO1:** {Analyse the different types of failure modes and be able to judge which criterion is to be applied in which situation.} {L1, L2} {PO1, PO2} **CO2:** {Discuss the overview of stress- life and strain life approach to understand the fatigue behaviour of materials.} {L1, L2 }{PO1, PO2} **CO3:** {Explain the linear elastic behaviour in fracture of materials and understand the statistical aspects of fatigue.} { L1, L2, L3} {PO1, PO2} **CO4:** {Describe the various counting methods, damage theories used in the fatigue design from variable amplitude loading.} { L1, L2, L3} {PO1, PO2, PO3} **CO5:** {Classify different types of wear and illustrate the various surface failures.}{ L1, L2, L3} {PO1, PO2, PO3}	
Text Books: T1. Ralph I. Stephens, Ali Fatemi, Robert .R. Stephens, Henry o. Fuchs, "Metal Fatigue in engineering", Second edition, John wiley Newyork, 2001. T2. Jack. A. Collins, "Failure of Materials in Mechanical Design", John Wiley, Newyork 1992. T3. Robert L. Norton, Machine Design, Pearson, 2005.	
Reference Books: R1. S.Suresh, "Fatigue of Materials", Cambridge university press, Cambridge, U.K., 1998. R2. Julie.A. Benantine, "Fundamentals of Metal Fatigue Analysis", Prentice Hall, 1990. R3. "Fatigue and Fracture", ASM Hand Book, Vol 19, 2002.	
Online Resources: W1. https://nptel.ac.in/courses/112106137/	

Course Name: Robotics					
Course Code : MTME134E2					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives: At the end of the course:

- Describe and explain 3D translation and orientation representation & Illustrate the robot arm kinematics and use of Robot Operating System usage.
- Design / Simulate a robot which meets kinematic requirements.
- Apply localization and mapping aspects of mobile robotics.
- Demonstrate self-learning capability
- To provide the student with some knowledge and analysis skills associated with trajectory planning.
- To develop the student's knowledge in various robot structures and their workspace

Units	**Teaching Hours**
Unit-1	
Introduction: Basic Concepts such as Definition, three laws, DOF, Misunderstood devices etc., Elements of Robotic Systems i.e. Robot anatomy, Classification, Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, RCC device, etc. Automation - Concept, Need, Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations, introduction to automation productivity.	9
Unit-2	
Robot Grippers: Types of Grippers, Design aspect for gripper, Force analysis for various basic gripper system. Sensors for Robots:- Characteristics of sensing devices, Selections of sensors, Classification and applications of sensors. Types of Sensors, Need for sensors and vision system in the working and control of a robot.	9
Unit-3	
Drives and control systems: Types of Drives, Actuators and its selection while designing a robot system. Types of transmission systems, Control Systems - Types of Controllers, Introduction to closed loop control Control Technologies in Automation:- Industrial Control Systems, Process Industries Verses Discrete-Manufacturing Industries, Continuous Verses Discrete Control, Computer Process and its Forms. Control System Components such as Sensors, Actuators and others.	9
Unit-4	
Kinematics: Transformation matrices and their arithmetic, link and joint description, Denavit – Hartenberg parameters, frame assignment to links, direct kinematics, kinematics redundancy, kinematics calibration, inverse kinematics, solvability, algebraic and geometrical methods. Velocities and Static forces in manipulators: - Jacobians, singularities, static forces, Jacobian in force domain. Dynamics:- Introduction to Dynamics , Trajectory generations.	9

Unit-5	
Machine Vision System: Vision System Devices, Image acquisition, Masking, Sampling and quantisation, Image Processing Techniques , Noise reduction methods, Edge detection, Segmentation. Robot Programming :- Methods of robot programming, lead through programming, motion interpolation, branching capabilities, WAIT, SIGNAL and DELAY commands, subroutines, Programming Languages: Introduction to various types such as RAIL and VAL II etc, Features of type and development of languages for recent robot systems	9
Self-study : Nil	
Site/Industrial Visits : Nil	
Course outcomes: CO 1. Understand basic terminologies and concepts associated with Robotics and automation (L1,2)(PO1,2,3) CO 2.Demonstrate comprehension of various Robotic sub-systems (L2,2)(PO1,3,4) CO 3.Understand kinematics and dynamics to explain exact working pattern of robots (L3,2)(PO1,3,4) CO 4. Aware of the associated recent updates in Robotics (L1,2)(PO1,2,4) CO5: To provide the student with some knowledge and analysis skills associated with trajectory planning. (L1,2)(PO1,2,3) CO6: To develop the student's knowledge in various robot structures and their workspace (L1,2,3)(PO1,2,4,5)	
Text Books: **T1.** John J. Craig, Introduction to Robotics (Mechanics and Control), Addison-Wesley, 2nd Edition, 04 **T2**. Mikell P. Groover et. Al., Industrial Robotics: Technology, Programming and Applications, McGraw – Hill International, 1986.. **T3**. Shimon Y. Nof , Handbook of Industrial Robotics , John Wiley Co, 01.. **T4**. Automation, Production Systems and Computer Integrated Manufacturing, M.P. Groover, Pearson Education. **T5**. Industrial Automation: W.P. David, John Wiley and Sons.	
Reference Books: **R1**. Richard D. Klafter , Thomas A. Chemielewski, Michael Negin, Robotic Engineering : An Integrated Approach , Prentice Hall India, 02. **R2**. Handbook of design, manufacturing & Automation: R.C. Dorf, John Wiley and Sons.	

Course Name: Optimization Techniques in Design					
Course Code : MTME134E3					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives: At the end of the course:

- Students will know the principles of optimization.
- Students will have knowledge of algorithms for design optimization
- Students will be able to formulate an optimization problem.
- Students should be able to find the optimum solution of their problems using optimization techniques.

Units	**Teaching Hours**
Unit-1	
Introduction to optimization, classification of optimisation problems, classical optimization techniques.	09
Unit-2	
Linear programming, simplex method and Duality in linear programming, sensitivity or post-optimality analysis, Karmarkar's methods.	09
Unit-3	
Non-Linear Programming: - One dimensional minimization, unconstrained and constrained minimization, direct and indirect methods.	09
Unit-4	
Geometric programming, Optimum design of mechanical elements like beams, columns, gears, shafts, etc	09
Unit-5	
Introduction to Genetic Algorithms, Operators, applications to engineering optimization problems.	09

Self-study : Nil

Site/Industrial Visits : Nil

Course outcomes:

CO1. Students will know the principles of optimization. {L1,2}{PO1,2}
CO 2. Students will have knowledge of algorithms for design optimization. {L1,2}{PO1,2,3}
CO 3. Students will be able to formulate an optimization problem. {L3}{PO1,2,3}
CO 4. Students should be able to find the optimum solution of their problems using optimization techniques. {L3}{PO1,2,3}

Text Books:

T1. S. S. Stricker, "Optimising performance of energy systems" Battelle Press, NY, 1983.
T2. R.C. Johnson, "Optimum Design of Mechanical Elements", Willey, New York, 1980.
T3. J. S. Arora, "Introduction to Optimum Design", McGraw Hill, New York, 1989.
T4. Kalyanmoy Deb, "Optimization for Engineering Design", Prentice Hall of India, 2005.

Reference Books:

R1. L.C.W. Dixon, "Non-Linear Optimisation – Theory & Algorithms", Birkhauser, Boston, 1980.
R2. R.J. Duffin, E.L. Peterson and C.Zener "Geometric Programming-Theory and Applications", Willey, New York, 1967.
R3. G.B. Dantzig "Linear Programming and Extensions Princeton University Press", Princeton, N. J., 1963.
R4. R. Bellman "Dynamic Programming-Princeton" University Press, Princeton, N.J. 1957.

Course Name: Advanced CAD Laboratory					
Course Code : MTME151					
	L	**T**	**P**	Category	**PCC**
Contact Hrs./Week	**0**	**0**	**4**	CIA Marks	**50**
Contact Hrs./Sem.	**0**	**0**	**60**	ESE Marks	**50**
Credits.	**0**	**0**	**2**	Exam Hours	**3**

Course objectives:

- The students will be able use Commercial CAD tools for solving real life Engineering Mechanics related problems.
- Students will be able to function as a design engineering team member.
- Students will be able to write technical reports.

List of Experiments:	**Practical Hours**
1. Introduction to CAD Commercial Tool.	4
2. Type of Modules and commands.	4
3. Introduction to Sketching	6
4. Introduction to Part Modelling.	10
5. Introduction to Assembly drawing	6
6. Introduction to drafting 3D model.	6
7. Exercises on Part Modelling.	6
8. Exercises on Assembly Drawing.	6
9. Generation of Bill of Materials (BOM).	6
10. Surface Modelling.	6

Course outcomes:

CO1: The students will be able use Commercial CAD tools for solving real life Engineering Mechanics related problems. {PO1,2 & L1,2,3}
CO2: Students will be able to function as a design engineering team member. {PO1,2,3,4 & L4,5}
CO3: Students will be able to write technical reports. {PO3,4 & L4,5}

Text Books:

T1: 'A Primer on Computer Aided Machine Drawing-2007', Published by VTU, Belgaum.
T2: 'Machine Drawing', N.D.Bhat & V.M.Panchal, 2012.

Reference Books:

R1: 'A Text Book of Computer Aided Machine Drawing', S. Trymbaka Murthy, CBS Publishers, New Delhi, 2007
R2: 'Machine Drawing', K.R. Gopala Krishna, Subhash Publication,2012.
R3: 'Machine Drawing with Auto CAD', Goutam Pohit & Goutham Ghosh, 1st Indian print Pearson Education, 2007
R4: 'Auto CAD 2015, for engineers and designers', Sham Tickoo. Dream tech 2015

Course Name: Simulation Laboratory					
Course Code : MTME152					
	L	**T**	**P**	Category	**PCC**
Contact Hrs./Week	**0**	**0**	**4**	CIA Marks	**50**
Contact Hrs./Sem.	**0**	**0**	**60**	ESE Marks	**50**
Credits.	**0**	**0**	**2**	Exam Hours	**3**

Course objectives:

- The students will be able use Commercial FEM tools for solving real life Engineering Mechanics related problems.
- Students will be able to function as a design engineering team member.
- Students will be able to write technical reports.

List of Experiments:	**Practical Hours**
11. Introduction to FEM Commercial Tool.	4
12. Types of Elements and their usages (1-D, 2-D and 3-D)	4
13. Selection and Simplification of the geometry and Meshing Techniques.	6
14. Beam and Frame Problems solving using FEM 3D tool.	10
15. Static loading problem solution using FEM tool.	6
16. Dynamic Loading problem solution using FEM tool.	6
17. Mesh convergence study using above two problems.	6
18. Effects of different types of friction on contact mechanisms.	6
19. Three dimensional truss problems	6
20. Study on natural frequency and influence of materials and boundary condition on it.	6

Course outcomes:

CO1: The students will be able use Commercial FEM tools for solving real life Engineering Mechanics related problems. {PO1,2 & L1,2,3}

CO2: Students will be able to function as a design engineering team member. {PO1,2,3,4 & L4,5}

CO3: Students will be able to write technical reports. {PO3,4 & L4,5}

Text Books:

T1. Hughes, T. J. R. (2007). Finite Element Method: Linear Static and Dynamic Finite Element Anlaysis. New York: Dover Publications.

