ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2021 SESSION

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

16-CI-A1 Elementary Structural Analysis

Question 1 (25%)

For the frame ACDB shown on *Figure 1,* compute the support reactions at A and B and draw the normal force diagram (NFD), the shear force diagram (SFD) and the bending moment diagram (BMD). For each diagram, calculate and indicate maximum and minimum values and the longitudinal coordinates where they occur.

Note: Support A is fixed, support B is hinged and the connections at points C and D are hinged.

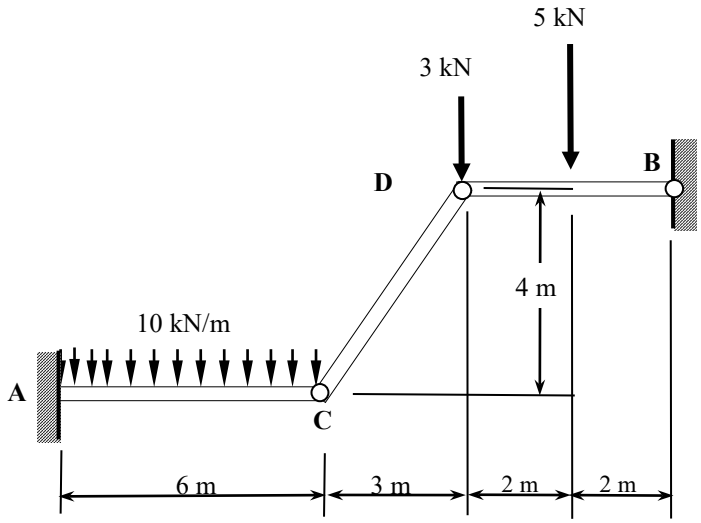


Figure 1

Question 2 (25%)

The beam ABCD shown on *Figure 2* is pin connected at support at D and supported at B by member (link) BE. Use **the principle of virtual work (unit force) and the Mohr integrals** to compute the horizontal displacement at point A. Most used Mohr integrals are given in the Table of the Appendix.

Neglect the deformations in the beam due to axial forces.

Properties of the sections

$\mathbf{E}_{link,BE} = \mathbf{E}_{BEAM}$ $= 70 \times 10^6$ kN/m^2
$\mathbf{A}_{link,BE}$ $= 2 \times 10^{-4}$ m^2
$\mathbf{I}_{BEAM}$ $= 750 \times 10^{-6}$ m^4

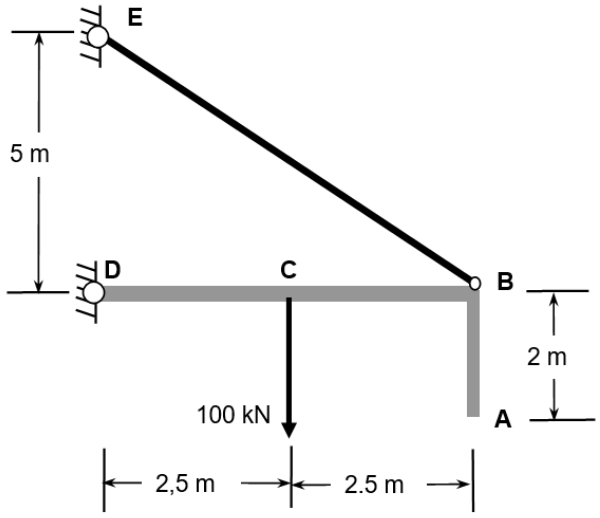


Figure 2

Question 3 (25%)

For the truss shown on *Figure 3*, use the method of virtual work to calculate:

a) The vertical displacement at point C due to the applied loads;
b) The vertical displacement of point C if the members DC and BC are subjected to a temperature increase of 60°C, in addition to the applied loads.

