SYLLABUS

(With effect from 2017-2018)
Out Come Based Education

I & II Semester

ಪಠ್ಯಕ್ರಮ

(ಶೈಕ್ಷಣಿಕವರ್ಷ 2017–18)
ಫಲಿತಾಂಶ ಆಧಾರಿತ ಶಿಕ್ಷಣ

Master of Technology
In
Machine Design
(Mechanical Engineering)

P.E.S. College of Engineering, Mandya - 571 401, Karnataka

(An Autonomous Institution Affiliated to VTU, Belagavi)
Grant -in- Aid Institution
(Government of Karnataka)
Accredited by NBA, New Delhi
Approved by AICTE, New Delhi.

ಪಿ.ಇ.ಎಸ್. ತಾಂತ್ರಿಕ ಮಹಾವಿದ್ಯಾಲಯ

ಮಂಡ್ಯ–571 401, ಕರ್ನಾಟಕ

(ವಿ.ಟಿ.ಯು, ಬೆಳಗಾವಿ ಅಡಿಯಲ್ಲಿನ ಸ್ವಾಯತ್ತ ಸಂಸ್ಥೆ)

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Preface

PES College of Engineering, Mandya, started in the year 1962, has become autonomous in the academic year 2008-09. Since, then it has been doing the academic and examination activities successfully. The college is running Eight undergraduate and Eight Postgraduate programs. It consists of Six M.Tech programs, which are affiliated to VTU. Other postgraduate programs are MBA and MCA.

India has recently become a Permanent Member by signing the Washington Accord. The accord was signed by the National Board of Accreditation (NBA) on behalf of India on 13th June 2014. It enables not only the mobility of our degree globally but also establishes equivalence to our degrees with that of the member nations such as Taiwan, Hong Kong, Ireland, Korea, Malaysia, New Zealand, Russia, Singapore, South Africa, Turkey, Australia, Canada and Japan. Among other signatories to the international agreement are the US and the UK. Implementation of Outcome Based Education (OBE) has been the core issue for enabling the equivalence and of Indian degrees and their mobility across the countries.

Our Higher Educational Institution has adopted the CBCS based semester structure with OBE scheme and grading system.

The credit based OBE semester system provides flexibility in designing curriculum and assigning credits based on the course content and hours of teaching.

The OBE, emphasize setting clear standards for observable, measurable outcomes of programs in stages. There lies a shift in thinking, teaching and learning processes moving towards Students Centric from Teacher Centric education. OBE standards focus on mathematics, language, science, attitudes, social skills & moral values.

The key features which may be used to judge, if a system has implemented an outcome based education system is mainly Standard based assessments that determines whether students have achieved the stated standard. Assessments may take any form, so long as the process actually measure whether the student knows the required information or can perform the required task. Outcome based education is a commitment that all students of all groups will ultimately reach the same minimum standards. Outcome Based Education is a method or means which begins with the end in mind and constantly emphasizes continuous improvement.

Choice Based Credit System (CBCS) provides choice for students to select from the prescribed courses (core, Foundation, Foundation Elective, elective, open elective and minor or soft skill courses). The CBCS provides a 'cafeteria' type approach in which the students can Choose electives from a wide range of courses of their choice, learn at their own pace, undergo additional courses and acquire more than the required credits, adopt an interdisciplinary approach to learning which enables integration of concepts, theories, techniques, and, perspectives from two or more disciplines to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline. These greatly enhance the skill/employability of students.

In order to increase the Industry/Corporate readiness, many Soft Skills and Personality Development modules have been added to the existing curriculum of the academic year 2015-16. Industry Interactions have been made compulsory to enhance the field experience. In order to enhance creativity and innovation Mini Project and Industrial visit & Interaction are included in all undergraduate programs

Sri.B.Dinesh Prabhu
Deputy Dean (Academic)
Associate Professor,
Dept. of Automobile Engg

Dr. P S Puttaswamy
Dean (Academic)
Professor,
Dept. of Electrical & Electronics Engg.

PES College of Engineering

Vision

"*A* leading institution imparting quality engineering and management education developing creative and socially responsible professionals"

Mission

Mission of P E S College of Engineering is to,

- Provide state of the art infrastructure, motivate the faculty to be proficient in their field of specialization and adopt best teaching-learning practices.
- Impart engineering and managerial skills through competent and committed faculty using outcome based educational curriculum.
- Inculcate professional ethics, leadership qualities and entrepreneurial skills to meet the societal needs.
- Promote research, product development and industry-institution interaction.

Department of Mechanical Engineering

ABOUT THE DEPARTMENT

The department of Mechanical Engineering was established in the year 1962 during the origination of the institute. The department was granted academic autonomy in the year 2009. The department presently offers B.E in Mechanical Engineering, M Tech in Computer Integrated Manufacturing (CIM), M Tech in Machine Design, M.Sc., (Engg.) by research and research leading to Ph.D. The present intake capacity of the department is 120 for BE, 18 for M Tech CIM and 24 for M Tech Machine Design. The department has a faculty-student ratio of 1:15 for UG courses and 1:12 for PG courses. The department has well established laboratories to meet the academic requirements of UG and PG programmes and a skilled technical faculty to train the students. The department has its own library which has a collection of about 3160 reference books.

The department regularly organizes industrial visits, technical lectures by experts from industries and institutes in contemporary areas to bridge the gap between syllabi and current developments. The students are encouraged to undergo industrial training as well as to take up industry oriented projects during their academic course. Mechanical Engineering Association, formed by the students and faculty of the department regularly organizes co-curricular and extracurricular activities for the students.

Vision

Be a department well recognized for its ability to develop competent mechanical engineers capable of working in global environment"

Mission

The Mission of the Department of Mechanical Engineering is to:

- Provide quality education by competent faculty.
- Provide adequate infrastructure and learning ambience for the development of essential technical skills.
- Inculcate a sense of higher education and research orientation.
- Foster industry interaction.

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Credit pattern

Programme: M.Tech. in Machine Design

Core Courses	I Semester	16 credits
	II Semester	12 credits
Elective Course	I Semester	08 credits
	II Semester	12 credits
Lab	I Semester	02 credits
	II Semester	02 credits
Self Study course	III Semester	04 credits
Pedagogy Training	III Semester	02 credits
Seminar	III Semester	02 credits
Project work	III Semester	08 credits
Industrial Training	III Semester	06 credits
Project work	IV Semester	22 credits
Term Paper	IV Semester	04 credits
A total of 100 credits for 2 years		

Evaluation Scheme							
Scheme	**Weightage**	**Marks**	**Event Break Up**				
CIE	50%	50	**Test I**	**Test II**	**Quiz I**	**Quiz II**	**Assignment**
			35	35	5	5	10
SEE	50%	100	**Questions to Set: 10**		**Questions to Answer: 5**		
Scheme of SEE Question Paper (100 Marks)							
Duration: 3Hrs		**Marks: 100**			**Weightage: 50%**		

- Each of the two questions set shall be so comprehensive as to cover the entire contents of the unit.
- There will be direct choice between the two questions within each Unit
- Total questions to be set are 10. All carry equal marks of 20
- The number of subdivisions in each main question shall be limited to three only

No. of questions to be answered by students is 5

P.E.S. COLLEGE OF ENGINEERING, MANDYA-571401

Scheme of Teaching and Examination for M. Tech course in Mechanical Engineering

(Machine Design)

First semester

Sl. No.	Sub. code	Subject	Teaching Dept.	Hrs./Week L:T:P:H	Total Credits	Marks Allotted		Total Marks
						CIE	SEE	
1.	P17MMDN11	Advanced Machine Design	Mechanical	4:0:0:4	04	50	50	100
2.	P17MMDN12	Finite Element Analysis	Mechanical	4:0:0:4	04	50	50	100
3.	P17MMDN13	Theory of Elasticity	Mechanical	4:0:0:4	04	50	50	100
4.	P17MMDN14	Tribology and Bearing Design	Mechanical	4:0:0:4	04	50	50	100
5.	P17MMDN15X	Elective – I	Mechanical	4:0:0:4	04	50	50	100
6.	P17MMDN16X	Elective – II	Mechanical	4:0:0:4	04	50	50	100
7	P17MMDL17	Design Lab -I	Mechanical	0:0:4:4	02	50	50	100
				Total	**26**	**350**	**350**	**700**

Elective – I			
Sl.No.	***Sub. code***	***Subject Name***	**Hrs./Week L:T:P:H**
1	P17MMDN151	Advanced Material Technology	4:0:0:4
2	P17MMDN152	Experimental Mechanics	4:0:0:4
Elective – II			
1	P17MMDN161	Computer Application in Design	4:0:0:4
2	P17MMDN162	Additive Manufacturing	4:0:0:4

Second semester

Sl. No.	Sub. code	Subject	Teaching Dept.	Hrs./Week L:T:P:H	Total Credits	Marks Allotted		Total Marks
						CIE	SEE	
1.	P17MMDN21	Dynamics & Mechanism Design	Mechanical	4:0:0:4	04	50	50	100
2.	P17MMDN22	Advanced Theory of Vibration	Mechanical	4:0:0:4	04	50	50	100
3.	P17MMDN23	Theory of Plasticity	Mechanical	4:0:0:4	04	50	50	100
4.	P17MMDN24X	Elective – III	Mechanical	4:0:0:4	04	50	50	100
5.	P17MMDN25X	Elective – IV	Mechanical	4:0:0:4	04	50	50	100
6.	P17MMDN26X	Elective – V	Mechanical	4:0:4:4	04	50	50	100
7	P17MMDNL27	Design Lab-II	Mechanical	0:0:4:4	02	50	50	100
				Total	**26**	**350**	**350**	**700**

Elective- III			
Sl No	**Sub Code**	**Sub Name**	**Hrs/Week L:T:P:H**
1	P17 MMDN241	Metrology and Computer Aided Inspection	4:0:0:4
2	P17 MMDN242	Theory of Plates and Shells	4:0:0:4
Elective- IV			
1	P17 MMDN251	Fracture Mechanics	4:0:0:4
2	P17 MMDN252	Advanced Industrial Robotics	4:0:0:4
Elective- V			
1	P17 MMDN261	Statistical Modeling and Experimental Design	4:0:0:4
2	P17 MMDN262	Vehicle Dynamics	4:0:0:4

P.E.S. COLLEGE OF ENGINEERING, MANDYA-571401

Scheme of Teaching and Examination for M. Tech course in Mechanical Engineering

(Machine Design)

Third semester

Sl. No.	Sub. code	Subject	Teaching Dept.	Hrs./Week L:T:P:H	Total Credits	Marks Allotted		Total Marks
						CIE	SEE	
1.	P17MMDN31	Self study course	Mechanical	4:0:0:4	04	50	50	100
2.	P17MHUM32	Pedagogy/ Research Methodology	HS&M	0:2:2:4	02	100	--	100
3.	P17MMDN33	Seminar	Mechanical	--	02	100	--	100
4.	P17MMDN34	Project-Phase-I	Mechanical	--	04	100	--	100
5.	P17MHSM35	Project-Phase-II	Mechanical	--	04	100	--	100
6.	P17MMDN36	Industrial Training	Mechanical	--	06	100	--	100
Total					**22**	**550**	**50**	**600**

Fourth semester

Sl. No.	Sub. code	Subject	Teaching Dept.	Hrs./Week L:T:P:H	Total Credits	Marks Allotted		Total Marks
						CIE	SEE	
1.	P17MMDN41	Project-Phase-III	Mechanical	--	04	100	--	100
2.	P17MMDN42	Project-Phase-IV (Thesis Evaluation)	Mechanical	--	10	100	--	100
3.	P17MMDN43	Project-Phase-V (Viva-Voce)	Mechanical	--	08	--	100	100
4.	P17MMDN44	Term Paper	Mechanical	--	04	--	100	100
Total					**26**	**200**	**200**	**400**

Note:

1 Eight weeks of compulsory Industrial Training to be undergone by the students during their third semester. A report on Industrial Training is to be submitted by the student. The report has to be evaluated by Industrial guide and Institute guide for CIE of 50 marks (industry and supervisor evaluation average marks for 50 each). The student must give seminar based on Industrial Training before a committee constituted by the department for remaining CIE of 50 marks.

