



ORDRE DES INGÉNIEURS DU QUÉBEC
MAY 2011 SESSION

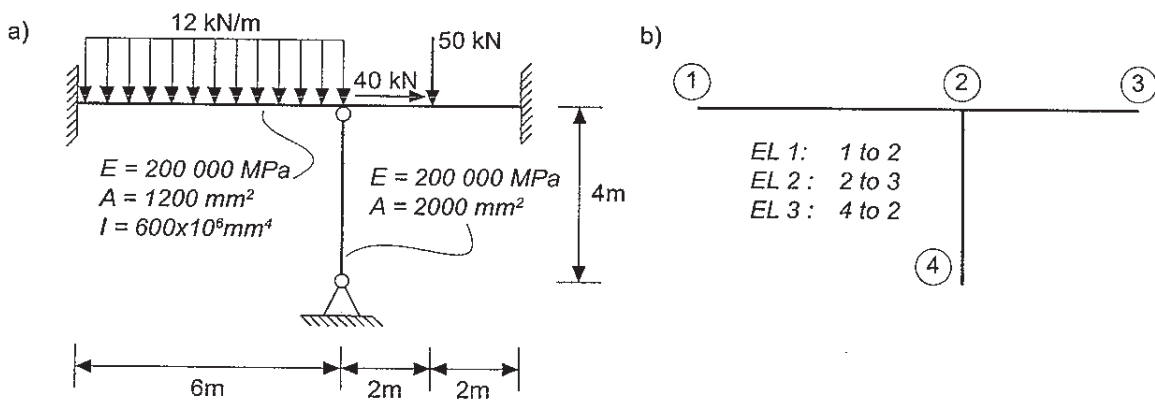
Open book examination
Calculators: only authorized models
Duration: 3 hours

98-Civ-B1
Advanced structural analysis

Note: The following structures all have linear elastic behavior.

Question 1 (25 points):

Consider the structure illustrated below. Use the **matrix displacement method** ($[K][U] = [P]$). The load case is illustrated in Fig (a). Node and element numbers are illustrated in Fig (b). Use [kN] and [m] units. The 40kN horizontal load is applied on node #2.



- (15 pts) Write the element stiffness matrices $[K_1]_{6 \times 6}$, $[K_2]_{6 \times 6}$ and $[K_3]_{6 \times 6}$ in global coordinates.
- (10 pts) Assemble the global stiffness matrix $[K]_{3 \times 3}$.

Question 2 (30 points) :

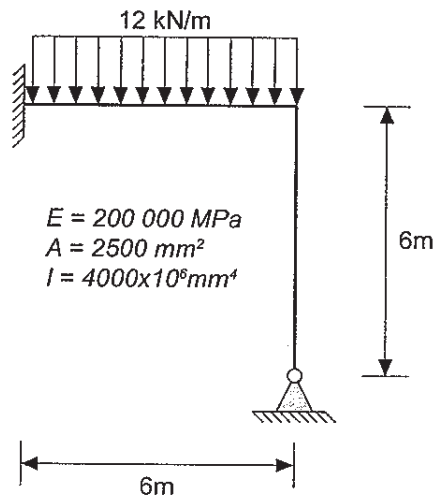
Consider the structure illustrated above (Question 1). Use [kN] and [m] units.

- (10 pts) Assemble the nodal force vector $[P]_{3 \times 1}$.
- (5 pts) Calculate and plot the displacements $[U]_{3 \times 1}$.
- (15 pts) Calculate the internal member forces. Illustrate the axial force diagram, the shear diagram and the bending moment diagram for the structure.



Question 3 (30 points) :

Consider the structure illustrated below. Calculate the reactions. Plot the free-body diagram, the axial force diagram, the shear diagram and the bending moment diagram for the structure. Suggestion: use a force method, such as the consistent displacements method, considering only the flexure deformations for the calculations.



Question 4 (15 points) :

Consider the 18-m bridge illustrated below. The deck is modeled with 18 beam elements, each having a 1-m length. A vertical unit load is moving on the bridge. Draw an **approximate illustration** of the influence line for the moment at sections AA, BB and CC. Make three distinct drawings.

