ORDRE DES INGÉNIEURS DU QUÉBEC
MAY 2013 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**]). The load case is illustrated in Fig 1**(a)**. Node and element numbers are illustrated in Fig 1**(b).** Member #3 is a truss element. The support at node #3 only allows horizontal displacement. Use [**kN**] and [**m**] units**.**

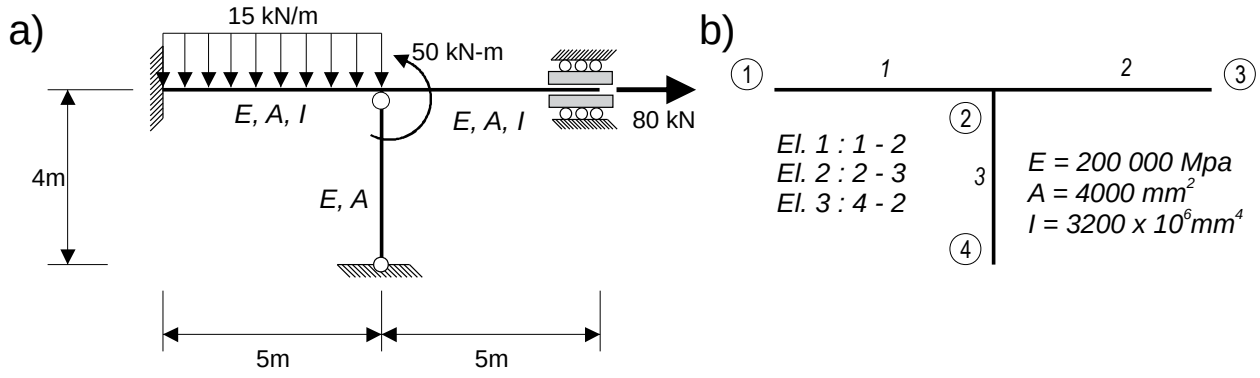


Figure 1

a) (10 pts) Write the element stiffness matrices $[\mathbf{K_1}]_{6x6}$ and $[\mathbf{K_3}]_{6x6}$ in **global** coordinates.
b) (15 pts) Assemble the global stiffness matrix $[\mathbf{K}]_{\mathbf{4x4}}$.
Important : the global stiffness matrix size will be **4x4**.

Question 2 (35 points):
Consider the structure illustrated above (Fig. 1). Use [**kN**] and [**m**] units.

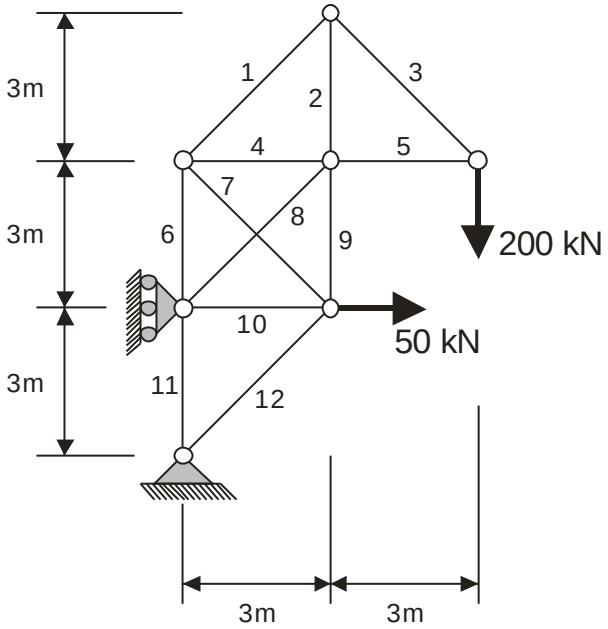
a) (10 pts) Assemble the nodal force vector $\mathbf{[P]}_{4x1}$ for the load case illustrated in Fig. 1a.

b) (5 pts) Calculate and plot the **4** displacements $\mathbf{[U]}_{3x1}$. Note that certain equations are uncoupled.

c) (20 pts) Calculate the internal forces and plot the axial force, shear, and moment diagrams.

Question 3 (30 points):

Consider the **truss** illustrated on the right (Fig 2). Compute the axial forces in each bar and indicate them on a sketch of the truss. The bars are numbered from 1 to 12.



E = 200 000 Mpa
A = 2000 mm²

Figure 2

Question 4 (10 points):

A plate is modeled with the finite element method, using 2D, 4-node elements. The nodes are numbered with two different schemes, as shown below in Fig. 3**(a)** and 3**(b)**. **Briefly** discuss the effect of both numbering schemes on the global stiffness matrix and on the problem solution efficiency.

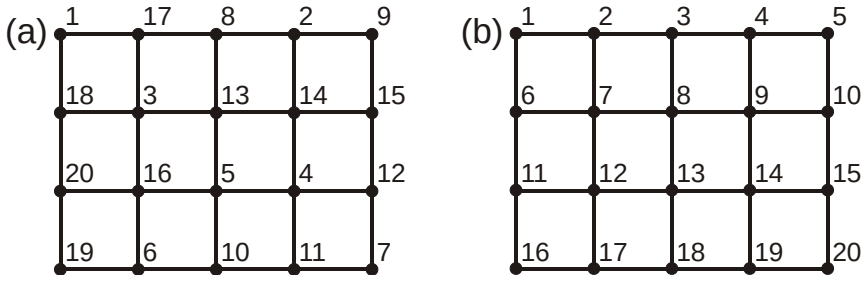


Figure 3