Indian Institute of Technology Bhubaneswar

School of Infrastructure

Session: Autumn 2025

CAD Laboratory (CE4P001) Assignment No. 2

Date: November 02, 2025 Total Marks: 100

Instructions:

(1) Solve the assignment problem by writing Julia codes and uploading the files to your GitHub account.

(2) If two or more files in different GitHub accounts appear identical, each of them will be awarded ZERO.

(3) Submit a hard copy explaining each part of the code in detail by November 17, 2025.

1. Given the two-dimensional body

$$\mathcal{B} = \{(X_1, X_2) \mid 0.1 < X_1 < 1, \quad 0.1 < X_2 < 1\},$$

and the displacement field

$$u_1 = \boldsymbol{u} \cdot \boldsymbol{e}_1 = 0.2 \ln(1 + X_1 + X_2), \qquad u_2 = \boldsymbol{u} \cdot \boldsymbol{e}_2 = 0.2 \exp X_1.$$

Plot the displaced shape of the body using Julia.

Hint: First set up some characteristic lines on the body. For each point compute its displacement and add it to the original position by noting $x_i = \boldsymbol{e}_i \cdot (\boldsymbol{X} + \boldsymbol{u})$. [10]

2. With respect to a two-dimensional rectangular cartesian coordinates system with orthonormal base vectors ($\boldsymbol{e}_1$,$\boldsymbol{e}_2$), let the rectangular coordinates of a point be denoted by (X_1, X_2). Consider a two-dimensional annular body $\mathcal{B}$ which occupies the region

$$\mathcal{B} = \{(X_1, X_2) \mid 1 < \sqrt{X_1^2 + X_2^2} < 2\}.$$

Because of the annual nature of the body consider a polar coordinates system in which the coordinates of points are expressed in terms (R, θ), which are related to the rectangular coordinates (X_1, X_2) by

$$R = \sqrt{X_1^2 + X_2^2} \text{ and } \theta = \tan^{-1}(X_2/X_1)$$

Further, the orthonormal base vectors $(\boldsymbol{e}_r, \boldsymbol{e}_\theta)$ of the polar coordinate system are related to $(\boldsymbol{e}_1, \boldsymbol{e}_2)$ by

$$\boldsymbol{e}_r = \cos\theta \boldsymbol{e}_1 + \sin\theta \boldsymbol{e}_2, \quad \boldsymbol{e}_\theta = -\sin\theta \boldsymbol{e}_1 + \cos\theta \boldsymbol{e}_2$$

Draw the deformed configuration of the annular body associated with the following deformation,

$$u_r = \boldsymbol{u} \cdot \boldsymbol{e}_r = 0.4(R-1)^2 \cos 3\theta$$
$$u_\theta = \boldsymbol{u} \cdot \boldsymbol{e}_\theta = 0.4(R-1)^3,$$

using Julia.

Hint: First set up some characteristic lines on the body in terms of their (R, θ) coordinates. Compute the (X_1, X_2) coordinates from

$$X_1 = R\cos\theta, \quad X_2 = R\sin\theta$$

For each point compute its displacement and add it to the original position by noting $x_i = \boldsymbol{e}_i \cdot (\boldsymbol{X} + \boldsymbol{u}) = \boldsymbol{e}_i \cdot (\boldsymbol{X} + u_r\boldsymbol{e}_r + u_\theta\boldsymbol{e}_\theta)$. [15]

3. Given the two-dimensional body

$$\mathcal{B} = \{(X_1, X_2) \mid 0.1 < X_1 < 1, \quad 0.1 < X_2 < 1\},$$

and the displacement field

$$u_r = \boldsymbol{u} \cdot \boldsymbol{e}_r = 0.2 \exp X_1, \qquad u_\theta = \boldsymbol{u} \cdot \boldsymbol{e}_\theta = 0.2 \ln(1 + X_1 + X_2).$$

Plot the displaced shape of the body using Julia. [10]

4. Find out the stress distribution by modeling the given rectangular plate of 2 mm thick with a circular hole. The dimensions of the steel plate and hole are shown in Figure 1: The section is made up of steel having a value of 210 GPa for Young's modulus and a value of 0.3 for Poisson's ratio.