T2. Babuška, I., Whiteman, J. R., & Strouboulis, T. (2011). Finite Elements: An introduction to the method and error estimation. Oxford ; New York: Oxford University Press.

T3. Gokhale, N. S. (2008). Practical finite element analysis. Maharashtra: Finte to Infinite.

Reference Books:

R1. Thompson, E. G. (2005). An introduction to the finite element method: Theory, programming, applications. New Delhi: Wiley.

Course Name: Research Methodology And Intellectual Property Rights					
Course Code : MTME135					
	L	**T**	**P**	Category	**MLC**
Contact Hrs./Week	**4**	**0**	**0**	CIA Marks	**40**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives:

- To understand some basic concepts of research and its methodologies.
- To identify appropriate research topics and developing hypothesis.
- To select and define appropriate research problem and parameters.
- To organize and conduct research/project in a more appropriate manner.
- To enable the students to imbibe and internalize the Values and Ethical Behaviour in the personal and Professional lives.
- To discuss the importance of intellectual property rights and IPR law.

Prerequisites:

Units	**Teaching Hours**
Unit-1	
Research methodology – definition and significance, Types of research – exploratory research, conclusive research, modelling research, algorithmic research, casual research, theoretical and empirical research, cross-sectional and time series research. Research process- steps, research problems, objectives, characteristics, hypothesis and research in an evolutionary perspective Research design- definition, types –descriptive and experimental, validity and reliability of instrument, Validity of findings- internal and external validity, Variables in Research, types of data – primary and secondary data, methods of a data collection for scientific and business research, experiments, construction and validation of questionnaire, measurement and scaling.	09
Unit-2	
Sampling methods – Probability sampling methods – simple random sampling with replacement and without replacement, stratified sampling, cluster sampling. Non-probability sampling method – convenience sampling, judgment sampling, quota sampling Hypothesis testing – Testing of hypotheses concerning means (one mean and difference between two means – one tailed and two tailed tests), concerning variance _ one tailed Chi-square test.	09
Unit-3	
Report writing – types of report, guidelines to write report, typing instruction, need of summary, importance of language in the preparation of research report, oral presentation. Recording the findings of research – publication-contents to meet the journals standard – impact factor – citation and citation index, policy on academic honesty and integrity – academics cheating and	09

plagiarism. Opportunities to carry out research projects with funding/assistance from various Government agencies.	
Unit-4	
INTRODUCTION TO INTELLECTUAL PROPERTY Multinational corporations- Environmental ethics- Computer ethics and Weapons developments. Meaning and Types of Intellectual Property, Intellectual Property. Law Basics, Agencies responsible for intellectual property registration, International Organizations, Agencies and Treaties, Importance of Intellectual Property Rights. Introduction, Meaning of Patent Law, Rights under Federal Law, United States patent and Trademark Office, Patentability, Design Patents, Plants patents, Double Patenting.	09
Unit-5	
FOUNDATIONS OF TRADEMARKS Meaning of Trademarks, Purpose and Functions of Trademarks, types of Marks, Acquisition of Trademark rights, Common Law rights, Categories of Marks, Trade names and Business Name, Protectable Matter, Exclusions from Trademark Protection. **FOUNDATIONS OF COPYRIGHTS LAW AND PATENT LAW** Meaning of Copyrights, Common Law rights and Rights under the 1976 copyright Act, Recent developments of the Copyright Act, The United States Copyright Office.	09
Self-study : Nil	
Site/Industrial Visits : Nil.	
Course outcomes: CO1: To develop understanding of the basic framework of research process and techniques. {L1, L2} {PO1, PO2, PO4} CO2: To identify various sources of information for literature review and data collection. {L1, L2, L4} {PO1, PO2, PO3, PO4} CO3: To appreciate the components of scholarly writing and evaluate its quality {L1, L2, L6} {PO8, PO10} CO4: To develop an ethical behaviour under all situations. {L1, L2} {PO8, PO12} CO5: To understand Trademark, Copy right and Patent Laws. {L1, L2} {PO8, PO12}	
Text Books: T1. Garg, B.L, Karadia R, Agarwal F, and Agarwal, "An introduction to Research Methodology", RBSA Publishers, 2002. T2. Kothari C.R, "Research Methodology: Methods and Techniques", New Age International, 1990. T3. Mike Martin and Roland Schinzinger "Ethics in Engineering", TMH, 2009. **T4.** Deborah E. Bouchoux, "Intellectual Property Rights", Cengage 2005.	

Reference Books:

R1. Sinha, S.C and Dhiman A.K, "Research Methodology", 2nd volume, Ess Publications, 2002.
R2. Trochim W.M.K, "Research Methods: the concise knowledge base", Atomic Dog Publishing, 2005.
R3. Donald R. Cooper and Pamela S. Schindler, business Research Methods, 9th edition, Tata Mcgraw Hill, 2006
R4. Jayashree Suresh & B.S.Raghavan "Human values and Professional Ethics", S. Chand, 2009.
R5. Govindarajan, Natarajan and Senthilkumar "Engineering Ethics", PHI:009.
R6. Nagarajan "A Text Book on Professional ethics and Human values", New Age International, 2009.
R7. Charles & Fleddermann "Engineering Ethics", Pearson, 2009.
R8. Rachana Singh Puri and Arvind Viswanathan, I.K."Practical Approach to Intellectual Property rights", International Publishing House, New Delhi. 2010.
R9. A.B.Rao "Business Ethics and Professional Values", Excel, 2009.

Online Resources:

W1. https://www.coursera.org/learn/research-methods
W2. https://nptel.ac.in/downloads/121106007/
W3. https://swayam.gov.in/courses/5146-intellectual-property

Course Name: Advanced Finite Element Method					
Course Code : MTME231					
	L	**T**	**P**	Category	**PCC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives:
This course provides an introduction to finite elements method with a focus on one and two dimensional problems in structures, heat transfer, static and dynamics.

Prerequisites:
1. Solid Mechanics
2. Theory Of Elasticity
3. Theory Of Plasticity

Units	**Teaching Hours**
Unit-1 Introduction To Finite Element Method	
INTRODUCTION: Engineering Analysis, History, Advantages, Classification, Basic steps, Convergence criteria, Role of finite element analysis in computer-aided design. Mathematical Preliminaries, Differential equations formulations, Variational formulations, weighted residual methods **ONE-DIMENSIONAL ELEMENTS-ANALYSIS OF BARS AND TRUSSES:** Basic Equations and Potential Energy Functional, 1-0 Bar Element, Admissible displacement function, Strain matrix, Stress recovery, Element equations, Stiffness matrix, Consistent nodal force vector: Body force, Initial strain, Assembly Procedure, Boundary and Constraint Conditions, Single point constraint, Multi-point constraint, 2-D Bar Element, Shape functions for Higher Order Elements.	**11**
Unit-2 Two-Dimensional Elements-Analysis Of Plane Elasticity Problems	
Three-Noded Triangular Element (TRIA 3), Four-Noded Quadrilateral Element (QUAD 4), Shape functions for Higher Order Elements (TRIA 6, QUAD 8) **AXI-SYMMETRIC SOLID ELEMENTS-ANALYSIS OF BODIES OF REVOLUTION UNDER AXI-SYMMETRIC LOADING:** Axisymmetric Triangular and Quadrilateral Ring Elements. Shape functions for Higher Order Elements.	**08**
Unit-3 Three-Dimensional Elements-Applications To Solid Mechanics Problems System	
Basic Equations and Potential Energy Functional, Four-Noded Tetrahedral Element (TET 4), Eight-Noded Hexahedral Element (HEXA 8), Tetrahedral elements, Hexahedral elements: Serendipity family, Hexahedral elements: Lagrange family. Shape functions for Higher Order Elements.	**08**

Unit-4 Beam Elements-Analysis Of Beams And Frames	
1–D Beam Element, 2–D Beam Element, Problems. **HEAT TRANSFER / FLUID FLOW:** Steady state heat transfer, 1 D heat conduction governing equation, boundary conditions, One dimensional element, Functional approach for heat conduction, Galerkin approach for heat conduction, heat flux boundary condition, 1 D heat transfer in thin fins. Basic differential equation for fluid flow in pipes, around solid bodies, porous media.	**10**
Unit-5 Dynamic Considerations	
Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, axisymmetric triangular element, quadrilatateral element, beam element. Lumped mass matrix, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.	**08**

Self-study :

Unit-1: Shape functions for Higher Order Elements (1-D).
Unit-2: Shape functions for Higher Order Elements (2-D).
Unit-3: Shape functions for Higher Order Elements (3-D).
Unit-4: Basic differential equation for fluid flow in pipes
Unit-5: Applications to bars, stepped bars, and beams.

Site/Industrial Visits : Nil.

Course outcomes:
The students will be able

CO1: To emonstrate understanding of FE formulation for linear problems in solid mechanics.
CO2: To classify a given problem on the basis of its dimensionality as 1-D, 2-D, or 3-D, time-dependence as Static or Dynamic, Linear or Non-linear.
CO3: To develop mathematical model of a problem following the Rayleigh Ritz and Galerkin weighted residual method.
CO4: To Find the shape function for different elements including higher order elements.
CO5: To derive Stiffness matrices, load vectors for bar, truss, beam and heat transfer problems
CO6: To obtain consistent and lumped mass matrices for axial vibration of bars and transverse vibration of beams and obtain fundamental frequency of natural vibration using the methods mentioned in the curricula.
CO7: To use commercial software like ANSYS or ABAQUS for implementation of FEM to obtain stress concentration due to a small hole in a rectangular plate subjected to traction on edges and concentrated loads at points on the edges and prescribed boundary conditions.

Text Books:

T1. Chandrupatla T. R., "Finite Elements in engineering"- 2nd Edition, PHI, 2007.
T2. Lakshminarayana H. V., "Finite Elements Analysis"– Procedures in Engineering, Universities Press, 2004.

Reference Books:

R1. Rao S. S. "Finite Elements Method in Engineering"- 4th Edition, Elsevier, 2006

R2. P.Seshu, "Textbook of Finite Element Analysis"-PHI, 2004.

R3. J.N.Reddy, "Finite Element Method"- McGraw -Hill International Edition. Bathe K. J. Finite Elements Procedures, PHI.

R4. Cook R. D., et al. "Concepts and Application of Finite Elements Analysis"- 4th Edition, Wiley & Sons, 2003.

Online Resources:

W1. https://nptel.ac.in/courses/112104116/

Course Name: ADVANCED THEORY OF VIBRATION					
Course Code : MTME232					
	L	**T**	**P**	Category	**PCC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives:

- To obtain the idea of classification of vibration, modal analysis.
- To acquire the knowledge of damping factor and measuring instruments.
- To know the DOF and the damping factors
- To understand the measuring instruments

Prerequisites: Finite Element Method, Kinematics of Machinery.

