MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

(Autonomous Institutionunder APJ Abdul Kalam Technological University)

Curriculum and Syllabus

of

Master of Technology in Engineering

Machine Design

(Year of Introduction:2022)

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MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY (AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

M.TECH DEGREE PROGRAMME

IN

MACHINE DESIGN

CURRICULUM AND DETAILED SYLLABI

Semesters I to II

Items	Board of Studies (BoS)	Academic council (AC)
Date of Approval	11-08-2022	15-11-2022

Head of Department
Chairman, Board of Studies (MED)

Principal
Chairman, Academic Council

Preface:

The exercise of preparing the draft M.Tech curriculum is undertaken to bring our curriculum in line with the curriculum being drafted by the University (KTU). The proposed PG programme is spread over two years in four semesters. Inclusion of audit courses, dissertation and research are the special features of the curriculum. The students are asked to learn IPR/ research methodology to understand importance and process of creation of patents through research. The revised curriculum shall make students capable to work in industrial environments.

The dissertation/research work of one-year duration is given strong weightage in the curriculum. It is expected that students will undertake industrially relevant problem to develop an optimal solution through extensive research work. At the completion of second semester, students will have to choose from two tracks of dissertation and research. The research track will be open to only those students who have secured a CGPA of 8.5 as well as a valid GATE score. These students are also required to publish a journal article in their third semester.

The students and faculty can design the research project in consultant with industry preferably in Trivandrum. The planning of laboratory work/ modelling/ computational work with execution schedule is suggested to facilitate creation of patents from the result of the programme.The students with advance knowledge and special skills would be able to offer innovative ideas, technology, product and process and fulfil their career goals.

This draft curriculum is open for taking feedback from stakeholders, experts from industry, research organizations and alumni to make it relevant, dynamic and updated.

Distinct features of the proposed M.Tech Curriculum

i) Standardized academic structure for all PG Programs with uniform credit distribution
ii) Advanced study of specialization through core subjects, flexible and diverse program specific electives
iii) Enhanced engagement of industry in developing innovations and problem solutions.Program elective 4isan industry based elective/ MOOC.
iv) Collaborative and interactive learning to ensure talent development.
v) Focus on development of advanced knowledge and specific skills required for industrial development.
vi) Focus on competency development of learner.
vii) Project-based, problem-based, site visit based or any experiential learning method for the theory courses.
viii) On-site experience for every student during the course.
ix) An industrial or research collaboration duringthe course.
x) Encouragement for students to make journal publications.
xi) Students will be permitted to avail a leave of absence for two semesters at a stretch during the course.

Semester wise distribution of credits

Semester	Credits
M1	**18**
M2	**18**
M3	**16**
M4	**16**
Total credits	**68**

1 hour of Lecture/ Tutorial per week: 1 credit

2 hours of Laboratory/ project per week: 1 credit

Semester wise details of the courses

Semester I (M1)

Slot	Course Code	Course Type	Course	Marks		Hours	Credits
				CIA	ESE	L - T - P	
A	22ME160A	DCC	Computational Methods for Engineers	40	60	3 – 0 - 0	3
B	22ME161A	PCC	Advanced Theory of Vibration	40	60	3 – 0 - 0	3
C	22ME161B	PCC	Advanced Mechanics of Solids	40	60	3 – 0 - 0	3
D		PEC	Program Elective 1	40	60	3 – 0 - 0	3
E		PEC	Program Elective 2	40	60	3 – 0 - 0	3
S	22MC160A	RM	Research Methodology & IPR	40	60	2 – 0 - 0	2
T	22ME169A	LBC	Mechanical Design Lab	100	-	0 – 0 - 2	1
Total				**340**	**360**	**19**	**18**

Teaching Assistance:6 hours

Semester II (M2)

Slot	Course Code	Course Type	Course	Marks		Hours	Credits
				CIA	ESE	L - T - P	
A	22ME160B	DCC	Design of Experiments	40	60	3 – 0 - 0	3
B	22ME161C	PCC	Finite Element Method	40	60	3 – 0 - 0	3
C		PEC	Program Elective 3	40	60	3 – 0 - 0	3
D		PEC	Program Elective 4	40	60	3 – 0 - 0	3
E		IEC	Industry/Interdisciplinary Elective	40	60	3 – 0 - 0	3
S		PR	Mini project	100	-	0 – 0 - 4	2
T	22ME169B	LBC	Computational Analysis Lab	100	-	0 – 0 - 2	1
Total				**400**	**300**	**21**	**18**

Teaching Assistance:6 hours

Semester III (M3)

Slot	Course Type	Course	Marks		Hours	Credits
			CIA	ESE	L - T - P	
TRACK 1						
A*	MOOC	MOOC	To be successfully completed		-	2
B	AC	Audit Course	40	60	3 – 0 - 0	-
C	PR	Internship	50	50	-	3

D	PR	Dissertation Phase I	100	-	0 – 0 - 17	11
TRACK 2						
A*	MOOC	MOOC	To be successfully completed		-	2
B	AC	Audit Course	40	60	3 – 0 - 0	-
C	PR	Internship	50	50	-	3
D	PR	Research project Phase I	100	-	0 – 0 - 17	11
Total			**190**	**110**	**20**	**16**

Teaching Assistance:6 hours

*MOOC must be successfully completed before the commencement of fourth semester. This course can be carried out at any time from M1 to M3.

Semester IV (M4)

Slot	Course Type	Course	Marks		Hours	Credits
			CIA	ESE	L - T - P	
TRACK 1						
D	PR	Dissertation Phase II	100	100	0 – 0 - 24	16
TRACK 2						
D	PR	Research project Phase II	100	100	0 – 0 - 24	16
Total			**100**	**100**	**24**	**16**

Teaching Assistance:5 hours

3) Elective courses

a) Program Elective courses

List of Program Elective courses

#	Course code	Course Name
1	**22ME162A**	Fracture Mechanics
2	**22ME162B**	Acoustics and Noise Control
3	**22ME162C**	Robotics
4	**22ME162D**	Mechanical Behaviour of Materials
5	**22ME162E**	Design and Analysis of Composite Structures
6	**22ME162F**	Advanced Theory of Mechanisms
7	**22ME162G**	Rotor Dynamics
8	**22ME162H**	Mechatronic System Design
9	**22ME162I**	Design of Power Transmission Elements
10	**22ME162J**	Optimization Techniques in Engineering
11	**22ME162K**	Theory of Plates and Shells
12	**22ME162L**	Advanced Vehicle Dynamics
13	**22ME162M**	Design of Pressure Vessels and Piping
14	**22ME162N**	Experimental Stress Analysis
15	**22ME162O**	Industrial Tribology
16	**22ME162P**	Modelling, Simulation and Analysis of Engineering Systems

b) Interdisciplinary courses

List of Interdisciplinary courses

#	Course code	Course Name	Offering Department
	22ME165A	Integrated Product Design and Process Development	Mechanical Engineering
	22ME165B	Advanced Non-Destructive Evaluation	Mechanical Engineering
	22ME165C	Introduction to 3D Printing Technology	Mechanical Engineering

Minimum Cumulative Credit Requirements for Registering to Higher Semesters

Semester	Allotted credits	Cumulative credits	Minimum credits required
M1	18	18	Not Applicable
M2	18	36	Not Insisted
M3	16	52	12 credits from M1
M4	16	68	Not Insisted

Grade and Grade Points

Grades	Grade Point	% of Total marks obtained in the course
S	10	90% and above
A+	9	85% and above but less than 90%
A	8.5	80% and above but less than 85%
B+	8	75% and above but less than 80%
B	7.5	70% and above but less than 75%
C+	7	65% and above but less than 70%
C	6.5	60% and above but less than 65%
D	6	55% and above but less than 60%
P (Pass)	5.5	50% and above but less than 55%
F (Fail)	0	Below 50% (CIA + ESE) or Below 45% for ESE
FE	0	Failed due to lack of eligibility criteria
AB	0	Could not appear for the ESE, but fulfils the eligibility criteria
I	0	Failure to submit the certificate of successful completion of MOOC by the end of Semester 3

ASSESSMENT PATTERN

(i) CORE COURSES

Evaluation shall be based on application, analysis or design based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Micro project/Course based project:	20 marks
Course based task/Seminar/Quiz:	10 marks
One Test paper:	10 marks

End Semester Examination: 60 marks

There will be two parts: Part A and Part B.

Part A contain 5 questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions.

Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks.

Total duration of the examination will be 150 minutes.

(ii) PROGRAM ELECTIVE COURSES

Evaluation shall be based on application, analysis or design based questions (for both internal and end semester examinations). If the program elective is an industry based elective, the evaluation will be as per (vi) below. If it is a MOOC, the evaluation will be as per (vii) below.

Continuous Internal Evaluation: 40 marks

Developing a review article based on peer reviewed original publications:15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks One
Test paper: 10 marks

End Semester Examination: 60 marks

There will be two parts: Part A and Part B.

Part A will contain 5 multiple choice/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students shall answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

(iii) RESEARCH METHODOLOGY & IPR

Continuous Internal Evaluation: 40 marks

Assignment (Individual task/Seminar/Problem solving): 20 marks
Two Test papers: 20 marks

End Semester Examination: 60 marks

The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

(iv) INTERNSHIP

A student shall opt for carrying out the Internship at an Industry/Research Organization or at another institute of higher learning and repute (Academia). The organization for Internship shall be selected/decided by the students on their own with prior approval from the faculty advisor, Supervisor, and HoD. Every student shall be assigned an internship Supervisor at the beginning of the Internship. The training shall be related to their specialization during the summer vacation and beginning of third semester for a minimum duration of four weeks and a maximum duration of six weeks. On completion of the course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

Guidelines:¬

i) All the students need to go for internship for minimum of 4 weeks.

ii) Students can take mini projects, assignments, case studies by discussing it with concerned authority from industry and can work on it during internship.

iii) All students should compulsorily follow the rules and regulations as laid by industry. Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any other document from industry.

iv) Student should follow all ethical practices and Standard Operating Procedure (SOP) of industry.

v) Students have to take necessary health and safety precautions as laid by the industry.

vi) Student shall contact his /her Supervisor from college on weekly basis to communicate the progress.

vii) Each student has to maintain a log book.

(v) LABORATORY COURSES

Continuous Internal Evaluation: 100 marks

These courses will be having only Continuous Internal Evaluation. Final assessment shall be done by two examiners from the department. ,one examiner from a sister department.

(vi) INDUSTRY BASED ELECTIVES

Continuous Internal Evaluation: 40 marks

The internal evaluation will be done by the respective Industry according to the evaluation plan provided by the College.

End Semester Examination: 60 marks

The examination will be conducted by the College with the question paper provided by the Industry. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question carries 12 marks. The valuation of the answer scripts shall be done by the experts from Industry.

(vii) MOOC COURSES

Total marks: 100.

The MOOC course shall be considered only if it is conducted by the agencies namely AICTE/NPTEL/SWAYAM or NITTTR. The MOOC course should have a minimum duration of 8 weeks and the content of the syllabus shall be enough for at least 40 hours of teaching. The course should have a proctored end semester examination. The list of MOOC courses will be provided by the concerned BoS if at least 70% of the course content match with the area/stream of study. The course shall not be considered if its content has more than 50% of overlap with a core/elective course in the concerned discipline or with an open elective.

The mark will be distributed between internal marks and end semester marks in the ratio 2:3, based on the marks scored in the proctored examination.

(viii) MINIPROJECT

Total marks: 100.

