JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

JAIPURENGINEERINGCOLLEGEANDRESEARCHCENTRE

JECRC Campus, Shri Ram ki Nangal, Via-Vatika, Tonk Road, Jaipur

Department of Mechanical Engineering

Name of Subject: Mechanics of Solids

Subject Code: 3ME4-07

Year: 2nd Year, 3rd Semester

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Department of Mechanical Engineering

VISION AND MISSION OF THE INSTITUTE

VISION OF JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

To become a renowned center of outcome based learning, and work towards academic, professional, cultural and social enrichment of the lives of individuals and communities.

MISSION OF JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

M1: Focus on evaluation of learning outcomes and motivate students to inculcate research aptitude by project based learning.

M2: Identify, based on informed perception of Indian, regional and global needs, areas of focus and provide platform to gain knowledge and solutions.

M3: Offer opportunities for interaction between academia and industry.

M4: Develop human potential to its fullest extent so that intellectually capable and imaginatively gifted leaders can emerge in a range of professions.

VISION AND MISSION OF THE DEPARTMENT

VISION OF DEPARTMENT OF MECHANICAL ENGINEERING

The Mechanical Engineering Department strives to be recognized globally for outcome based technical knowledge and to produce quality human resource, who can manage the advance technologies and contribute to society.

MISSION OF DEPARTMENT OF MECHANICAL ENGINEERING

M1: To impart quality technical knowledge to the learners to make them globally competitive mechanical engineers.

M2: To provide the learners ethical guidelines along with excellent academic environment for a long productive career.

M3: To promote industry-institute relationship.

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Department of Mechanical Engineering

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: To equip graduates with a strong foundation in engineering sciences, with an emphasis on mechanical engineering principles, enabling them to analyze, design, and solve real-world engineering challenges.

PEO2: To prepare graduates with sound scientific and engineering fundamentals to innovate and deliver effective solutions addressing practical challenges in mechanical engineering.

PEO3: To inculcate in graduates a professional and ethical attitude, effective communication and teamwork skills, a multidisciplinary approach, entrepreneurial mindset, and the ability to connect engineering solutions with societal and environmental concerns.

PEO4: To provide students with an academic environment that fosters excellence, leadership, adherence to ethical standards, and encourages self-motivated lifelong learning essential for a successful professional career in mechanical.

PEO5: To prepare students to excel in industry and higher education by providing quality education grounded in strong technical knowledge and high moral values.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Graduates will be able to design, analyze, and fabricate electric and hybrid vehicles using modern engineering tools and sustainable practices.

PSO2: Graduates will be able to apply design principles and computational techniques, including programming and data structures, to analyze and solve mechanical engineering problems.

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Department of Mechanical Engineering

PROGRAM OUTCOMES (POs)

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.

PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 toWK4)

PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)

PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).

PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)

PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).

PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences

PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

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SYLLABUS

3ME4-07: MECHANICS OF SOLIDS

Credit: 4 Max.Marks:100(IA: 30, ETE: 70)
3L+1T+0P EndTermExam: 3Hours

S. No	CONTENTS	Hours
1	**Stress and Strain:** Elementary definition of stress and strain, stress-strain relationship, elastic, plastic and visco-elastic behavior of common materials in tension and compression test, stress-strain curves, Hooke's law, Poisson's ratio, elastic constants and their Relations for anisotropic hookean material, anisotropic and orthotropic materials.	3
	Tension, compression, shearing stress and strain, thermals tresses, composite bars, equations of static equilibrium, concept of free body diagram. Strain energy due to axial loading.	5
2	**Members Subjected to Flexural Loads:** Theory of simple bending, bending moment and shear force diagrams for different types of Static loading and support conditions on beams.	4
	Bending stresses, section modulus and transverse shear stress distribution in circular, hollow circular, I, Box, T, angle sections etc. Strain energy due to bending.	5
3	**Principal Planes, Stresses and Strains:** Members subjected to combined axial, bending and torsional loads, maximum normal and shear stresses, concept of equivalent bending and equivalent twisting moments, Mohr's circle of stress and strain.	5
	Theories of Elastic Failures: The necessity for a theory, different theories, significance and comparison, applications.	2
4	**Torsion:** Torsional shear stress in solid, hollow and stepped circular shafts, angular deflection and power transmission capacity. Strain energy due to torsional loads.	4
	Stability of Equilibrium: Instability and elastic stability, long and short columns, ideal strut, Euler's formula for crippling load for columns of different ends, concept of equivalent length, eccentric loading, Rankine formula and other empirical relations.	3
5	**Transverse Deflection of Beams:** Relation between deflection, bending moment, shear force and load, transverse deflection of beams and shaft under static loading, area moment method, direct Integration method.	6
	Thin-walled Pressure Vessels: Stresses in cylindrical and spherical vessels	2
	TOTAL	**39**

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Department of Mechanical Engineering

COURSE OUTCOMES (COs)

Subject: MECHANICS OF SOLIDS **Code**: 3ME4-07

CO1. Explain stress, strain, and deformation in solids under various loading conditions.