2 The Laboratories are CIE with report submission and seminar presentation /Viva Voce of 50 marks each.

3 Pedagogy/Research methodology is CIE with objective type of question for evaluation

4 The seminar (III Semester) shall be of 100 marks CIE. It is based on the current topics presentation along with a report submission for evaluation each of 50 marks.

5 Project work Phase-1, 2 & 3 to be awarded by the Department committee constituted for the purpose

a) The Project Phase-I evaluation shall be of 100 marks CIE. It is based on Report Submission consisting of Title, Introduction, Literature Survey, Summary of Literature Survey, Objectives and Methodology (50 Marks) and Presentation (50 marks) each.

b) The Project Phase-II evaluation shall be of 100 marks CIE. It is based on Report Submission consisting of Experimentation, Theoretical analysis approach and results (if completed as a stage work) and Presentation for 50 marks each.

c) The Project Phase-III evaluation shall be of 100 marks CIE. It is based on Thesis manuscript and presentation for 50 marks each (work completion report).

6 The Project Phase-IV evaluation shall be of 100 marks CIE. It is based on the evaluation done separately by internal and external examiners and average marks of the two examiner shall be consider as final marks

7 The Project Phase-V evaluation shall be of 100 marks SEE. It is based on Thesis presentation and project viva voce has to be conducted jointly by internal and external examiner for a total of 100 marks SEE.

8 The term paper is purely based on the project work he/she chooses.

9 The Term paper shall be for 100 marks SEE. It has to be evaluated by the committee formed by HOD consisting of PG coordinator, guide and subject expert internal/ external for each candidate.

10 The term paper evaluation is based on the publication of an article in peer reviewed conference/ journal (national/ international) and quality of the journal. If the term paper is not published by the candidate or the same is communicated for publication at the end of his/ her tenure, then the committee formed by HOD consisting of PG coordinator, guide and subject expert internal/ external for each candidate will asses.

11 The self study course shall consist of five units with lab component and he/ she must be able to demonstrate the knowledge gained by the candidates. The course content must be tailer made by the department to suit their requirements.

12 The self study course shall be of 100 marks. The course evaluation is based on the lab report submission/ assignment/ viva -voce as CIE 50 marks and SEE for 50 marks.

Course Title: Advanced Machine Design		
Course Code: P17MMDN11	**Sem: I**	**L:T:P:H : 4:0:0:4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course Objectives: The course aims at strengthening the design capabilities of students by enhancing their understanding of fatigue failure, crack propagation and life estimation of machine elements subjected to fatigue loads.

Course Content

UNIT – 1

Fatigue of Materials: Introduction**,** Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples. Fatigue failure, High cycle and low cycle fatigue, macro/micro aspects of fatigue of metals, fatigue fracture surfaces and macroscopic features, fatigue mechanisms and microscopic features, strategies in fatigue design, Fatigue design models, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens. **10Hrs**

UNIT – 2

Stress-Life (S-N) Approach: Introduction, S-N curves, General S-N behavior, fatigue limit under fully reversed uniaxial stressing, Mean stress effects on S-N behaviour, factors influencing S-N behaviour, stress concentration and notch sensitivity, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach. Fatigue from variable amplitude loading: spectrum loads and cumulative damage, damage quantification and concepts of damage fraction and accumulation, Palmgren-Miner linear damage rule, load interaction and sequence effects, cycle counting – level crossing counting, peak counting, simple range counting, Rainflow counting method, life estimation. Strengths, limitations and typical applications of S-N approach.

12 hrs

UNIT – 3

Strain-Life(ε-N)approach: Introduction, Monotonic stress-strain behavior, stress-strain relationships, Strain controlled test methods ,Cyclic stress-strain behavior, cyclic strain hardening and softening, cyclic stress-strain curve, Strain based approach(**ε-N)** to life estimation, determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach. Variable amplitude loading: life estimation under variable amplitude loading. Strengths, limitations and typical applications of strain-life approach. **10 hrs**

UNIT – 4

LEFM Approach: Introduction, LEFM& EPFM concepts. Loading modes, stress intensity factor, K expressions for common cracked members, Crack tip plastic zone, plane stress and plane strain conditions, Fracture toughness, monotonic and cyclic plastic zone size, Fatigue crack growth, sigmoidal curve, constant amplitude fatigue crack growth test methods, fatigue crack growth for R = 0, Crack growth life estimation, Mean stress effects, crack closure. Crack growth under variable amplitude loading, load interaction models, wheeler model. Strengths, limitations and typical applications of LEFM approach. **10 hrs**

UNIT – 5

Notches and their effects: Introduction, concentrations and gradients of stress and strain, S-N approach for notched members, notch sensitivity and fatigue notch factor, effects of stress levels, mean stress effect, Haigh diagrams, notch strain analysis and strain-life approach, Neuber's rule, Glinka's rule, life estimation using strain-life approach, applications of fracture mechanics to crack growth at notches. **10 hrs**

Text Books

1 Ralph I. Stephens, Ali Fatemi, Robert .R. Stephens, Henry O. Fuchs, **"Metal Fatigue in Engineering**,**"** John Wiley and Sons, 2nd Edition, 2001, ISBN: 9780471510598.

2 Julie A.Bannantine, **"Fundamentals of Metal Fatigue Analysis,"** Prentice Hall, 1990, ISBN: 978-0133401912.

References

1 Robert L. Norton, **"Machine Design,"** Pearson Education, 5th Edition, 16th September 2013, ISBN: 978-0133356717.

2 **Failure of Materials in Mechanical Design,** Jack. A. Collins, John Wiley, 2nd Edition, 4th October 1993, ISBN: 978-0471558910.

3 **Richard** G Budynas and Keith J Nisbett, **"Shigley's Mechanical Engineering Design,"** Tata McGraw-Hill publications, 10th Edition, 1st February 2014, ISBN:978-0073398204.

Course Outcomes

At the end of the course the students should be able to:

1 **Describe** failure theories, **design** machine elements based on different static failure criteria, **describe** fatigue concepts and fatigue test methods.

2 **Describe** concepts of stress life approach and **employ** stress life approach for life estimation of machine elements.

3 **Describe** concepts of strain life approach and **employ** strain life approach for life estimation of machine elements.

4 **Describe** concepts of LEFM and **estimate** crack growth life of machine elements.

5 **Explain** the influence of notches on fatigue life of machine elements and **apply** concepts of fracture mechanics to crack growth at notches.

Course Title: Finite Element Analysis		
Course Code: P17MMDN12	**Sem: I**	**L:T:P:H: 3:0:2:5**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course Objectives: The course aims at strengthening the capabilities of students to use various aspects of finite element method as a basic numerical tool for solving mechanical engineering problems.

Course Content

UNIT-1

Introduction to Finite Element Method: Introduction to FEM, Advantages and disadvantages of FEM, Applications of FEM, Boundary conditions: Essential and Non-essential boundary conditions, Basic steps in FEM, Element types, Displacement model, Convergence criteria, Different coordinate systems. Potential energy functional for 3-D elastic body. Methods of deriving finite element equations- Principle of minimum potential energy method, virtual work principle, method of weighted residuals (only description), strong and weak formulation. O**ne-Dimensional Elements-Analysis of Bars**: Introduction, potential energy functional for 1-D bar element, Admissible displacement function, Derivation of shape functions for linear and quadratic bar elements, Element equations - stiffness matrix, consistent nodal force vector due to traction and body forces for linear and quadratic bar elements by Galerkin approach, Assembly Procedure, Treatment of boundary conditions: Elimination and Penalty approach, Multi-point constraints, Initial strain (Temperature effects), Numericals on 1-D bar problems. **12 hrs**

UNIT-2

Two-Dimensional Elements-Analysis of Plane Elasticity Problems: Plane stress and plain strain assumptions, Derivation of shape functions, strain- displacement matrix, stiffness matrix and load vectors for three-noded triangular element (TRIA 3) by variational principle. Lagrangian polynomial – shape functions for 9-noded quadrilateral elements. Isoparametric, subparametric and superparametric elements, Concept of Jacobian matrix: Derivation of Jacobian matrix for CST and 4-noded quadrilateral (QUAD 4) elements. **Three-Dimensional Elements:** Introduction, Finite element formulation - shape functions, strain-displacement matrix, element stiffness matrix, force terms for Four-Noded Tetrahedral Element (TET 4), shape functions for Eight-noded Hexahedral Element (HEXA- 8). **10 hrs**

UNIT-3

Axi-symmetric Solid Elements: Axi-symmetric formulation, Axi-symmetric Triangular Elements– Derivation of strain-displacement matrix, stiffness matrix and load vectors by potential energy approach. **Analysis of Plane Trusses**: Local and Global co-ordinate systems, element stiffness matrix, stress calculations, temperature effects. **10 hrs**

UNIT- 4

Analysis of Beams: Derivation of Hermite shape functions for beam element, Stiffness matrix and load vector for beam element by Galerkin approach, element shear force and bending moment. Numericals on plane trusses and beams. **Dynamic Considerations**: Formulation for point mass and distributed masses, Element mass matrices for one dimensional bar element, truss

element, CST element, beam element. Lumped mass matrix, Evaluation of eigen values and eigen vectors for one-dimensional bars. **10 hrs**

UNIT- 5

Heat Transfer: Introduction, Equations for heat conduction and convection. Governing equation for three-dimensional bodies, boundary and initial conditions, derivation of finite element equations by Galerkin approach, Steady state heat transfer, one-dimensional heat conduction equation, one-dimensional element - Galerkin approach for heat conduction, One-dimensional heat transfer in thin fins, numericals on 1D steady state heat transfer through composite walls and fins. **10 hrs**

Lab exercises*:

1. Introduction to MATLAB.
2. MATLAB code to solve axially loaded bar problems.
3. MATLAB code for the analysis of plane stress problems (plate with traction) using CST and 4-noded quadrilateral (QUAD 4) elements.
4. MATLAB code to analyze 2D plane Trusses and 3D space trusses.
5. MATLAB code for the analysis of beam bending problems.

* *Evaluation of lab exercises is for 10 marks as assignment in CIE only, an average of one assignment, report submission and one test for 10 marks each.*

Text Books

1 Chandrupatla T. R. and Belegundu A. D, **"Introduction to Finite Elements in Engineering,"** Pearson Hall India, 4th Edition, 19th October 2011, ISBN: 978-0132162746.