Unit	**Teaching Hours**
Unit-1	
REVIEW OF MECHANICAL VIBRATIONS: Basic concepts; free vibration of single degree of freedom systems with and without damping, Forced vibration of single DOF-systems, Force and motion isolation, Two DOF-systems, natural frequency.	09
Unit-2	
TRANSIENT VIBRATION OF SINGLE DEGREE-OF FREEDOM SYSTEMS: Impulse excitation, Arbitrary excitation, Laplace transform formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation, Finite difference numerical computation.	08
Unit-3	
VIBRATION CONTROL: Introduction, Vibration isolation theory, Vibration isolation theory for harmonic excitation, practical aspects of vibration analysis, shock isolation, Dynamic vibration absorbers, and Vibration dampers. **VIBRATION MEASUREMENT AND APPLICATIONS:** Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis.	10
Unit-4	
MODAL ANALYSIS & CONDITION MONITORING: Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis. **NON LINEAR VIBRATIONS:** Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations.	09

Unit-5	
RANDOM VIBRATIONS : Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms, FTs and response. **CONTINUOUS SYSTEMS:** Vibrating string, Longitudinal vibration of rods, Torsional vibration of rods, Suspension bridge as continuous system, Euler equation for beams, Vibration of membranes.	09
Self-study : Nil	
Site/Industrial Visits : Nil	
Course outcomes: CO1: To learn the classification of mechanical vibration {L1, L2} {PO1, PO2, PO4} CO2: To acquire the knowledge of damping factor and transient vibration. {L1, L2, L4} {PO1, PO2, PO3, PO4} CO3: To learn about vibration control and the damping factors. {L1, L2, L6} {PO8, PO10} CO4: To understand the working of measuring instruments and condition monitoring systems. {L1, L2} {PO8, PO12} CO5: To learn random vibration and continuous systems. {L1, L2} {PO8, PO12}	
Text Books: T1. William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, "Theory of Vibration with Application", 5th edition Pearson Education, 2008. T2. S. Graham Kelly, "Fundamentals of Mechanical Vibration" 2nd edition, McGraw Hill, 2000. T3. S. S. Rao, "Mechanical Vibrations", 4th edition Pearson Education, 2003. T4. W.T. Thomson and Marie Dillon Dahleh, "Theory of Vibration with Applications", Pearson Education 5th edition, 2007. T5. V.P. Singh, "Mechanical Vibrations", Dhanpat Rai & Company Pvt. Ltd., 3rd edition, 2006.	
Reference Books: R1. S. Graham Kelly, Schaum's Outlines, "Mechanical Vibrations", Tata McGraw Hill, 2007. R2. J.S. Rao & K. Gupta, "Theory & Practice of Mechanical vibrations" New Age International Publications, New Delhi, 2001. R3. Leonanrd Meirovitch, "Elements of Vibrations Analysis", Tata McGraw Hill, Special Indian edition, 2007.	
Online Resources: W1. https:// nptel.ac.in/courses/112103111/ W2. https://nptel.ac.in/courses/112103111/18 W3. https://web.itu.edu.tr/~gundes/sdof.pdf W4. http://www.emtengineering.com/wp-content/uploads/2013/04/RANDVIB.pdf W5.http://www1.aucegypt.edu/faculty/mharafa/MENG%20475/Continuous%20Systems%20Fall%202010.pdf	

Course Name: TRIBOLOGY AND BEARING DESIGN					
Course Code : MTME233E1					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives:

- To study the types of contacts, types of bearing.
- Design a bearing based on their application and types of load.
- To know the response of idealized bearing systems.

Prerequisites: Design of Machine Elements.

Units	**Teaching Hours**
Unit-1	
INTRODUCTION TO TRIBOLOGY: Introduction, Friction, Wear, Wear Characterization, Regimes of lubrication, Classification of contacts, lubrication theories. Newton's Law of viscous forces, Effect of pressure and temperature on viscosity. **HYDRODYNAMIC LUBRICATION:** Newton's Law of viscous forces, Flow through stationary parallel plates. Hagen's poiseuille's theory, viscometers. Numerical problems, Concept of lightly loaded bearings, Petroff's equation, Numerical problems.	10
Unit-2	
HYDRODYNAMIC BEARINGS: Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynolds's 2D equation with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of centre of pressure, Numerical problems. **JOURNAL BEARINGS:** Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Sommerfeld number and its significance. Comparison between lightly loaded and heavily loaded bearings, Numerical problems.	10
Unit-3	
EHL CONTACTS: Introduction to Elasto - hydrodynamic lubricated bearings. Introduction to 'EHL' constant. Grubin type solution. Introduction to gas lubricated bearings. Governing differential equation for gas lubricated bearings.	08

Unit-4	
HYDROSTATIC BEARINGS: Types of hydrostatic Lubrication systems Expression for discharge, load carrying capacity, Flow rate, Condition for minimum power loss. Torque calculations. Numerical problems. **POROUS & GAS BEARINGS:** Introduction to porous bearings. Equations for porous bearings and working principal, Fretting phenomenon and it's stages	09
Unit-5	
MAGNETIC BEARINGS: Introduction to magnetic bearings, Active magnetic bearings. Different equations used in magnetic bearings and working principal. Advantages and disadvantages of magnetic bearings, Electrical analogy, Magneto-hydrodynamic bearings.	08
Self-study: Nil.	
Site/Industrial Visits: Nil.	
Course outcomes: **CO1:** To understand the principles of tribology for selecting compatible materials for minimizing friction and wear in machinery. {L1, L2} {PO1, PO2} **CO2:** To understand the principles of bearing selection based on the application. {L1, L2} {PO1, PO2, PO3} **CO3:** To learn the computations required for selecting and designing bearings in machines. {L2, L3, L4} {PO1, PO2, PO3, PO4} **CO4:** To understand the fundamental principles of gas lubricated bearings. {L1, L2} {PO1, PO2, PO3} **CO5:** To understand the fundamental principles of magnetic bearings .{L2, L3, L5} {PO1, PO2 PO3, PO4}	
Text Books: T1. B.C. Majumdar "Introduction to Tribology of Bearing", Wheeler Publishing, New Delhi, 2001. T2. Susheel Kumar Srivasthava "Tribology in industry" S. Chand and Co, 2000. T3. D. Berthe, D. Dowson, M. Godet, C.M. Taylor, "Tribological Design of Machine Elements", Elsevier Science, 1989. T4. E. Richard Booser, Michael M. Khonsari, "Applied Tribology Bearing Design and Lubrication" Wiley, 2017.	
Reference Books: R1. Dudley D. Fulier, "Theory and practice of Lubrication for Engineers", New York Company, 1998. R2. Moore "Principles and applications of Tribology" Pergamon press, 1st Edition, 1975. R3. Pinkus .O. Stemitch. "Theory of Hydrodynamic Lubrication", Mc-Graw Hill Book Company Inc., New York, 1961. R4. Gerhandschwetizer, Hannes Bleuler & Alfons Traxler, "Active Magnetic bearings", Authors working group, www.mcgs.ch., 2003. R5. Radixmovsky, "Lubrication of Bearings - Theoretical principles and design", The Oxford press Company, 2000.	
Online Resources: W1. https://nptel.ac.in/downloads/112105125/ W2. https://nptel.ac.in/syllabus/112106137/ W3. https://onlinecourses.nptel.ac.in/noc18_ce18/preview	

Course Name: CONDITION BASED MONITORING					
Course Code : MTME233E2					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives:
The aim of this module is to provide the learner with the knowledge of a variety of concepts and the skill to apply a variety of techniques associated with fault finding and condition monitoring in engineering systems.

Prerequisites: Instrumentation & Control, Design of Machine Elements and Tribology

Units	**Teaching Hours**
Unit-1	
INTRODUCTION: Introduction to Condition Monitoring Basic concept, visual monitoring, temperature monitoring, vibration monitoring, lubricant monitoring, crack monitoring, thickness monitoring, noise and sound monitoring. Economics of Condition Monitoring, Setting up a Condition Monitoring Activity, Implementation of Condition Based Maintenance, Consequences of implementation of Condition Based Maintenance. Information System, Selection of Monitoring Methods, Assessment of monitoring techniques, Case studies.	09
Unit-2	
VIBRATION MONITORING AND ANALYSIS: Introduction, Machinery signatures, Selection of Transducers. Analysis Techniques, Machine failure modes, Measurement location, Vibration severity criteria, Vibration frequency analysis. Permanent Monitoring, Case studies. **VIBRATION MONITORING OF BALL AND ROLLER BEARINGS:** Introduction, Shock pulse method, SPM for testing Antifriction bearings, Manual Monitoring Continuous monitoring, The Kurtosis method, Fiber optics system, Vibration signature analysis, Contact resistance method, Case studies. SPM and its Applications.	09
Unit-3	
SPECIALIZED TECHNIQUES OF CONDITION MONITORING: Acoustic imaging, Ultra sonic triangulation fault location Acoustic emission technique (AET)- Instrumentation, Transducers, Preamplifier and filter, Main amplifier and Signal processing/ Display unit, Signals and processing, Magnetic testing Methods, Current flow Magnetisation, Induction Magnetic Flow Method, Induction Threading bar method, Induction Magnetising Coil method, Induced Current flow method, Magnetic particle Inspection Inks, Strippable Magnetic film, Eddy Current apparatus, Thermography-Thermo graphic Equipment, Application of Thermography.	09
Unit-4	

MECHANICAL FAULT DIAGNOSIS: Wear monitoring and lubricant analysis - sources of contamination, techniques, Spectrometric Oil Analysis Procedure (SOAP) and ferrography. **NON-DESTRUCTIVE TESTING TECHNIQUES** Measurement of surface and subsurface flaws – liquid penetrant inspection, eddy current inspection, radiographic inspection, ultrasonic inspection	09
Unit-5	
CONDITION MONITORING CASE STUDIES & APPLICATIONS: Failure of fan bearings, Analysis of the failures, Solution. High frequency vibration of gas compressor, History of trouble, Analysis of trouble, Solution. Monitoring of cracks in rotors- Turbo compressor misalignment. Detection of faulty electrical components. Turbine shell distortion. Symptoms and Detections, Tool wear monitoring Introduction, techniques and case studies.	09
Self-study: Nil.	
Site/Industrial Visits: Nil.	
Course outcomes: CO1: To understand the role of condition based monitoring and its significance {L1, L2} {PO1, PO2} CO2: Understand the role of vibration monitoring and analysis, its methodology and its use in monitoring of ball and roller bearings.{L1, L2} {PO1, PO2, PO3} CO3: To learn various specialized condition monitoring techniques. {L2, L3, L4} {PO1, PO2, PO3, PO4} CO4: Understand the significance of mechanical fault diagnosis and non-destructive testing techniques in monitoring and maintenance.. {L1, L2} {PO1, PO2, PO3} CO5: To do analysis of failure based on condition monitoring to various industrial applications. {L2, L3, L5} {PO1, PO2 PO3, PO4}	
Text Books: T1. R.A., Caollacatt Chapman "Mechanical Fault Diagnosis and Condition Monitoring", Chapman and hall, 2nd edition, 1977. T2. John S. Mitchell, "Introduction to Machinery Analysis and Monitoring", Penn Well Books, 1993. T3. R.C.Mishra, K.Pathak – Maintenance Engineering and Management, Prentice Hall of India Pvt. Ltd., 2002.	
Reference Books: R1. R.A. Collacot – "Mechanical Fault Diagnosis", Chapman and Hall Ltd., 1977. R2. Robert Bond Randall – "Vibration-Based Condition Monitoring – Industrial, Aerospace and Automotive applications", John Wiley & Sons Ltd., 2011. R3. Dr. K. Balaveera Reddy, ISTE Summer School on Machinery Diagnostics and Preventive Maintenance, KREC, Surathkal, June 19-25, 1995.	
Online Resources: W1. http://www.bksv.com/media/doc/16-054.pdf W2. http://www.bindt.org/What-is-CM/Vibration-monitoring-and-analysis/ W3. https://www.kau.edu.sa/Files/0057850/Subjects/fault%20course%202018.pdf W4. https://web.itu.edu.tr/~arana/ndt.pdf W5. https://www.bksv.com/media/doc/BO0163.pdf	

Course Name: THEORY OF PLATES AND SHELLS					
Course Code : MTME233E3					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives:

- To facilitate the students to appreciate the shell structures, stresses in a plates and the different load conditions.
- To impart the knowledge of symmetrical bending for cylindrical and rectangular plates.
- To be able to find the bending of plates using differential equation for certain plates under different boundary and loading condition.
- To understand the analytical and numerical techniques to design the plates and shells for practical applications.
- To course aims at enumerating the behaviour of plates and shell elements.

