ORDRE DES INGÉNIEURS DU QUÉBEC
NOVEMBER 2012 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 (figure 1). Use the matrix displacement method ([**K**][**U**] = [**P**]). Node, element, and degree-of-freedom numbers are illustrated in Fig 1(**a**). The load case is illustrated in Fig 1(**b**). **Members #4 and #5 are truss elements.** It is assumed that the axial stiffness of the beam (members #1, #2 and #3) is very high, and that the horizontal degrees of freedom are therefore neglected.

Use [**kN**] and [**m**] units.

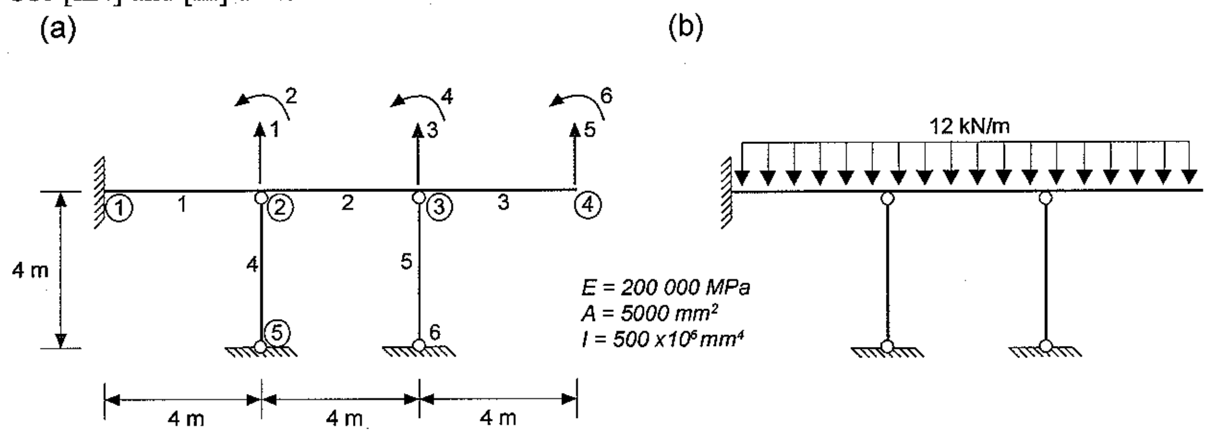

Figure 1

a) (10 pts) Write the element stiffness matrices $[\mathbf{K_1}]_{6x6}$ and $[\mathbf{K_4}]_{6x6}$ in **global** coordinates.
b) (15 pts) Assemble the global stiffness matrix $[\mathbf{K}]_{6x6}$.
Important : the global stiffness matrix size will be **6x6**.

Question 2 (30 points):
Consider the structure illustrated above (Fig. 1). Use [**kN**] and [**m**] units. Assume that the rotation degrees-of-freedom are neglected. The structure now has a total of **3 degrees-of-freedom** (DOF 1, 3 and 5 on Fig 1a).

a) (10 pts) Assemble the global stiffness matrix $[\mathbf{K}]_{3x3}$.
Important : the global stiffness matrix size will be **3x3**.
b) (10 pts) Assemble the nodal force vector $[\mathbf{P}]_{3x1}$ for the load case illustrated in Fig. 1b.
c) (10 pts) Calculate and plot the **3** displacements $[\mathbf{U}]_{3x1}$

Question 3 (30 points):
Consider the truss illustrated below (Fig. 2). Calculate the **flexibility matrix,** only for the 2 degrees-of-freedom indicated. Suggestion: apply a unit load on DOF #1 and calculate the displacements for DOFs #1 and #2. Repeat the process with a unit load applied on DOF #2.

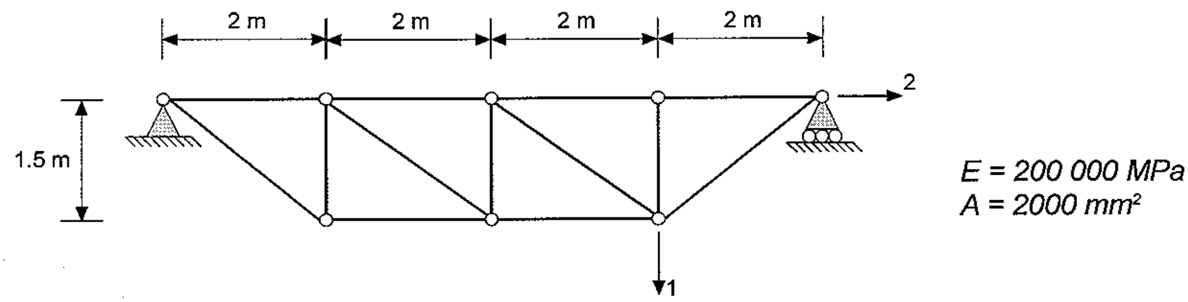

Figure 2

Question 4 (15 points) :
Two models are presented below (Fig. 3) for a roof truss in which each member consists of back-to-back channel sections.

- In the first case (a), the model is a true truss, with only two degrees-of-freedom per node (translation) and zero-inertia members.
- In the second case (b), the truss is modeled with three degrees-of-freedom per node (2 translations and 1 rotation). In this model (b), the bottom and top chords are continuous, and the web members have pinned connections at both ends.

Briefly explain, for the load cases illustrated below (concentrated loads on the top chord nodes), what are the differences between both models with respect to internal forces (axial forces, moments and shear forces). Which of the two models should be used for design?

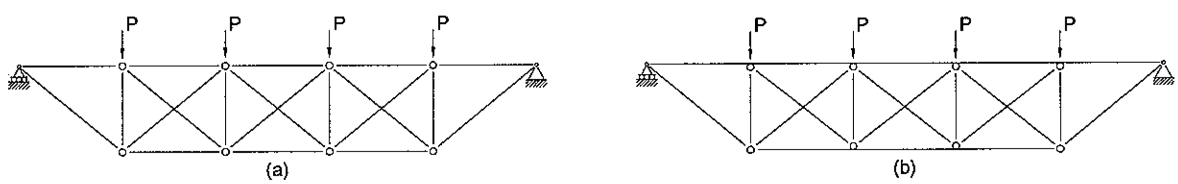

Figure 3