(17)

B. Sc. Engg. (CEE)/7th Semester | 15 December, 2023 (Morning 9:00-12:00 pm)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Semester Final Examination | **Winter Semester: 2022–2023**
Course Number: CEE 4711 | **Full Marks: 150**
Course Title: Structural Analysis and Design II | **Time: 3 Hours**

There are 7 (Seven) questions. Question no. 1 is COMPULSORY. Answer 6 questions including question 1. The figures in the right margin indicate full marks. COs and POs are also specified in the right margin of the questions. The symbols have their usual meaning.

1. (a) Derive the displacement and force transformation matrices for the frame member shown in **Fig. 1**. The local coordinate systems are denoted by (x', y', z') and the global coordinate systems are denoted by (x, y, z). **(CO1) (PO1)** **(10)**

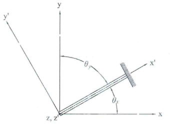


Fig. 1 for Question 1 (a)

(b) Draw the quantitative influence line (showing coordinates at A, B, C, D, E, F, and G) for the support reactions, shear at C and moment at F for the beam shown in **Fig. 2**. EI is constant. **(CO3) (PO2)** **(25)**

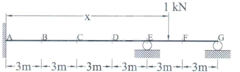


Fig. 2 for Question 1(b)

2. Analyze the beam shown in **Fig. 3** using stiffness method and determine reactions at the supports and draw the shear force and bending moment diagram. EI is constant. Horizontal movement of the beam is neglected. **(CO2) (PO2)** **(23)**

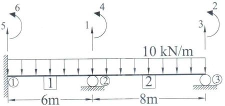
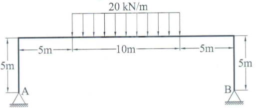


Fig. 3 for Question 2

3. Analyze the frame shown in **Fig. 4** using flexibility method and determine the reactions at the supports. EI is constant. **(CO2) (PO2)** **(23)**

Fig. 4 for Question 3



4. Analyze the beam shown in **Fig. 5** using moment distribution method and determine the support reactions and draw the shear force and bending moment diagram. EI is constant. **(CO2) (PO2)** **(23)**

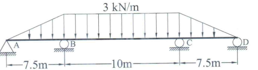


Fig. 5 for Question 4

5. Analyze the beam shown in **Fig. 6** using stiffness method and determine reactions at the supports and draw the shear force and bending moment diagram. EI is constant. **(CO2) (PO2)** (23)

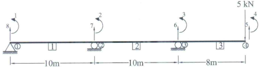


Fig. 6 for Question 5

6. Analyze the frame shown in **Fig. 7** using moment distribution method and determine the support reactions and end moment of all the members. EI is constant **(CO2) (PO2)** (23)

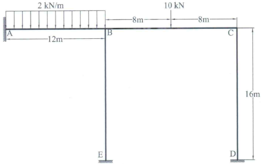


Fig. 7 for Question 6

7. Analyze the beam shown in **Fig. 8** using flexibility method and determine the reactions at the supports and draw the shear force and bending moment diagram. **(CO2) (PO2)** (23)

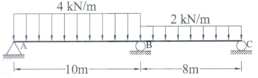
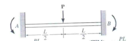


Fig. 8 for Question 7

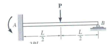
$$
\begin{bmatrix} q_{Ny'} \\ q_{Nz'} \\ q_{Fy'} \\ q_{Fz'} \end{bmatrix}
=
\begin{array}{c}
\begin{array}{cccc} \quad N_{y'} & \quad N_{z'} & \quad F_{y'} & \quad F_{z'} \end{array} \\
\begin{bmatrix}
\frac{12EI}{L^3} & \frac{6EI}{L^2} & -\frac{12EI}{L^3} & \frac{6EI}{L^2} \\
\frac{6EI}{L^2} & \frac{4EI}{L} & -\frac{6EI}{L^2} & \frac{2EI}{L} \\
-\frac{12EI}{L^3} & -\frac{6EI}{L^2} & \frac{12EI}{L^3} & -\frac{6EI}{L^2} \\
\frac{6EI}{L^2} & \frac{2EI}{L} & -\frac{6EI}{L^2} & \frac{4EI}{L}
\end{bmatrix}
\end{array}
\begin{bmatrix} d_{Ny'} \\ d_{Nz'} \\ d_{Fy'} \\ d_{Fz'} \end{bmatrix}
$$