2 Daryl L Logan, **"Finite Element Methods,"** Cengage Learning Engineering, 5th Edition, 15th April 2010, ISBN: 978-0495668251.

3 Singiresu S. Rao, **"Finite Elements Method in Engineering,"** Butterworth-Heinemann, 5th Edition, 17th November 2010, ISBN: 9781856176613.

References

1 Cook R. D., et al., **"Concepts and Application of Finite Elements Analysis,"** Wiley & Sons, 4th Edition, 2003, ISBN: 978-0471356059.

2 David V. Hutton, **"Fundamentals of Finite Element Analysis,"** McGraw Hill Higher Education, 1st July 2003, ISBN: 978-0071122313.

3 C S Desai and J F Abel, **"Introduction to the Finite Element Method,"** CBS Publisher, 1st Edition, 2005, ISBN: 9788123908953.

Course Outcomes

At the end of the course the students should be able to:

1 **Explain** the concept of finite element method, finite element discretization process and methods of deriving finite element equations and **Solve** one-dimensional structural

problems.

2 **Formulate** finite element equations for two-dimensional and three-dimensional elements and **Analyze** two-dimensional plane stress and strain problems.

3 **Formulate** finite element equations for axi-symmetric and plane truss elements and **Solve** axi-symmetric and plane truss problems.

4 **Formulate** finite element equations for beams and dynamic problems and **estimate** bending moment, shear force and stresses in beam and natural frequencies and mode shape of one-dimensional structural problems.

5 **Formulate** finite element equations for three-dimensional heat transfer problems and **estimate** temperature distribution and heat flow in composite walls and fins.

Course Title: Theory of Elasticity		
Course Code: P17MMDN13	**Sem: I**	**L:T:P:H: 4-0-0-4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course objective: The course aims at enabling the students to understand the mathematical and physical principles of Elasticity, with different solution strategies while applying them to practical cases.

Course Content

Unit -1

Stress Analysis: Introduction to the general theory of elasticity, assumptions and applications of linear elasticity. Stress tensors, state of stress at a point, principal stresses, direction cosines, stress invariants, equilibrium equations, octahedral stresses, decomposition of state of stress, stress transformation, numerical, Mohr's stress circle and construction of Mohr Circle for 2D stress systems. **12 hrs**

Unit-2

Strain Analysis: Deformation, strain-displacement relation, strain components, The state of strain at a point, principal strains, strain invariants, Equations of Compatibility for Strain, strain transformation cubical dilation. **10 hrs**

Unit-3

Stress–Strain Relations: Generalized Hooke's law in terms of engineering constants. Existence and uniqueness of solution, Saint Venant's principle, principle of superposition, Prandtl's membrane analogy, Kirchoff's law, Fundamental boundary value problems, Inverse and Semi-inverse method of solving elasticity problems. General case of Plane stress and Plane strain, transformation of compatibility condition from strain component to stress components. Relation between plane stress and plane strain. **10 hrs**

Unit-4

2D Problems in Cartesian Coordinates: Airy stress function, stress function for plane stress and plane strain case. Investigation for simple beam problems. Bending of narrow cantilever under end load, simply supported beam with uniform load by the use of polynomials. **Torsion** of circular and elliptical bars, stress function, torsion of thin walled and multiple cell closed sections. **10 hrs**

Unit-5

General Equations in Cylindrical coordinate: Equilibrium equation in cylindrical coordinates, thick cylinder under uniform internal and / or external pressure, stresses in composite tubes (shrink fit), stresses in spheres with purely radial displacements.**Thermal Stresses:** Thermo elastic stress strain relationship, equations of equilibrium, thermal stresses in thin circular disks and in long circular cylinder. **10 hrs**

Text Books

1. Timoshenko and Goodier, **"Theory of Elasticity,"** McGraw Hill Education, 3rd Edition, 2nd February 2010, ISBN: 978-0070701229
2. L S Srinath,**"Advanced Mechanics of Solids,"** McGraw Hill,3rd Edition, 10th May 2010, ISBN: 978-0070702608.

References

1. Sadhu Singh, **"Theory of Elasticity,"** Khanna Publisher, 1st December, 2003, ISBN: 978-8174090607.
2. Wang. C. T, **"Applied Elasticity,"** McGraw Hill Inc. US,1st December 1963, ISBN: 978-0070681255.
3. T.G.Sitharam and Govindaraju, **"Applied Elasticity,"** Interline Publishing, 2008, ISBN: 9788172960834.
4. Arthur P Boresi and Richard J Schmidt, **"Advanced Mechanics of Materials,"** John Wiley and Sons, 6th Edition, 2002, ISBN: 978-0471438816.

Course Outcomes

At the end of the course the students should be able to:

1. **Describe** and **calculate** the state of stress and principal stresses at a point and **construct** the Mohr's circle.
2. **Determine** state of a strain at a point and principal strains.
3. **Discuss** the stress and strain relations.
4. **Compute** and **analyze** bending and shear stresses and deflections induced in beams and torsional stresses of thin walled and multiple cell closed sections.
5. **Determine** stresses in thin and thick cylinders and **analyze** stress concentration.

Course Title: Tribology and Bearing Design		
Course Code: P17MMDN14	**Sem: I**	**L:T:P:H:: 4-0-0-4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course Objectives: Tribology is the science and engineering of friction and wear between two bodies in relative motion. Knowledge of tribology is essential for a design engineer in his practice to reduce energy consumption in mechanical systems. This course provides the necessary theoretical background for the design of fluid film bearings.

Course Content

UNIT – 1

Introduction: Nature of surfaces – Analysis of surface roughness, Measurement of surface roughness, Friction – Causes, adhesion theory, abrasive theory, junction growth theory, laws of rolling friction, Wear - mechanisms, adhesive wear, abrasive wear, corrosive wear, fatigue and fretting wear, wear analysis, Lubrication and lubricants – types and properties of lubricants, lubricant additives, Newton's Law of viscous forces, effect of pressure and temperature on viscosity, viscosity index, regimes of lubrication, Numerical problems. **10 hrs**

UNIT – 2

Fluid dynamics fundamentals: Hagen - Poiseuille's theory, Flow through stationary parallel plates, Pressure induced and velocity induced flow, Numerical problems. **Hydrodynamic Bearings:** Concept of lightly loaded bearings, Petroff's equation, Pressure development mechanism. Reynolds' 2D equation with assumptions. Introduction to idealized slider bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity and Location of center of pressure of idealized slider bearing, Numerical problems. **12 hrs**

UNIT – 3

Journal Bearings: Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Sommerfeld number and its significance. Comparison between lightly loaded and heavily loaded bearings, Numerical problems. **Bearing design:** Introduction, Practical considerations, Design of journal bearings. **10 hrs**

UNIT – 4

Hydrostatic Bearings: Types of hydrostatic Lubrication systems Expression for discharge, load carrying capacity, Flow rate, Condition for minimum power loss. Torque calculations. Numerical problems. **Elastohydrodynamic Lubrication**: Introduction, Theoretical consideration, Grubin type solution, Accurate solution, Different regimes in EHL contacts.

10 hrs

UNIT – 5

Gas Bearings: Introduction to gas lubricated bearings. Governing differential equation for gas lubricated bearings. **Porous Bearings**: Introduction to porous bearings. Equations for porous bearings and working principle. **Magnetic Bearings**: Introduction to magnetic bearings, Active magnetic bearings. Different equations used in magnetic bearings and working principle. Advantages and disadvantages of magnetic bearings, Electrical analogy, Magneto-hydrodynamic bearings. **10 hrs**

Text Books

1 MajumdarB.C,**"Introduction to Tribologyof Bearing,"**S Chan and Company,1st December 2010, ISBN: 978-8121929875.

2 E. I. Radzimovsky, **"Lubrication of Bearings: Theoretical Principles and Design,"** Oxford Press Company, 2000.

References

1 BharathBhushan, **"Introduction to Tribology,"** John Wiley and Sons, 2nd Edition, 1st April 2013, ISBN: 978-1119944539.

2 Stachowiak G W, Batchelor A W, "Engineering Tribology,"Elsevier Butterworth-Heinemann, 2005, ISBN: 9780080875880.

3 Michael M. Khonsari, E. Richard Booser, **"Applied Tribolgy,"** John Wiley and Sons, 2nd Edition, 27th May 2008, ISBN: 978-0470057117.

4 GerhandSchwetizer, HannesBleuler and AlfonsTraxler, **"Active Magnetic Bearings,"** Springer-Verlag Berlin Heidelberg, 2009, ISBN: 978-3-642-00496-4.

Course Outcomes

At the end of the course the students should be able to:

1 **Explain** nature of surfaces and parameters used in characterizing surface roughness, laws of friction, theories of friction and different wear mechanisms.

2 **Describe** the pressure development mechanism in fluid film bearings and **derive** Reynolds 2D equation.

3 **Apply** Reynolds equation to pad and plain bearings to **estimate** pressure distribution and load carrying capacity.

4 **Apply** Reynolds equation to hydrostatic bearings and **estimate** load carrying capacity, frictional torque.

5 **Derive** governing differential equations for gas and porous bearings.

Course Title: Advanced Materials Technology		
Course Code: P17MMDN151	**Sem: I**	**L:T:P:H : 4:0:0:4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course objective: The aim of the course is to enable the students to understand principles and working of various processing techniques for identifying material and recommend appropriate methods to improve process performance.

Course Content

UNIT -1

Structure-Property Relations & Newer Materials: Introduction, Atomic structure, atomic bonds, secondary bonds, crystal structure, **C**rystal structure, crystal defects, grain structure, elastic and plastic deformation in single crystals, strain /work hardening, plastic deformation in polycrystalline metals, fracture of metals. **Newer Materials**: Plastics, polymerization, thermosetting and thermoplastic materials and properties. Ceramic materials and their properties. Composite materials – classification, matrix and reinforcement materials, properties, rule of mixtures, longitudinal strength and modulus (isostrain model), transverse strength and modulus (isostress model), applications of composites. **11hrs**

UNIT - 2

Processing of Composites: Processing of MMCs : matrix and reinforcement materials, diffusion bonding, squeeze casting, reocasting, arc spray forming, superplastic forming, in situ process. **Processing of CMCs** : matrix and reinforcement materials, fabrication of glass fibers, boron fibers, carbon fibers, alumina fibers, silicon carbide fibers. Processing- slurry infiltration process, melt infiltration process, direct oxidation or Lanxide process. **Processing of PMCs**: matrix and reinforcement materials, processing of polyethylene fibers, aramid fibers. Processing of PMCs – hand layup process, spray-up technique, filament winding process, pultrusion process, autoclave moulding. **11hrs**

UNIT- 3

Powder Metallurgy: Introduction, Production of Powder, Characterization & Testing of Powders, Powder Conditioning, Powder Compaction, Sintering, Finishing operations, Applications of PM components. **10hrs**

UNIT - 4

Surface Treatment: Introduction, Surface Engineering, Surface quality & integrity concepts, Mechanical treatment, Thermal spraying processes and applications, Vapour depositions processes and applications, Ion-implantation. **10hrs**

UNIT -5

Nano Technology: Concept of Nanotechnology, Nanomaterials, preparation of Nanomaterials-plasma arcing, CVD, sol-gel method, electrode deposition, ball milling, New forms of carbon, types of nano-tubes, properties of ofnano-tubes, Nano material characterization –TEM, scanning probe microscopy, atomic force microscopy, scanning tunneling microscopy, applications of nanotechnology. **10hrs**

Text books

1 E. Paul Degarmo, J.T. Black, and Ronald A Kohser. **"Materials and Processing in Manufacturing,"** John Wiley and Sons Inc., 12th Edition, 5th July 2017, ISBN: 978-1118987674.

