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**MANIPAL INSTITUTE OF TECHNOLOGY**
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**V SEMESTER B. TECH (MECHANICAL ENGG.) END SEMESTER ONLINE EXAMINATIONS, JANUARY-FEBRUARY 2021**

**SUBJECT:** FINITE ELEMENT METHOD [MME 3152]

**REVISED CREDIT SYSTEM**

Time: 3 Hours MAX. MARKS: 50

**Instructions to Candidates:**

- Answer **ALL** the questions.
- Missing data (if any) may be suitably assumed.

**1A.** The component shown in **figure 1**A is spinning at $\omega$ rad/sec. Assuming 1D structure, determine the finite element interpolation functions and obtain the expression for element stiffness matrices in terms of these interpolation functions. Use minimum number of finite elements. **05 M**

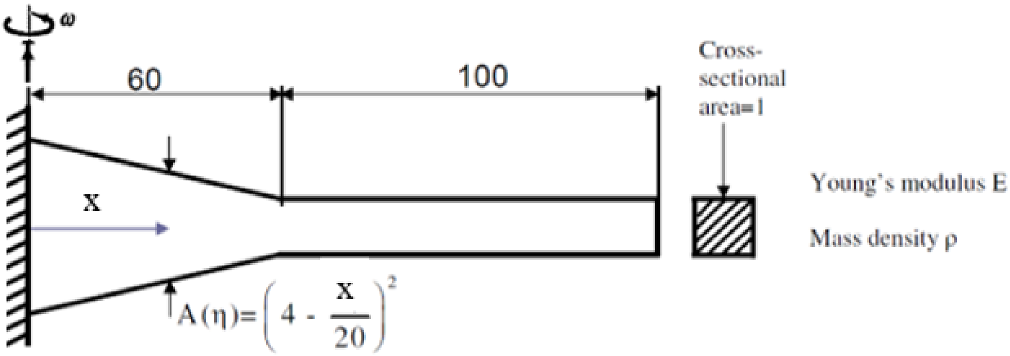


**FIGURE 1A**

**1B.** A pipe line is laid to transport water at a velocity of 25 m/s to the top of a steep hill, whose inclination is assumed to be $45^0$. A small section of this pipeline system of length 1.5 m and 400 mm uniform diameter is required to be analyzed for pressure head distribution using FEM. The pressure at inlet and outlet are known as 29.43 N/cm$^2$ and 22.56 N/cm$^2$ respectively. Discretize the continuum into three equal length elements and determine unknown pressure heads. Use penalty approach for handling boundary conditions. **03 M**

**1C.** Solve the given integral function using two-point Gauss Quadrature rule. **02 M**

$$I = \int_1^3 x^6 - x^2 \sin(2x)\, dx$$

**2A.** Consider a simple bar fixed at one end (x = 0) and subjected to a concentrated force at the other end (at x = 180) as shown in **figure 2A**. **05 M**

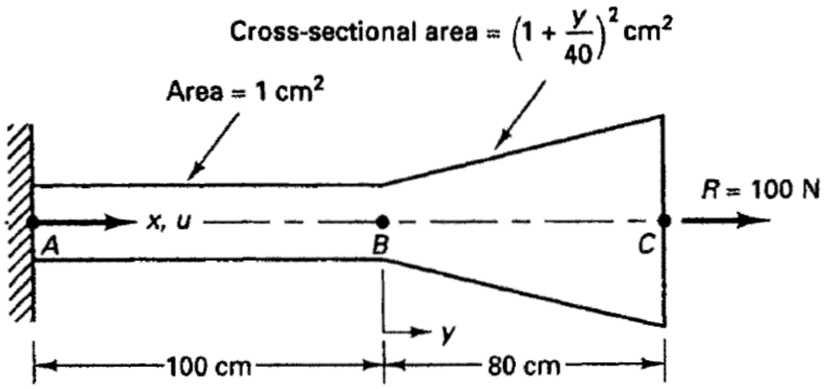


**FIGURE 2A**

Using the notations in the figure, the total potential energy of the structure is given by,

$$\Pi = \int_0^{180} \frac{1}{2} EA\left(\frac{du}{dx}\right)^2 dx - 100u\big|_{x=180}$$ **and $u_A = 0$ $at$ $x = 0$.**

Calculate the displacement and stress distributions in the structure using the Rayleigh-Ritz method with the following displacement assumptions:

$$u = \frac{xu_B}{100}; \qquad 0 \le x \le 100$$

**and,**

$$u = \left(1 - \frac{x-100}{80}\right)u_B + \left(\frac{x-100}{80}\right)u_C; \qquad 100 \le x \le 180$$

where, $u_A$ , $u_B$ and $u_C$ are displacements at points A, B and C respectively and E is material constant.