CO2. Apply concepts of axial, torsional, bending, and shear stresses in machine elements.

CO3. Analyze deflection, slope, and stresses in beams and shafts using theoretical methods.

CO4. Evaluate principal stresses, strain energy, and failure criteria in solids.

CO5. Solve problems using energy methods and elastic constants in structures.

CO6. Perform stress analysis of real-world mechanical components using analytical methods.

CO-PO/PSO MAPPING

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	2	2	3
CO2	3	3	2	1	1	1	1	1	1	1	2	2	3
CO3	3	3	3	2	2	1	1	1	1	1	3	2	3
CO4	3	3	3	3	3	1	1	1	1	1	3	3	3
CO5	3	3	3	3	3	1	1	1	1	1	3	2	3
CO6	3	3	3	2	2	2	1	1	1	1	3	2	3

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COURSE PLAN

Name of the Course: MECHANICS OF SOLIDS
Code of the course: 3ME4-07
Name of Faculty: Dayal S. Rathore

Course Outcome

CO1. Explain stress, strain, and deformation in solids under various loading conditions.

CO2. Apply concepts of axial, torsional, bending, and shear stresses in machine elements.

CO3. Analyze deflection, slope, and stresses in beams and shafts using theoretical methods.

CO4. Evaluate principal stresses, strain energy, and failure criteria in solids.

CO5. Solve problems using energy methods and elastic constants in structures.

CO6. Perform stress analysis of real-world mechanical components using analytical methods.

Unit No.	Lec. No.	Topic	CO no.	Specific Objective	Expected Outcome	Book Referred	From page to
1.	1	Elementary definition of stress and strain, stress-strain relationship	CO -1	Explain stress and strain concepts.	Understand stress-strain relationship.	T-1	5 to 6
1	2	Elastic, plastic and visco-elastic behavior of common materials in tension and compression test	CO -1	Explain material behavior under load.	Differentiate elastic and plastic behavior.	T-1	1 to 4
1	3	Stress-strain curves, Hooke's law, Poisson's ratio	CO -1	Explain Hooke's law and Poisson's ratio.	Apply basic stress-strain laws.	T-1	10 to 17
1	4	Elastic constants and their relations for an isotropic hookean material, anisotropic and orthotropic materials	CO -1	Explain elastic constants.	Relate elastic constants of materials.	T-1	97 to 115
1	5	Tension, compression, shearing stress and strain	CO -1	Explain different types of stresses.	Identify tensile, compressive and shear stresses.	T-1	6 to 9
1	6	Thermal stresses, composite bars, equations of static equilibrium	CO -5	Explain thermal stress and composite bars.	Calculate thermal stresses.	T-1	38 to 51
1	7	Concept of free body diagram. Strain energy due to axial loading.	CO -5	Explain FBD and strain energy.	Draw FBD and estimate strain energy.	T-1	204 to 207
2	8	Theory of simple bending, bending moment and shear force diagrams for different types of static loading	CO -2	Explain beam bending theory.	Draw SFD and BMD.	T-1	346-349 & 281-285
2	9	Numericals based on Cantilever beam	CO -2	Solve cantilever beam problems.	Analyze cantilever beams.	T-1	285 to 288

