



Birla Institute of Technology & Science, Pilani
Hyderabad Campus

FIRST SEMESTER 2022-2023

Course Handout Part II

Date: 10-08-2022

In addition to part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

Course No. : **ME G641**
Course Title : **THEORY OF ELASTICITY & PLASTICITY**
Instructor-in-Charge : **BRAJESH KUMAR PANIGRAHI**
Lab Instructors : **G. DEEPAK KUMAR, BRAJESH KUMAR PANIGRAHI**

Description: Basic equations of theory of elasticity; elementary elasticity problems in two and three dimensions; theories of plastic flow; problems in plastic flow of ideally plastic and strain hardening materials; theory of metal forming processes.

1. Course Description: The theory of elasticity continues to play an essential role in mechanical, civil, materials, and aerospace engineering applications. Indeed, many important mechanical systems, ranging from space crafts to trabecular bones, are studied within the context of linear elastic theory. The studies deal with the determination of stresses and displacements in common structural forms- plates, beams, shells etc. subjected to external forces. The course covers basic theory of elasticity, 2-D and 3-D problems of elasticity, Theories of plastic flow, Flow of ideally plastic and strain hardening metals, and theory of metal forming processes.

2. Scope and Objective of the Course: The objective of this course is to introduce the student to the analysis of linear elastic solids under application of loads. The material presented in this course will provide the foundation for pursuing other solid mechanics courses such as theory of plates and shells, elastic stability, composite structures and fracture mechanics. Students are also encouraged to do assignments and practice coding using the ANSYS/ABAQUS/MATLAB package to solve problems of elasticity and plasticity to compare the analytical solutions.

3. Textbooks:

- T1 Timoshenko S. P. & Goodier J. N., Theory of Elasticity, 3rd Edition, Mc-Graw Hill, 1982.
T2 Chakrabarty J., Theory of Plasticity, Mc-Graw Hill Book Company, Singapore, 1987.

4. Reference books

- R1 M. Filonenko-Borodich, Theory of Elasticity, Foreign Language Publishing House, Moscow.
R2 T.G. Sitharam, L. GovindaRaju, Applied Elasticity, Interline Publishing ISBN: 81-7296083-2.



- R3 Alexander Mendelson Plasticity-Theory & application, The Macmillan Company, New York, 1968.
- R4. Martin H Sadd, Elasticity: Theory, Applications and Numerics, Elsevier Butterworth–Heinemann, New York.

5. Course Plan:

Lecture No.	Learning objectives	Topics to be covered	Chapter in the Text Book
1-2	Introduction to Elasticity	Elasticity, Stress, Component of Stress and strain, Hooke's Law	Ch 1-2 of T1, R2
3-7	Plane stress and plane strain (Plane stress and plane strain conditions, significance of equilibrium and compatibility conditions)	Stress at point, strain at point, Measurement of surface strain, construction of Mohr circle, differential equation of equilibrium, compatibility equation	Ch 2 of T1, R2
8-18	2D Problems in Rectangular coordinates (Elasticity based approach, difference between MOM based approach and elasticity based approach)	Saint-Venant's Principle, Determination of displacements, Bending of beam, 2D problems in the form of Fourier series.	Ch 3 of T1, R2
19-25	2D Problems in Polar Coordinates (Elasticity based approach for curved boundary problems)	General equations, Pure bending of curved beam, strain component, Effect of circular hole on stress distribution, stresses in circular disk, Generalized solution of the 2D problem in polar coordinates.	Ch 4 of T1, R2
26-28	Photoelastic and Moire Experimental Methods (Introduction of optical based experimental stress analysis methods)	Experimental methods and verifications, photoelastic stress measurement, Examples, Determination of principle stresses, Moire method	Ch 5 of T1
29-34	Analysis of stress strain in 3D (State of stress at a point, Stress tensors, strain tensors)	Principle stresses, Stress Invariants, Homogeneous deformation, strain at point, Principle axes of strain	Ch 7 of T1
35-38	Torsion (Displacement and stress based approach, Membrane analogy)	Torsion of straight bar, rectangular bar, energy method, torsion of hollow shaft, circular shaft with variable diameter.	Ch 10 of T1
39-41	Basic of Plasticity (Introductory lectures on plasticity, hardening, stress and strain rates)	Stress strain behavior in plastic region, Work hardening, Hardening laws, Influence of pressure, strain rate and temperature, Analysis of strain rate, Concepts of stress rate	Ch 1 of T2
41-43	Foundation of Plasticity (Basic hardening models,	Criterion of yielding, Isotropic Hardening, Anisotropic, The rule of	Ch 2 of T2



	flow rules, some examples on elastoplastic deformations)	plastic flow, Constitutive relations, Application of plasticity for sheet metal processes.	
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Practical No.	Experiment Title
1	Computation and Simulation Lab: Introduction to LAB Course (Basics of Coding using Matlab, Basics of ABAQUS, Understanding structure of input files, Multiple steps etc.)
2	Basic computational solid mechanics, Basics of ABAQUS, Contacts, Pre-processing, Post processing
3-4	Fundamentals of FEM solutions of Elasticity problems through ABAQUS
5	Some elementary solid mechanics problems and FEM validations
6	Validation Advanced problems of Elasticity
7	Basic example of bending of cantilever beam with all pre and post processing, which includes how to extract results and Interpretation. Validating with Theory of Elasticity approach.
8	Comparison of FEM and Analytical results (Theory of Elasticity Approach) of Axisymmetric objects : Thick Cylinders
9	Comparison of FEM and Analytical results (Theory of Elasticity Approach) of Axisymmetric objects : Rotating Disks
10	Comparison of FEM and Analytical results (Theory of Elasticity Approach) for plates with a circular hole
11	Experimental Stress Analysis using Polariscope : 1. Disk with diametric compression
12	Experimental Stress Analysis using Polariscope : 2. Tensile/Compressive tests
13	Experimental Stress Analysis using Polariscope :3. TBT specimen
14	Experimental Stress Analysis using Polariscope : 4. Plate with circular hole
15	Experiment on Tensile testing using different strain rates
16	Experiment on Tensile testing on elevated temperatures



6. Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of Component
Midsemester Test	90 min	25	03/11 1.30 - 3.00PM	CB
Projects/Case studies/ Article presentation	-	20	Continuous throughout the semester	Open Book
Lab	-	20	Continuous throughout the semester	Open Book
Comprehensive Exam	180 min	35	26/12 AN	CB

7. Chamber Consultation Hour: To be announced in the class.

8. Notices concerning the course: All notices concerning the course are displayed on CMS only.

9. Make-up Policy: No makeup for Project presentations, Quizzes, Lab component and Case studies.

Makeup for Midsemester test and comprehensive examination will be given for genuine cases with prior permission.

10. Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by, all the students throughout the semester and no type of academic dishonesty is acceptable.

Dr. Brajesh Kumar Panigrahi

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