Prerequisites: Strength of Materials, Design of Machine Elements

Units	**Teaching Hours**
Unit-1	
BENDING OF LONG RECTANGULAR PLATE INTO A CYLINDRICAL SURFACE, DIFFERENTIAL EQUATION: Bending of plated with different boundary conditions - Long plate on elastic foundation. PURE BENDING: Moment and curvature relations problems of simply supported plates-Strain energy impure bending.	9
Unit-2	
SYMMETRICAL BENDING OF CIRCULAR PLATES: Differential equation uniformly loaded plates, Plates concentricity loaded plates - loaded at the centre.	9
Unit-3	
RECTANGULAR PLATES: Differential equations - Solution of simply supported plate Various loading conditions, viz, uniformly distributed load, hydrostatic pressure and concentrated load, central as well as noncentral, Navier and Levy type solutions with various edge boundary conditions, viz., all edges simply supported, Two opposite edge fixed and two adjacent fixed. **BENDING OF PLATE UNDER COMBINED ACTION:** Bending of Plate Under Combined Action of lateral and transverse loads derivation of differential equation simply supported rectangular plate.	9

Unit-4	
INTRODUCTION TO SHELL STRUCTURES: General description of various types. Membrane Theory of thin shells (Stress Analysis): Cylindrical shells - Spherical Shells- Shells of double curvature, Viz, cooling tower Hyperbolic, Parabolic and elliptic paraboloid. **MEMBRANE DEFORMATION OF SHELLS:** Symmetrical 'loaded shell, symmetrically loaded spherical shell. General Theory of cylindrical shells: Circular; Cylindrical shell loaded symmetrically.	9
Unit-5	
General equation of circular cylindrical shells, Approximate investigation of bending of circular cylindrical shell.	9
Self-study: Nil.	
Site/Industrial Visits: Nil.	
Course outcomes: **CO1:** Analyse the solutions of bending of rectangular plates into a cylindrical surface with different boundary conditions. {L1, L2, L3} {PO1, PO2, PO3} **CO2:** Apply the analytical methods to find the solutions for the circular plates subjected to symmetric bending.{L1, L2, L3 }{PO1, PO2, PO3} **CO3:** Analyse the solutions of simply supported plate various loading conditions and bending of plate under combined action. { L1, L2, L3} {PO1, PO2, PO3} **CO4:** Discuss the various types of shell structure and membrane deformation of shells. { L1, L2, L3} {PO1, PO2, PO3} **CO5:** Apply the numerical techniques and tools for bending of circular cylindrical shells. { L1, L2, L3} {PO1, PO2, PO3}	
Text Books: T1. Timoshenko, Woinowsky and Krieger, "Theory of plates and Shells" McGraw Hill, Newyork.2ND Edition,2017 T2. Flugge, "Stresses in Shells "Springer Verlag, Berlin.	
Reference Books: R1. Goldnvizer, "Theory of Elastic Thin Shells" - Pergamon Press, New York,2014	
Online Resources: W1. https://nptel.ac.in/courses/112101095/34 W2. https://www.mae.ust.hk/~meqpsun/Notes/Chapter3.pdf W3. https://www.ct.upt.ro/suscos/files/2016-2018/L16_17_Shell%20structures.pdf	

Course Name: DESIGN FOR MANUFACTURE					
Course Code : MTME234E1					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course Objectives:

- To know the design consideration for manufacturing of components.
- To describe the different types of features in the design for manufacturing the components.
- To know the geometrical tolerance for manufacturing the components.
- To learn the theory behind Component design with machining considerations.
- To learn to design gauges, suitable for checking of components in assembly.

Prerequisites: 1. Design of Machine Elements. 2. Engineering Metrology.

Units	**Teaching Hours**
Unit-1	
EFFECT OF MATERIALS AND MANUFACTURING PROCESS ON DESIGN: Major phases of design, Effect of material properties on design Effect of manufacturing processes on design. Material selection process cost per unit property, Weighted properties and limits on properties methods. **TOLERANCE ANALYSIS:** Process capability, mean, variance, skewness, kurtosis, Process capability metrics, Cp, Cpk, Cost aspects, Feature tolerances, Geometries tolerances, Geometric tolerances, Surface finish, Review of relationship between attainable tolerance grades and different machining process. Cumulative effect of tolerance - Sure fit law and truncated normal law.	09
Unit-2	
SELECTIVE ASSEMBLY: Interchangeable part manufacture and selective assembly, Deciding the number of groups - Model-1, Group tolerance of mating parts equal, Model total and group tolerances of shaft equal. Control of axial play-Introducing secondary machining operations, Laminated shims, examples. **DATUM FEATURES:** Functional datum, Datum for manufacturing, changing the datum, Examples.	09
Unit-3	
DESIGN CONSIDERATIONS: Design of components with casting consideration, Pattern, Mould, and Parting line, Cored holes and Machined holes, identifying the possible and probable parting line, casting requiring special sand cores, designing to obviate sand cores.	08
Unit-4	
COMPONENT DESIGN: Component design with machining considerations link design for turning components-milling, Drilling and other related processes including finish-machining operations.	10

TRUE POSITIONAL THEORY: Comparison between co-ordinate and convention method of feature location. Tolerance and true position tolerancing virtual size concept, Floating and fixed fasteners, Projected tolerance zone, Assembly with gasket, zero position tolerance. Functional gauges, Paper layout gauging.	
Unit-5	
DESIGN OF GAUGES: Designs of gauges for checking components in assemble with emphasis on various types of limit gauges for both hole and shaft.	09
Self-study: Nil.	
Site/Industrial Visits: Nil.	
Course outcomes: CO1: Outline the appropriate design for economical production and select the materials. {L1, L2} {PO1, PO2} CO2: Select between various machining and metal joining processes. . {L1, L2} {PO1, PO2, PO3} CO3: Apply a systematic understanding of knowledge in the field of metal casting and forging. {L2, L3, L4} {PO1, PO2, PO3, PO4} CO4: Fabricate basic parts and assemblies using powered and non – powered machine shop equipment in conjunction with mechanical documentation. {L1, L2} {PO1, PO2, PO3} CO5: To learn to design gauges suitable for checking of components in assembly. {L1, L3, L5} {PO1, PO2 PO3, PO4}	
Text Books: T1. Harry Peck, "Designing for Manufacturing "- Pitman Publications, 1983. T2. R.K. Jain ,"Engineering Metrology" - Khanna Publication ,2011. T3. Corrado Poli, "Design for Manufacturing", Butterworth-Heinemann, 2001.	
Reference Books: R1. Geoffrey Boothroyd, peter dewhurst, Winston Knight,"Product design for manufacture and assembly" - Merceldekker.Inc. New York, CRC Press, 3rd Edition, 2010. R2. "Material selection and Design", Vol. 20 - ASM Hand book. R3. O. Molloy, E.A. Warman, S. Tilley, "Design for Manufacturing and Assembly: Concepts, architectures and implementation", Springer Science & Business Media, 1998.	
Online Resources: W1. https://nptel.ac.in/courses/107103012/ W2. https://www.scribd.com/doc/51195775/05-True-Position-Theory. W3. https://synthetica.eng.uci.edu/mechanicaldesign101/GDandT.pdf W4. http://textofvideo.nptel.ac.in/112106179/lec16.pdf	

Course Name: Analysis and Synthesis of Mechanism					
Course Code : MTME234E2					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives:

- To Learn the graphical and analytical techniques commonly used in the synthesis of mechanisms.
- To Orient applications of analytical techniques by means of computer programs.
- To simplify the mechanism for analysis purposes.

Prerequisites: Kinematics of Mechanism

Unit	**Teaching Hours**
Unit-1	
Basic Concepts: Definitions and assumptions; planar and spatial mechanisms; kinematic pairs; degree of freedom; equivalent mechanisms; Kinematic Analysis of Planar Mechanisms. Review of graphical and analytical methods of velocity and acceleration analysis of kinematically simple mechanisms, velocity-acceleration, analysis of complex mechanisms by the normal acceleration and auxiliary-point methods.	09
Unit-2	
Curvature Theory: Fixed and moving centrodes, inflection circle, Euler-Savary equation, Bobillier constructions, cubic of stationary curvature, Ball's point, Applications in dwell mechanisms.	09
Unit-3	
Kinematic Synthesis of planar mechanisms, accuracy (precision) points, Chebesychev spacing, types of errors, Graphical synthesis for function generation and rigid body guidance with two, three and four accuracy points using pole method, centre and circle point curves, Analytical synthesis of four-bar and slider-crank mechanisms.	09

Unit-4	
Freudenstein's equation, synthesis for four and five accuracy points, compatibility condition, synthesis of four-bar for prescribed angular velocities and accelerations using complex numbers, three accuracy point synthesis using complex numbers.	09
Unit-5	
Coupler Curves: Equations of coupler curve, Robert-Chebychev theorem, double points and symmetry. Kinematic Analysis of Spatial Mechanisms, Denavit - Hartenberg parameters, matrix method of analysis of spatial mechanisms	09

Course outcomes:

CO1: To develop analytical equations describing the relative position, velocity and acceleration of all moving links. {L1,2,3} {PO1,2,3}

CO2: To select, configure, and synthesize mechanical components into complete systems. {L2,3} {PO1,2,3,4}

CO3. Use kinematic geometry to formulate and solve constraint equations to design linkages for specified tasks. {L3,4} {PO2,3,4}

CO4. Formulate and solve four position synthesis problems for planar and spherical four-bar linkages by graphical and analytical methods. {L2,3,4} {PO2,3,4,5}

CO5. Analyze and animate the movement of planar and spherical four-bar linkages. {L2,3} {PO1,2,3}.

Text Books:

T1. R.S. Hartenberg and J. Denavit, "Kinematic Synthesis of Linkages", McGraw-Hill, New York, 1980.

T2. Robert L.Nortan ,"Design of Machinery", Tata McGraw Hill Edition

T3. Hamilton H. Mabie, "Mechanisms and Dynamics of Machinery", John Wiley and sons New York.

T4. S.B.Tuttle, "Mechanisms for Engineering Design" John Wiley and sons New York, 1989.

Reference Books:

R1. A. Ghosh and A.K. Mallik, "Theory of Machines and Mechanisms", Affiliated East-West Press, New Delhi, 1988.

R2. A.G. Erdman and G.N. Sandor, "Mechanism Design – Analysis and Synthesis", (Vol. 1 and 2), Prentice Hall India, 1988.

R3. A.S. Hall, "Kinematics and Linkage Design", Prentice Hall of India, 1984.