2	10	Numericals based on Simply supported beam	CO -2	Solve simply supported beam problems.	Analyze simply supported beams.	T-1	289 to 296
2	11	Numericals based on Uniformly varying load	CO -2	Solve UVL beam problems.	Calculate beam loading effects.	T-1	297 to 304
2	12	bending stresses, section modulus and transverse shear stress distribution in circular section,	CO -2	Explain bending and shear stresses.	Determine section stresses.	T-1	395 to 398
2	13	section modulus and transverse shear stress distribution in hollow circular, I, Box, T, angle sections etc	CO -2	Explain stresses in different sections.	Compare stress distribution.	T-1	399 to 408
2	14	Strain energy due to bending. Numericals based on above topics.	CO -5	Explain strain energy in bending.	Solve bending energy problems.	T-1	201 to 204
	15	**BC**-Area Moment Method in Fixed Beams	CO -3	Introduce Area Moment Method.	Calculate beam deflection.	BC	**NPTEL**
3	16	Introduction to Principal Planes, Stresses and Strains	CO -4	Explain principal stresses and strains.	Identify principal planes.	T-1	123,148 & 177
3	17	Members subjected to combined axial, bending and torsional loads	CO -4	Explain combined loading.	Analyze combined stresses.	T-1	633 to 636
3	18	Calculation for maximum normal and shear stresses	CO -4	Explain maximum normal and shear stresses.	Calculate maximum stresses.	T-1	124 to 130
3	19	Concept of equivalent bending and equivalent twisting moments	CO -4	Explain equivalent moments.	Determine equivalent bending and twisting moments.	T-1	759 to 760
3	20	Mohr's circle representation of stress and strain	CO -4	Explain Mohr's circle.	Represent stresses graphically.	T-1	137 to 146
3	21	**Theories of Elastic Failures:** The necessity for a theory,	CO -4	Introduce failure theories.	Understand failure criteria.	T-1	233 to 234
3	22	Different theories, significance and comparison	CO -4	Explain different failure theories.	Compare failure theories.	T-1	234 to 243
3	23	Applications of theories of failures	CO -4	Apply failure theories.	Select suitable failure theory.	T-1	244 to 245
	24	**BC**-Combined Direct and Bending Stresses	CO -6	Explain combined direct and bending stresses.	Analyze practical stress conditions.	BC	**NPTEL**
4	25	Introduction to Pure Torsion, Torsional shear stress in solid circular shafts	CO -2	Introduce pure torsion.	Calculate torsional shear stress.	T-1	735 to 737
4	26	Torsional shear stress in hollow circular shafts	CO -2	Explain torsion in hollow shafts.	Analyze hollow shaft stresses.	T-1	737 to 738
4	27	Torsional shear stress in stepped circular shafts	CO -2	Explain stepped shaft torsion.	Calculate stresses in stepped shafts.	T-1	747 to 749
4	28	Angular deflection and power transmission capacity	CO -3	Explain angular deflection.	Calculate shaft deflection and power.	T-1	739 to 740
4	29	Numericals on above topics. Strain energy due to torsional loads.	CO -5	Solve torsion problems.	Evaluate torsional strain energy.	T-1	745 to 747

4	30	Introduction to columns and struts Instability and elastic stability	CO -6	Introduce columns and struts.	Understand column behavior.	T-1	687 to 688
4	31	Long and short columns, ideal strut	CO -6	Explain long and short columns.	Differentiate column types.	T-1	708 to 710
4	32	Euler's formula for crippling load for columns of different ends,	CO -6	Explain Euler's column theory.	Calculate crippling load.	T-1	689 to 693
4	33	Concept of equivalent length	CO -6	Explain equivalent length.	Determine effective column length.	T-1	693 to 697
4	34	Eccentric loading. Rankine formulae and other empirical relations	CO -6	Explain eccentric loading and Rankine formula.	Analyze eccentrically loaded columns.	T-1	702 to 705
5	35	Introduction to slope and deflection of beams.	CO -3	Introduce slope and deflection.	Understand beam deflection concepts.	T-1	425 to 426
5	36	Relation between deflection, bending moment, shear force and load.	CO -3	Explain load-deflection relationship.	Relate load, shear, moment and deflection.	T-1	471 to 472
5	37	Transverse deflection of beams and shafts under static loading using area moment method	CO -3	Explain Area Moment Method.	Calculate beam deflection.	T-1	491 to 496
5	38	Transverse deflection of beams and shafts under static loading using double integration method	CO -3	Explain Double Integration Method.	Determine beam slope and deflection.	T-1	428 to 435
5	39	**Thin-walled Pressure Vessels:** Stresses in cylindrical and spherical vessels	CO -6	Explain thin pressure vessels.	Calculate vessel stresses.	T-1	813 to 820
	40	Brief Review of Linear Structural Analysis	CO -6	Explain basics of linear structural analysis.	Analyze simple structural components.	BC	**NPTEL**

Reference Books

T1- Mechanics of Materials by Dr. B. C. Punmia