$$
\begin{bmatrix} q_{Nx'} \\ q_{Ny'} \\ q_{Nz'} \\ q_{Fx'} \\ q_{Fy'} \\ q_{Fz'} \end{bmatrix}
=
\begin{array}{c}
\begin{array}{cccccc} \quad N_{x'} & \quad N_{y'} & \quad N_{z'} & \quad F_{x'} & \quad F_{y'} & \quad F_{z'} \end{array} \\
\begin{bmatrix}
\frac{AE}{L} & 0 & 0 & -\frac{AE}{L} & 0 & 0 \\
0 & \frac{12EI}{L^3} & \frac{6EI}{L^2} & 0 & -\frac{12EI}{L^3} & \frac{6EI}{L^2} \\
0 & \frac{6EI}{L^2} & \frac{4EI}{L} & 0 & -\frac{6EI}{L^2} & \frac{2EI}{L} \\
-\frac{AE}{L} & 0 & 0 & \frac{AE}{L} & 0 & 0 \\
0 & -\frac{12EI}{L^3} & -\frac{6EI}{L^2} & 0 & \frac{12EI}{L^3} & -\frac{6EI}{L^2} \\
0 & \frac{6EI}{L^2} & \frac{2EI}{L} & 0 & -\frac{6EI}{L^2} & \frac{4EI}{L}
\end{bmatrix}
\end{array}
\begin{bmatrix} d_{Nx'} \\ d_{Ny'} \\ d_{Nz'} \\ d_{Fx'} \\ d_{Fy'} \\ d_{Fz'} \end{bmatrix}
$$

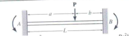
Fixed End Moments



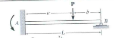
$(FEM)_{AB} = \frac{PL}{8}$ $(FEM)_{BA} = \frac{PL}{8}$



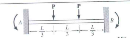
$(FEM)'_{AB} = \frac{3PL}{16}$



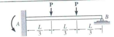
$(FEM)_{AB} = \frac{Pb^2a}{L^2}$ $(FEM)_{BA} = \frac{Pa^2b}{L^2}$



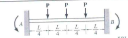
$(FEM)'_{AB} = \left(\frac{P}{L^2}\right)\left(b^2a + \frac{a^2b}{2}\right)$



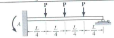
$(FEM)_{AB} = \frac{2PL}{9}$ $(FEM)_{BA} = \frac{2PL}{9}$



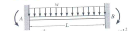
$(FEM)'_{AB} = \frac{PL}{3}$



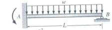
$(FEM)_{AB} = \frac{5PL}{16}$ $(FEM)_{BA} = \frac{5PL}{16}$



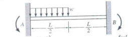
$(FEM)'_{AB} = \frac{45PL}{96}$



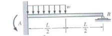
$(FEM)_{AB} = \frac{wL^2}{12}$ $(FEM)_{BA} = \frac{wL^2}{12}$



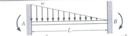
$(FEM)'_{AB} = \frac{wL^2}{8}$



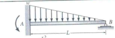
$(FEM)_{AB} = \frac{11wL^2}{192}$ $(FEM)_{BA} = \frac{5wL^2}{192}$



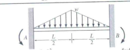
$(FEM)'_{AB} = \frac{9wL^2}{128}$



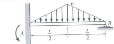
$(FEM)_{AB} = \frac{wL^2}{20}$ $(FEM)_{BA} = \frac{wL^2}{30}$



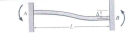
$(FEM)'_{AB} = \frac{wL^2}{15}$



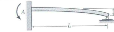
$(FEM)_{AB} = \frac{5wL^2}{96}$ $(FEM)_{BA} = \frac{5wL^2}{96}$



$(FEM)'_{AB} = \frac{5wL^2}{64}$

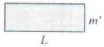
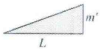
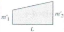
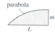
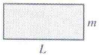
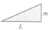
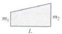
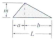
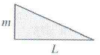