2 K.K.Chawla,**"Composite Materials: Science & Engineering,"** Springer-Verlag, New York, 3rd Edition, 2012, ISBN: 978-0387743646.

3 A.K. Sinha. **"Powder Metallurgy,"** Dhanpat Rai Publications, ISBN: 978-9383182145.

References

1 Mich Wilson, Kamalikannangara, et. Al., **"Nano Technology: Basic Science and Emerging Technology,"** Chapman and Hall/CRC, 1st Edition, 27th June 2002, ISBN: 978-1584883395.

2 V. S. R Murthy, A. K. Jena, K. P. Gupta and G.S.Murthy, **"Structure and Properties of Engineering Materials,"** Tata McGraw Hill Education, 2003, ISBN: 9780070482876.

3 M. M. Schwartz, **"Composite Materials Hand Book,"** McGraw Hill Higher Education, ISBN: 9780070557437.

4 Rakesh Rathi, **"Nanotechnology,"** S.Chand and Company, 1st December 2010, ISBN: 978- 8121930826.

Course Outcomes

At the end of the course the students should be able to:

1. **Explain** the concepts and principles of advanced materials and manufacturing processes
2. **Select** materials and processes for particular application
3. **Explain** the concept of powder metallurgy technique
4. **Explain** the principles and application of surface treatment methods
5. **Define** Nanotechnology**, Describe** nano material characterization.

Course Title: EXPERIMENTAL MECHANICS		
Course Code: P17MMDN152	**Sem:I**	**L:T:P:H : 4:0:0:4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE: 50; SEE: 50**	

Course Objective: Experimental Stress Analysis provides the knowledge about the experimental techniques to analyze the stresses induced in the mechanical components. It also deals with the direct and indirect methods associated with the measurement of stresses. It includes the concept of brittle coatings, analysis of coating data, crack detection methods and many other photo elastic techniques.

Course Content

UNIT- 1

Introduction, Calibration standards, dimension and units, generalized measurement system, basic concept in dynamic measurement, system response, distortion impedance matching, experiment planning, **Data acquisition and processing:** general data acquisition system, signal conditioning revisited data transmission, analog to digital and digital to analog conversion, basic component(storage and display) of data acquisition system. **Analysis of experimental data**: cause and types of experimental errors, error analysis, statistical analysis of experimental data, probability distribution, Gaussian, normal distribution, chi-square test, method of least square, correlation coefficient multivariable regression, standard deviation of mean, graphical analysis and curve fitting. **10 hrs**

UNIT-2

Strain gauge: Characteristics of strain gauge, LVDT, electrical strain gauge, gauge factor, temperature compensation methods, strain rosette: Two element and three element rectangular and delta rosette. Wheat stone bridge, balanced and unbalanced, balancing technique, Potentiometer circuit, sensitivity, range, calibration of potentiometer. **12hrs**

UNIT- 3

Two dimensional photoelasticity: Introduction, nature of light, wave theory of light, polarization, natural double refraction, stress optic law, effect of stressed models in plane and circular polariscopes, isoclinics, isochromatics, fringe order determination, fringe sharpening, separation methods-shear difference method, numerical problems. **12 hrs**

UNIT- 4

Coating methods: Birefringence coating technique, reflection polariscope, sensitivity of birefringent coating separation of principal stresses. **Brittle coating**: coating technique, laws of failure of brittle coating, isostatics and isoentatics, properties of stress coat materials, crack pattern, crack detection technique, Types of brittle coating, calibration of brittle coating materials. **10 hrs**

UNIT- 5

Holography and Moire Technique: Holography: Equation for plane waves and spherical waves, intensity, coherence, recording process, reconstruction process, Holographic interferometer. **Moire techniques**: Moiré phenomenon, fringe analysis, geometrical approach, displacement approach, advantages and applications. **8 hrs**

Text Books

1 Dr.Sadhu Singh, **"Experimental Stress Analysis,"** Khanna Publishers, 1st December 2009, ISBN: 978-8174091826.

2 Dally and Riley, **"Experimental Stress Analysis,"** McGraw Hill Education, 3rd Edition, 1st March 1991, ISBN: 978-0070152182.

References

1 Srinath, Lingaiah, et al., **"Experimental Stress Analysis,"** Tata McGraw Hill Education, 1984, ISBN: 9780074519264.

2 M.M Froncht, **"Photoelasticity Vol I and II,"** John Wiley and Sons.

3 Kuske Albrecht and Robertson,**"Photoelastic Stress Analysis,"** John Wiley and Sons, 1st January 1974, ISBN: 978-0471511014.

4 Nakra and Chaudhary, **"Instrumentation, Measurement and Analysis,"** Tata McGraw Hills Companies, New York, 7th Edition,2006, ISBN: 978-9385880629.

Course Outcomes

At the end of the course the students should be able to:

1 **Describe** the Concept of Data acquisition, processing and **analysis** of experimental data.

2 **Explain** Electrical Resistance Strain Gauges and Strain Rosettes circuits for strain measurements and potentiometer.

3 **Employ** the suitable technique, enumerate and **analyse** the stresses.

4 **Analyse** the concept of different methods of coating techniques to analyse the stresses.

5 **Conceptualise** Holography and Moire experimental Technique.

Course Title: Computer Application in Design		
Course Code: P17MMDN161	**Sem: I**	**L:T:P:H : 4:0:0:4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course objective: The course aims at producing designers and manufacturing professionals with expertise in application of state of the art knowledge in modeling for computer assisted design.

Course Content

UNIT -1

Introduction: Definitions, Design Process, Product Cycle, Computer Aided Design (CAD)-, Hardware Integration and Networking. **Cad Software-** Data Structure, Database, Database Management System (DBMS) Database Coordinate System, Working Coordinate System, Screen Coordinate System, Modes of Graphics Operations, User Interface, Software Modules-Operating System(OS) Module, Graphics Module, Applications Module, Programming Module, Communications Module, Modeling and Viewing, Software Documentation and Development. **10hrs**

UNIT – 2

Computer Graphics: Rasterscan Graphics, DDA Algorithm, Bresenham Algorithm, Anti-Aliasing Lines. Database Structures-Data Structure- Organisation, Data Models; Geometric Model Data, Engineering Data Management (EDM) System. **Transformations:**Translation, Scaling, Reflection or Mirror, Rotation, Concatenations, Homogeneous Transformation, 2D/3D Transformations-Translation, Scaling, Rotation about, X, Y and Z axes. Numericals. Mathematics of Projections- Orthographic and Isometric Projections. Clipping, Hidden Line or Surface removal, Color and Shading. **10hrs**

UNIT- 3

Geometric Modeling: Requirements of Geometric Modeling, Geometric Models, Geometric Construction Methods, Constraint- Based Modeling, Other Modeling Methods- Cell Decomposition, Variant Method, Symbolic Programming, form Features; Wireframe Modeling-Definitions of Point lines, Circles, Arcs, etc. Modeling Facilities-Geometric Modeling Features, Editing or Manipulating, Display Control, Drafting, Programming, Analytical and Connecting Features. **Graphic Standards** -Standardization in Graphics, Graphical Kernel System (GKS), Other Graphic Standards-GKS 3D, PHIGS, Exchange of Modeling Data-IGES, STEP, Drawing Exchange Format (DXF), Dimension Measurement Interface Specification (DMIS). **11hrs**

UNIT – 4

Modeling Curves & Surfaces: Curve Representation-Line, Circle, Parabola, Hyperbola, Curve Fitting- Interpolation Techniques- Legrangian Polynomial, B-Splines, Approximate Methods-Method of Least Squares, Polynomial Curve Fitting, Synthetic Curves-Hermite Cubic Spline, Bermestine Polynomials, Bezier Curve, rational Curves, and NURBS. **Surface Representation** - Analytic Surfaces, Surfaces of Revolution, Ruled Surfaces, Synthetic Surfaces- Hermite Cubic Surface, Bezier Surface, B-Spline Surface, Coons Surface Patch, Tabulated Cylinder, Sculptured Surfaces, Surfaces of Manipulation-Surface Display, Segmentation. **10hrs**

UNIT -5

Modeling of Solids: Solid Representation-Concepts, Boundary Representations (B-Rep),

Constructive Solid Geometry (CSG), Half Space Method, sweep representation. Organization of solid modelers. **Mechanical Assembly:** Introduction, Assembly Modeling, Parts Modeling and Representation, Hierarchical Relationships, Mating Conditions, Inference of Position from Mating Conditions, Representation Schemes, Graph Structure, Location Graph, Virtual Link, Generation of Assembling Sequences, Precedence Diagram, Liaison-Sequence Analysis, Precedence Graph, Assembly Analysis. **11hrs**

Text books

1 P.N. Rao, **"CAD/CAM Principles and Applications,"** McGrawHill, Education Pvt. Ltd., 3rd Edition, 2010, ISBN: 978-0070681934.

2 Ibrahim Zeid and R. Shivasubramanian, **"CAD/CAM Theory &Practice,"** Tata McGraw Hill Education Pvt. Ltd., 2nd Edition, 2010, ISBN: 978-0070151345.

References

1 M.P. Groover and E W Zimmers, **"CAD/CAM Computer Aided Design and Manufacture,"** Prentice Hall, 1984, ISBN: 978-0131101302.

2 C. B. Besant and E.W.K. Lui, **"Computer Aided design and Manufacture,"** Ellis Horwood Ltd., 1988, ISBN: 9780853129523.

3 Kunwoo Lee, **"Principles of CAD/CAM/CAE Systems,"**Pearson, US Edition, 1999, ISBN: 978-0201380361.

Course Outcomes

At the end of the course the students should be able to:

1 **Explain** the Design Process, Product Cycle, CAD, CAD Hardware and Networks.

2 **Discuss** Data Structure, Database Management System (DBMS), Coordinate Systems and Software Modules.

3 **Explain** Rasterscan Graphics, Algorithm's, Database Structures and organization. **Describe** 2D/3D Transformations and **Apply** the transformations to various situations.

4 **Discuss** the Requirements of Geometric Modeling, Modeling Facilities, 2D Modeling. **Describe** the Graphic Standards.

5 **Identify** the different types of Curves & Surfaces. **Explain the** various Representation and manipulation Techniques.

6 **Explain** techniques of Solid Modeling. **Represent** and **Analyze** Mechanical Assemblies

Course Title: Additive Manufacturing		
Course Code: P17MMDN162	**Sem: I**	**L:T:P:H : 4:0:0:4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course objective: The course enables the students to understand different additive manufacturing techniques also to identify different rapid tools development techniques.