**2B.** For the truss configuration shown in **figure 2B**, setup global {F} = [K] {Q} relationship and apply all boundary conditions. **03 M**

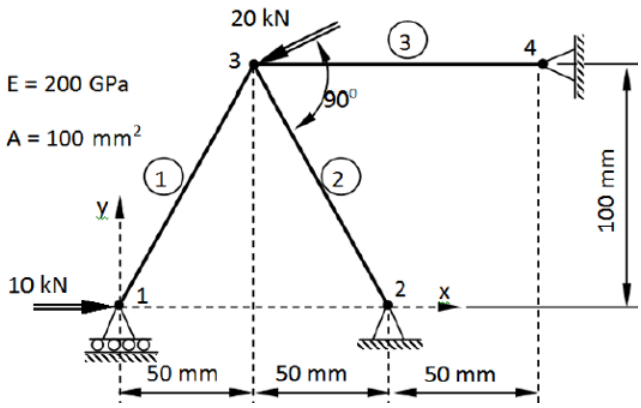


**FIGURE 2B**

**2C.** "A simple 4 noded 2D plane element is a complete element". Justify. **02 M**

**3A.** A disc with a centerline hole of radius 20 mm is shown in **figure 3A**, spinning at a rotational velocity of $\omega$ radians/ second. Idealize the structure as an assembly of 2 noded minimum number of finite elements and determine: **05 M**

i) Interpolation functions.

ii) Strain-displacement relationship matrix.

iii) Stiffness matrix in integral form.

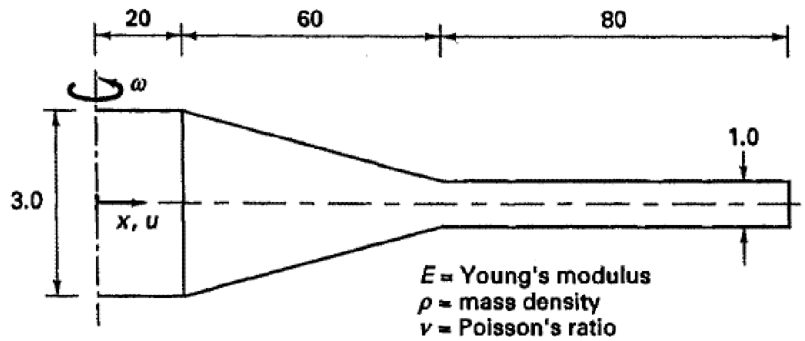


**FIGURE 3A**

**3B.** For the bar element with varying cross-section shown in **figure 3B**, derive the element stiffness matrix. Assume Elastic modulus (E) as constant and Area (A) varies linearly. **03 M**

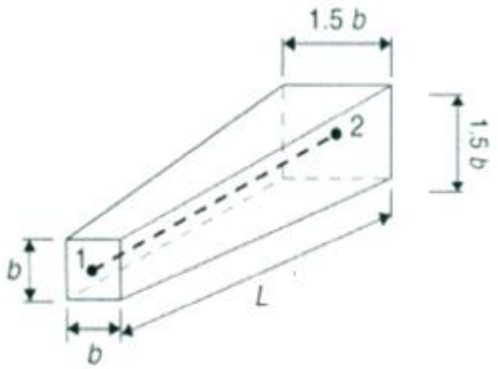


**FIGURE 3B**

**3C.** Write the displacement functions using polynomials for simplest 3D element and mention how the number of equations and number of terms in the equations are decided? **02 M**

**4A.** The structure shown in **figure 4A,** need to be analyzed using 3 noded 2D elements. Discretize the domain using minimum no elements and sketch discretized representation. Also, obtain the global {F} = [K] {Q} relationship and apply boundary conditions. Take elastic modulus as 20 x $10^6$ N/cm$^2$, ratio of lateral strain to longitudinal strain as 0.3 and thickness of the plate as 1 cm. **05 M**

