Indian Institute of Technology Bhubaneswar

School of Infrastructure

Session: Autumn 2025

Solid Mechanics (CE2L001) Class Test 2

Date: November 06, 2025 Total Marks: 50

Instructions:
(1) Zeroth-order tensors or scalars are represented by small letters. For eg. a.
(2) First-order tensors or vectors are represented by bold small letters. For eg. $\boldsymbol{a}$.
(3) Second-order tensors are represented by bold capital letters. For eg. $\boldsymbol{A}$.

1. A square material element with side length 1 unit undergoes a volume-preserving deformation given by:

$$x_1' = \alpha x_1, \qquad x_2' = \frac{x_2}{\alpha},$$

where $\alpha = 1.5$.

(a) Determine the deformation gradient tensor $\boldsymbol{F}$.
(b) Plot the reference and current configurations.
(c) Calculate the stretch ratio in the x_1 direction and the contraction ratio in the x_2 direction. [10]

2. The stress components in a material are given by:

$$\sigma_{11} = a_1\, x_1 x_2, \qquad \sigma_{22} = a_2\, x_2 x_3, \qquad \sigma_{12} = a_3\, x_1 x_3,$$

where a_1, a_2, and a_3 are small constants. Determine:
(a) The body force components.
(b) The strain components using Hooke's law.
(c) Whether the compatibility condition is satisfied. [10]

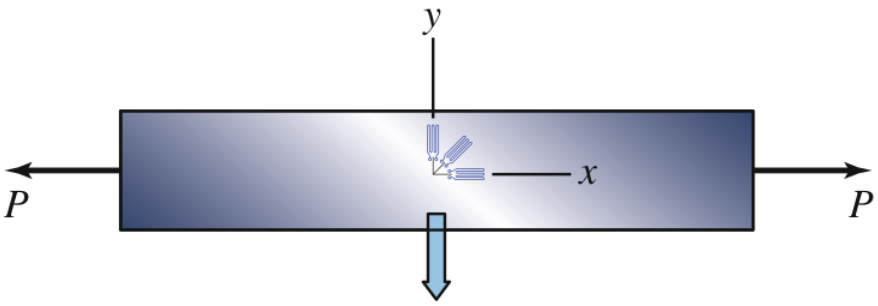
3. The displacement field is given by:

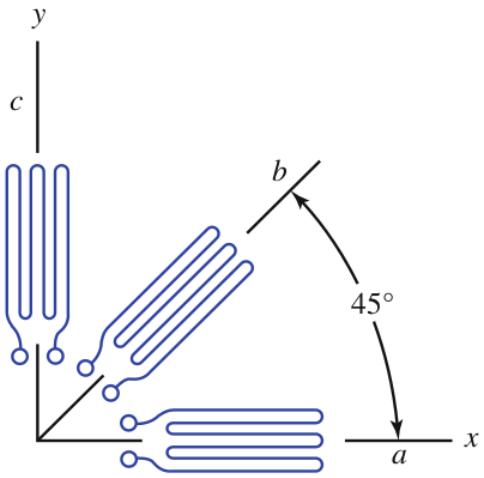
$$u_1 = \alpha\, x_1 x_2, \qquad u_2 = \beta\, x_1^2,$$

where α and β are constants. Calculate the strain tensor and derive the principal strains and principal directions. [10]

4. Consider a homogeneous deformation of a cube with initial side length a. The cube is sheared in the x-y plane by an angle γ. Determine:
   (a) Deformation gradient tensor $\boldsymbol{F}$.
   (b) Finite strain tensor $\boldsymbol{E}$.
   (c) Linearized strain tensor $\boldsymbol{E}_s$ for small deformations.
   (d) Provide a comparison between the finite strain components and the linearized strain components through a numerical example. [10]

5. A bar is subjected to axial forces. The strains measured by a strain gauge rosette oriented as shown in the below figure are $E_{aa} = 0.003$, $E_{bb} = 0.001$, and $E_{cc} = -0.001$. What are the strain components E_{xx}, E_{yy}, and E_{xy}?





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