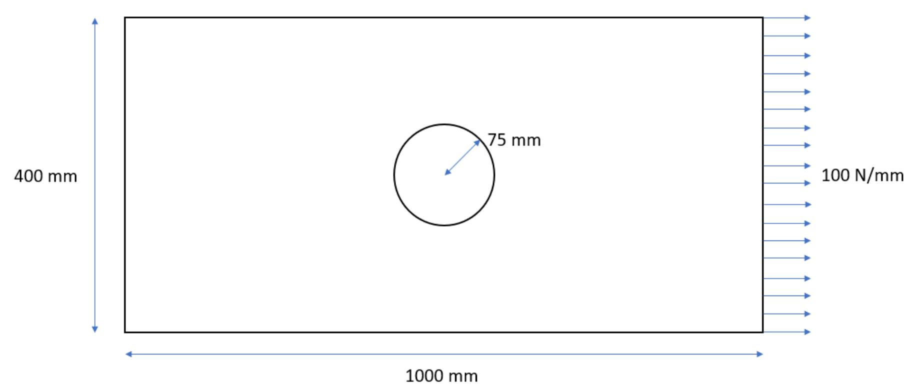

Figure 1

(a) Provide the steps for finite element meshing both in Julia and Abaqus.

(b) Mention the governing PDEs that are required to solve for the stress distribution.

(c) Provide a comparison between the results obtained from Gridap in Julia and Abaqus. [20]

5. Find out the stress distribution of the cantilever beam of 1000 mm in length and has a 250mm x 200mm rectangular cross-section under the point load of 1000 N at the free end as shown in Figure 2. The section is made up of a concrete having a value of 25000 N/mm^2 for Young's modulus and a value of 0.2 for Poisson's ratio in the respective fields.

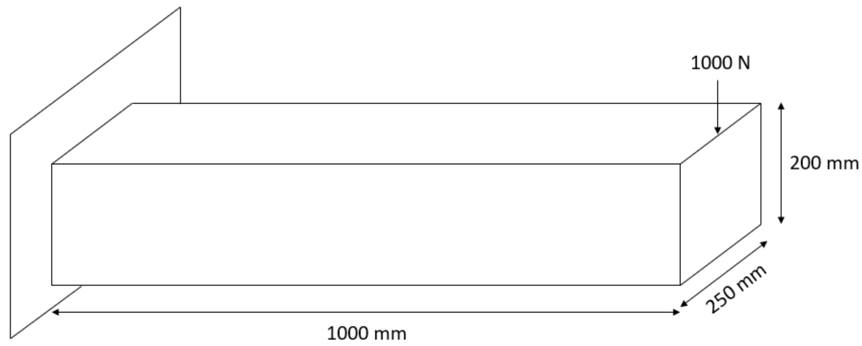

Figure 2

(a) Provide the steps for finite element meshing both in Julia and Abaqus.

(b) Mention the governing PDEs that are required to solve for the stress distribution.

(c) Provide a comparison between the results obtained from Gridap in Julia and Abaqus. [20]

6. Find out the stress distribution of the cantilever beam of 1000 mm in length and has a 250mm x 200mm rectangular cross-section under the uniform distributed load of 1000 N/mm^2 applied on the top surface as shown in Figure 3. The section is made up of a concrete having a value of 25000 N/mm^2 for Young's modulus and a value of 0.2 for Poisson's ratio in the respective fields.

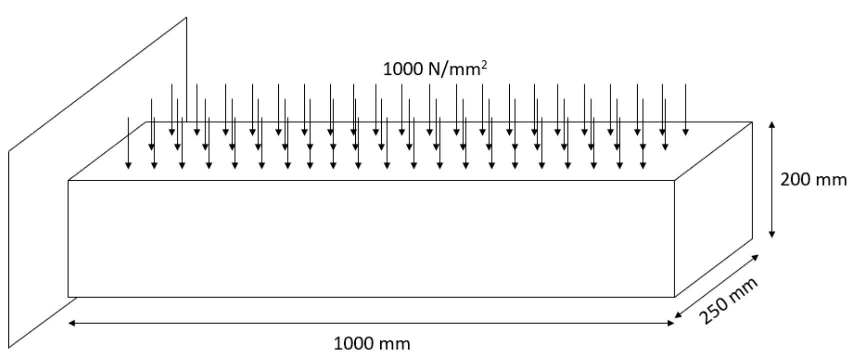

Figure 3

(a) Provide the steps for finite element meshing both in Julia and Abaqus.

(b) Mention the governing PDEs that are required to solve for the stress distribution.

(c) Provide a comparison between the results obtained from Gridap in Julia and Abaqus. [25]