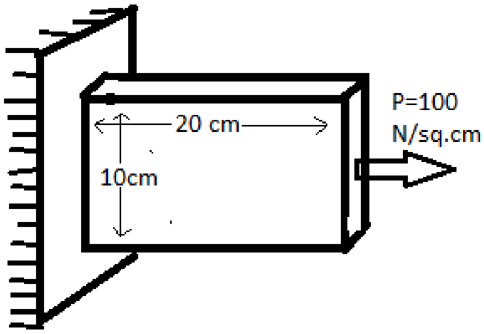


**FIGURE 4A**

**4B.** For the structural configuration shown in **figure 4B**, obtain the displacement and slope using FEM. Take the flexural rigidity constant as EI and spring constant as, **03 M**

$$K = \frac{76EI}{L^3}.$$

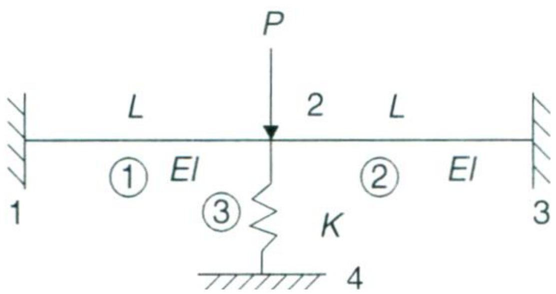


**FIGURE 4B**

**4C.** Illustrate the limitations of minimum potential energy method with suitable example. **02 M**

**5A.** A transverse load carrying member having uniform circular cross section of 100 mm diameter is loaded with uniformly distributed load as shown in **figure 5A.** Using minimum no of finite elements determine the deflection at the midpoint of the distributed load region. Take material constant E = 200 GPa. **04 M**

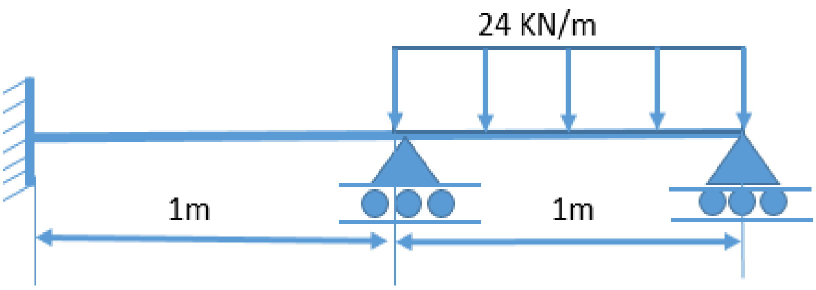


**FIGURE 5A**

**5B.** Using principle of minimum potential energy, setup the global {F} = [K]{Q} relationship for the spring assemblages shown in **figure 5B** and determine unknown displacements. **04 M**

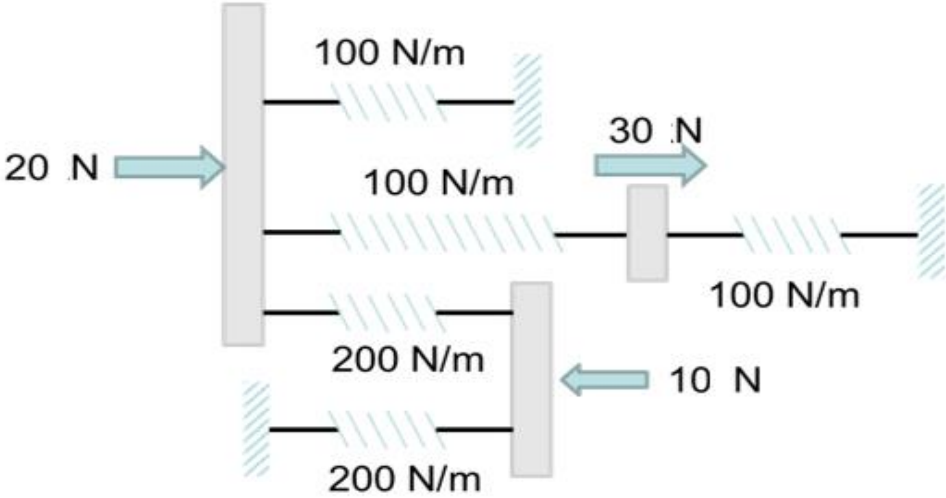

**FIGURE 5B**

**5C.** With an example illustrate the term “spacial isotropy” of an element in finite element method. **02 M**