Course Content

UNIT -1

Introduction: Definition of Prototype, Types of prototype, roles of prototype, Need for the compression in product development, History of RP systems, classification of RP systems, STL file, and basic steps in RP, advantages and disadvantages of RP system, Survey of applications. **Stereo lithography Systems:** Principle, Process parameter, process details, Data preparation, data files and machine details, merits and demerits, materials, Applications. Case study. **10hrs**

UNIT - 2

Fusion Deposition Modelling: Principle, Process parameter, merits and demerits, machine details materials, Applications, Case study. **Selective Laser Sintering:** Type of machine, Principle of operation, process parameters, Data preparation for SLS, merits and demerits, machine details materials, Applications, Case study. **Laminated Object Manufacturing:** Principle of operation, LOM materials, process parameters, process details, merits and demerits, materials, application. **Solid Ground Curing:** Principle of operation, process parameters, Machine details, merits and demerits, materials, Applications, Case study. **11hrs**

UNIT- 3

Laser Engineering Net Shaping (Lens): Principle of operation, process details, merits and demerits, materials, applications, Case study. **Medical modeling:** method of modeling, MAGICS, MIMICS, MAGIC communicator, etc. Internet based software**,** Applications, Case study. **Concepts Modelers:** Concept modelers and its uses, difference between concept modelers and RP machine. Principle of operation, merits and demerits, Applications of Thermal jet printer, Sander's model market, 3-D printer, GenisysXs printer, JP system 5, object Quadra systems. **10hrs**

UNIT - 4

Indirect Rapid Tooling: Types of rapid tooling, Indirect Rapid Tooling -Silicon rubber tooling, Aluminum filled epoxy tooling, Spray metal tooling, Cast Kirksite, 3D Keltool**. Direct Rapid Tooling** — Soft Tooling v/s. Hard tooling. Direct AIM, Quick cast process, Rapid steel 1.0, Rapid steel 2.0, Copper polyamide, and Sand Form. Rapid Tool, DMLS, ProMetal, Sand casting tooling, Laminate tooling. **11hrs**

UNIT -5

Rapid Manufacturing Process Optimization: factors influencing accuracy, data preparation errors, Part building errors, Error in finishing, influence of build orientation**. Allied Processes:** vacuum casting, surface digitizing, surface generation from point cloud data, surface modification — data transfer to solid models. **10hrs**

Text books

1 Paul F. Jacobs, **"Stereo Lithography and other RP & M Technologies,"** SME, NY, 1996, ISBN: 978-0872634671.

2 Pham D.T & Dimov S.S, **"Rapid Manufacturing,"** Springer-Verlog, London, 2001, ISBN: 978-1447111825.

References

1 Terry Wohler's, **"Wohler's Report 2000,"** Wohler's Association 2000.

Course Outcomes

At the end of the course the students should be able to:

1. **Describe** Rapid prototyping techniques.
2. **Explain** concept modelers
3. **Discuss** different types rapid tools production
4. **Explain** rapid prototyping process optimization.
5. **Discuss** surface digitization from other types of data.

Course Title: Design lab-I		
Course Code: P17MMDL17	**Sem: I**	**L:T:P:H : 0:0:3:3**
Contact Period: 36 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course objective: The course aims at strengthening the domain skill capabilities of students in terms of structural and thermal analysis of machine elements using commercial FEA tools. Further, the course also enhances the ability of the students to analyse experimentally, some of the design aspects of machine elements.

Course Content

PART-A

Exp-1 Static stress analysis of structural elements using ANSYS workbench

- **a)** Plate with hole subjected to plane stress
- **b)** Beams of different cross-section subjected to bending and shear

Exp-2 Static stress analysis of structural elements using ANSYS workbench

- **a)** Buckling analysis of columns
- **b)** Torsion analysis of shafts

Exp-3 Fatigue analysis using ANSYS workbench

- **a)** Leaf spring
- **b)** Shaft under torsion

Exp-4 Thermal analysis using ANSYS workbench

- **a)** Heat transfer in Circular fins

Exp-5 Structural analysis of composite laminates using ANSYS workbench

- **a)** Rectangular plate with unidirectional fiber orientations having different cut-out

PART-B

Exp-6 Rotating beam bending fatigue test
Exp-7 Polariscope experiments for stress analysis
Exp-8 Study of pressure distribution in a Journal bearing
Exp-9 Casting of Metal Matrix Composites
Exp-10 Processing of Polymer composites by Hand layup method

Text Books

1 Ralph I. Stephens, Ali Fatemi, Robert .R. Stephens, Henry O. Fuchs, **"Metal Fatigue in Engineering**,**"** John Wiley and Sons, 2nd Edition, 2001, ISBN: 9780471510598.
2 Julie A.Bannantine, **"Fundamentals of Metal Fatigue Analysis,"** Prentice Hall, 1990, ISBN: 978-0133401912.

References

1 Robert L. Norton, **"Machine Design,"** Pearson Education, 5th Edition, 16th September 2013, ISBN: 978-0133356717.
2 Jack. A. Collins, **"Failure of Materials in Mechanical Design,"** John Wiley, 2nd Edition, 4th October 1993, ISBN: 978-0471558910.
3 Richard G Budynas and Keith J Nisbett, **"Shigley's Mechanical Engineering Design,"** Tata McGraw-Hill publications, 10th Edition, 1st February 2014, ISBN: 978-0073398204.

Course Outcomes

At the end of the course the students should be able to:

1 **Solve** Structural Engineering problems using FEA tool ANSYS Workbench
2 **Solve** Fatigue and Thermal Engineering problems using ANSYS Workbench
3 **Perform** Structural analysis of composite laminates using ANSYS Workbench
4 **Demonstrate** experimentally, stress distribution using polariscope and pressure distribution in journal bearings
5 **Prepare** laminates using Polymer Matrix Composites/Metal Matrix Composites

Evaluation scheme				
Scheme		**Marks**	**Event Break up**	
CIE	50%	50	**Test**	**Record**
			20	30
SEE	50%	50	Seminar/viva voce	

Scheme for Examination	
One Question from Part –A	20 Marks
One Question from Part –B	20 Marks
Viva – Voice	10 Marks
Total	**50 Marks**

Course Title: Dynamics and Mechanism Design		
Course Code: P17MMDN21	**Sem: II**	**L:T:P:H : 4:0:0:4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course Objectives: The course aims at strengthening the capabilities of students in the analysis and synthesis of mechanisms by enhancing their understanding of kinematics and dynamics of mechanical systems.

Course Content

UNIT – 1

Principles of Dynamics: Introduction to dynamics, equations of motion, generalized coordinates, Configuration space, Constraints, Virtual work- virtual displacement, virtual work and principle of virtual work, D' Alembert's principle, generalized force. Energy and momentum- potential energy, work and kinetic energy, Kinetic energy of a system, Angular momentum, Generalized momentum. Problems on principle of virtual work, D' Alembert's principle and generalized force. **11 hrs**

UNIT – 2

Lagrange's Equation: Lagrange's equation from D'Alembert's principles, examples. Hamilton's equations- Hamilton's principle, Derivation of Hamilton's equations, examples. Gyroscopic action in machines, Euler's equation of motion, problems on gyroscopic action. **10 hrs**

UNIT – 3

System Dynamics: Phase Plane representation, Phase plane analysis, stability of dynamical systems-Liapunov's direct method and theorems, Routh's stability criteria. Open and closed loop systems, Proportional, Integral and Derivative control actions and their characteristics. **Geometry of Motion:** Introduction, analysis and synthesis, Mechanism terminology and definition- mechanism and machine, rigid and resistant bodies, link, kinematic pair, types of kinematic pairs, kinematic chain. Planar, Spherical and spatial mechanisms, mobility, equivalent mechanisms, unique mechanisms, Grashoff's law. **11 hrs**

UNIT – 4

Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebychev spacing, Two position synthesis of slider crank mechanisms and crank-rocker mechanism, Crank-rocker mechanisms with optimum transmission angle. Motion Generation: Poles and relative poles, Location of poles and relative poles.**Ana1ytical Methods of Dimensional Synthesis:** Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra. **10 hrs.**

UNIT – 5

Graphical Methods of Dimensional Synthesis: Two position synthesis of crank and rocker mechanisms, Three position synthesis, Four position synthesis (point precision reduction), Overlay method, Coupler curve synthesis, Cognate linkages. **10 hrs.**

Text Books

1 Joseph E. Shigley and J.J.Uicker, **"Theory of Machines and Mechanism,"** Oxford University Press, 4th Edition, 26th February 2010, ISBN: 978-0195371239.

2 K.J.Waldron and G.L.Kinzel, **"Kinematics, Dynamics and Design of Machinery"** Wiley India, 3rd Edition, May 2016, ISBN: 978-1-118-93328-2.

3 D T Greenwood, **"Classical Dynamics,"** Dover Publications Inc., New Edition, 21st October 1997, ISBN: 978-0486696904.

References

1 A.G.Ambekar. **"Mechanism and Machine Theory,"** Prentice Hall India Pvt. Ltd., 2011, ISBN: 9788120331341.

2 Ghosh and Mallick. **"Theory of Mechanism and Machines,"** East West Press, 2008, ISBN: 978-8185938936.

3 David H. Myszka, **"Machines and Mechanisms,"** Pearson Education, 4th Edition, 9th January 2011, ISBN: 978-0132157803.

Course Outcomes

At the end of the course the students should be able to:

1. **Define** generalized coordinates, constraints, virtual work and D' Alembert's principle, **estimate** the generalized forces in the mechanical system and **formulate** equation of motion of mechanical systems using virtual and D' Alembert's principles.
2. **Apply** Lagrange's and Hamilton's equations to **Formulate** equation of motion of mechanical systems. **Estimate** and **Analyze** the effect of gyroscopic couple on Aero planes, naval ships and automobiles
3. **Describe** phase plane analysis of dynamic systems and use of Liapunov's method and Routh's stability criteria in stability analysis of systems. **Define** mechanism terminology, **predict** mobility of planar mechanisms and **draw** equivalent mechanisms.
4. **Synthesize** slider crank and four bar mechanisms using graphical and analytical methods.
5. **Synthesize** the four bar linkages for the number of positions.

Course Title: Advanced Theory of Vibrations		
Course Code: P17MMDN22	**Sem: II**	**L:T:P:H : 4:0:0:4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course Objectives: The course aims at enabling the students to have a thorough understanding of the principles involved in the analysis of structural vibration and to provide a sound theoretical basis for further study.