R4. J.E. Shigley and J.J. Uicker, "Theory of Machines and Mechanisms", 2nd Edition, McGraw-Hill, 1995.

Online Resources:

W1. http://library.msri.org/books/Book32/files/kuiper.pdf

W2. http://ocw.metu.edu.tr/pluginfile.php/3960/mod_resource/content/1/ch7/7-4.htm.

W3. https://www.oreilly.com/library/view/theory-of-machines.

W4. http://ocw.upm.es/ingenieria-mecanica/mechanical-devices-for-industry/contenidos/learning-guide.

Course Name: MULTI BODY DYNAMICS					
Course Code : MTME234E3					
	L	**T**	**P**	Category	**PE**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives:

- Design Multibody systems in two and three dimensions starting from scratch using sound theoretical principles and state of the art software.
- Design of rigid body systems with applications to mechanisms and working assemblies in two and three dimensions.
- Dynamic analysis models for kinematic (position, velocities accelerations) and kinetics (forces and moments).
- Perform simulations of rigid and flexible multi-body assemblies to determine loads, dynamic forces, energy and momentum and control. Finite Element Analysis under dynamic loads.
- Analyze forces and moments in two and three dimensions under impulsive impact forces and collisions.
- Apply these techniques to, ground, space vehicles and machinery.

Prerequisites: Engineering Mechanics, Numerical methods and Finite Element Methods.

Units	**Teaching Hours**
Unit-1	
BASIC CONCEPTS IN 3-D RIGID-BODY MECHANICS: Degrees-of-freedom; Rigid body vs flexible body; Spatial kinematics (3-D rotation transformations); Euler theorem, rotation parameterization, Rodriguez formula; Moments and products of inertia; Newton-Euler equations of motion; Lagrange Equation; Generalized forces. BASIC PRINCIPLES FOR ANALYSIS OF MULTI-BODY SYSTEMS: The automatic assembly of the systems of equations for position, velocity and acceleration analysis. Iterative solution of systems of nonlinear equations. Geometry of masses. The principle of virtual work and Lagrange's equations.	09
Unit-2	
FORMULATION OF EQUATIONS OF MOTION FOR INTER-CONNECTED BODIES: Relative coordinates, generalized coordinates, Cartesian co-ordinates ; Lagrange' s equations and other approaches; Differential equations (DE) and differential algebraic equations (DAE); Co-ordinate partitioning and Lagrange multipliers; Types of analyses (kinematic, static, quasi-static, kineto-static, dynamic and linear dynamic).	09
Unit-3	
INTER-CONNECTED RIGID BODIES: Kinematic pairs (joints) with classification of constraints; holonomic and non-holonomic constraints; Springs, dampers, actuators and controllers with brief introduction of controls theory. COMPUTATION OF FORCES:	09

Computation of spatial generalized forces for external forces and for actuator-spring-damper element. Computation of reaction forces from Lagrange's multi- pliers.	

Unit-4	
APPLICATION OF NUMERICAL METHODS: NR method, Jacobian, Differential equation integrators (Euler methods and Implicit methods); Stability, accuracy and Dahlquist's trade off criteria; Stiffness and damping - physical vs numerical; Lock-up, bifurcation and singularities	09
Unit-5	
FLEXIBLE MULTIBODY SYSTEMS: Introduction to flexible multi body systems, Multibody system approach, Dynamic analyses using classical approximation, FEM. DYNAMICS OF PLANAR SYSTEMS: Dynamics of planar systems. Systematic computation and assembly of mass matrix. Computation of planar generalized forces for external forces and for actuator-spring-damper element. Simple applications of inverse and forward dynamic analysis.	09
Self-study: Nil.	
Site/Industrial Visits: Nil.	
Course outcomes: CO1: To understand the basic principles for analysis of multi-body systems and 3-dimensional rigid bodies.{L1, L2} {PO1, PO2} CO2: To analyse interconnected bodies in a multi-body system.{L1, L2} {PO1, PO2, PO3} CO3: To formulate equation of motion for inter connected bodies. {L2, L3, L4} {PO1, PO2, PO3, PO4} CO4: To learn the application of numerical methods in multi body dynamics. {L1, L2} {PO1, PO2, PO3} CO5: To gain analytical understanding of flexible multi body systems. {L2, L3, L5} {PO1, PO2 PO3, PO4}.	
Text Books: T1. A. A. Shabana, "Dynamics of Multibody systems", Wiley, New York, 2005. T2. R. E., Roberson and S. Richard, "Dynamics of Multibody systems", Springer-Verlag, 1998. T3. H. Chaudhary, and S.K. Saha, "Dynamics and Balancing of Multibody Systems", Springer (India) 2013. T4. Claus Führer With Edda Eich -Soellner, "Numerical Methods in Multibody Dynamics" Springer Fachmedien Wiesbaden, 2013. T5. Ronald L. Huston "Multibody Dynamics", Butterworth-Heinemann, 1990.	
Reference Books: R1. Homer Rahnejat, Steve Rothberg, "Multi-body Dynamics: Monitoring and Simulation Techniques – III ", Wiley; 1 edition, 2004. R2. Banerjee and K. Arun, "Flexible Multibody Dynamics - Efficient Formulations and Applications", Wiley, 2016. R3.Arun K. Banerjee, "Flexible Multibody Dynamics: Efficient Formulations and Applications", 2005. R4. E.J. Haug, "Computer-Aided Kinematics and Dynamics of Mechanical Systems -Basic Methods", Allyn and Bacon, 1989. R5. J. Wittenburg, "Dynamics of Systems of Rigid Bodies", B.G. Teubner, Stuttgart, 1977.	

Online Resources:

W1. http://web.mit.edu/8.01t/www/materials/modules/chapter21.pdf
W2. http://www.sc.iitb.ac.in/~banavar/resources/notes/sneha_banavar_multibody.pdf
W3. http://users.physics.harvard.edu/~morii/phys151/lectures/Lecture10.pdf
W4. http://pages.isir.upmc.fr/~amar/COURS%20DYNAMIQUE/SLIDES.pdf
W5. https://www.uni-due.de/imperia/md/content/mechatronik/lehre/vehicledynamics_chap3.pdf

Course Name: Advanced Design Laboratory					
Course Code : MTME251					
	L	**T**	**P**	Category	**PCC**
Contact Hrs./Week	**0**	**0**	**4**	CIA Marks	**50**
Contact Hrs./Sem.	**0**	**0**	**60**	ESE Marks	**50**
Credits.	**0**	**0**	**2**	Exam Hours	**2 hrs**

Course objectives:

- To develop skills in the field of design Engineering.
- Verify the principles of the course, Application of the theory, Understanding of fundamentals of the subject design Engineering.
- Be in a position to relate theory and practice

Prerequisites: Strength of Materials.

List of Experiments (If any):	**Practical Hours**
1. Tensile, shear and compression tests of metallic and non metallic specimens using Universal Testing Machine.	8
2. Bending Test on metallic and nonmetallic specimens.	
3. Preparation of specimen for Metallographic examination of different engineering materials. Identification of microstructures of plain carbon steel, tool steel, gray C.I, SG iron, Brass, Bronze & composites	4
4. Determination of critical speed of a rotating shaft.	4
5. Determination of Fringe constant of Photoelastic material using. a. Circular disc subjected to diametral compression. b. Pure bending specimen (four point bending)	6
6. Determination of stress concentration using Photoelasticity for simple components like plate with a hole under tension or bending, circular disk with circular hole under compression, 2D Crane hook	6
7. To study the wear characteristics of ferrous, non-ferrous and composite materials for different parameters.	4
8. Determination of Pressure distribution in Journal bearing.	4
9. Determination of Principal Stresses and strains in a member subjected to combined loading using Strain rosettes.	4
10. Determination of stresses in Curved beam using strain gauge.	4
11. Determination of natural frequency, logarithmic decrement, damping ratio and damping coefficient in a single degree of freedom vibrating systems (longitudinal and torsional)	8
12. Non-destructive test experiments like, (a). Ultrasonic flaw detection (b). Magnetic crack detection (c). Dye penetration testing. To study the defects of Cast and Welded specimens	8
Self-study: Nil	

Site/Industrial Visits : Nil.

Course outcomes:

CO1: Will be able to apply the concepts of design Engineering, appreciate its application in various engineering application {L1,2} {PO1,2,5}

CO2: Will be able to perform design engineering experiments for various mechanical elements. {L1,2,5} {PO1,2,5}

CO3: Calculate the stresses, strain and elongation/Contraction in a bars and beams. (L1,L2,L3) (PO1, PO2,PO3)

CO4: To correlate the theoretical principles with application based studies. {PO1,2,5}

CO5: Determine and illustrate principal stresses, maximum shearing stress, and the stresses acting on a structural Member. (L1,L2) (PO1, PO2)

Text Books:

T1.Mechanical Vibrations, S. S. Rao, Pearson Education Inc, 4th edition, 2003.

T2.Mechanical Vibrations, V. P. Singh, Dhanpat Rai & Company, 3rd edition, 2006.

T3. Egor P. Popov, Engineering Mechanics of Solids, Prentice Hall of India, New Delhi, 2001.

T4. R. Subramanian, Strength of Materials, Oxford University Press, 2007.

T5. Ferdinand P. Been, Russel Johnson Jr and John J. Dewole, Mechanics of Materials, Tata McGrawHill Publishing Co. Ltd., New Delhi 2005.

Reference Books:

R1. S.S. Rattan, "Strength of Materials", 3rd Edition, Tata McGraw Hill, 2011.

R3. K.V. Rao, G.C. Raju, "Mechanics of Materials", First Edition, 2007.

R4. Egor.P. Popov,"Engineering Mechanics of Solids", Pearson Edu. India, 2008.

R5. W.A. Nash, Schaum's Outlines Strength of Materials,Tata Mcgraw-Hill Publishing Company 2010.

R6 R.K. Rajput"Strength of Materials",S.Chand & co Ltd. New Delhi, 2015.

R7. R.KBansal, "Strength of Materials",Lakshmi Publication (P) Ltd, New Delhi,2009.

Course Name: Analysis Laboratory					
Course Code : MTME252					
	L	**T**	**P**	Category	**PCC**
Contact Hrs./Week	**0**	**0**	**4**	CIA Marks	**50**
Contact Hrs./Sem.	**0**	**0**	**60**	ESE Marks	**50**
Credits.	**0**	**0**	**2**	Exam Hours	**3**

Course objectives:

- To understand the concept of Finite Element Analysis and their applications, advantages and disadvantages.
- To understand the Steps involved in FEA and factors influencing FEA results.
- Discuss the assumptions on material properties and boundary conditions.

List of Experiments:	**Practical Hours**
1. Introduction to FEM Commercial Tool.	4
2. Types of Elements and their usages (1-D, 2-D and 3-D)	8
3. Bars of constant cross section area, tapered cross section area and stepped bar, Trusses – (Minimum 2 exercises)	8
4. Beams – Simply supported, cantilever, beams with UDL, beams with varying load etc. (Minimum 6 exercises)	10
5. Stress analysis of a rectangular plate with a circular hole	10
6. Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions(Minimum 4 exercises)	10
7. Dynamic Analysis a) Fixed – fixed beam for natural frequency determination b) Bar subjected to forcing function c) Fixed – fixed beam subjected to forcing function	10

Course outcomes:

CO1: To gain the basic knowledge about FEM tools and their characteristics. {L1,2} {PO1,2,5}

CO2: To elaborate the selection of geometry and it simplification. {L1,2,5} {PO1,2,5}

CO3: To understanding of types of material data and application of boundary conditions. {L1,2,5} {PO1,2,5}

CO4: To defining the solution parameters and defining output requests. {L1,2,5} {PO1,2,5}

Text Books:

T1. Introduction to Finite Elements in Engineering, T.R.Chandrupatla, A.D Belegund, 3rd Ed PHI, 2002.