Mini project has only Continuous internal assessment. Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problemsolving skills. The mini projects ensure preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with Faculty advisor, that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Interim evaluation: 40

20 marks for each interim review.

Final evaluation by the committee: 60 marks

The level of completion and demonstration of functionality/specifications, clarity of presentation, oral examination, work knowledge and involvement: 35 marks
Report (The technical content, adequacy of references, templates followed and permitted plagiarism level is not more than 25%): 15 marks
Supervisor: 10 marks

(ix) RESEARCH PROJECT/DISSERTATION:

Phase -1

Total marks: 100.

1) There will be three interim progress review of the Project (Phase I). The first review shall focus on the topic, and objectives. This review will be conducted within one month of the commencement of third semester classes.

2) The second review shall focus on the methodology. This review will be conducted within two months of the commencement of third semester classes.

3) The third review shall focus on the design and expected results, and scope of the work which has to be accomplished in the fourth semester. This review will be conducted towards the close of the third semester.

Phase -2

Total marks: 100.

1) There will be three interim progress review of the Project (Phase II). The first review shall focus on the progress of the implementation of the design made in Project (Phase I). This review will be conducted within one month of the commencement of third semester classes.

2) The second review shall focus on the quality and quantum of the work completed. This review will be conducted within two months of the commencement of third semester classes.

3) The third review shall focus on the completed implementation and the results. This review will be conducted towards the close of the third semester.

4) At least one technical paper has to be prepared and published in journals / conferences based on their project work.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME160A	Computational Methods for Engineers	DCC	3	0	0	3	2022

1) **Course Objectives:** The goal of the course is toprovide the students with a solid foundation of the theory of Numerical Techniques thus equipping them to solve mathematical models of engineering systems. Focus is on implementationof numerical methods in MATLAB.

2) **Course Outcomes:**

After the completion of the course the student will be able to:

#	Description	Level
CO1	Apply numerical methods to find out solution of linear and nonlinear algebraic equations and analyse various errors associated with numerical techniques	Apply
CO2	Apply various interpolation methods and finite difference concepts	Apply
CO3	Apply numerical differentiation and integration methods whenever and wherever routine methods are not applicable.	Apply
CO4	Solve numerically the ordinary differential equations using different methods.	Apply
CO5	Solve numerically the partial differential equations using different methods	Apply

3) **Syllabus:** Introduction to MATLAB Programming, Approximations and Errors, Numerical Differentiation and Integration, Linear and Nonlinear equations, Regression and interpolation, Solution of Ordinary and Partial Differential Equations.

4) **References:**

i) Schilling R.J and Harris S L, "Applied Numerical Methods for Engineering using MatLab and C", Brooks/Cole Publishing Co., 2000.

ii) .Chapra S C and Canale R P, "Numerical Methods for Engineers", McGraw Hill, 2016.

iii) SanthoshK.Gupta, "Numerical Methods for Engineers", New age international publishers, 2005.

5) Course Plan:

Module	Contents	Hours
I	Introduction to MATLAB, Basics of MATLAB programming, Array operations in MATLAB, Loops and execution control, Working with files: Scripts and Functions, Plotting and program output. Defining errors and precision in numerical methods, Truncation and round-off errors, Error propagation, Global and local truncation errors.	**9**
II	Numerical Differentiation in single variable, Numerical differentiation: Higher derivatives, Differentiation in multiple variables, Newton-Cotes integration formulae, Multi-step application of Trapezoidal rule, MATLAB functions for integration	**9**
III	Linear algebra in MATLAB, Gauss Elimination, LU decomposition and partial pivoting Iterative methods: Gauss Siedel, Special Matrices: Tri-diagonal matrix algorithm. Nonlinear equations in single variable, MATLAB function fzero in single variable, Fixed-point iteration in single variable Newton-Raphson in single variable, MATLAB function fsolve in single and multiple variables, Newton-Raphson in multiple variables	**9**
IV	Introduction to Linear least squares regression(including lsqcurvefit function), Functional and nonlinear regression (including lsqnonlin function), Interpolation in MATLAB using spline and pchip Introduction to ODEs; Implicit and explicit Euler's methods, Second-Order Runge-Kutta Methods MATLAB ode45 algorithm in single variable Higher order Runge-Kutta methods Error analysis of Runge-Kutta method	**9**
V	MATLAB ode45 algorithm in multiple variables, Stiff ODEs and MATLAB ode15s algorithm, Practical example for ODE-IVP, Solution of Partial differential Equations. Types. Solving transient PDE using Method of Lines.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME161A	ADVANCED THEORY OF VIBRATIONS	PCC	3	0	0	3	2022

1) Course Objectives:

The objective of this course is

- To understand the principles of vibration theory
- To introduce techniques for solving vibration problems.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Derive the differential equations of motion of a vibrating system.	Apply
CO2	Determine the natural frequencies and response to free vibrations and to external periodic forces.	Analyse
CO3	Apply the matrix methods and other numerical approaches to solve multi degree of freedom systems.	Apply
CO4	Analyse the free vibration of continuous systems.	Analyse

3)Syllabus:

Analysis of un-damped, damped, free and forced SDOF systems, non-periodic excitation of Single DOF systems. Two degree of freedom systems -dynamic vibration absorbers.
Multi-degree freedom system Matrix formulation.Lagrange's equation, Matrix Iteration, Holzer method.
Vibration of continuous system. Approximate numerical methods, Introduction to nonlinear vibrations.

4) References:

i) Leonard Meirovitch, Elements of Vibrations Analysis, Tata McGraw Hill - 2007
ii) Thomson W.T, Theory of Vibration with Applications, Pearson Education; 5 Edition, 2008.
iii) S. Graham Kelly, Mechanical Vibrations, Schaum's Outline Series, Tata McGraw Hill 2011 Special Indian Edition
iv) S.S Rao, Mechanical Vibrations, Pearson Education India; Sixth edition, 2018.
v) Den Hartog, J P, Mechanical Vibrations, McGrawHill, 1956.

5) Course Plan:

Module	Contents	Hours
I	Oscillatory motion – Periodic motion- Analysis of un-damped, damped , free vibration- Logarithmic decrement – Introduction to harmonically excited vibrations.-Numerical problems Forced Vibration- magnification factor – Rotating and revolving unbalance – Base excitation – transmissibility – Vibration isolation-Structural damping- Numerical problems	9
II	Transients – non periodic excitation of Single DOF systems – Impulse excitation- Convolution Integral – Laplace Transform- Shock response spectrum Two degree of freedom systems – normal modes and natural frequencies – Principal co-ordinates –co-ordinate coupling - dynamic vibration absorbers – Vibration Damper- Numerical problems	9
III	Introduction to multi-degree freedom system - Matrix formulation- Influence coefficients- Flexibility and stiffness- Orthogonality of Eigen vectors. Lagrange‘s equation – Generalized co-ordinates- Virtual work – Derivation of Lagrange‘s equation- Mode summation	9
IV	Eigen Value problem-Eigen value and Eigen vectors. Frequency mode shape -Modal analysis. Matrix Iteration– Sweeping methods- Cholesky Decomposition. – Jacobi diagonalisation- Holzer's method. Numerical problems	9
V	Vibration of continuous system-Transverse vibration of strings- Longitudinal vibration of Rods. Torsional vibration of Rods- Euler Equation for beams- Numerical problems. Approximate numerical methods- Dunkerley's method - Rayleigh method – Rayleigh –Ritz method .	9
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME161B	Advanced Mechanics of Solids	PCC	3	0	0	3	2022

1) Course Objectives:

1. Establish the concepts of continuum theory and apply the principles of indicial notations, tensors, and transformations to demonstrate the characteristics of motion and deformation.
2. Inculcate the knowledge to formulate & solve continuum-based problems in the area of Solid Mechanics.
3. Inculcate the concepts of deformation, strain, and stress measures for the case of finite and infinitesimal deformations for different load bearing members under different configurations.
4. Familiarize methods to solve and analyze special problems like torsion in prismatic bars, stresses & deflections in beams subjected to unsymmetrical bending.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Demonstrate and solve the characteristics of motion and deformation of continua utilizing the concepts of indicial notations, tensors, and transformations, based on the continuum theory	Apply
CO2	Develop and apply material constitutive laws, compatibility conditions, and governing equations using different measures of stresses and strains	Apply
CO3	Formulate and solve continuum-based problems in the area of Solid Mechanics for different loading conditions	Apply
CO4	Analyze stresses, strains, and deflections using the Energy method	Apply
CO5	Analyze special problems like torsion in prismatic bars, stresses & deflections in beams subjected to unsymmetrical bending	Apply

3) Syllabus:

Introduction to Continuum Theory & Continuum Approach, Analysis of stress and strain, Planar problems: Plane Stress and Plane Strain, Mohr's circle for three dimensional stresses. Airy's stress function, Saint venant's principle. Lame's thick cylinder problem. Thin rotating discs of uniform thickness, solid disc and disc with a central hole.Membrane analogy, torsion of a narrow rectangular section. Thin rectangular plates.Thin spherical shell.Concept of shear center in symmetrical and unsymmetrical bending, stress and deflections in beams subjected to unsymmetrical bending.Energy methods for analysis of stress, strain and deflection.

4) References:

1.G. T. Mase, R. E. Smelser and G. E. Mase, Continuum Mechanics for Engineers, Third Edition, CRC Press, 2004.

2.Sadd, Martin H., "Elasticity: Theory, applications and Numeric", Academic Press, 2005.

3.L. S. Srinath, "Advanced Mechanics of Solids", Third Edition, Tata McGraw-Hill, 2009.

4.S. P. Timoshenko and J. N. Goodier, "Theory of Elasticity", Third Edition, Tata McGraw-Hill, 2010.

5) Course Plan:

Module	Contents	Hours
I	Introduction to Continuum Theory & Continuum Approach: Vectors and Tensors, Stress Tensor & Principles, Analysis of stress, strain, displacement-equation of equilibrium, constitutive relations, kinematics relations, compatibility equations, boundary conditions-in Cartesian and polar coordinates. Mohr's circle for three dimensional stresses.	**9**
II	Airy's stress function – Saint venant's principle-plane stress and plane strain problems-problem of a cantilever carrying a point load at the free end, problem of a simply supported beam carrying a uniformly distributed load throughout-Lame's thick cylinder problem	**9**
III	Thin rotating discs of uniform thickness, solid disc and disc with a central hole, stress concentration, necessity for varying thickness. Concept of shear center in symmetrical and unsymmetrical bending, stress and deflections in beams subjected to unsymmetrical bending	**9**
IV	Membrane analogy, torsion of a narrow rectangular section. Thin rectangular plates-governing differential equation, boundary conditions- Navier solution for a rectangular plate carrying a uniformly distributed load – Thin spherical shell.	**9**
V	Energy method for analysis of stress, strain and deflection: Theorem of virtual work, Theorem of least work, Castigliano's theorem, Rayleigh Ritz method, Galerkin's method	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22MC160A	Research Methodology & IPR	RM	2	0	0	2	2022

1) Course Objectives:

This course is intended to prepare the M. Tech students to carry out their dissertation/ research project work effectively, with a research bias. The student will be able to formulate a viable research problem, do a critical analysis of publications in the area of research, and identify a research method suitable for the work. The student will achieve the capability to write a technical paper based on his/her dissertation/ research project.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Explain research ethics, Citation, Impact factor and Plagiarism.	Apply
CO2	Formulate a research problem, make a suitable research design, and identify the data collection methods.	Apply
CO3	Analyse the collected data.	Analyse
CO4	Explain the role of IPR and Patent law in fostering research work, leading to creation of improved products, thus supporting economic growth and social benefits.	Apply
CO5	Write a technical paper for publication.	Apply

3) Syllabus:

Introduction to Research Methodology- motivation for research, types of research, ethical issues. Identifying a research area and collecting related literature. Research problem- scope-objectives, literature review, identifying research gaps, and formulate the research problem. Research design and methods, data collection and analysis.Copy right – royalty - IPR and patent law.Process of patenting and development, Procedure for grant of patents.Copy left-open access, citation, plagiarism, iImpact factor.Writing a technical paper.