Course Content

UNIT – 1

Vibration under General Forcing Conditions: Introduction, Response Under a General Periodic Force, Response Under a Periodic Force of Irregular Form, Response Under Non periodic Force, Convolution integral, Response to an impulse, Response to step input, Response to general forcing condition, Response to base excitation, Response spectrum, Numerical Problems. **12 hrs**

UNIT – 2

Multi-Degree of Freedom Systems – exact analysis: Introduction, Free vibrations-equations of motion, Matrix equations, Influence coefficients, flexibility and stiffness coefficients, Generalized coordinates and coordinate coupling: Only static coupling-no dynamic coupling, Only dynamic coupling-no static coupling, Static and dynamic coupling, Modal analysis - Natural frequencies and mode shapes (Eigen values and Eigen vectors), Undamped free vibrations, Undamped Forced vibrations, Torsional vibrations of multi-rotor systems (undamped), Numerical problems. **10hrs**

UNIT – 3

Continuous Systems: Introduction, Transverse Vibration of a String or Cable: free vibration of a uniform string, free vibration of a string with both ends fixed. Longitudinal Vibration of a Bar or Rod: Equation of motion and solution, Torsional Vibration of a Shaft or Rod, Lateral Vibration of Beams, Rayleigh's Method, Rayleigh-Ritz Method, Numerical Problems. **8 hrs**

UNIT – 4

Vibration Measurement: Introduction, Response of single degree of freedom system to base excitation, Vibration measurement scheme, Principle of vibration pickups, Vibrometer, Accelerometer, Velometer, phase distortion, numerical problems. Transducers: Variable resistance transducers, Piezoelectric transducers, Electrodynamic transducers, Linear variable differential transformer (LVDT) transducer. Capacity pickup (condenser vibrometer), fiber optic probe, Rotary Variable Differential Transducer (RVDT). Frequency Measuring Instruments, single-reed and multi-reed instruments, numerical problems. Vibration Exciters: Mechanical exciters, Electrodynamic shaker. Signal Analysis: Basic principle of data acquisition system, analogue and digital systems, analogue-to-digital converter (ADC), impulse response function, frequency response function, sampling of continuous time signals, sources of vibration in rotating machines, classification of forces, common machinery faults requiring diagnosis, Spectrum analyzers, Dynamic Testing of Machines and Structures, experimental modal analysis of beams. **10 hrs**

UNIT – 5

Non-Linear Vibrations: Introduction, Examples of non-linear systems – simple pendulum, vibration of a string, hard and soft spring, variable mass system, abrupt non-linearity, Phase plane, phase plane for linear system, phase plane plot and displacement time plot. Method of isoclines, phase-plane trajectories of a linear

system, trajectory of a system having dry – friction damping. Undamped free vibrations with non-linear spring forces, phase plane plot for hard spring system and soft spring system. Perturbation method, Forced vibration with non-linear spring forces. **12 hrs**

Text Books

1 S.S. Rao, **"Mechanical Vibrations,"** Pearson Education Inc., 5th Edition, 7th September 2011, ISBN: 978-0132128193.

2 G.K. Grover, **"Mechanical Vibrations,"** Nem Chand & Bros, 2009, ISBN: 978-8185240565.

3 C. Sujatha, **"Vibration and Acoustics: Measurement and Signal Analysis,"** McGraw Hill Education Pvt. Ltd., 23rd December 2009, ISBN: 978-0071332996.

References

1 S. Graham Kelly, **"Mechanical Vibrations,"** Cengage Learning, 1st Edition, 1st March 2011, ISBN: 978-1439062128.

2 Austin H Church, **"Mechanical Vibrations,"** John Wiley & Sons, 2nd Edition, 1963, ISBN: 978-1114187887.

Course Outcomes

At the end of the course the students should be able to:

1. **Formulate** mathematical models for vibrating systems subjected to generalized forcing conditions and **analyze** system response.
2. **Formulate** mathematical models of multi-degree of freedom systems and **determine** Eigen values and Eigen vectors.
3. **Compute** system response expressions for continuous systems and **determine** response for different boundary conditions.
4. **Explain** the principle of vibration measurement and signal analysis.
5. **Explain** the behavior of simple non-linear systems by graphical and analytical methods.

Course Title: Theory of Plasticity		
Course Code: P17MMDN23	**Sem: II**	**L:T:P:H : 4:0:0:4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course objective: The course aims at enabling the students to understand the mathematical and physical principles of plasticity, with different solution strategies while applying them to practical cases.

Course Content

UNIT-1

Introduction: Definition and scope of the subject, Brief review of elasticity, Octahedral normal and shear stresses, Spherical and deviatoric stress, Invariance in terms of the deviatoric stresses, Representative stress. Concept of strain, Engineering and natural strains, Cubical dilation, finite strains co-efficient Octahedral strain, Strain rate and the strain rate tensor. **10 hrs**

UNIT-2

Mechanism of Plastic Deformation: Introduction, factors affecting plastic deformation, strain hardening, recovery, recrystalization and grain grouth. **Yield Criteria for Ductile Metals:** General considerations Von Mises andTresca yield criterion, Yield surface for an Isotropic perfectly plastic materials, Haigh-Westergaard Stress space representation of yield criteria, Experimental verification of Yield criteria, Yield criteria for an anisotropic material. **10 hrs**

UNIT -3

Stress - Strain Relations: Idealised stress-strain diagrams for different material models, Elastic stress –strain relation, Plastic stress-strain relations, Prandtl- Reuss, Saint Venant's, Levy-Von Mises equations, Plastic work and strain-Hardening hypothesis, Experimental verification of the Prandtl-Reuss equations, The plastic potential, convexity of yield locus. **10 hrs**

UNIT -4

Plasticity Analysis: Bending of beams-Introduction, analysis of stresses, shear stress distribution, Residual stresses in plastic bending and Plastic torsion of a circular bar, residual stresses. Stresses in wire drawing, stresses in extruding cylindrical rods, 2D radial plastic flow, stresses in drawing and extruding a strip (without friction), work consumption in drawing and extruding. **12 hrs**

UNIT-5

Slip Line Theory: Introduction, Basic equations for incompressible two dimensional flows, continuity equations (Geiringer), Stresses in conditions of plain strain, convention for slip-lines, solution of plastic deformation problems, Hencky's equations, boundary conditions, Geometry of slip lines, Properties of slip lines, Construction of Slip-Line Nets. **10 hrs**

Text books

1. R.A.C. Slater, **"Engineering Plasticity**: **Theory and Application to Metal Forming Process,"** McMillan Press Ltd., 12th March 2011, ISBN: 9780333157091.
2. Sadhu Singh, **"Theory of Plasticity and Metal Forming Process,"** Khanna Publishers, Delhi, 3rd Edition, 2003, ISBN: 9788174090508.

References

1. William Johnson and Peter Bassindale Mellor, "Plasticity for Mechanical Engineers," Van Nostrand Publisher, 1966.
2. Chakraborty, **"Theory of plasticity,"** Butter-Heinemann Publisher, 3rd Edition, 2nd May 2006, ISBN: 978-0750666381.
3. Jacob Lubliner, **"Plasticity Theory,"** Dover publications Inc. 25th April 2008, ISBN: 978-0486462905.
4. L.M. Kachnov, **"Fundamentals of the Theory of Plasticity,"** Courier Corporation, 2004, ISBN: 9780486435831.

Course Outcomes

At the end of the course the students should be able to:

1. **Determine** the elastic behavior of solid bodies subjected to various types of loading.
2. **Determine** the yielding and plastic deformation of solid metal bodies.
3. **Establish** the plastic stress-strain relations.
4. **Calculate** plastic deformation and **discuss** the theorems.
5. **Relate** macroscopic behavior of plasticity and yielding to microscopic slip line theory

Course Title: Metrology & Computer Aided Inspection.		
Course Code: P17MMDN241	**Sem: II**	**L:T:P:H : 4:0:0:4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course objective: This course aims at imparting the knowledge, basic concept and importance of metrology, to educate the students on different types of measurement systems. Learn about the various measuring instruments to measure the linear, angular, form and surface finish measurements. Introduce the applications of computer and laser in the field of metrology, quality control and inspection.

Course Content

UNIT -1

Limits, Fits and Gauges: Introduction, Tolerances, Interchangeability, Limits of size, Terminology, Selection of Fits, ISO System of limits and fits, Types of Gauges, Gauge Design, Problems. **Metrology of Screw Thread:** Introduction, Screw threads terminology, Effect of pitch errors, Measurement of various elements of thread, problems. **10hrs**

UNIT - 2

Measurement of Straightness, Flatness, Squareness, Parallelism, Circularity and Rotation: Straightness, Straight edge, Test for straightness by using spirit level and

autocollimator, Flatness testing, Mathematical treatment of determination of straightness and flatness of surfaces, Laser equipment for alignment testing, Parallelism, Equidistance and Coincidence, Squareness, Measurement of circularity, Tests for checking rotation, Profile measurements. **Measurement of Surface Finish:** Introduction, Surface texture and definitions, Surface roughness, Terminology as per Indian Standards, Methods of measuring surface finish-Direct instrument measurement, Replica method, The sample length or Cut-off length, Analysis of surface traces, Assessment of surface roughness as per Indian Standard, Roughness comparison specimens, Mechanical roughness indicator. **10hrs**

UNIT- 3

Machine Tool Metrology: Introduction, Machine tools tests, Alignment tests on lathe, Alignment tests on milling machine, Alignment tests on pillar type drilling machine, Tool wear measurement using microscope. **Co-Ordinate Measuring Machine:** Types of CMM, Probes used, Applications, Non-contact CMM using electro optical sensors for dimensional metrology, Non-contact sensors for surface finish measurements, statistical evaluation of data using computer, Data integration of CMM and data logging in computers. **12hrs**

UNIT - 4

Machine Vision: Shape identification, Edge detection techniques, Normalization, gray scale color relation, Template Techniques, Surface roughness using vision system, Interfacing robot and image processing system. **Laser Applications in Metrology:** Laser interferometer, Laser inspection, Dimensional measurement techniques-Scanning Laser gauge, Photo diode array imaging, Diffraction pattern technique, Laser triangulation sensors, Two frequency laser interferometer, Laser scanning gauge and Gauging wide diameter from the diffraction pattern formed in a laser. **10hrs**

UNIT-5

Testing and Calibration of Gauges and Dynamic Measurement: Introduction, calibration of linear and angular measuring instruments, measurement of limit gauges, checking of slip gauges, dynamic measurement of size, form and position, automatic inspection machines, measurment during machining, electronic gauging, contactless three dimensional measurement by laser based system, multi-dimensions automatic gauging and sorting machines, electro-optical inspection, some recent developments in optical measurements. **Evaluating Uncertainty in Measurement:** Introduction, sources of uncertainty in measurements, method of evaluation of uncertainty, competence of testing and calibration laboratories, apex level calibration 2nd NPL, international traceability, mass metrology, coordinate measuring machine and uncertainty in measurements, length measurement uncertainty of CMM. **10 hrs**

Text books

1 T G Beckwith, Roy D Marangoni and John H Lienhard, **"Mechanical Measurements,"** Pearson Prentice Hall, 2007, ISBN: 9780201847659.

2 Sabrie Soloman, **"Sensors and Control systems in Manufacturing,"** McGraw Hill Book, 2nd Edition, 23rd November 2009, ISBN: 978-0071605724.

3 Donald D Eckman, **"Industrial Instrumentation,"** CBS, 1st Edition, 1st December 2004, ISBN: 978-8123908106.

4 T. Busch and R. Harlow, **"Fundamentals of Dimensional Metrology,"** Delmar Cengage Learning, 5th Edition, 21st November 2006, ISBN: 978-1418020620.
5 G. G. Thomas, **"Engineering Metrology,"** Butter Worth Publications, 1974, ISBN: 9780408705103.
6 Alan S. Morris, **"The Essence of Measurement,"** Prentice Hall of India, 1997, ISBN: 978-0133716757.
7 E. O. Doebelin, **"Measurement systems: Applications & Design,"** McGraw Hill Higher Education, 4th Education, 1st January 1990, ISBN: 978-0070173385.