T2. Finite Element Method in Engineering, S.S. Rao, 5th Edition, Elsevier, 2011.

Reference Books:

R1. Finite Element Methods for Engineers U.S. Dixit, Cengage Learning, 2009

R2. Concepts and applications of Finite Element Analysis, R.D. Cook D.S Maltus, M.E Plesha, R.J.Witt, Wiley 4th Ed, 2009.

R3. First Course in Finite Element Methods, Daryl. L. Logon, Cengage Learning 5th edition, 2012.

R4. An Introduction to the Finite Element Method, J.N.Reddy, 3rd Edition, 2006 McGraw -Hill Publication.

Course Name: DESIGN FOR MANUFACTURE					
Course Code : MTME331E1					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**50**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course Objectives:

- To know the design consideration for manufacturing of components.
- To describe the different types of features in the design for manufacturing the components.
- To know the geometrical tolerance for manufacturing the components.
- To learn the theory behind Component design with machining considerations.
- To learn to design gauges, suitable for checking of components in assembly.

Prerequisites: 1. Design of Machine Elements. 2. Engineering Metrology.

Units	**Teaching Hours**
Unit-1	
EFFECT OF MATERIALS AND MANUFACTURING PROCESS ON DESIGN: Major phases of design, Effect of material properties on design Effect of manufacturing processes on design. Material selection process cost per unit property, Weighted properties and limits on properties methods. **TOLERANCE ANALYSIS:** Process capability, mean, variance, skewness, kurtosis, Process capability metrics, Cp, Cpk, Cost aspects, Feature tolerances, Geometries tolerances, Geometric tolerances, Surface finish, Review of relationship between attainable tolerance grades and different machining process. Cumulative effect of tolerance - Sure fit law and truncated normal law.	10
Unit-2	
SELECTIVE ASSEMBLY: Interchangeable part manufacture and selective assembly, Deciding the number of groups - Model-1, Group tolerance of mating parts equal, Model total and group tolerances of shaft equal. Control of axial play-Introducing secondary machining operations, Laminated shims, examples. **DATUM FEATURES:** Functional datum, Datum for manufacturing, changing the datum, Examples.	10
Unit-3	
DESIGN CONSIDERATIONS: Design of components with casting consideration, Pattern, Mould, and Parting line, Cored holes and Machined holes, identifying the possible and probable parting line, casting requiring special sand cores, designing to obviate sand cores.	10
Unit-4	
COMPONENT DESIGN: Component design with machining considerations link design for turning components-milling, Drilling and other related processes including finish-machining operations.	10

TRUE POSITIONAL THEORY: Comparison between co-ordinate and convention method of feature location. Tolerance and true position tolerancing virtual size concept, Floating and fixed fasteners, Projected tolerance zone, Assembly with gasket, zero position tolerance. Functional gauges, Paper layout gauging.	
Unit-5	
DESIGN OF GAUGES: Designs of gauges for checking components in assemble with emphasis on various types of limit gauges for both hole and shaft.	10
Self-study: Nil.	
Site/Industrial Visits: Nil.	
Course outcomes: CO1: Outline the appropriate design for economical production and select the materials. {L1, L2} {PO1, PO2} CO2: Select between various machining and metal joining processes. . {L1, L2} {PO1, PO2, PO3} CO3: Apply a systematic understanding of knowledge in the field of metal casting and forging. {L2, L3, L4} {PO1, PO2, PO3, PO4} CO4: Fabricate basic parts and assemblies using powered and non – powered machine shop equipment in conjunction with mechanical documentation. {L1, L2} {PO1, PO2, PO3} CO5: To learn to design gauges suitable for checking of components in assembly. {L1, L3, L5} {PO1, PO2 PO3, PO4}	
Text Books: T1. Harry Peck, "Designing for Manufacturing "- Pitman Publications, 1983. T2. R.K. Jain ,"Engineering Metrology" - Khanna Publication ,2011. T3. Corrado Poli, "Design for Manufacturing", Butterworth-Heinemann, 2001.	
Reference Books: R1. Geoffrey Boothroyd, peter dewhurst, Winston Knight,"Product design for manufacture and assembly" - Merceldekker.Inc. New York, CRC Press, 3rd Edition, 2010. R2. "Material selection and Design", Vol. 20 - ASM Hand book. R3. O. Molloy, E.A. Warman, S. Tilley, "Design for Manufacturing and Assembly: Concepts, architectures and implementation", Springer Science & Business Media, 1998.	
Online Resources: W1. https://nptel.ac.in/courses/107103012/ W2. https://www.scribd.com/doc/51195775/05-True-Position-Theory. W3. https://synthetica.eng.uci.edu/mechanicaldesign101/GDandT.pdf W4. http://textofvideo.nptel.ac.in/112106179/lec16.pdf	

Course Name: Rotor Dynamics					
Course Code : MTME331E2					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**50**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**03**

Course objectives

- To know the critical speed of shaft for the rotating body.
- To find the fluid flow with in the body when it subjected to dynamic consideration.
- To know the lubrication characteristics used in the fluid film flow

Prerequisites: Nil

Units	**Teaching Hours**
Unit-1	
FLUID FILM LUBRICATION: Basic theory of fluid film lubrication, Derivation of generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, Stability and dynamic response for hydrodynamic journal bearing, Two lobe journal bearings. **STABILITY OF FLEXIBLE SHAFTS:** Introduction, equation of motion of a flexible shaft with rigid support, Radial elastic friction forces, Rotary friction, friction Independent of velocity, friction dependent on frequency, Different shaft stiffness Constant, gyroscopic effects, Nonlinear problems of large deformation applied forces, instability of rotors in magnetic field	10
Unit-2	
CRITICAL SPEED: Dunkerley's method, Rayleigh's method, Stodola's method. **ROTOR BEARING SYSTEM:** Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the center.	10
Unit-3	
TURBO ROTOR SYSTEM STABILITY BY TRANSFER MATRIX FORMULATION: General turborotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions.	10
Unit-4	
TURBO ROTOR SYSTEM STABILITY BY FINITE ELEMENT FORMULATION: General turborotor system, generalized forces and co-ordinates system assembly element matrices, Consistent mass matrix formulation, Lumped mass model, linearised model for journal bearings, System dynamic equations Fix stability analysis non dimensional stability analysis, unbalance response and Transient analysis.	10
Unit-5	

BLADE VIBRATION: Centrifugal effect, Transfer matrix and Finite element, approaches	10
Self-study :	
Site/Industrial Visits :	
Course outcomes: At end of this course, students will be able to: CO1: Derive the equations of motion of a rigid rotor in the absolute and rotating coordinate systems.(L1,L2,L4)(PO1,PO2,PO4) CO2: Explain the critical speed of revolution and the self-balancing effect. (L1,L2) (PO1,PO2,PO4) CO3: Explain the external damping, and internal damping and their effects. (L1,L2) (PO1,PO2,PO4) CO4: Explain the change of a critical speed in the case that the gyro effect is considered. (L1,L2) (PO1,PO2,PO4) CO5: Explain the characteristics of the whirling vibration of a non-isotropic rotor. (L1,L2) (PO1,PO2,PO4)	
Text Books: T1. Cameron Longmans "Principles of Lubrication" ,John Wiley & Sons Inc; 3rd edition ,2016 T2.Yiwei Li ,James H. Starnes Jr ,"Nonconservative problems of the Theory of elastic stability"- Bolotin, Pergamon. Cambridge University Press ,2001	
Reference Books: R1. E.C. Pestel and F.A. Leckie, "Matrix methods of Elastomechanics" McGraw Hill. R2.Timosenko, Young, "Vibration Problems in Engineering"- Von Nostrand,2017 R3..Zienkiewicz, "The Finite Element Method", McGraw Hill	
Online Resources: W1. W2.	

Course Name: Robust Design					
Course Code : MTME331E3					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**50**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**03**

Course objectives

- To learn steps in robust design, parametric design and tolerance design.
- To know the role of S-N ratios in reliability improvement.
- To know the parametric and tolerance design system
- Understand the concept of Taguchi's orthogonal arrays.

Prerequisites: Nil

Units	**Teaching Hours**
Unit-1	
QUALITY BY EXPERIMENTAL DESIGN : Quality, western and Taguchi quality philosophy, Elements of cost, Noise factors causes of variation, Quadratic loss function and variation of quadratic loss functions. **Robust Design :**Steps in robust design : parameter design and tolerance design, reliability improvement through experiments, illustration through numerical examples. **EXPERIMENTAL DESIGN:** Classical experiments: factorial experiments, terminology, factors. Levels, Interactions, Treatment combination, randomization, 2-level experimental design for two factors and three factors. 3-level experiment deigns for two factors and three factors, factor effects, factor interactions, Fractional factorial design, Saturated design, Central composite designs, Illustration through numerical examples**.**	10
Unit-2	
MEASURES OF VARIABILITY : Measures of variability, Concept of confidence level, Statistical distributions : normal, log normal and Weibull distributions. Hipothesis testing, Probability plots, choice of sample size illustration through numerical examples. **ANALYSIS AND INTERPRETATION OF EXPERIMENTAL DATA:**Measures of variability, Ranking method, column effect method and ploting method, Analysis of variance (ANOVA), in factorial experiments: YATE's algorithm for ANOVA,Regression analysis, Mathematical models from experimental data, illustration through numerical examples.	10
Unit-3	
TAGUCHI'S ORTHOGONAL ARRAYS : Types orthogonal arrays, Selection of standard orthogonal arrays, Linear graphs and interaction assignment, dummy level technique, Compound factor method, modification of linear graphs, Column merging method, Branching design, Strategies for constructing orthogonal arrays.	10
Unit-4	

SIGNAL TO NOISE RATIO (S-N RATIOS) : Evaluation of sensitivity to noise, Signal to noise ratios for static problems, Smaller – the – better types, Nominal – the – better – type, larger – the- better – type. Signal to noise ratios for dynamic problems, Illustrations through numerical examples.	10
Unit-5	
PARAMETER DESIGN AND TOLERANCE DESIGN: Parameter and tolerance design concepts, Taguchi's inner and outer arrays, Parameter design strategy, Tolerance deign strategy, Illustrations through numerical examples**.** **RELIABILITY IMPROVEMENT THROUGH ROBUST DESIGN :** Role of S-N ratios in reliability improvement ; Case study; Illustrating the reliability improvement of routing process of a printed wiringboardsusing robust design concept.	10
Self-study :	
Site/Industrial Visits :	

Course outcomes:

CO1: Given a set process data, characterize the process behavior using descriptive statistics. (L1)(PO1.PO2)

CO2: Given sampled process data over time, establish control charts for monitoring processes. (L2) (PO1.PO2)

CO3: Identify if the process is in-control. If not, identify special patterns that may exist. (L2) (PO1.PO2)

CO4: Given a process that is in-control and the process specification, identify if a process is capable. (L2) (PO1.PO2)

CO5:Given a measurement system, design a plan to identify if the measurement system is capable. (L2) (PO1.PO2)

Text Books:

T1.Madhav S. Phadake,"Quality Engineering using Robust Design" Prentice Hall, Englewood Clifts, New Jersey 07632, 1st Edition,2008.