4) References:

1.Stuart Melville and Wayne Goddard, *Research methodology: an introduction for science & engineering students.*
2. .Ranjit Kumar, 2nd Edition, *Research Methodology: A Step by Step Guide for beginners*.
3.Ramappa T., *Intellectual Property Rights Under WTO*, S. Chand, 2008.

4.Robert P. Merges, Peter S. Menell, Mark A. Lemley, *Intellectual Property in New Technological Age*, 2016.
5.Mayall, *Industrial Design*, McGraw Hill, 1992. Niebel, “Product Design”, McGraw Hill, 1974.

5) Course Plan:

Module	Contents	Hours
I	Introduction to Research Methodology: Motivation towards research, Types of research. Professional ethics in research: Ethical issues, ethical committees. Identification of major conferences and important journals in a chosen area of interest. Collection of at least 10 published papers on a research problem in the chosen area.	**6**
II	Defining and formulating the research problem: Literature Survey, Analysing the collected papers to understand how the authorshaveidentified the research gaps, arrived at their objectives, and formulated their research problem. Understanding how their research work is different from the previous works in the chosen area.	**6**
III	Research design and methods: Analyzing the collected papers to understand how the authors have formulated the research methods, both analytical methods and experimental methods. Data Collection and analysis: Analyzing the collected papers to understand the methods of data collection, data processing, analysis strategies, and tools used for analyzing the data.	**6**
IV	Copy right - royalty - Intellectual property rights and patent law – Process of Patenting and Development, Procedure for grant of patents. Reproduction of published material: Copy left- Open access, Citation and acknowledgement. Plagiarism, Impact factor.	**6**
V	Technical writing - Structure and components of a typical technical paper, abstract and conclusion, illustrations and tables, bibliography, referencing and footnotes. Writing a technical paper – based on the identified research problem, and using the collected papers, Literature survey, Problem formulation, and Research design, and a hypothetical result.	**6**
	Total hours	**30**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME169A	Mechanical Design Lab	LBC	0	0	2	1	2022

1) Course Objectives:

The goal of the course is to make the students

- Aware of the types of accelerometers in use.
- Aware of the vibration inducing devices in use.
- Aware of the softwares available for vibration measurement.
- Aware of the methods used to measure natural frequency.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO 1	Conduct free and forced vibration tests.	Apply
CO 2	Apply data acquisition procedure in vibration measurement	Apply
CO 3	Determine the sloshing frequency in a liquid filled tank	Analyse

3) Syllabus:

Experimental determination of natural frequencies of vibrating systems. Determination of mode shapes using accelerometers, impact hammers and data acquisition system. Use of LABVIEW software for data analysis.

4) References:

i) C Sujatha, Vibration, Acoustics and Strain Measurement - Theory and Experiments, Ane Books PvtLtd , Prentice Hall India,2020.

ii) Noise and Vibration Analysis: Signal Analysis and Experimental Procedures, Anders Brandt, John Wiley & Sons, Ltd ,2011.

iii) Singiresu S Rao, Mechanical Vibrations, Pearson, 2016.

5) Course Plan:

	Experiment	Main equipment required
1	Study of free and forced vibration using universal vibration machine	Speed controller, motor, disc, tachometer, spring, damper, drum. Etc.
2	Estimation of damping of beam specimen for different damping treatments	Beam specimen of Steel, Viscoelastic material for attachments, Accelerometer, Charge amplifier, Oscilloscope
3	To find the natural frequencies and mode shapes of a free-free beam experimentally.	Vibration exciter, Arbitrary function generator, free-free beam, Oscilloscope, Amplifier, laser displacement meter
4	Determination of natural frequencies and mode shapes of a free-free plate.	laser displacement meter/Accelerometer, Oscilloscope, Exciter, plate, Labview sound and vibration tool kit
5	Determination of whirling speed of shaft.	Whirling shaft apparatus.
6	Determination of sloshing frequency in a liquid filled tank.	Sloshing tank, Exciter, plate, Accelerometer, Labview vibration tool kit
7	To determine natural frequencies corresponding mode shapes of the disc and mode shapes	Accelerometers, oscilloscope, charge amplifier,electrodynamics exciter, disk etc.
8	Demonstrate the effect of unbalancesresulting from rotary motions	Balancing Apparatus
9	Demonstrate the working principleof gyroscope and demonstrate the effect of forces and moments on their motion	Gyroscope
10	Material characterization of viscoelastic, hyper elastic and biological membrane material	Bi-axial testing machine
11	Fatigue fracture study of composites	Fatigue fracture testing machine

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME160B	Design of Experiments	DCC	3	0	0	3	2022

1) Course Objectives:

Objective of this course is to impart students a holistic view of the fundamentals of experimental designs, analysis tools and techniques, interpretation and applications

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Explain the fundamentals of experimental design and its uses	Understand
CO2	Select the correct hypothesis based on statistical results	Apply
CO3	Apply ANOVA to check the quality of the experimental results	Apply
CO4	Choose the ideal experimental design for a given condition	Apply
CO5	Analyse experimental data using statistical tools	Apply

3) Syllabus:

Strategy of Experimentation, Graphical Data analysis toolsStatistical Distributions: Measures of variability, Analysis of variance (ANOVA) in Factorial Experiments
Factorial Experiments: Taguchi design,

4) References:

i) D. C. Montgomery: *Design & Analysis of Experiments*, 8th Edition, Wiley, 2012
ii) H. Toutenburg and Shalabh: *Statistical Analysis of designed experiments,* Springer 2009
iii) M. J. Anderson, and P. J. Whitcomb, *Doe Simplified: Practical Tools for Effective Experimentation*, 3rd ed., Productivity Press, USA, 2015
iv) J. Lawson, and J. Erjavec, *Modern Statistics for Engineering and Quality Improvement*, Thomson Duxbury, Indian EPZ edition, 2000.
v) G. E. P. Box, W. G. Hunter, and S. J. Hunter, *Statistics for Experimenters- Design, Innovation and Discovery*, 2nd ed., John Wiley & Sons Inc., 2005.
vi) Paul Mathews, *Design of Experiments with Minitab,* ASQ Quality Press, 2004

5) Course Plan:

Module	Contents	Hours
I	**Strategy of Experimentation**, Typical applications of Experimental design, Basic Principles, Guidelines for Designing Experiments.Concepts of random variable, probability, density function cumulative distribution function. Sample and population, Measure of Central tendency; Mean median andmode, Measures of Variability, Concept of confidence level. **Graphical Data analysis tools** - Stem and leaf plot, Dot plot, Box plot. Illustration through Numerical examples.	9
II	**Statistical Distributions**: Normal, Log Normal, t &Weibull distributions. **Hypothesis testing**, Probability plots, choice of sample size. Illustration through Numerical examples.	9
III	**Measures of variability**, Ranking method, Column effect method & Plotting method, **Analysis of variance (ANOVA) in Factorial Experiments**: YATE's algorithm for ANOVA, Regression analysis, Mathematical models from experimental data. Illustration through Numerical examples.	9
IV	Classical Experiments: **Factorial Experiments**: Terminology: factors, levels, interactions, treatment combination, randomization, Two-level experimental designs for two factors and three factors. Three-level experimental designs for two factors and three factors, Factor effects, Factor interactions, Fractional factorial design, Saturated Designs, Central composite designs. Illustration through Numerical examples.	9
V	**Taguchi design**, Orthogonal arrays, Evaluation of sensitivity to noise. Signal to Noise ratios for static problems: Smaller-the-better type, Nominal-the –better-type, Larger-the-better type. Illustration through Numerical examples. Analysis of experimental design using Minitab/Design of Expert	9
	Total hours	**45**

Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME161C	FINITE ELEMENT METHOD	PCC	3	0	0	3	2022

1) Course Objectives:

The objective of this course is

1. Basic understanding and conduct of FEA.
2. Solution for nodal unknowns and derived quantities over each element
3. Finite element mesh refinement and convergence.
4. Implementation and application of FEM in 1-D, 2-D and 3D static and dynamic structural analysis.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Explain the fundamental ideas of the FEM like meshing, solution and postprocessing	Understand
CO2	Prepare a suitable FE model for structural mechanical analysisproblems	Apply
CO3	Apply various numerical methods for solution of Engineering problems..	Apply
CO4	Explain higher order elements	Understand
CO5	Efficient and effective use of commercial FE software like ANSYS, NASTRAN, ABAQUS	Apply

3) Syllabus:

Matrix algebra in FEM, Methods of solution of simultaneous equations, Basic concepts of FEM, Virtual work and variational methods.
Introduction to the Stiffness (Displacement) Method, Spring, Bar elements and torsion element, Development of truss equations (Stiffness matrix, load vectors).
Development of Euler beam equations, Frame and grid equations, Transformation of coordinates.
Interpolation functions for general element formulation. Patch test, different type of refinements (h, p and r).
Development of the Plane Stress and Plane Strain Stiffness Equations.Practical Considerations in Modelling, Interpreting Results and Examples of Plane Stress/Strain.
Axisymmetric Elements, Natural coordinates systems.
Structural Dynamics, Mass matrix computation, Evaluation of eigen values and eigen vectors.

4) References:

1.David V Hutton, Fundamentals of FEM, McGraw Hill, July 2003

2. Reddy J N, An introduction to the Finite Element Method, January 2005.
3. S SRao, The Finite element methods in engineering, Butterworth-Heinemann; 3 Edition, 1998.
4. Zeinkiewicz O. C., The Finite Element Method, Butterworth-Heinemann Ltd. 2000.
5. Lary J Segerlind, Applied finite element analysis, Wiley publications, 1984.

5) Course Plan:

Module	Contents	Hours
I	Matrix algebra in FEM, Methods of solution of simultaneous equations, Basic concepts of FEM, Virtual work and variational methods. Introduction to the Stiffness (Displacement) Method, Spring, Bar elements and torsion element, Development of truss equations (Stiffness matrix, load vectors)	**9**
II	Development of Euler beam equations, Frame and grid equations, Transformation of coordinates. Interpolation functions for general element formulation. Patch test, different type of refinements (h, p and r)	**9**
III	Development of the Plane Stress and Plane Strain Stiffness Equations Practical Considerations in Modelling, Interpreting Results and Examples of Plane Stress/Strain Analysis	**9**
IV	Development of the CST, Linear-Strain Triangle equations, Method of weighted residuals (Galerkin), Boundary conditions (Neumann, Dirichlet and Robin), Plate Bending Element	**9**
V	Axisymmetric Elements, Natural coordinates systems, Isoparametric Formulation Numerical integration, Full and reduced integration Three-Dimensional Stress Analysis, Lagrange and Serendipity Elements.	**9**
	Total hours	**45**

Course Number	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME169B	COMPUTATIONAL ANALYSIS LAB	LBC	0	0	2	1	2022

1) COURSE OBJECTIVES:

This course helps the students to apply the conceptual theories in design, analysis of mechanical systems using simulation software platforms.

2) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO1	Develop 3D components in modelling software	Apply
CO2	Develop 3D assembly in modelling software	Apply
CO3	Solve structural problems using finite element software	Apply
CO4	Develop computer programing code for solving design problems involving different types of mathematical models and equations	Apply

3) SYLLABUS:

Modelling of 3D machine components and creating assemblies in modelling Software, Solving structural problems using finite element software, Modal analysis using MATLAB.

4) REFERENCES:

1. Leonard Meirovitch, Elements of Vibration Analysis, McGraw Hill, 1995.
2. ShigleyJ.E and Mischke C. R., Mechanical Engineering Design, Sixth Edition, Tata McGraw-Hill, 2003.

5) COURSE PLAN

	Experiment	Main equipments/Software required
1	3D Modelling of Universal Coupling	Any Three Modelling Package
2	3D modeling of Clutch Assembly	Any Three Modelling Package
3	3D Modelling of a 4 speed Gear box	Any Three Modelling Package
4	Numerical Study of Nonlinear systems, Linear Stability Analysis	MATLAB.
5	Modal analysis of beam by modeling in CAD software and exporting the same to finite element analysis software.	Any FEM Software package, (ANSYS/NASTRAN/ABACUS/ADINA/COMSOL) Any 3D modeling CAD package (Pro-E, Inventor, Solidworks, Catia)

6	Modal analysis of plate using to finite element analysis software.	Any FEM Software package, (ANSYS/NASTRAN/ABACUS/ADINA/COMSOL) Any 3D modeling CAD package (Pro-E, Inventor, Solidworks, Catia)
7	Modal analysis of beam using computer program code	Software – MATLAB/FORTRAN/C++
8	Modal analysis of plate using computer program code	Software – MATLAB/FORTRAN/C++
9	For a SDOF system measure the FRF and identify the mass, stiffness and damping using the peak picking method	Spring mass system, accelerometer, FFT analyzer, exciter,
10	To get the spatial distribution of SPL of a Noise Generator	Signal generator, amplifier, speaker, sound level meter
11	To study the frequency distribution of a signal generated and check the frequency content of human voice and compare it for two persons	Signal generator, oscilloscope, speaker and microphone

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162A	FRACTURE MECHANICS	PEC	3	0	0	3	2022

1) Course Objectives:

To provide the students:

a. A foundation in the fundamentals of Fracture mechanics.

b. Practice in the analytical formulation of fracture problems, analyse them and take necessary corrective actions.

c. An introduction to fracture prevention in practice.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Develop geometry of stress and strain, elastic deformation, plastic and elastoplastic deformation.	Apply
CO2	Determine Stress intensity solutions for 2-D and 3-D crack geometries	Analyse
CO3	Analysis of crack tip field and Elements of elasticity including linear elastic crack tip fields	Apply
CO4	Determine Fatigue crack growth test, crack arrest and retardation test	Analyse
CO5	Analyize non-linear fracture mechanics	Apply

3) Syllabus:

Introduction to Fracture mechanics; Elastic, Plastic and Elasto-plastic deformation; Damage tolerant fracture mechanics; Analysis of crack tip field; Crack resistance curve; Principles of crack arrest; crack growth relation in SSY - Plane stress and Plane strain fracture; Nonlinear fracture mechanics; J integral - fracture Mechanics design; Selection of materials for fracture mechanics’ design; Stress intensity factor; Use of crack growth law.

4) References:

1. Janssen, J. Zuidema and R. J. H. Wanhill., Fracture Mechanics, Taylor & Francis, 2nd ed., 2002.
2. D. Broek, Elementary Engineering Fracture Mechanics, Kluwer Academic Publishers, Dordrecht, 1986.
3. T.L. Anderson, Fracture Mechanics Fundamentals and Applications, CRC PRESS, 3rd ed., 2005.
4. E.E. Gdowan, Fracture Mechanism: An Introduction, Springer, 2005.

5) Course Plan:

Module	Contents	Hours
I	Fracture mechanics: The geometry of stress and strain, elastic deformation, plastic and elastoplastic deformation - limit analysis. Damage tolerant fracture mechanics – Fatigue testing methods - statistical nature of fatigue data - theories of fatigue - crack initiation and growth in fatigue	**9**
II	Notches and stress concentration – Stress intensity solutions for 2-D and 3-D crack geometries – Fractography - Structure modes and types.	**9**
III	Analysis of crack tip field: Elements of elasticity - linear elastic crack tip fields. Stress intensity factor - energy release rate - Criterion for crack growth - Crack resistance curve - Principles of crack arrest – Small scale yielding (SSY) - crack growth relation in SSY – Stable crack growth in SSY. Irwin plastic zone correction- Actual shape of plastic zone - Plane stress - Plane strain.	**9**
IV	Fatigue crack growth: Fatigue crack growth test - stress intensity factor, factors affecting stress intensity factor - variable amplitude service loading – Dynamic energy balance – crack arrest - retardation model.	**9**
V	Nonlinear fracture mechanics: J integral – Elastic – plastic stationary crack tip fields, ductile structure criterion, J-controlled crack growth and stability – Tearing modulus – the x factor. Engineering approach to plastic fracture - J-integral – testing single specimen testing - standard test methods	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162B	ACOUSTICS AND NOISE CONTROL	PEC	3	0	0	3	2022

1) Course Objectives:

The goal of this course is

- To impart the basic principles of acoustics
- To impart the studentsuse and application of acoustic analysis instruments.
- To provide detailed information on engineering noise control options and applications for specific equipment to address a variety of noise control challenges.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Conceptualize sound and its propagation in environments	Apply
CO2	Analyze acoustical problems to determine the need for noise- control measures	Analyse
CO3	Design noise- control measures to solve basic noise problem	Apply
CO4	Assess the results of acoustical measurements or calculations.	Analyse
CO5	Evaluate acoustic enclosures, barriers and walls for effective noise control	Apply

3) Syllabus:

Introduction: Basic Acoustic Principles - Acoustic terminology and definitions Transmission through pipes branched and unbranched-resonators-Transmission losses Noise measurement: Decibel scale-relationship between pressure intensity and power-sound level meter Noise analyser and graphic level recorder. Human reaction to sound-definitions of speech interference level. Acoustic insulation-acoustic materials acoustic filter and mufflers. Principlesofnoisecontrol in Machinery.

4) References:

1) Harris, C.K., Handbook of Noise Control , McGraw Hill, 1979.
2) Berenek, L.L., Noise and Vibration Control , McGraw Hill, 1971.
3) Kinsler and Frey, Fundamentals of Acoustics , Wiley, 1950.
4) Petrusowicz and Longmore, Noise and Vibration control for industrialists, Elsevier, 1974.
5) Thumann and Miller, Secrets of noise control, Fairmont press, 1974.

6) Graf, Industrial noise and vibration, Prentice Hall, 1979.

5) Course Plan:

Module	Contents	Hours
I	Introduction, Basic acoustic principles- acoustic terminology and definitions Plane wave harmonic solution. Velocity of sound in inviscid fluids relationship between wavelength- particle velocity, acceleration Energy density acoustic intensity reference standards	**8**
II	Transmissionthroughone,twoandthreemediaTransmissionthroughpipes branched and unbranched resonators Transmission loss reflection at plane surface sphericalwavesradiationsimplesourcehemisphericalsourceradiating piston pressure intensity distribution Beam width and directivity indexsound absorbing materials	**9**
III	Noise measurement: Decibel scale relationship between pressure, intensity and power sound level meter, noise analyser and graphic level recorder Measurement in anechoic and reverberation chambers Standing waves standing wave apparatus.	**8**
IV	Environmental noise control: Human reaction to sound definitions of speechinterferencelevel,perceivednoiselevel,phonandsoneetc,hearing loss principles of noise control, control at source, during transmission and at receiver- protection of receiver. Acoustic insulation acoustic materials acoustic filter and mufflers plenum chamber noise criteria and standards noise and number index guide lines for designing quieter equipments.	**10**
V	Methods of controlling noise using baffles, coverings, perforations etc. transmission through structures control, vibration damping and other methods. Principlesofnoisecontrolinmachinerysuchaspumps,rotatingmachines, reciprocating machinesetc. Introduction sound design requirements of an auditorium	**10**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162C	ROBOTICS	PEC	3	0	0	3	2022

1) Course Objectives:

Goal of this course is

- To introduce the basic concepts, parts of robots and types of robots.
- To make the student familiar with the various drive systems for robot, sensors and their applications in robots and programming of robots.
- To discuss about the various applications of robots, justification and implementation of robot.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Explain the basics of Robot Kinematics and Dynamics	Analyse
CO2	Compare different Robot Drives And Power Transmission Systems	Apply
CO3	Develop automatic manufacturing cells with robotic control	Apply
CO4	Analyse the principle behind robotic drive system, end effectors, sensor, machine vision robot kinematics and programming.	Analyse
CO5	Develop the computer control in Robotic software.	Apply

3) Syllabus:

Specifications of Robots, Classifications of robots, Work envelope.Flexible automation versus Robotic technology, Applications of Robots.

Robot kinematics and dynamics: Translations, Rotations and Transformations. D-H Representation, Forward and inverse Kinematics of Six Degree of Freedom Robot Arm, Robot Arm dynamics. Robot drives and power transmission systems

Robot end effectors Hooks & scoops. Gripper force analysis and gripper design. Active and passive grippers. Drive system for grippers. Mechanical adhesive vacuum-magnetic grippers. Hooks &scoops. Gripper force analysis and gripper design. Active and passive grippers.Robot languages computer control and Robot software Industrial Application of robots.

4) References:

i) Deb S. R. and Deb S., Robotics Technology and Flexible Automation, Tata McGraw Hill Education Pvt. Ltd, 2010.

ii) John J.Craig, Introduction to Robotics, Pearson, 2009.

iii) Mikell P. Grooveret. al., Industrial Robots - Technology, Programming and Applications, McGraw Hill, New York, 2008.

iv) Richard D Klafter, Thomas A Chmielewski, Michael Negin, Robotics Engineering – An Integrated Approach, Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., 2006.

v) Fu K S, Gonzalez R C, Lee C.S.G, Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 1987

5) Course Plan:

Module	Contents	Hours
I	Specifications of Robots- Classifications of robots – Robot kinematics and dynamics : Positions, Orientations and frames, Mappings: Changing descriptions from frame to frame, Operators: Translations, Rotations and Transformations Transformation Arithmetic - D-H Representation - Forward and inverse Kinematics of Six Degree of Freedom Robot Arm–Robot Arm dynamics	**10**
II	Robot drives and power transmission systems:Robot drive mechanisms, hydraulic , electric , servomotor, stepper motor Pneumatic drives, Mechanical transmission method . Gear transmission, Belt drives, cables, Roller chains, Link Rod systems. Rotary-to-Rotary motion conversion, Rotary-to-Linear motion conversion, Rack and Pinion drives, Lead screws, Ball Bearing screws	**10**
III	Robot end effectors: Classification of End effectors, Tools as end effectors. Drive system for grippers- Mechanical adhesive, vacuum, magnetic grippers. Hooks & scoops. Gripper force analysis and gripper design. Active and passive grippers.	**9**
IV	Drive system for grippers- Mechanical adhesive-vacuum-magnetic- grippers. Hooks &scoops. Gripper force analysis and gripper design. Active and passive grippers.	**8**
V	Robot languages .computer control and Robot software.Industrial Application of robots.	**8**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162D	MECHANICAL BEHAVIOR OF MATERIALS	PEC	3	0	0	3	2022

1) Course Objectives:

The goal of this course is

- To provide information about the structure of crystalline materials, imperfections in crystals
- To know about its implications in the strength of materials, elastic and plasticbehaviour of crystalline materials to applied forces

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Explain about the structure of crystalline solids and the various imperfections in it.	Understand
CO2	Explain about dislocation theory and the various strengthening mechanisms	Understand
CO3	Explain basic concepts of fracture mechanics and failure mechanisms like fatigue and creep	Understand
CO4	Examine about the mechanical behaviour of polymers, ceramics and composites.	Apply

3) Syllabus:

Structure and imperfections in crystals, Mechanical behaviour of metals, Strengthening mechanisms, recovery, recrystallisation and grain growth, Alloying Fracture, Fatigue and creep Mechanical behaviour of composites, polymers and ceramics. Advanced materials

4) References:

i) Marc Andre Meyers, Mechanical Behaviour Materials, PHI, 2013.

ii) Thomas H. Courtney, Mechanical Behaviour Materials, Waveland PrInc, 2nd edition 2010.

