GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: CAD / CAM

Course / Subject Code : ME01000591

Course / Subject Name : Advanced stress analysis

w. e. f. Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	PEC

Prerequisite:	Nil
Rationale:	Analysis of stresses in a component subjected to loading is an inevitable part of design process. This requires understanding and knowledge of various theories. The course aims to expose students to such theories while emphasizing their applications under stated conditions. This includes, theories of elasticity, theory of plasticity and experimental stress analysis.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
1	Analyse stresses in components subjected to various loading.	
2	Apply concepts of theory of elasticity and plasticity.	
3	Analyse structures idealized as plates.	
4	Analyse contact stresses in components forced against each other.	
5	Learn experimental techniques for stress analysis.	

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Stress:** Surface forces and body forces, Cartesian components of stress on small cubic element, Stress at a point, Stress equations of equilibrium, Principal stresses, Maximum shear stress, Two dimensional state of stress, Special cases: Pure shear stress, Hydrostatic state of stress, Strain equations of transformations, Principal strain, Energy method for analysis of stress, strain and deflection , three theorem's -theorem of virtual work, theorem of least work, Castiglioni's theorem, Rayleigh Ritz method, Galerkin's method,	06	8
2.	**Theory of Elasticity** Elasticity problems in two dimensions - stress strain relationship for brittle materials, ductile materials. Compatibility equations in two and three dimensions, Airy's stress function, Polar component of stress in terms of stress function free body diagram of complicated structures and stress calculations, stress functions in rectangular and cylindrical coordinate systems, evaluation of stresses in flat rectangular plates with different clamp and load conditions evaluation of the stresses in the flat and circular plate with center hole/holes using stress function.	12	25
3.	**Theory of Plasticity:** Different criterions for three-dimensional stress analysis using plasticity, evaluation of stress concentration factors in different geometries using plasticity theorem, practical problems on stress analysis for plasticity, stress in the sharp groove of the shaft, stress in the L shaped bracket under cantilever load, strain rate effects on highly deformable materials and stress calculations.	11	20
4.	**Plate bending:** Bending of plate to cylindrical surface, bending of a long uniformly loaded rectangular plate, pure bending in two perpendicular directions, bending of circular plates loaded symmetrically w.r.t. center, bending of circular plates of variable thickness, circular plate with circular hole at center symmetrically loaded and load distributed along inner and outer edges.	08	17
5.	**Contact stresses:**	08	17

	Geometry of contact surfaces, method of computing contact stresses and deflection of bodies in point contact, stress for two bodies in line contact with load normal to contact area and load normal and tangent to contact area, gear contacts, contacts between cam and follower, ball bearing contacts.		
6.	**Experimental stress analysis:** Dimensional analysis, analysis techniques, strain gauges, types of strain gauges, materials, configuration, instrumentation, characteristics of strain gauge measurement, theory of photoelasticity, elements of polariscope, simple and circular polariscope, fringes in dark and white field, isoclinic and isochromatic fringe patterns, evaluation of stresses from these fringe patterns	**	12
	Total	**45**	**100**

****Should be covered during practical sessions (10 hrs)**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	**20**	**20**	**30**	**20**	**-**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Advanced Strength and Applied Stress Analysis, Richard G. Budynas, McGraw Hill.
2. Advanced Mechanics of Materials and Applied Elasticity, A C Ugural and A K Fenster, Pearson.
3. Theory of Elasticity, Timoshenko and Goodier, McGraw Hill.
4. Advanced Strength of Materials, Vol. 1, 2, Timoshenko, CBS.
5. Experimental Stress Analysis, J W Dally & W F Riley, Mc Graw Hill.
6. K. Ramesh, e-Book on Experimental Stress Analysis, IIT Madras, 2009.
URL: http://apm.iitm.ac.in/smlab/kramesh/book_5.htm
7. Theory of Plates and Shells, Timoshenko McGraw Hill
8. The Mathematical Theory of Plasticity - R. Hill, Oxford University Press.

(b) Open-source software and website:

1. https://nptel.ac.in/

Suggested Course Practical List:

1. Strain gauge Wheatstone Bridge circuit
2. To measure the strain in a loaded steel cantilever using strain gauges
3. Study of Polariscope and its components
4. Photo elastic stress measurements and fringe constant determination
5. Determination of crack depth using crack depth meter
6. Determination of SIF using Photoelasticity
7. Problems on theory of elasticity
8. Problems on plate bending
9. Problems on contact stresses

List of Laboratory/Learning Resources Required: --

Major Equipment:

1. Strain measurement kit
2. Digital Polariscope
3. Crack depth meter

List of Open Source Software/learning website:

1. http://www.ni.com/white-paper/3642/en/
2. http://nptel.ac.in/downloads/112106068/

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