T2.DouglasMontgomery,"Design and analysis of experiments "- Willey India Pvt. Ltd., V8th Ed., 2013.

T3. Phillip J. Ross: Taguchi,"Techniques for Quality Engineering"McGraw Hill Int. Ed., 2nd edition.1996.

Reference Books:

R1. Thomas B. Barker,"Quality by Experimental Design" Marcel Dekker Inc ASQC Quality Press, 2005

R2. C.F. Jeff Wu, Michael Hamada,"Experiments planning, analysis and parameter design optimization"John Willey Ed., 2002.

R3."W.L. Condra, Marcel Dekker"Reliability improvement by Experiments: Marcel Dekker Inc ASQC Quality Press,2001

Online Resources:

W1.

W2.

Course Name: Research Methodology					
Course Code : MTME331E4					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives:

- To understand some basic concepts of research and its methodologies
- To identify appropriate research topics
- To select and define appropriate research problem and parameters
- To organize and conduct research/project in a more appropriate manner
- To write a research report and thesis

Prerequisites:

Units	**Teaching Hours**
Unit-1	
Research methodology – definition and significance, Types of research – exploratory research, conclusive research, modelling research, algorithmic research, casual research, theoretical and empirical research, cross-sectional and time series research. Research process- steps, research problems, objectives, characteristics, hypothesis and research in an evolutionary perspective	9
Unit-2	
Research design- definition, types –descriptive and experimental, validity and reliability of instrument, Validity of findings- internal and external validity, Variables in Research, types of data – primary and secondary data, methods of a data collection for scientific and business research, experiments, construction and validation of questionnaire, measurement and scaling. Types of scale – Thurstone's Case V scale model, Osgood's Semantic Differential scale, Likert scale, Q-sort scale.	9
Unit-3	
Sampling methods – Probability sampling methods – simple random sampling with replacement and without replacement, stratified sampling, cluster sampling. Non-probability sampling method – convenience sampling, judgment sampling, quota sampling. Nonparametric tests- One sample tests – one sample sign test, Kolmogorov-Smirnov test, run test for randomness, two sample tests – two sample sign test, Mann-Whitney U test, K-sample test – Kruskal Wallis test (H-test)	9
Unit-4	
Hypothesis testing – Testing of hypotheses concerning means (one mean and difference between two means – one tailed and two tailed tests), concerning variance _ one tailed Chi-square test. Introduction to Discriminant, Factor analysis, cluster analysis, multi-dimensional scaling, conjoint analysis, multiple egression and correlation, application of statistical software for data analysis.	9
Unit-5	

Report writing – types of report, guidelines to write report, typing instruction, need of summary, importance of language in the preparation of research report, oral presentation. Recording the findings of research – publication-contents to meet the journals standard – impact factor – citation and citation index, policy on academic honesty and integrity – academics cheating and plagiarism. Opportunities to carry out research projects with funding/assistance from various Government agencies.	9

Self-study :

Site/Industrial Visits :

Course outcomes:

CO1: To develop understanding of the basic framework of research process. {L1, L2} {PO1, PO2}

CO2: To develop an understanding of various research designs and techniques. {L1, L2} {PO1, PO4}

CO3: To identify various sources of information for literature review and data collection. {L1, L2, L4} {PO1, PO2, PO3, PO4}

CO4: CO4: To develop an understanding of hypothesis testing and analysis. { L-1, L-2, L-4, L-5} {PO1, PO3, PO4}

CO5: Appreciate the components of scholarly writing and evaluate its quality {L1, L2, L6} {PO8, PO10}

Text Books:

T1. Garg, B.L, Karadia R, Agarwal F, and Agarwal, "An introduction to Research Methodology", RBSA Publishers, 2002.

T2. Kothari C.R, "Research Methodology: Methods and Techniques", New Age International, 1990.

Reference Books:

R1. Sinha, S.C and Dhiman A.K, "Research Methodology", 2nd volume, Ess Publications, 2002.

R2. Trochim W.M.K, "Research Methods: the concise knowledge base", Atomic Dog Publishing, 2005.

R3. Donald R. Cooper and Pamela S. Schindler, business Research Methods, 9th edition, Tata Mcgraw Hill, 2006.

R4. Y. P. Agarwal, "Statistical Methods: Concepts, Application and Computation", Sterling Publs., Pvt., Ltd., New Delhi, 2004Gall, "Metals Hand Book", American Society for Metals, 1988.

Online Resources:

W1. https://www.coursera.org/learn/research-methods

W2. https://nptel.ac.in/downloads/121106007/

Course Name: ADVANCED THEORY OF VIBRATION					
Course Code : MTME332E1					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**50**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**03**

Course objectives

- To obtain the idea of classification of vibration, modal analysis.
- To acquire the knowledge of damping factor and measuring instruments.
- To know the DOF and the damping factors
- To understand the measuring instruments

Prerequisites: Nil

Units	**Teaching Hours**
Unit-1	
REVIEW OF MECHANICAL VIBRATIONS: Basic concepts; free vibration of single degree of freedom systems with and without damping, Forced vibration of single DOF-systems, Force and motion isolation, Two DOF-systems, natural frequency.	10
Unit-2	
TRANSIENT VIBRATION OF SINGLE DEGREE-OF FREEDOM SYSTEMS: Impulse excitation, Arbitrary excitation, Laplace transform formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation, Finite difference numerical computation.	10
Unit-3	
VIBRATION CONTROL: Introduction, Vibration isolation theory, Vibration isolation theory for harmonic excitation, practical aspects of vibration analysis, shock isolation, Dynamic vibration absorbers, and Vibration dampers. **VIBRATION MEASUREMENT AND APPLICATIONS:**Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis.	10
Unit-4	
MODAL ANALYSIS & CONDITION MONITORING: Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis. **NON LINEAR VIBRATIONS:** Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations.	10
Unit-5	
RANDOM VIBRATIONS : Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms, FTs and response.	10

CONTINUOUS SYSTEMS: Vibrating string, Longitudinal vibration of rods, Torsional vibration of rods, Suspension bridge as continuous system, Euler equation for beams, Vibration of membranes.	
Self-study :	
Site/Industrial Visits :	
Course outcomes: CO1: To learn the classification of mechanical vibration {L1, L2} {PO1, PO2, PO4} CO2: To acquire the knowledge of damping factor and transient vibration. {L1, L2, L4} {PO1, PO2, PO3, PO4} CO3: To learn about vibration control and the damping factors. {L1, L2, L6} {PO8, PO10} CO4: To understand the working of measuring instruments and condition monitoring systems. {L1, L2} {PO8, PO12} CO5: To learn random vibration and continuous systems. {L1, L2} {PO8, PO12}	
Text Books: T1. William T. Thomson, Marie Dillon Dahleh, ChandramouliPadmanabhan,"Theory of Vibration with Application", Pearson Education,5th edition,2008 T2.S. Graham Kelly,"Fundamentals of Mechanical Vibration". McGraw Hill.2nd edition,2000 T3. S. S. Rao., "Mechanical Vibrations",Pearson Education,4th edition,2003	
Reference Books: R1. S. Graham Kelly,"MechanicalVibrations"Schaum's Outlines, Tata McGraw Hill, 2007.	
Online Resources: W1. W2.	

Course Name: OPTIMUM DESIGN					
Course Code : MTME332E2					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**50**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**03**

Course objectives

- Introduction to classical optimization technique.
- To learn non-linear programming
- To know the constrained optimization techniques.

Prerequisites: Nil

Units	**Teaching Hours**
Unit-1	
INTRODUCTION: Engineering application of optimization, Statement of optimization problem, Classification of optimization problems, **CLASSICAL OPTIMIZATION TECHNIQUES:** single variable optimization, Multivariable optimization with no constraints.	10
Unit-2	
CLASSICAL OPTIMIZATION TECHNIQUES II: Multivariable optimization with equality constraints and inequality constraints, Kuhn - Tucker conditions. **NON - LINEAR PROGRAMMING: One -** dimensional minimization methods**:** Unimodal function, Unrestricted search, Exhaustrive search, Dichotomous search, Fibonacci method, Golden section method.	10
Unit-3	
INTERPOLATION METHODS: Quadratic, Cubic and Direct root interpolation methods. **UNCONSTRAINED OPTIMIZATION TECHNIQUES:** Direct search methods**:** Univariate method, Hook and Jeeves' method, Powell's method, Simplex method.	10
Unit-4	
DESCENT METHODS: Steepest descent, Conjugate gradient, Quasi - Newton, Davidon - Fletcher - Powell method. **CONSTRAINED OPTIMIZATION TECHNIQUES:**Direct methods: characteristics of a constrained problem, Indirect methods: Transformation techniques, Basic approach of the penalty function method.	10
Unit-5	
DYNAMIC PROGRAMMING: Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming, Initial value problem, Examples.	10
Self-study :	
Site/Industrial Visits :	

Course outcomes:

CO1. Students will know the principles of optimization. {L1,2}{PO1,2}
CO 2. Students will have knowledge of algorithms for design optimization. {L1,2}{PO1,2,3}
CO 3. Students will be able to formulate an optimization problem. {L3}{PO1,2,3}
CO 4. Students should be able to find the optimum solution of their problems using optimization techniques. {L3}{PO1,2,3}

Text Books:

T1. S. S. Rao, "Optimisation - Theory and Application" - Willey Eastern.
T2. R.L Fox,"Optimization methods for Engg. Design "Addison – Wesley.

Reference Books:

R1. Ram,"Optimisation and Probability in System Engg"VanNostrand.
R2. K. V. Mital and C. Mohan, "Optimization methods" - New age International Publishers, 2016

Online Resources:

W1.
W2.

Course Name: VEHICLE DYNAMICS					
Course Code : MTME332E3					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**50**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**03**

Course objectives

- To know the response of idealized suspension systems.
- To learn sinusoidal transmissibility function to predict means square motion of spring mass.
- Find the kinematic behavior of vehicles with rigid wheels and with compliant tyres

Prerequisites: Nil

Units	**Teaching Hours**
Unit-1	
VEHICLE RIDE: Human response to vibration: ISO standards, Response of idealized suspension systems to stop and sinusoidal disturbances in bounce and to wheel out of balance. Combined pitch and bounce motion: application to multi wheel station vehicles. Random ground input excitation: Use of sinusoidal transmissibility function to predict mean square motion of spring mass.	10
Unit-2	
WHEELED VEHICLE HANDLING: Handling control loop, vehicle transfer function. Kinematic behavior of vehicles with rigid wheels and with compliant tyres: neutral steer point, static margin, over and under-steer.	10
Unit-3	
TRANSIENT RESPONSE: Natural frequency and damping in yaw. Frequency response in yaw. Extension of two degree of freedom theory to include effects of traction and braking, aerodynamics, self-aligning torque, dual wheels and bogies, Handling of multi-axle vehicles. Development of equations of motion to include roll of sprung mass: Effect on steady state and frequency response.	10
Unit-4	
TRACKED VEHICLE HANDLING: Analysis of sprocket torques and speeds, required to skid steer a tracked vehicle. Extension of theory to include three degrees of freedom.Modification of theory to allow for soil conditions and lateral weight transfer Application of theory of steering of articulated and half-track vehicles.	10
Unit-5	
DERIVATION OF GENERALIZED EQUATIONS: Equation of motion for a vehicle: stability derivative notation. Solution with two degree of freedom in the steady state: stability factor, characteristic and critical speeds.	10

Self-study :
Site/Industrial Visits :
Course outcomes: CO1: Simulate acceleration and braking performance of common vehicles(L4)(PO1,PO2,P3) CO2: Model the normal road loads acting on vehicles(L3) (PO1,PO2,P3) CO3: Model and simulate suspension forces due to road inputs and steady state cornering forces(L4) (PO1,PO2,P3) CO4: Design and simulate common suspension and steering geometries(L4) (PO1,PO2,P3) CO5: Apply tire properties to vehicle performance(L5) (PO1,PO2,P3)
Text Books: T1. Vehicle Dynamics, 19&9,IR Ellis, Business Book. T2. Theory of Ground vehicles, 2001,JY Wong, Wily.
Reference Books: R1. Vehicles & Bridging, igSs/Tytler, Brassey's. R2. Fundamental of vehicle dynamics: Thomas D Gillespie
Online Resources: W1. W2.