5) Course Plan:

Module	Contents	No. of hours
I	Elementsofcrystalstructure,Imperfectionsincrystals,dislocationmotion and dislocationtheory. Slip in crystalline solids, Deformation twinning and kink bands, Grain boundaries and poly crystalline aggregates, Plasticity and the theoretical strength of materials.	9
II	Elementsofcrystalstructure,Imperfectionsincrystals,dislocationmotion and dislocationtheory. Slip in crystalline solids, Deformation twinning and kink bands, Grain boundaries and poly crystalline aggregates, Plasticity and the theoretical strength of materials.	9
III	Strengthening mechanisms: solid solution, grain refinement, strain hardening, precipitation hardening, Recovery, recrystallisation and grain growth, Principles of Alloying - Solid solutions and intermediate phases. Gibbs phase rule and equilibrium diagram Types of binary phase diagrams , Isomorphous - Eutectic - Peritectic and Peritectoid reactions, Iron-iron carbide equilibrium diagram, TTT diagram, martensitic transformation	9
IV	Ceramics, polymers and composites. Advances and modern materials. Mechanical behavior of ceramics, Polymers and Composites. Types of fractures - Ductile and brittle fractures - features of fracture , surface for ductile, brittle and mixed modes. The history of failure of engineering structures and parts, high strain rate, stress concentration and low temperature effects, impact tests and results, transition temperature and factors affecting transition temperature.	9
V	Stresscycle,fatiguecurve,fatiguefracturecharacteristics.Fatiguetesting and testing machines, determination of fatigue strength. Factors affecting fatigue- size, surface, stress concentration, Creep, Creep curve,Creep mechanisms, Lowtemperatureandhightemperaturecreeptheories,Fractureatelevated temperature.Stress rupture, Deformation mechanism maps, Material aspects of creep design, Creep resistance as related to material properties and structure, Super plasticity.	9
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162E	Design and Analysis of Composite Structures	PEC	3	0	0	3	2022

1) Course Objectives:

The goal of this course is to

- To gain knowledge of Different types of engineering materials, anisotropy, orthotropic and composite materials.
- To gain knowledge of composites, types, applications, manufacturing and mechanics of composite structures.
- To gain knowledge of stress analysis and failure analysis of composites.
- To gain knowledge of basic design principles of composite structures

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Apply Hooke's law in the micromechanical analysis of Lamina and Laminate	Apply
CO2	Explain the failure mechanisms.	Understand
CO3	Determine the macro mechanical properties of laminate.	Apply
CO4	Perform FEA of Composite structures	Apply

3) Syllabus:

Design Classifications of Composites, Micro mechanics, Macro mechanics of laminates, Analysis based on classical laminate theory, Failure theory of laminated composites, Testing of composite materials.

4) References:

1.R. M. Jones, Mechanics of Composite Materials, Taylor & Francis, 2nd Edition, 2015.

2.Autar Kaw, Mechanics of Composite Materials, Taylor & Francis-India, 2nd Edition, 2006.

3.Krishan K. Chawla, Composite Materials, Science &Engg., 3rd Edition, Springer publication, 2013.

4.S.S. W. Tsai, Introduction to Composite Materials, Technomic Publication, 1986.

5) Course Plan:

Module	Contents	Hours
I	Classical laminate theory - Hooke‘s law for anisotropic, monoclinic, orthotropic and transversely isotropic material. Macro mechanical behavior of a lamina. Determination of laminate mechanical properties for laminates. Strength failure criteria- maximum stress, maximum strain criteria, Tsai Hill and Tsai-Wu theories for an angle laminate.	9
II	Micromechanical behavior of a lamina- volume and mass fractions, density and void content, evaluation of elastic moduli. Kirchhoff’s assumption, Equilibrium equations for laminated plates, bucklingequationsforlaminatedplates,vibrationequationsforlaminated plates Solution techniques- symmetric, antisymmeric cross ply laminates. Impact and fatigue characteristics	9
III	Differences in fracture behviour of isotropic and composites. Type of fracture in composites- interlaminar and intralaminar fracture. Modified crack closure approach - assess the failure strength. Evaluation of fracture toughness.	9
IV	Basic principles of sandwich structures, manufacturing process, sandwich local instabilities like, dimpling, wrinkling, shear crimpling, crushing. Stringer stiffened structures. Design of a sandwich plate. Design of stiffened plates.	9
V	Types of textile weaving, 3D composite and inflatable structures, stitched composites and nano-composites. Finite element analysis of composite beam, plate/ shell type composite structures.	9
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162F	ADVANCED THEORY OF MECHANISMS	PEC	3	1	0	4	2022

1) Course Objectives:

The goal of this course is to develop the problem-solving skills in the area of kinematics of different mechanisms, synthesis and design of mechanisms and dynamic analysis.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Analyse the velocity and acceleration in mechanisms.	Apply
CO2	Synthesize and design mechanisms for specific motions and other Applications.	Analyse
CO3	Design cams and analyse its dynamic effects.	Apply
CO4	Analyse the dynamics of moving members in the machinery and design appropriately	Analyse

3) Syllabus:

Planar Kinematics of Rigid Bodies:. Graphical approach to velocity and acceleration in mechanisms. Brief introduction to complex Mechanisms.Curvature TheoryFour-bar coupler-point curves . Synthesis of mechanisms, Cam DynamicsDynamics: Plane motion of rigid bodies using the principle ofimpulse and momentum. Motion of a rigid body in three dimensions. Euler‘s equation of motion.

4) References:

1) John J. Uicker, Gordon R. Pennock& Joseph E. Shigley, Theory of Machines and Mechanisms, Oxford University Press, 4th edition, 2014.
2) Myskza, Machines and Mechanisms Applied Kinematic Analysis, Pearson Education, 4th edition, 2012.
3) Richard S. Hartenberg, Jacques Denavit, Kinematic synthesis of Linkages, McGraw Hill book company 1964.
4) Allen S. Hall, Kinematics and linkage design, Prentice Hall of India, Ltd 1986.

5) Course Plan:

Module	Contents	Hours
I	Planar Kinematics of Rigid Bodies: Velocity and acceleration relationships for two points in a rigid link -Vector approach, two-coordinate system approach for velocity and acceleration, applied to planar mechanisms: Slider-crank mechanisms, four bar linkages. Graphical approach to velocity and acceleration in mechanisms. Brief introduction to complex mechanisms Curvature Theory: Instantaneous centre or Pole, centrode or polode, polode curvature, collineation axis, radius of curvature.	**9**
II	The Euler-Savary equation, the inflection circle, Hartmans construction, Bobillierconstructions,thecubicofstationarycurvature.Designbasedont heabove. Four-bar coupler-point curves: Equation of coupler curves, circle of foci, multiple points, imaginary points, asymptote. Singular foci, double points and symmetry, cusp, crunode, symmetry. The Roberts-Chebychev Theorem and cognate linkages	**9**
III	Cams:Polydyne cams: Cam Dynamics: Acceleration and Jerk. Analysis of eccentric cam, effect of sliding friction, Analysis of disc cam with reciprocating roller follower. Analysis of elastic cam systems, follower response: Phase-plane method, Johnson‘s numerical analysis .Position error, Jump and cross-over shock, unbalance, spring surge and wind-up. Cam force analysis.	**8**
IV	Synthesis of mechanisms: The four-bar linkage, Two and Three position design. Design of slider crank and double lever mechanisms for specified input crank motion and output crank motion, Determination of minimum Transmission angle.	**9**
V	Dynamics: Plane motion of rigid bodies using the principle ofimpulseand momentum. Kinetics of rigid bodies in three dimensions :-Angular momentum of a rigid body in three dimensions. Application of the principle of impulse and momentum to the three-dimensional motion of a rigid body Kinetic energy of a rigid body in three dimensions. Motion of a rigid body in three dimensions. Euler‘s equation of motion. Motion of a rigid body about a fixed axis. Motion of gyroscope: Eulerian angles Steady precession of a gyroscope. Motion of an axi-symmetrical body under no force	**10**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162G	Rotor Dynamics	PEC	3	0	0	3	2022

Pre-requisite: Advanced Theory of Vibrations

1) Course Objectives:

- Impart basic understanding of the rotor dynamics phenomena with the help of simple rotor models and subsequently carry out the analysis for real life rotor systems.
- Ability to write down the differential equations of motion for simple, geared and branched rotor bearing system under transverse and torsional vibrations.
- Capability to find out the critical speeds using different numerical methods, balance the unbalanced system and perform the instability analysis.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Analyze the various effects associated with the rotor dynamics.	Analyse
CO2	Develop the vibration models of rotor bearing systems with changing complexities for real engineering systems.	Apply
CO3	Formulate the response due to unbalance and instability in practical rotor systems	Analyse
CO4	Analysevarious vibration measuring and balancing instruments.	Apply
CO5	Identify rotor bearing system parameters and capability to carry out condition monitoring and fault identification in rotors.	Analyse

3) Syllabus:

Introduction, Simple rotors with rigid bearings, Rotor-bearing interactions, Equivalent discrete systems, geared and branched systems. Balancing of rotors and balancing criteria. Bearing dynamic parameters estimation.

4) References:

i) J.S.Rao, Rotor Dynamics. Wiley Eastern, 1985.

ii) Krämer E., Dynamics of Rotors and Foundations, Springer-Verlag, New York, 1993.

iii) Yamamoto, T., Ishida, Y., 2001, Linear and Nonlinear Rotordynamics: A Modern Treatment with Applications, Wiley, New York, 2001.

iv) M. I.Friswell, J.E.T.Penny, S.D.Garvey, and A. W. Lees, Dynamics of Rotating Machines. Cambridge University Press, 2010.