References

1 R K Jain, **"Engineering Metrology,"** Khanna Publishers, 1st January 2009, ISBN: 978-8174091536
2 Ulrich Rembold, Armbruster and Ulzmann, **"Interface Technology for Computer Controlled Manufacturing Processes,"** CRC Press, 1st Edition, 25th January 1983, ISBN: 978-0824718367.
3 J. Watson, **"Optoelectronics,"** Van Nostrand Reinhold (UK), March 1988, ISBN: 978-0278000087.
4 Jayal A.K, **"Instrumentation and Mechanical Measurements,"** Galgotia Publications, 2000.
5 Robert G. Seippel, **"Optoelectronics for Technology and Engineering,"** Prentice Hall India, 1st October 1988, ISBN: 978-0136384045.
6 Gupta S.C, **"Engineering Metrology,"** Dhanpat rai Publications, 2005.

Course Outcomes

At the end of the course the students should be able to:

1 **Define** limits, fits and gauges. **Explain** tolerances, interchangeability, ISO system of limits and fits. **Solve** problems. **Define** and **Explain** metrology of screw thread. **Solve** problems.

2 **Define** surface finish. **Explain** surface texture, surface roughness and methods of measuring surface finish. **Explain** measurement of straightness, flatness, squareness, parallelism, circularity and rotation.

3 **Define** machine tool metrology. **Explain** machine tools tests, alignment tests and tool wear measurement using microscope. **Explain** co-ordinate measuring machine**,** data integration of CMM and data logging in computers. **List** types of CMM.

4 **Define** Machine Vision**. Explain** different types of identification and detection techniques using Machine Vision. **Define** and **Explain** Laser applications in metrology.

5 **Explain** uncertainty in measurements and method of evaluation of uncertainty. **Discuss** Testing and Calibration of gauges and dynamic measurement

Course Title: Theory of Plates and Shells		
Course Code: P17MMDN242	**Sem: III**	**L:T:P:H : 4:0:0:4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE: 50; SEE: 50**	

Course Objective: Theory of plates and shells provides the knowledge about the bending aspects of plates, Differential analysis of loaded plates, behavior of plate material when it is fabricated into shells, different theories which explain about cylindrical shell loaded symmetrically, investigates on bending of cylindrical shells.

Course Content

UNIT – 1

Introduction: Bending of long rectangular plate into a cylindrical surface, cylindrical bending of rectangular plates, Equilibrium equation of rectangular plates, Differential equation - Bending of plated with different boundary conditions - Long plate on elastic foundation, strain energy in pure bending of plates. **10 hrs**

UNIT – 2

Pure Bending: Moment and curvature relations problems of simply supported plates-Strain energy impure bending. Numericals. **Symmetrical Bending of Circular Plates:** Basic relations in polar co-ordinates**,** Axi-symmetric circular plates, Differential equation uniformly loaded plates, Plates concentricity loaded plates- loaded at the center, Annular circular plates, Numericals. **12hrs**

UNIT – 3

Plate subjected to combined lateral and in-plane loading: Differential equations - Solution of simply supported plate Various loading conditions, viz, uniformly distributed load, hydrostatic pressure and concentrated load, central as well as non-central, Navier and Levy type solutions with various edge boundary conditions, viz., all edges simply supported, Two opposite edge fixed and two adjacent fixed\, comparison between Lavy's and Navier's solution Bending of plate under combined action of lateral and transverse loads derivation of differential equation, simply supported rectangular plate. **12 hrs**

UNIT – 4

Introduction to Shell Structures - General description of various types. Classification, Membrane Theory of thin shells (Stress Analysis): Cylindrical shells -Spherical Shells- Shells of double curvature, viz, cooling tower Hyperbolic, Parabolic and elliptic paraboloid. **Membrane Deformation of Shells:** Symmetrical 'loaded shell, symmetrically loaded spherical shell. **10 hrs**

UNIT – 5

Theories of cylindrical shells: DKJ theory, Beam theory, Bending theory, Cylindrical shell loaded symmetrically. General equation of circular cylindrical shells. Approximate investigation of bending of circular cylindrical shell. **8 hrs**

Text Books

1. Timoshenko, Woinowsky and Krieger, **"Theory of Plates and Shells,"** McGraw Hill, Newyork, 2nd Revised Edition, 1st January, 1959, ISBN: 978-0070647794.
2. Ansel C Ugral, **"Stresses in Plates and Shells,"** Taylor & Francis Publishers, 3rd Illustrated Revised Edition, 2009, ISBN: 9781439802700.
3. Eduard Ventsel, Theodor Krauthammer, **"Thin Plates and Shells: Theory: Analysis, and Applications,"** Marcell Dekker Inc, New York, 1st Edition, 24th August, 2001, ISBN: 9780824705756.

References

1. N K Bairagi, **"Theory of Plates,"** Khanna Publishers, New Delhi.
2. Goldnvizer, **"Theory of Elastic Thin Shells,"** Pergamon Press, New York.
3. Wilhelm Flugge, **"Stresses in Shells,"** Springer Verlag, Berlin, ISBN: 9783662010280.

Course Outcomes

At the end of the course the students should be able to:

1. **Explain** the bending aspects of plates
2. **Understand** aspects of Symmetrical Bending of Circular Plates
3. **Describe** different equations for combined lateral and in-plane loading on plates
4. **Conceptualize** the types of shells
5. **Analyze** using different theories of cylindrical shells

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Course Title: Fracture Mechanics		
Course Code: P17MMDN251	**Sem:II**	**L:T:P:H : 4:0:0:4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE: 50; SEE: 50**	

Course Objective: Fracture mechanics provides methodology for prediction, prevention and control of fracture in materials, components and structures subjected to static, dynamic and sustained loads. Fracture mechanics analysis is the basis for damage tolerant design methodology. It quantifies toughness as material resistance to crack propagation.

Course Content

UNIT – 1

Fracture Mechanics Principles: Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, Griffith's energy balance approach. Fracture mechanics approach to design. NDT and Various NDT methods used in fracture mechanics. The Airy stress function, Complex stress function, Solution to crack problems, Effect of finite size, Special cases, Elliptical cracks, Numerical problems. **12 hrs**

UNIT – 2

Linear Elastic Fracture Mechanics: Plasticity effects, Irwin plastic zone correction. Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, Plastic constraint factor. The thickness effect, numerical problems. Determination of Stress intensity factors and plane strain fracture toughness: Introduction, analysis and numerical methods, experimental methods, estimation of stress intensity factors. Plane strain fracture toughness test, The Standard test, Size requirements, Non-linearity. Applicability. **10hrs**

UNIT – 3

Elastic-plastic Fracture Mechanics: The energy release rate, Criteria for crack growth, The crack resistance(R curve), Compliance, J integral, Tearing modulus, Stability, Elastic plastic fracture mechanics: Fracture beyond general yield. The Crack-tip opening displacement. The Use of CTOD criteria, Experimental determination of CTOD, Parameters affecting the critical CTOD. Use of Jintegral. Limitation of J integral. **10 hrs**

UNIT – 4

Dynamics and crack arrest: Crack speed and kinetic energy, Dynamic stress intensity and elastic energy release rate, Crack branching, Principles of crack arrest, Fatigue pre-cracking, Instrumentation, K-R Curve, Damage Tolerant Design Methodology, Factors affecting crack propagation. Variable amplitude service loading, Means to provide fail-safety, Mixed mode fracture and strain energy density criteria. **10 hrs**

UNIT – 5

Computational Fracture Mechanics: Overview of Numerical Methods, Finite Element Method, Boundary Integral Equation Method, Traditional Methods in Computational Fracture Mechanics, Stress and Displacement Matching, Elemental Crack Advance, Contour Integration, Virtual Crack Extension: Stiffness Derivative Formulation, Virtual Crack Extension: Continuum Approach, The Energy Domain Integral, Generalization to Three Dimensions, Finite Element Implementation, Mesh Design, Linear Elastic Convergence Study, Properties of Singularity Elements, Quadrilateral Element, Triangular Element. **10 hrs**

Text Books

1. T.L. Anderson, **"Fracture Mechanics - Fundamental and Application,"** Taylor and Francis group, CRC Press, Boca Raton, 3rd edition, 24th June, 2005, ISBN: 978-0849316562.
2. David Broek, **"Elementary Engineering Fracture Mechanics,"** Springer Publisher, 4th revised edition, 2012, ISBN: 978-8132207900.
3. Prasanth Kumar, **"Elements of Fracture Mechanics,"** McGraw Hill Educational Ltd, New Delhi, 1st edition, 2009, ISBN: 978-0070656963.

References

1. R. J. Sanford, **"Principles of Fracture Mechanics,"** Prentice Hall, Pearson Education Inc., 1st edition, 8th April, 2002, ISBN: 978-0130929921.
2. S.A. Meguid, **"Engineering Fracture Mechanics,"** Elsevier Applied Science, 1st Edition, 1989, ISBN: 9781851662821.
3. Knott, **"Fundamentals of Fracture Mechanics,"** Butterworth & Co Publishers Ltd., 1st October, 1973, ISBN: 978-0408705295.
4. Jayatilake, **"Fracture of Engineering Brittle Materials,"** Elsevier Applied Science Publishers, 1979, ISBN: 9780853348252.

Course Outcomes

At the end of the course the students should be able to:

1. Describe the basic fundamental understanding of the effects of crack like defects on the performance of aerospace, mechanical and civil engineering structures.
2. Explain LEFM and different test methods in fracture mechanics.
3. Analyse EPFM criteria and nonlinear behaviour of the material
4. Conceptualize the dynamics of crack propagation and crack arrest techniques and the concept of fatigue crack growth law and mixed mode criteria
5. Design the computational techniques to be use in fracture mechanics and to analyse different approaches.

Course Title: Advanced Industrial Robotics.		
Course Code: P17MMD252	**Sem: II**	**L:T:P:H : 4:0:0:4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course objective: To be familiar with the automation and brief history of robot and applications. To give the student familiarities with the kinematics of robots, knowledge about autonomous mobile robots and their design. mobile robot maneuverability. Knowledge about mobile robot planning & navigation.

Course Content

UNIT -1

Introduction to Robotics: Geometrical configuration of robots and its work volume, Precision of movement, Numericals, Advantages, disadvantages and industrial applications of robot. Grippers, classification, Working principle. **11 hrs**

UNIT - 2

Kinematic Analysis & Coordinate Transformation: Direct Kinematic Problem in Robotics, Geometry based direct Kinematic Analysis Coordinate & Vector Transformation using Matrices, The orientation Matrix & Translator Vector, Homogeneous Transformation Matrices, Three dimensional Homogeneous Transformations, Denavit-Hartenberg Convention-Implementing the DH Convention, Obtaining the DH Displacement Matrices. Applications of DH method- Three axis Robot Arms, Three Axis wrists, six axis Robot Manipulators, Assigning the Tool Coordinate System. **11 hrs**

UNIT- 3

Robot Programming: Lead through programming methods- Robot program as a path in space, motion interpolation. Wait, signal & delay command, branching examples. **Robot languages-** Robot languages elements & functions, types of commands, programs control & sub routines, example programs, types of robot languages. **10 hrs**

UNIT - 4

Autonomous Mobile Robots: Introduction, Locomotion - Key issues for locomotion, Legged Mobile Robots, Leg-Types and configurations & stability, Examples of legged robot locomotion, Gaits-Biped, Quadraped and Hexaped; Wheeled Mobile Robots, Wheeled locomotion-the design space, Wheeled locomotion and Case studies. **Mobile Robot Kinematics:**Introduction, Kinematics Models & Constraints, Representing robot position, Forward Kinematics models, Wheel Kinematics constraints, Robot kinematics constraints and Examples. **10 hrs**

UNIT -5

Mobile Robot Maneuverability: Mobile Robot Maneuverability- Degree of mobility, Degree of steerability, Robot maneuverability. Mobile Robot Workspace-Degree of freedom, holonomic robots, path & trajectory considerations. Motion Control - Openloop control, Feedback control and Examples. **Mobile Robot Planning &Navigation:** Introduction, Competences for Navigation-Planning & Reacting, Path planning, Obstacle avoidance. Navigation Architectures-Modularity for code reuse & sharing, Control localization,Techniques for decomposition,Case studies-tiered robot architectures. **10 hrs**

Text books

1. Y.Koren, **"Robotics For Engineers,"** McGraw Hill, 1st Edition, 1987, ISBN: 978-0070353992.
2. M.P.Groover, **"Industrial Robotics,"** McGraw Hill, 2ndEdition, 23rd May 2012, ISBN: 978-1259006210.