Course Name: TRIBOLOGY AND BEARING DESIGN					
Course Code : MTME333E1					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**50**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**03**

Course objectives

- To study the types of contacts, types of bearing.
- Design a bearing based on their application and types of load.
- To know the response of idealized bearing systems.

Prerequisites: Nil

Units	**Teaching Hours**
Unit-1	
INTRODUCTION TO TRIBOLOGY: Introduction, Friction, Wear, Wear Characterization, Regimes of lubrication, Classification of contacts, lubrication theories. Newton's Law of viscous forces, Effect of pressure and temperature on viscosity. **HYDRODYNAMIC LUBRICATION:** Newton's Law of viscous forces, Flow through stationary parallel plates. Hagen's poiseuille's theory, viscometers.Numerical problems, Concept of lightly loaded bearings, Petroff's equation, Numerical problems.	10
Unit-2	
HYDRODYNAMIC BEARINGS: Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynolds's 2D equation with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity.Location of center of pressure, Numerical problems. **JOURNAL BEARINGS:** Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Sommerfeld number and its significance. Comparison between lightly loaded and heavily loaded bearings, Numerical problems.	10
Unit-3	
EHL CONTACTS: Introduction to Elasto - hydrodynamic lubricated bearings. Introduction to 'EHL' constant.Grubin type solution. Introduction to gas lubricated bearings. Governing differential equation for gas lubricated bearings.	10
Unit-4	
HYDROSTATIC BEARINGS: Types of hydrostatic Lubrication systems Expression for discharge, load carrying capacity, Flow rate, Condition for minimum power loss. Torque calculations.Numerical problems. **POROUS & GAS BEARINGS:** Introduction to porous bearings. Equations for porous bearings and working principal, Fretting phenomenon and it's stages	10
Unit-5	

MAGNETIC BEARINGS: Introduction to magnetic bearings, Active magnetic bearings. Different equations used in magnetic bearings and working principal.Advantages and disadvantages of magnetic bearings, Electrical analogy, Magneto-hydrodynamic bearings.speeds.	10
Self-study :	
Site/Industrial Visits :	
Course outcomes: **CO1:** To understand the principles of tribology for selecting compatible materials for minimizing friction and wear in machinery. {L1, L2} {PO1, PO2} **CO2:** To understand the principles of bearing selection based on the application. {L1, L2} {PO1, PO2, PO3} **CO3:** To learn the computations required for selecting and designing bearings in machines. {L2, L3, L4} {PO1, PO2, PO3, PO4} **CO4:** To understand the fundamental principles of gas lubricated bearings. {L1, L2} {PO1, PO2, PO3} **CO5:** To understand the fundamental principles of magnetic bearings .{L2, L3, L5} {PO1, PO2 PO3, PO4}	
Text Books: T1. Mujamdar.B.C "Introduction to Tribology of Bearing", Wheeler Publishing, New Delhi 2001. T2. Susheel Kumar Srivasthava "Tribology in industry" S.Chand and Co. .	
Reference Books: T1. Dudley D.Fulier" Theory and practice of Lubrication for Engineers", New York Company.1998 T2. Moore "Principles and applications of Tribology" Pergamon press. T3. Pinkus '0' Stemitch. "Theory of Hydrodynamic Lubrication" T4. Gerhandschwetizer, HannesBleuler&AlfonsTraxler, "Active Magnetic bearings", Authors working group, www.mcgs.ch., 2003. T5. Radixmovsky, "Lubrication of Bearings - Theoretical principles and design" The Oxford press Company, 2000.	
Online Resources: W1. W2.	

Course Name: Theory of Plates and shells					
Course Code : MTME333E2					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**45**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**3**

Course objectives:

- To facilitate the students to appreciate the shell structures, stresses in a plates and the different load conditions.
- To impart the knowledge of symmetrical bending for cylindrical and rectangular plates.
- To be able to find the bending of plates using differential equation for certain plates under different boundary and loading condition.
- To understand the analytical and numerical techniques to design the plates and shells for practical applications.
- To course aims at enumerating the behaviour of plates and shell elements.

Prerequisites: Strength of Materials, Design of Machine Elements

Units	**Teaching Hours**
Unit-1	
BENDING OF LONG RECTANGULAR PLATE INTO A CYLINDRICAL SURFACE, DIFFERENTIAL EQUATION- Bending of plated with different boundary conditions - Long plate on elastic foundation. PURE BENDING: Moment and curvature relations problems of simply supported plates-Strain energy impure bending.	9
Unit-2	
SYMMETRICAL BENDING OF CIRCULAR PLATES: Differential equation uniformly loaded plates, Plates concentricity loaded plates- loaded at the center.	9
Unit-3	
RECTANGULAR PLATES: Differential equations - Solution of simply supported plate Various loading conditions, viz, uniformly distributed load, hydrostatic pressure and concentrated load, central as well as noncentral, Navier and Levy type solutions with various edge boundary conditions, viz., all edges simply supported, Two opposite edge fixed and two adjacent fixed. **BENDING OF PLATE UNDER COMBINED ACTION:** of lateral and transverse loads derivation of differential equation, simply supported rectangular plate.	9
Unit-4	
INTRODUCTION TO SHELL STRUCTURES- General description of various types. Membrane Theory of thin shells (Stress Analysis): Cylindrical shells - Spherical Shells- Shells of double curvature, Viz, cooling tower Hyperbolic, Parabolic and elliptic paraboloid.	9

MEMBRANE DEFORMATION OF SHELLS: Symmetrical 'loaded shell, symmetrically loaded spherical shell. General Theory of cylindrical shells: Circular; Cylindrical shell loaded symmetrically.	
Unit-5	
General equation of circular cylindrical shells. Approximate investigation of: bending of circular cylindrical shell.	9
Self-study :	
Site/Industrial Visits :	
Course outcomes: CO1: {Analyse the solutions of bending of rectangular plates into a cylindrical surface with different boundary conditions.} {L1, L2, L3} {PO1, PO2, PO3} CO2: {Apply the analytical methods to find the solutions for the circular plates subjected to symmetric bending}{L1, L2, L3 }{PO1, PO2, PO3} CO3: {Analyse the solutions of simply supported plate various loading conditions and bending of plate under combined action.} { L1, L2, L3} {PO1, PO2, PO3} CO4: {Discuss the various types of shell structure and membrane deformation of shells.} { L1, L2, L3} {PO1, PO2, PO3} CO5: {Apply the numerical techniques and tools for bending of circular cylindrical shells.} { L1, L2, L3} {PO1, PO2, PO3}	
Text Books: T1. Timoshenko, Woinowsky and Krieger, "Theory of plates and Shells" McGraw Hill, Newyork.2ND Edition,2017 T2. Flugge, "Stresses in Shells "Springer Verlag, Berlin.	
Reference Books: R1. Goldnvizer,"Theory of Elastic Thin Shells" - Pergamon Press, New York,2014	
Online Resources: W1. https://nptel.ac.in/courses/112101095/34	

Course Name: ADVANCED MECHANISMS DESIGN AND SIMULATION					
Course Code : MTME333E3					
	L	**T**	**P**	Category	**PEC**
Contact Hrs./Week	**3**	**0**	**0**	CIA Marks	**50**
Contact Hrs./Sem.	**50**	**0**	**0**	ESE Marks	**50**
Credits.	**3**	**0**	**0**	Exam Hours	**03**

Course objectives

- To know the modelling and simulation of physical systems.
- To learn study of sensors and transducers and electrical actuation
- To know the simulation and its concept.

Prerequisites: Nil

Units	**Teaching Hours**
Unit-1	
INTRODUCTION: Definition and Introduction to Mechatronic Systems. Modeling & Simulation of Physical systems Overview of Mechatronic Products and their functioning measurement systems.Control**.** **STUDY OF SENSORS AND TRANSDUCERS:**Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics.	10
Unit-2	
ELECTRICAL ACTUATION SYSTEMS: Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors. **SYSTEM MODELS:** Mathematical models:- mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic system	10
Unit-3	
SIGNAL CONDITIONING: Signal conditioning, the operational amplifier, Protection, Filtering, Wheatstone Bridge, Digital signals , Multiplexers, Data Acquisition, Introduction to digital system processing, pulse-modulation. **MEMS AND MICROSYSTEMS:** Introduction, Working Principle, Materials for MEMS and Microsystems, Micro System fabrication process, Overview of Micro Manufacturing, Micro system Design, and Micro system Packaging.	10
Unit-4	
DATA PRESENTATION SYSTEMS: Basic System Models, System Models, Dynamic Responses of System.	10
Unit-5	
ADVANCED APPLICATIONS IN MECHATRONICS: Fault Finding, Design, Arrangements and Practical Case Studies, Design for manufacturing, User-friendly design.	10
Self-study :	

Site/Industrial Visits :

Course outcomes:

CO1: Design a mechatronics system for a specific application(L4)(POPO1,PO2,PO3,PO5)
CO2: Select the sensors and actuators required for mechatronics system (L3) (POPO1,PO2,PO3)
CO3: Design a signal conditioning circuit (L4) (POPO1,PO2,PO3,PO5)
CO4: Understand dynamics and control of a mechatronics system(L2) (POPO1,PO2,PO3,PO5)
CO5: Understand MEMS based systems and their fabrication methods(L2) (POPO1,PO2,PO3,PO5)

Text Books:

1. W. Bolton, "Mechatronics" 2 Ed. earson Education; 4 edition ,2010
2. HSU "MEMS and Microsystems design and manufacture"- TMH McGraw Hill Education; 1 edition ,2017

Reference Books:

1. Kamm, "Understanding Electro-Mechanical Engineering an Introduction to Mechatronics"- PHI. Wiley-Blackwell , 1995
2. "Fine Mechanics and Precision Instruments"- Pergamon Press, .1971.
3. Shetty and Kolk "Mechatronics System Design"-Thomson,Cengage; 2 edition 2012
4. Mahalik "Mechatronics"- TMH.
5. "Mechatronics"– HMT, TMH.
6. Michel .B. Histand&David"Introduction to Mechatronics & Measurement Systems"–. Alciatore.McGraw Hill Education; 4 edition ,July 2017

Online Resources:

W1.
W2.