5) Course Plan:

Module	Contents	Hours
I	Review of vibration; forced vibration of MDOF system, modal decomposition of undamped and damped systems. Introduction, Simple rotors with rigid bearings, Jeffcott rotor model and variant of Jeffcott rotor model, Shafts stiffness constants,	**9**
II	Rotor-bearing interactions: Effects of rolling element bearings and fluid film bearings on rigid and flexible rotors. Flexural and torsional vibrations; critical speeds of shafts using Rayleigh's method, matrix iteration methods, Prohal and Myklested method.	**9**
III	Equivalent discrete systems; geared and branched systems; Gyroscopic effects. Instability of rotors mounted on fluid film bearings; rigid rotor instability; instability of a flexible rotor;	**9**
IV	Instability threshhold by transfer matrix methods; internal hysteresis of shafts; instability in torsional vibrations Balancing of rotors and balancing criteria for rigid and flexible rotors.	**9**
V	Bearing dynamic parameters estimation; measurement & digital processing techniques; condition monitoring of rotating machineries	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162H	MECHATRONIC SYSTEM DESIGN	PEC	3	0	0	3	2022

1) Course Objectives:

The goal of this course is to

- Equip students with state of the art techniques and skills in the fields of automation and robotics.
- Make students aware of the latest trends in sensors, actuators, pneumatic and hydraulic systems, PLC etc.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Design and develop complicated pneumatic and hydraulic circuits to automate various equipment's.	Apply
CO2	Apply latest cutting edge technologies like MEMS, Robotics in system design	Apply
CO3	Explain about microprocessors and microcontrollers which are an essential part of modern automatic devices	Apply
CO4	Interface various types of sensors and actuators with computers by using data acquisition cards	Analyse

3) Syllabus:

Introduction to mechatronics sensors and transducers, Automation system design, Modelling and simulation of mechatronics systems.Microprocessors & microcontrollers Real time interfacing, Robotic vision and case studies.

4) References:

1) W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Person Education Limited, 2015.

2) HMT, Mechatronics, McGraw Hill Education. 2017.

3) K.P. Ramachandran, G.K. Vijayaraghavan, M.S. Balasundaram. Mechatronics: Integrated Mechanical Electronic Systems. Wiley India Pvt. Ltd., 2008.

4) David G. Aldatore, Michael B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw Hill Higher Education, 2003.

5) Course Plan:

Module	Contents	Hours
I	Characteristics. Displacement and position sensors. Resolvers and synchros. Velocity and motion sensors. Principle and types of force, temperature, vibration and acoustic emission sensors. Actuators: Pneumatic, hydraulic and mechanical actuation systems used for Mechatronics devices	**9**
II	Automation System Design: Design of fluid power circuits cascade, KV-map and step counter method. PLC ladder logicdiagram, Programming of PLC, fringe condition modules, sizing of components in pneumatic and hydraulic systems. Analysis of hydraulic circuits	**8**
III	ModelingAnd Simulation: Definition, key elements, mechatronics approach for design process, modeling of engineering systems, modeling system with spring, damper and mass. Modeling chamber filled with fluid, modeling pneumatic actuator. Transfer functions, frequency response of systems, bode plot. Software and hardware in loop simulation.	**9**
IV	Microprocessors & Microcontrollers: Microprocessors - introduction, 8085 architecture, types of memory, machine cycles and timing diagram, addressing modes, instruction set, development of simple programs. 8051 microcontroller architecture, registers, addressing modes, interrupts, port structure, timer blocks and applications- stepper motor speed control.	**9**
V	Real Time Interfacing: Introduction to data acquisition and control systems, overview of I/O process. Virtual instrumentation, interfacing of various sensors and actuators with PC, Condition monitoring, SCADA systems. Real Time Interfacing: Introduction to data acquisition and control systems, overview of I/O process. Virtual instrumentation, interfacing of various sensors and actuators with PC, Condition monitoring, SCADA systems. Case Studies Of Mechatronics Systems: Pick and place robot, Automatic Bottle filling unit, Automobile engine management system.	**10**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162I	DESIGN OF POWER TRANSMISSION ELEMENTS	PEC	3	0	0	3	2022

1) Course Objectives:

The goal of this course is to

- To understand the various elements involved in a transmission system.
- To analyse the various forces acting on the elements of a transmission system.
- To design the system based on the input and the output parameters.

2) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Design different power transmitting elements like Belt drives and Chain drives.	Apply
CO 2	Design different clutches and brakes.	Apply
CO 3	Design shafts subjected to different loading.	Apply
CO 4	Design different types of gears.	Apply
CO 5	Design different types of gear boxes.	Apply

3) Syllabus:

Flexible Transmission Elements: Design of Clutches, Design of Brakes, Design of Spur Gear: Design of Helical & Bevel Gears: Design of Worm Gear. Design of Gear Boxes, Design of multi speed gear boxes. Design of sliding mesh gear box, Constant mesh gear box. Synthesis of multi speed gear boxes.

4) References:

i. Newcom and Spurr, “Braking of road vehicles”, Chapman and Hall, 1967.

ii. Nieman, “Design of Machine elements – Vol. II”, Springer Verlag.

iii. Dobrovolksy, “Design of Machine elements”, Mir Publishers, 1977.

iv. Wong, “Theory of Ground Vehicles”, Wiley, 2001.

Text Books:

i. P. Kannaiah, Design of Machine Elements, Scitech Publications, 2006

ii. Reshetov, “Design of Machine elements”, Mir Publication, 1978

5) Course Plan:

Module	Contents	No. of hours
I	Selection of V belts and pulleys, selection of Flat belts and pulleys Selection of Wire ropes and pulleys, Selection of Transmission chains and Sprockets. Design of pulleys and sprockets.	9
II	Design of plate clutches, axial clutches, cone clutches, internal expanding rim clutches.Brakes, internal and external shoe brakes disk brakes-self actuating brakes fixed, link and sliding anchor drum brakes.	9
III	Gear Terminology, Speed ratios and number of teeth, Force analysis, Tooth stresses, Dynamic effects, Fatigue strength, Factor of safety, Gear materials, Module and Face width-power rating calculations based on strength and wear considerations, Parallel axis Helical Gears, Pressure angle in the normal and transverse plane- Equivalent number of teeth-forces and stresses. Estimating the size of the helical gears.	9
IV	Straight bevel gear: Tooth terminology, tooth forces and stresses, equivalent number of teeth. Estimating the dimensions of pair of straight bevel gears. Worm Gear: Merits and demerits- terminology. Thermal capacity, materials-forces and stresses, efficiency, estimating the size of the worm gear pair.	9
V	Geometric progression, Standard step ratio, Ray diagram, Structural diagram, kinematics layout Design of sliding mesh gear box, Constant mesh gear box. Synthesis of multi speed gear boxes.	9
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162J	OPTIMIZATION TECHNIQUES IN ENGINEERING	PEC	3	0	0	3	2022

1) Course Objectives:

- To provide the basic knowledge of optimization techniques and optimal output.
- Design optimization for achieving best result compared with conventional design.

2) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Formulate the given problem in a mathematical format which is acceptable to an optimization algorithm.	Apply
CO 2	Explain the techniques and applications of engineering optimization.	Understand
CO 3	Apply the appropriate optimization method that is more efficient to the problem at hand.	Apply
CO4	Apply the linear and nonlinear programming methods of optimization.	Apply
CO 5	Apply the computational tools of optimization.	Apply

3) Syllabus:

Introduction to Optimization: Engineering application of Optimization, Optimal Problem formulation Optimum design concepts: Linear programming methods for optimum design, Application of LPP models in design and manufacturing. Optimization algorithms for solving unconstrained optimization problems – Gradient based method: Optimization algorithms for solving constrained optimization problems. Applications.

4) References:

i. Singiresu.S.Rao., “Engineering Optimization Theory and Practice” New Age International (P) Limited, Publishers 1996.

ii. Johnson Ray.C., “Optimum design of mechanical elements” Wiley, John & Sons, 1990

iii. Goldberg, DE “Genetic algorithms in search, Optimization and Machine: Barmen, Addison – Wesely, New York 1989.

iv. Saravanan.R, “Manufacturing Optimization through intelligent techniques”, Taylor and Francis Publications, CRC Press. 2006.

5) Course Plan:

Module	Contents	No. of hours
I	Introduction, Formulation of optimization problems, examples Classification of optimization problems, Properties of objective function Maxima, minima and points of inflection , Concavity and convexity of one and two variable functions, Taylor's theorem: single variable and multi variable function. Hessian matrix, Unconstrained Optimization of multi variable functions, Lagrange multiplier method	9
II	Single variable optimization: optimality criteria, Exhaustive search and dichotomous search. Region elimination methods- Fibonacci search and Golden section search, Gradient based methods- Newton Raphson method, Secant method Multivariable optimization: optimality criteria, Unidirectional Search, Direct search method-Simplex search method, Powell's conjugate direction method. Gradient based methods- Method of steepest ascent/ steepest descent, conjugate gradient method	9
III	Constrained optimization: Kuhn Tucker conditions, Transformation method- Penalty function method. Linearized search-Frank-Wolfe method Geometric programming.Dynamic programming; Integer programming.	9
IV	Goal programming. Modern Methods in Optimization: Genetic Algorithm - Simulated Annealing - Particle Swarm Optimization Neural Network based optimization, Optimization of Fuzzy systemsMulti-Objective optimization. Design of experiment based optimization - Data Analytics and optimization using Machine learning approach.	9
V	Implementing optimization algorithm using Matlab / Programming: Design optimization - Robust design - Optimization in manufacturing / machining – Multi objective optimization - Structural optimization - Shape optimization - Optimization in production planning and control.	9
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162K	THEORY OF PLATES AND SHELLS	PEC	3	0	0	3	2022

1) Course Objectives:

The goal of this course is to enable students to:

- Identify the various thin walled structures in the form of plates and shells suitable for use in different structural systems.
- Study the behaviour of the plates and shells with variable geometry under the action of different types of loads.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Identify the various thin walled structures such as plates and shells that are suitable for different structural systems	Apply
CO2	Analyse the behaviour of plates and shells of different geometry under the action of various types of load.	Apply
CO3	Apply Classical Plate theoryto solve problems	Apply
CO4	Apply Shell theoryto solve problems	Apply

3) Syllabus:

Introduction to plates and shells - Assumptions in the theory of thin plates; Bending of long rectangular plates; Pure bending of plates; Small deflections of laterally loaded plates – Navier solution and Levy’s solution for simply supported rectangular plates; Symmetrical bending of circular plates - Classical Plate theory; Mindlin’s plate theory. Theory of folded plates; Introduction to shell theory; cylindrical shells; hyperbolic shells, Hyperbolic paraboloid shells and Conoids.

4) References:

1) Timoshenko S.P. and Krieger S. W., Theory of Plates and Shells, Tata McGraw Hill,

Chandrashekhara K., Theory of Shells, Universities (India) Press Ltd, 2000.

2) Ramaswamy G. S., Design and Construction of Concrete Shell Roofs, CBS Publishers, 2005.

3) Bairagi N. K., Plate Analysis, Khanna Publishers, 1986.
4) Kelkar V. S. and Sewell R.T., Fundamentals of the Analysis and Design of Shell Strutures, Prentice Hall Inc, 1987.