$(FEM)_{AB} = \frac{6EI\Delta}{L^2}$ $(FEM)_{BA} = \frac{6EI\Delta}{L^2}$

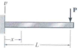
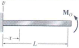


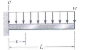
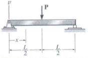
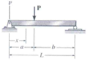
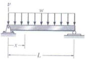
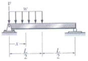
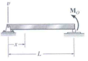
$(FEM)'_{AB} = \frac{3EI\Delta}{L^2}$

Table for Evaluating $\int_0^L m\, m'\, dx$

$\int_0^L m\,m'\,dx$				
	$mm'L$	$\frac{1}{2}mm'L$	$\frac{1}{2}m(m_1' + m_2')L$	$\frac{2}{3}mm'L$
	$\frac{1}{2}mm'L$	$\frac{1}{3}mm'L$	$\frac{1}{6}m(m_1' + 2m_2')L$	$\frac{5}{12}mm'L$
	$\frac{1}{2}m'(m_1 + m_2)L$	$\frac{1}{6}m'(m_1 + 2m_2)L$	$\frac{1}{6}[m_1'(2m_1 + m_2) + m_2'(m_1 + 2m_2)]L$	$\frac{1}{12}[m'(3m_1 + 5m_2)]L$
	$\frac{1}{2}mm'L$	$\frac{1}{6}mm'(L + a)$	$\frac{1}{6}m[m_1'(L + b) + m_2'(L + a)]$	$\frac{1}{12}mm'\left(3 + \frac{3a}{L} - \frac{a^2}{L^2}\right)L$
	$\frac{1}{2}mm'L$	$\frac{1}{6}mm'L$	$\frac{1}{6}m(2m_1' + m_2')L$	$\frac{1}{4}mm'L$

Beam Deflections and Slopes

Loading	$v + \uparrow$	$\theta + \curvearrowleft$	Equation $+\uparrow\ +\curvearrowleft$
	$v_{max} = -\frac{PL^3}{3EI}$ at $x = L$	$\theta_{max} = -\frac{PL^2}{2EI}$ at $x = L$	$v = \frac{P}{6EI}(x^3 - 3Lx^2)$
	$v_{max} = \frac{M_O L^2}{2EI}$ at $x = L$	$\theta_{max} = \frac{M_O L}{EI}$ at $x = L$	$v = \frac{M_O}{2EI}x^2$

	$v_{max} = -\dfrac{wL^4}{8EI}$ at $x = L$	$\theta_{max} = -\dfrac{wL^3}{6EI}$ at $x = L$	$v = -\dfrac{w}{24EI}(x^4 - 4Lx^3 + 6L^2x^2)$
	$v_{max} = -\dfrac{PL^3}{48EI}$ at $x = L/2$	$\theta_{max} = \pm\dfrac{PL^2}{16EI}$ at $x = 0$ or $x = L$	$v = \dfrac{P}{48EI}(4x^3 - 3L^2x)$, $0 \le x \le L/2$
		$\theta_L = -\dfrac{Pab(L+b)}{6LEI}$ $\theta = \dfrac{Pab(L+a)}{6LEI}$	$v = -\dfrac{Pbx}{6LEI}(L^2 - b^2 - x^2)$ $0 \le x \le a$
	$v_{max} = -\dfrac{5wL^4}{384EI}$ at $x = \dfrac{L}{2}$	$\theta_{max} = \pm\dfrac{wL^3}{24EI}$	$v = -\dfrac{wx}{24EI}(x^3 - 2Lx^2 + L^3)$
		$\theta_L = -\dfrac{3wL^3}{128EI}$ $\theta_R = \dfrac{7wL^3}{384EI}$	$v = -\dfrac{wx}{384EI}(16x^3 - 24Lx^2 + 9L^3)$ $0 \le x \le L/2$ $v = -\dfrac{wL}{384EI}(8x^3 - 24Lx^2 + 17L^2x - L^3)$ $L/2 \le x \le L$
	$v_{max} = -\dfrac{M_O L^2}{9\sqrt{3}EI}$	$\theta_L = -\dfrac{M_O L}{6EI}$ $\theta_R = \dfrac{M_O L}{3EI}$	$v = -\dfrac{M_O x}{6EIL}(L^2 - x^2)$