3 Roland Siegwart and Illah R Nourbakhsh, **"Introduction to Autonomous Mobile Robots,"**MIT Press, 2nd Edition, 18th March 2011, ISBN: 978-0262015356.

References

1 John J Craig, **"Introduction to Robotics: Mechanics & Control,"**Pearson, 3rdEdition, 27th July 2004, ISBN: 978-0201543612.

2 J.Duffy, **"Analysis of Mechanism and Robot Manipulators,"** John Willey & Sons, 1980, ISBN: 978-0470270028.

Course Outcomes

At the end of the course the students should be able to:

1 **Define and Classify** Robots and Structures of Robotic Systems, Grippers

2 Describe Robot Program methods. **Write** Robot Program

3 **Define** Kinematic Analysis, Direct Kinematic Problem in Robotics. **Describe** Three dimensional Homogeneous Transformations, Denavit-Hartenberg Convention, Applications of DH method

4 **Define and Classify** Autonomous Mobile Robots**. Describe** Mobile Robot Kinematics

5 **Describe** Mobile Robot Maneuverability- Degree of mobility, Degree of steerability, Motion Control. **Explain** Mobile Robot Planning & Navigation.

Course Title: Statistical Modeling and Experimental Design.		
Course Code: P17MMDN261	**Sem: II**	**L:T:P:H : 4:0:0:4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course objective: The objective of this course is to frame business problems in appropriate statistical terms in order use data to make better decisions. The students will learn to make sense of data along with the basics of statistical inference and regression analysis and their hands-on implementation using software.

Course Content

UNIT -1

Statistical Modeling and Data Analysis: Introduction, Review of basic statistical concepts: Concepts of random variable, Sample and population, Measure of Central tendency; Mean, median and mode. Normal & Log- Normal distributions. Illustration through Numerical examples. **10hrs**

UNIT - 2

Introduction to Designed Experiments: Strategy of experimentation, Some typical applications of experimental design, Basic principles, Guidelines for designing experiments, A brief history of statistical design, Summary: Using statistical techniques in experimentation. **10hrs**

UNIT- 3

Factorial Experiments: Basic definitions, The advantages of factorials, The two factorial design. Introduction, Factorial Experiments Terminology: factors, levels, interactions, Two-level experimental designs for two factors and three factors. Illustration through Numerical examples. **10hrs**

UNIT - 4

Regression Analysis: linear and multiple Regression analysis, Mathematical models from experimental data. Illustration through Numerical examples. **10hrs**

UNIT -5

Signal to Noise Ratio: Evaluation of sensitivity to noise. Signal to Noise ratios for static problems: Smaller-the-better type, Nominal the-better-type, Larger-the better type. Signal to Noise for Dynamic problems. Illustration through Numerical examples. **12hrs**

Text books

1 Douglas C. Montgomery,**"Design and Analysis of Experiments,"** Wiley India Pvt. Ltd., 8th Edition, 2013, ISBN: 978-8126540501.

2 Madhav S. Phadke, **"Quality Engineering Using Robust Design,"**Pearson Education, 1st Edition, 2008, ISBN: 978-8131722398.

References

1 Thomas B. Barker,**"Quality if Experimental Design,"**Prentice Hall, 12th May 1989, ISBN: 978-0137451678.

2 C.F. Jeff Wu and Michael Hamada,**"Experiments Planning Analysis, and Parameter Design Optimization,"**Wiley,2nd Editions, 2009, ISBN: 978-0-471-69946-0.

3 W.L. Condra,**"Reliability Improvement by Experiments,"**CRC Press, 2nd Edition, 19th April 2001, ISBN: 9780824705275.

4 Phillip J. Ross,**"Taguchi Techniques for Quality Engineering,"**McGraw Hill International,2ndEditions, 1996, ISBN: 978-0070539587.

Course Outcomes

At the end of the course the students should be able to:

1 **Describe**basic statistical concepts. **Solve** numerical on Mean, median and mode

2 **Explain**Guidelines for designing experiments.

3 **Discuss** Factorial Experiments Terminology

4 **Explain**Regression analysis. **Solve** Mathematical models

5 **Discuss**signal to noise ratio.

Course Title: Vehicle dynamics		
Course Code: P17MMDN262	**Sem: II**	**L:T:P:H : 4:0:0:4**
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course Objectives: The course aims at strengthening the automobile design capabilities of students by enhancing their understanding of various dynamic forces acting on an automobile and the stability issues.

Course Content

UNIT – 1

Introduction: introduction to vehicle dynamics, the driver-vehicle-ground system, SAE vehicle coordinate system. **Tire fundamentals**: desirable tire properties, tire force and movements, rolling resistance of tier, factors affecting the rolling resistance of tire. Tire construction, Bias-ply tire, radial –ply tire, hydro planning, specification of tire, factors affecting tire life. **Acceleration performance:** power for propulsion, air resistance, rolling resistance, grade resistance, traction and traction effort, road performance curve, calculation of equivalent weight, Numerical problems. **10 hrs**

UNIT – 2

Vehicle stability: stability on level ground, front wheel driven vehicle, rear wheel driven vehicle, four wheel driven vehicle, vehicle taking turn on level ground, stability on inclined ground, stability of vehiclerunning on a banked track, determination of centre of gravity of a vehicle, transverse weight shift due to drive torque, effect of C.G position on maximum achievable acceleration, stability of two and three wheeler vehicles and Numericals. **12 hrs**

UNIT – 3

Braking system and performance: braking requirements, construction and comparison of drum brake and disc brake, introduction to hydraulic braking system. Energy of motion and frictional force, brake balance, stopping distance, brake fade, work done in brakes, braking efficiency, load transfer during braking, brake applied to rear wheels, brakes applied to front wheel, brake applied to four wheels, brake proportioning, conditions for wheel lockup, antilock brake system., Numerical problems. **10 hrs**

UNIT – 4

Handling characteristics of road vehicles: steering geometry, effect of camber, kingpin inclination, castor, toe-in, toe-out, condition for true rolling, turning circle radius. Ackerman linkage geometry – analytical and graphical solution, four wheel steering. Cornering properties of tiers – cornering force, slip angle, self aligning torque, Steady state handling characteristics: fundamental equation, neutral steer, under steer, over steer, steady state response to steering input, yaw velocity response, lateral acceleration response, curvature response, testing of handling characteristics and Numerical problems. **10 hrs**

UNIT – 5

Vehicle ride characteristics: vehicle vibration and human comfort, vehicle ride models, two – degrees of freedom vehicle model for sprung and unsprung mass, two degrees of freedom vehicle model for pitch and bounce, introduction to random vibration, frequency response function, evolution of vehicle vibration. **Aerodynamics:** mechanics of air flow around vehicles, pressure distribution on a vehicle, aerodynamics forces and moments. Effect of shape, angle of attack, operation parameters on drag and lift, aerodynamic aids. **10 hrs**

Text Books

1 J.Y.Wong, **"Theory of Ground Vehicles,"**John Wiley and Sons, 4th Edition, 22nd August 2008, ISBN: 978-0470170380.

References

1 Thomas D. Gillespie, **"Fundamentals of Vehicle Dynamics,"** SAE, 2008, ISBN: 978-1560911999.

2 DrN.K.Giri, **"Automobile Mechanics,"**Khanna Publications, 2011, ISBN: 978-8174092168.

3 Reza N.Jazar, **"Vehicle Dynamics,"**Springer Publications, 3rd Edition, 4th November 2009, ISBN: 978-0387742434.

Course Outcomes

At the end of the course the students should be able to:

1 **Describe** mechanics of pneumatic tiers; **Explain** performance of vehicle during acceleration at different road and operating conditions.

2 **Describe** stability of vehicle when the vehicle is moving on level ground and inclined ground.

3 **Explain** performance of vehicles during braking at different road and operating conditions.

4 **Explain** steering geometry, effect of steering geometry on handling characteristics, steady state handling characteristics.

5 **Describe** cause of vibration in vehicles, different mathematical model for vertical vibration of a vehicle; **Explain** different aerodynamic forces and movements, various parameters affecting these forces and movements.

Course Title: Design lab II		
Course Code: P15MMDL27	**Sem:II**	**L:T:P:H : 0:0:3:3**
Contact Period: 36 Hr; Exam: 3 Hrs	**Weightage: CIE:50; SEE:50**	

Course objective: The course aims at enhancing the ability of students to analyze and characterize mechanical systems subjected to various operating conditions. The course also helps the students in understanding the influence of material and geometry of the component on its structural characteristics.

Course Content

PART-A

Exp-1 Modal analysis of machine elements using ANSYS workbench
- **a)** Natural frequency and mode shapes of connecting rod, crank shaft.

Exp-2 Harmonic analysis of machine elements using ANSYS workbench
- **a)** Harmonic analysis of connecting rod, crank shaft.

Exp-3 Contact stress and Bending stress analysis of Spur gear using ANSYS workbench

Exp-4 Fluid flow analysis using ANSYS workbench
- **a)** CFD analysis of Flow through Venturimeter
- **b)** Mixing of fluids in Elbow Tube

Exp-5 Explicit dynamic analysis using ANSYS workbench
- **a)** Impact analysis of plate

PART-B

Exp-6 Modal analysis of Cantilever Beam by Impact Hammer test

Exp-7 Harmonic analysis of Cantilever Beam and determination of damping ratio

Exp-8 Modal analysis of Plate using FFT analyzer

Exp-9 Wear study using pin-on-disc equipment

Exp-10 Experiment on thrust bearing

Evaluation scheme				
Scheme		**Marks**	**Event Break up**	
CIE	50%	50	**Test**	**Record**
			20	30
SEE	50%	50	Seminar/viva voce	

Scheme for Examination	
One Question from Part –A	20 Marks
One Question from Part -B	20 Marks
Viva – Voice	10 Marks
Total	**50 Marks**

Course Outcomes

At the end of the course the students should be able to:

1. **Perform** dynamic analysis of machine elements using ANSYS Workbench
2. **Solve** fluid flow problems using ANSYS Workbench
3. **Carryout e**xplicit dynamic analysis using ANSYS Workbench
4. **Demonstrate** experimentally, vibration characteristics of simple structural elements using FFT analyser
5. **Demonstrate** experimentally, the wear of materials using a pin-on-disk apparatus