5) Course Plan:

Module	Contents	Hours
I	Introduction to plates and shells –Classifications, Assumptions in the theory of thin plates; Differential equation to Bending of long rectangular plates to a cylindrical surface. Pure bending of plates –Relation between slope and curvature, bending moments and curvature; Particular cases of pure bending	**9**
II	Small deflections of laterally loaded plates -Differential equation; Navier solution and Levy's solution for simply supported rectangular plates-Effect of transverse shear deformation.	**9**
III	Symmetrical bending of circular plates -Differential equations; Uniformly loaded circular plates with simply supported and fixed boundary conditions. Annular plate with uniform moments and shear forces along the boundaries.	**9**
IV	Classical Plate theory for Orthotropic plates and layered plates; Mindlin's plate theory-Navier solution and Levy's solution for orthotropic plates-Theory of folded plates. Introduction to shell theory. Classification of shells, Membrane theory of shells, Application to spherical, conical and cylindrical shells, Deformation of shells without bending -definitions and notations. Shells in the form of a surface of revolution and loaded symmetrically with respect to their axis.	**9**
V	Membrane and General theories of cylindrical shells - Circular cylindrical shell loaded symmetrically with respect to its axis; stresses in cylindrical shell under dead and snow loads, symmetrical deformation. General case of deformation of cylindrical shells with supported edges; Hyperbolic shells, hyperbolic paraboloid shells and Conoids. Analysis of cylindrical shells.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162L	ADVANCED VEHICLE DYNAMICS	PEC	3	0	0	3	2022

1) Course Objectives:

The goal of this course is to develop an essential knowledge about dynamic behavior and mathematical modeling and simulation of vehicles.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Analyse different parameters that affect the static and dynamic behavior of vehicles	Analyse
CO2	Analyse the braking performance of automobiles	Analyse
CO3	Explain tyre mechanics and modelling of tire system.	Understand
CO4	Analyse the methods of Vibration control	Analyse

3) Syllabus:

Introduction to dynamics, Stability of Vehicles, Vehicle kinematics, Dynamic stability of vehicles, Tire dynamics and modeling, Driveline dynamics, Steering dynamics, Vehicle vibrations

4) References:

1. Vehicle dynamics-Theory and applications - Reza.N.Jazar–Springer-2008
2. Fundamentals of Vehicle Dynamics - Gillespie T.D, SAE USA1992.
3. Tire and Vehicle Dynamics - Ham B, Pacejka - SAE Publication -2002
4. Vehicle Dynamics and Control,- Rajesh RajamaniSpringer-2008
5. Mechanics of road vehicles, W. Steeds- Wildlife book Ltd, London,1990

5) Course Plan:

Module	Contents	Hours
I	Introduction to dynamics Stability of Vehicles- load distribution weight transfer during acceleration and braking, optimum braking, wheel locking and vehicle skidding, antilock braking system. Over steer, under steer, steady state cornering. Effect of	**9**

	braking, driving torques on steering. Effect of camber, transient effects in cornering. Directional stability of vehicles.	
II	Vehicle kinematics Coordinate transformations, Euler angles, time derivative and coordinate frames, rigid body dynamics. Dynamic stabilityofvehicles-Vehicle planar dynamics Longitudinal vehicle dynamics-Lateral vehicle dynamics - Vehicle rolldynamics	**9**
III	Tire dynamics and modelling -Tire and rim fundamentals, Tire components, Tire coordinate frame and tire force systems, Tire Stiffness-linear and non-linear tire stiffness, hysteresis effect, Static tire stresses Effective radius Rolling resistance. Effect of speed on rolling resistance Effect of inflation pressure, load camber angle and side slip angle on rolling resistance, Forces on the tire- linear force, lateral force and camber force, Stresses and deformation of arollingtireMathematicalmodelofrollingtire-dampingstructureandSpringStructure.	**9**
IV	Driveline dynamics- Basic engine dynamics - power, speed and torque Characteristics. Driveline components -Gear box and clutch dynamics, gear box design. Steering dynamics- Analysis of steering mechanisms, Steering of multi- axle vehicles, vehicles with trailer. Four wheel steering, optimization of steering mechanisms, Suspension mechanisms- Suspension optimization	**9**
V	Vehicle vibrations Fundamentals of vibrations- single degree freedom and multi degree freedom vibrations. Passenger comfort and vibrations Numerical modelling of vehiclevibrations-Quarter car model Half car model, full car model	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162M	Design of Pressure Vessels and Piping	PEC	3	0	0	3	2022

1) Course Objectives:

Goal of this course is to gainknowledge of pressure vessel design, designing of piping and piping systems, and using of design codes in pressure vessel design.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Explain the various types of stress acting on pressure vessels.	Understand
CO2	Design various types of pressure vessels.	Apply
CO3	Familiarize the various ASME codes and standard practices associated with Pressure vessel design.	Understand
CO4	Explain the phenomenon of buckling in pressure vessels.	Understand
CO5	Distinguish between the various types of piping elements involved in Pressure vessels.	Apply

3) Syllabus:

Terminology of Pressure Vessels-
Stresses in pressure vessels
Stresses in Thick walled cylinders & Built up cylinders
Design of Tall Cylindrical Self supporting process column
Reinforcement theory
Buckling of Pressure Vessels Design of Piping

4) References:

1. John F. Harvey, 'Theory and Design of Pressure Vessels' CBS Publisher and Distributors

2.Brownell, L. E., and Young, E. H., Process Equipment Design, John Wiley and Sons

3.SomnathChathopadhyay, Pressure Vessels Design and practice, C. R. C Press

4.Henry H. Bender, 'Pressure Vessels Design hand book'

5.ASME Pressure Vessel Codes Section VIII, 2006.

6.Dennis Moss Pressure Vessel Design Manual Gulf publishing, 2003.

Design Data Book is to be permitted in the University examination.

i) P S G Data book by Faculty of Mechanical Engineering, P S G,

ii) Design Data Handbook for Mechanical Engineering in SI and Metric Units by K. Mahadevan, K. Balaveera Reddy

iii) Standard Pressure Vessel Design Data Handbook ref. ASME ISI IBR)

5) Course Plan:

Module	Contents	Hours
I	Pressure vessel – Terminology , Types of loads , Types of pressure. Stresses in pressure vessels, Dilation of pressure vessels, Membrane stress analysis of vessel shell components Cylindrical shells, spherical shells, conical head, elliptical head, Discontinuity stresses in pressure vessels Thermal stresses	**9**
II	Stresses in thick walled cylinders Lame's equation, Shrinkfit stresses in Built up cylinders, auto frettage of thick cylinders, Thermal stresses and its significance	**9**
III	Design of vessels : Design of tall cylindrical vessels supports for short vessels, Support for horizontal vessels. Design for wind load, design for seismic load and vibration, Theory of reinforcement, Familiarization of relevant ASME codes and standard practices	**9**
IV	Buckling - buckling phenomenon , Elastic buckling of cylinders under external pressure Stiffeners buckling under combined compressive pressure and external load	**9**
V	Piping - Pipe specification , Pipe classification Piping elements , Piping layout and piping stress Analysis , Flexibility Analysis (Practice of software such as CAESAR,CAEPIE, PVELITE etc. Not included in examination)	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162N	EXPERIMENTAL STRESS ANALYSIS	PEC	3	0	0	3	2022

1) **Course Objectives:** Goal of this course is to impart to the students, the basic aspects of theory of elasticity and stress-strain relationship as well as experimental stress analysis techniques that includes the most versatile techniques like photoelasticity, strain gauges and non-destructive test (NDT) methods

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Explain various aspects of stress analysis and various methods employed to find out stress experimentally.	Understand
CO2	Explain the working of various strain measurement devices.	Understand
CO3	Choose between various Non-destructive testing methods.	Apply
CO4	Explain photoelastic methods of determining stress in materials.	Understand
CO5	Explain the fundamentals of electrical strain measurements and the various configurations they can be used.	Understand

3.Syllabus.

Overview of stress analysis, Strain measurement, Instrumentation, Oscillograph, Crack detection, Non-destructive testing (NDT) methods

4.References:

1) J. W. Dally and W. F. Riley, Experimental Stress Analysis - McGraw Hill, 1991

2) L.S. Srinath, M.R. Raghavan, K. Lingaiah, G. Gargesa, B. Pant, and K. Ramachandra, Experimental Stress Analysis, Tata McGraw Hill, 1984.

3) Sadhu Singh, Experimental Stress Analysis, Khanna Publishers, 1996.

4) Jayamangal Prasad, C. G. Krishnadas Nair, Non-Destructive Test and Evaluation Of Materials, Tata McGraw-Hill, 2008.

5) J. P. Holman, Experimental methods for engineers, McGraw-Hill Mechanical Engineering, 2009.

5.Course Plan:

Module	Contents	Hours
I	Overview of stress analysis: Theory of Elasticity, Plane stress and plane strainconditions,compatibilityconditions,problemusingplanestress and plane strain conditions, three-dimensional stress strain relations. Principal stresses and strains. Mohr 's circle-measurement of strains and stresses. Stress analysis – Analytical, Numerical and Experimental approaches.	**8**
II	Strain measurement: Strain gauges and Stress gauges.Mechanical, Optical and Electrical gauges- construction and applications. Variable resistance strain gauges, Gauge characteristics, Gauge sensitivity, static and dynamic strains- reduction of strain gauge data- compensation-strain measurement over long period at high and low temperature. Strain rosettes- Rectangular rosette, Delta rosette. Residual stresses: Beneficial and harmful effects. Principle of residual stress measurement- methods only. Moire Method of Strain Analysis	**8**
III	Instrumentation : Strain Circuits, Potentiometer Circuits ,Range and sensitivity, The Wheatstone Bridge , Sensitivity, Galvanometer, Transient response, Principles of Measurement: Errors, Accuracy and Precision, Uncertainity analysis, Curve fittingOscillograph, Cathode Ray Oscilloscope, Transducers-Displacement, Force, Pressure, Velocity, Acceleration	**9**
IV	Photoelasticity : The Polariscope, stress optic law, Photo elastic modelmaterials, Polariscope arrangements – Plane polariscope and Circular polariscope.Dark Field and Light field, Isochromatics and Isoclinics, Jones Calculus, Partial fringe value and compensation techniques. Introduction to threedimensional photoelasticity, Use of photo elastic coatings	**9**
V	Brittle coatings : Coating stresses, Failure theories, Brittle coating crack patterns produced by direct loading, refrigeration, load release, Crack detection, Types of coatings, Steps in brittle coating tests, Coating selection, Surface preparation. Non destructive testing (NDT) methods : Types –dye penetrate methods, Radiography-X-ray and Gamma ray-X-ray fluoroscopy-Penetrameter-Magnetic particle method. Introduction to lasers in NDT – Ultrasonic flaw detection	**11**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162O	INDUSTRIAL TRIBOLOGY	PEC	3	0	0	3	2022

1.Course Objectives: Goal of this course is to develop the essential knowledge both practical and theoretical in the field of tribology.

2. Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO 1	Explain the principles of friction, wear and lubrication.	Understand
CO 2	Explain the methods used to combat friction and wear-related problems.	Understand
CO 3	Identify, friction and wear-related problems.	Apply
CO4	Analyse the mechanism for selection for lubricants.	Apply
CO 5	Design hydrodynamic, hydrostatic and antifriction bearings.	Apply

3.Syllabus:

Introduction to Tribology: - Analysis of surface roughness- Measurement of surface roughnessWear, Lubrication. Bearings, Hydrostatic bearings: hydrostatic step bearings- Rolling element bearings, Selection of bearings.

4.References:

i) Radzimovsky, Theory of lubrication of bearings, The Donald Press Company, London 1959.

ii) Fuller D.D: Theory and practice of lubrication for Engineers – John Willey& Sons, Inc.1966.

iii) Bharat Bhusan, Introduction to Tribology- John Wiley &Sons,Inc. 2002.

iv) Khonsari and Booser, Applied Tribology: Bearing Design and Lubrication,Wiley, 2017.

V) Principles of Lubrication – A Cameron, Longman's Green Co.Ltd, 1966.

5.Course Plan:

Module	Contents	Hours
I	Introduction to tribology- Origins and significance of Micro/Nanotribology – tribological parameters like friction, wear and lubrication. Nature of surfaces-Physico-chemical characteristics of surface layers- Analysis of surface roughness- Measurement of surface roughness- Measurement of real area of contact. Surface force apparatus (SFA) studies- Description of an SFA- Static, Dynamic and Shear properties of molecularly thin liquid films- Description of Atomic force microscope (AFM) and Friction force Microscope (FFM)-Friction and adhesion-Atomic scale friction- Microscale friction - Nanoscale wear - Microscale scratching - Microscale wear.	9
II	Friction: Types of friction-dry-boundary and fluid-laws of friction and friction theories-Tomlinson hypothesis, Bowden and Tabor theory.Friction of metals, ceramic materials and polymers-Variables in friction – Surface cleanliness – effect of pressure, velocity, temperature, vibration etc.	9
III	Wear – Classification – Running in wear-theories of wear- stages of wear- Types of wear mechanisms- adhesive and abrasive wear-factors affecting wear. Types of particles present in wear debris.Wear of materials. Tests and Instrumentation in Tribology. Sliding friction and wear abrasion test, rolling contact and fatigue test, solid particle and erosion test, Corrosion test.	9
IV	Lubrication: Role of lubrication- Lubricants-selection of lubricants-Importance of viscosity and methods for measuring viscosity-fundamentalsofviscousflow-flowthroughcapillarytube–flowbetween parallel pates -radial flow between parallel circularplates. Flow between parallel pates -radial flow between parallel circular plates, Squeeze film lubrication –Reynolds's equation.	9
V	Bearings- classification and applications- Selection of bearings. Hydrodynamic bearings:Journal bearings eccentricity-pressure distribution–attitudeangle,loadcarryingcapacity,Petroff'sequation-friction and power loss-ideal and real bearings leakage factors-Sommerfield number and design charts. Oil flow and heat dissipation in bearings- Analysis of hydro thrust bearings – Fixed and pivoted shoe bearings.Hydrostatic bearings, Rolling element bearings.	9
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME162P	Modelling, Simulation and Analysis of Engineering Systems	PEC	3	0	0	3	2022

1) Course Objectives:

This course covers modelling and simulation principles with applications to different systems in engineering. Students will use simulation tools and conduct studies to address current research issues for complex systems. It covers modelling approaches with a focus on continuous and discrete simulation, and surveys applications for complex systems across a variety of engineering domains.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Explain the art and science of the modelling process, especially as applied to complex systems.	Apply
CO2	Develop and execute simulation models.	Apply
CO3	Develop simulation related term projects that address critical research issues	Apply
CO4	Analyse different feedback systems	Apply

3) Syllabus:

Fundamental Concepts in Mathematical Modelling, Modeling of First–order and Second–order Systems, Frequency response of Linear, Time invariant systems, Feedback systems.

4) References:

1.Cha P. D., Rosenberg J. J. and Dym C. L. – 'Fundamentals of Modeling and Analyzing Engineering Systems'- Cambridge University – 2000
2.Woods Robert L. and Kent L.- 'Modeling and Simulation of Dynamic Systems'- Prentice Hall – 1997
3.Mukherjee A. and Karmakar R. – 'Modeling and Simulation of Engineering Systems through Bondgraphs' – Narosa – 2000
4.Frederick C. – 'Modeling and Analysis of Dynamic Systems' – Wiley – 2001 – 3rd Edition

5) Course Plan:

Module	Contents	No. of hours
I	Fundamental Concepts in Mathematical Modelling: Abstraction linearity and superposition – balance and conservation laws and the system boundary approach.	**9**
II	Lumped Element Modeling: Mechanical systems Translational, rotational. Hydraulic systems. Thermal systems. RLC Electrical Systems.	**9**
III	Modeling of First–order and Second–order Systems: Governing equations for free and forced responses, transient response specifications – experimental determination – Laplace transform. Time Domain, Frequency Domain and State Space.	**9**
IV	Frequency response of Linear, Time invariant systems frequency response of first–order and second–order systems ,state space formulations of systems problems relating frequency response to pole location – transient response-poles and frequency response.	**9**
V	Feedback systems: Systems with feedback – block diagrams – properties of feedback systems – relative stability – phase and gain margins.	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME165A	Integrated Product Design and Process Development	IEC	3	0	0	3	2022

1) **Course Objectives:** The course aims at providing the basic concepts of product design, product features and its architecture so that student can have a basic knowledge in the common features a product has and how to incorporate them suitably in product.

2) **Course Outcomes:**

After the completion of the course the student will be able to:

#	Description	Level
CO1	Explain the integration of customer requirements in product design	Understand
CO2	Apply structural approach to concept generation, selection and testing	Apply
CO3	Analyse various aspects of design such as industrial design, design for manufacture, economic analysis and product architecture.	Apply

3) **Syllabus:** Need for IPPD, Plan and establish product specifications, Product development management, Integrate process design.

4) **References:**

1. Product Design and Development, Karl T.Ulrich and Steven D.Eppinger, McGraw –Hill International Edns.1999

2.ConcurrentEngg./Integrated Product Development. Kemnneth Crow, DRM Associates, 6/3,ViaOlivera, Palos Verdes, CA 90274(310) 377-569,Workshop Book

3.Effective Product Design and Development, Stephen Rosenthal, Business One Orwin, Homewood, 1992,ISBN, 1-55623-603-4.

5) Course Plan:

Module	Contents	Hours
I	Need for IPPD-Strategic importance of Product development - integration of customer, designer, material supplier and process planner, Competitor and customer – behavior analysis. Understanding customer-promoting customer understanding-involve customer in development and managing requirements Organization process management and improvement	
II	Plan and establish product specifications. Task - Structured approaches - clarification - search-externally and internally-Explore systematically - reflect on the solutions and processes - concept selection - methodology - benefits. Implications - Product change - variety - component standardization - product performance - manufacturability – Concept Testing Methodologies.	
III	Product development management - establishing the architecture - creation - clustering - geometric layout development - Fundamental and incidental interactions - related system level design issues - secondary systems - architecture of the chunks - creating detailed interface specifications-Portfolio Architecture.	
IV	Integrate process design - Managing costs - Robust design - Integrating CAE, CAD, CAM tools – Simulating product performance and manufacturing processes electronically – Need for industrial design-impact – design process - investigation of customer needs - conceptualization - refinement - management of the industrial design process – technology driven products - user - driven products - assessing the quality of industrial design	
V	Definition - Estimation of Manufacturing cost-reducing the component costs and assembly costs, Minimize system complexity - Prototype basics - Principles of prototyping – Planning for prototypes - Economic Analysis - Understanding and representing tasks-baseline project planning - accelerating the project-project execution	
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME165B	ADVANCED NON DESTRUCTIVE EVALUATION	PEC	3	0	0	3	2022

1) Course Objectives:

Goal of this course is

- To familiarize the various non-destructive evaluation techniques
- To the identification of technique suitable for particular requirement.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Explain various surface and volumetric nondestructive evaluation techniques and its sensitivity towards various types of defects	Understand
CO2	Analyse various advanced NDE techniques.	Apply
CO3	Explain the principle of ultrasonic NDE and mechanics of elastic wave propagation	Understand
CO4	Analyse different advanced ultrasonic testing methods.	Apply
CO5	Explain different radiographic methods.	Understand

3) Syllabus:

Introduction to Non Destructive evaluation,
Electro-Magnetic Methods
Principles of Thermography.
Radiographic Methods.
Overview of advance ultrasonic techniques.

4) References:

1. P.J. Shull, Nondestructive evaluation, theory techniques and application,Marcell Decker Inc, New York2002.
2. D.E. Bray and R.K.Stanley, Nondestructive evaluation, a tool indesign manufacturing and service, CRC Press,1996.

3.Paul E. Mix, Introduction to nondestructive testing- a training guide, Wiley International, USA,2005.

5) **Course Plan:**

Module	Contents	Hours
I	Introduction to nondestructive evaluation, Visual inspection, LiquidPenetrantTesting– principles,typesandpropertiesofliquidpenetrants,developers,advantage sandlimitationsofvarious methods. Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, inspection materials. Magnetisation methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.	**9**
II	Electro-Magnetic Methods - Maxell's Equations, Magnetic Flux Leakage. Eddy Current, Low Frequency Eddy Current, Remote Field Eddy Current, Pulsed Eddy Current.	**9**
III	Principles of Thermography, Contact and non-contact inspection methods Heat sensitive paints - Heat sensitive papers - thermally quenched phosphors liquid crystals – techniques for applying liquid crystals calibration and sensitivity Other temperature sensitive coatings non-contact thermographic inspection - Advantages and limitation -infrared radiation and infrared detectors, Instrumentations and methods, applications.	**9**
IV	Radiographic Methods Principles of X-ray NDT, Equipment, Calibration, Image Collection, Quantification, and Interpretation. High power sources and high quality films. Digital Radiography. Introduction to TomographyandLaminography.Formulation of elastic wave equation, Elastic wave propagation in isotropic and anisotropic materials, Cristoffel equation. Overview of advance ultrasonic techniques-Phased array technique, Time of flight diffraction technique, Ultrasonic guided waves, EMAT, laser ultrasonics, nonlinear ultrasonics,acoustic emission technique.	**9**
V	Nature of sound waves, wave propagation, modes of Sound wave generation longitudinal waves, transverse waves, surface waves, lamb waves, Velocity, frequency and wavelength of ultrasonic waves. Ultrasonic pressure, intensity and impedance, Attenuation of ultrasonic waves - reflection, refraction and mode convection, Snell'slaw and critical angles, Fressnel and Faunhofereffects ultrasonic beamsplit. Various methods of ultrasonic wave generation, Piezoelectric effect,Piezoelectricmaterialsandtheirproperties,contacttesting, Pulse echo method and through transmission method, immersion testing, couplants, Data presentation A, B and C scandisplays	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
22ME165C	INTRODUCTION TO 3D PRINTING TECHNOLOGY	IEC	3	0	0	3	2022

1) Course Objectives:

The objective of this course is to impart students to the fundamentals of various 3D Printing Techniques for application to various industrial needs. Student will be able to convert part file into STL format and will understand the method of manufacturing of liquid based, powder based and solid based techniques.

2) Course Outcomes:

After the completion of the course the student will be able to:

#	Description	Level
CO1	Make use of software tools for 3D printing	Apply
CO2	Build 3D printed modules	Apply
CO3	Develop products using LOM and FDM technologies	Apply

3) Syllabus:

Introduction to 3D printing
3D modelling
Data Conversion and transmission
Stereo lithography apparatus (SLA)
Solid ground curing (SGC)
Laminated object manufacturing (LOM)
Fused Deposition Modeling (FDM)

4) **References:**

1.Chua C.K., Leong K.F. and LIM C.S Rapid prototyping: Principles an Applications, World Scientific publications, 3rdEd., 2010
2. D.T. Pham and S.S. Dimov, “Rapid Manufacturing”, Springer, 2001
3. Terry Wohlers, “ Wholers Report 2000”, Wohlers Associates, 2000
4. Paul F. Jacobs, “ Rapid Prototyping and Manufacturing”–, ASME Press, 1996
5. Ian Gibson, Davin Rosen, Brent Stucker “Additive Manufacturing Technologies, Springer, 2nd Ed, 2014.

5) Course Plan:

Module	Contents	Hours
I	Introduction to Design, Prototyping fundamentals. Introduction to 3D printing, its historical development, advantages. Commonly used terms, process chain, 3D modelling,	**9**
II	Data Conversion, and transmission, Checking and preparing, Building, Post processing, RP data formats, Classification of 3D printing process, Applications to various fields.	**9**
III	Stereo lithography apparatus (SLA): Models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. Solid ground curing (SGC): Models and specifications, process, working, principle, applications, advantages and disadvantages, case studies	**9**
IV	Laminated object manufacturing (LOM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies.	**9**
V	Fused Deposition Modeling (FDM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies, practical demonstration	**9**
	Total hours	**45**