For all members:

A = 250 mm^2

E = 200×10^6kN/m^2

$\alpha = 10^{-5}$/°C

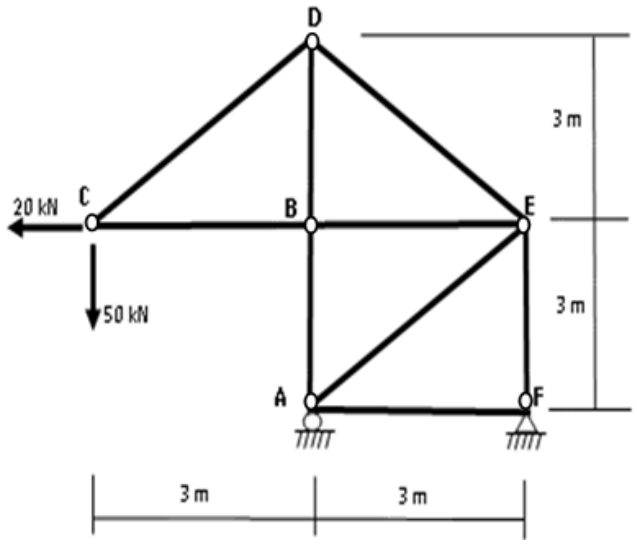


Figure 3

Question 4 (25%)

The indeterminate beam ABC shown on *Figure 4* has fixed supports at points A and C. Use the **slope deflection method** to compute:

c) The rotation at joint B;

d) The bending moments at joints A, B and C;

e) The reactions at supports A, B and C and draw the free body diagrams *(FBD)* of segments AB and BC.

Consider EI = 600 kN·m² for all members and neglect their own weight.

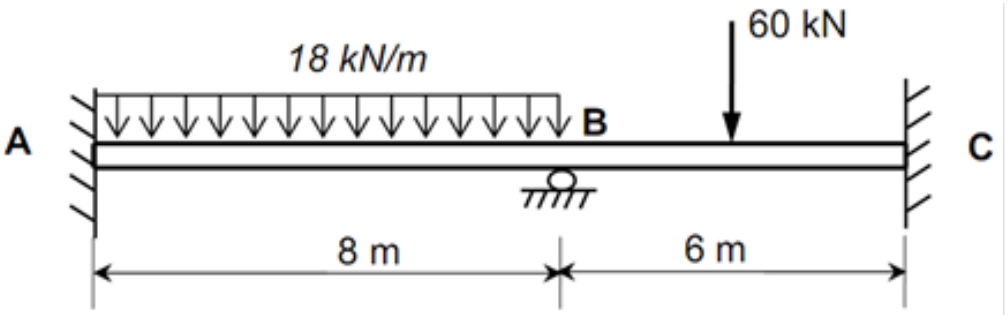
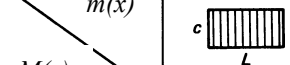
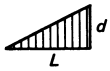
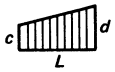
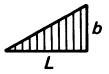
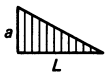
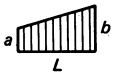
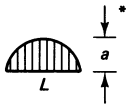
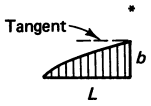
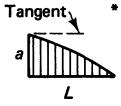
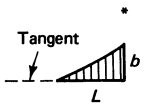
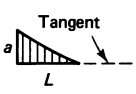
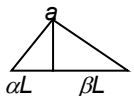


Figure 4

Mohr Integrals $\int_O^L m(x)\,M(x)\,dx$

$M(x)$ \ $m(x)$			
	$\frac{1}{2}Lbc$	$\frac{1}{3}Lbd$	$\frac{Lb}{6}(c+2d)$
	$\frac{1}{2}Lac$	$\frac{1}{6}Lad$	$\frac{La}{6}(2c+d)$
	$\frac{L}{2}(a+b)c$	$\frac{Ld}{6}(a+2b)$	$\frac{L}{6}(2ac+ad+2bd+bc)$
	$\frac{2}{3}Lac$	$\frac{1}{3}Lad$	$\frac{La}{3}(c+d)$
	$\frac{2}{3}Lbc$	$\frac{5}{12}Lbd$	$\frac{Lb}{12}(3c+5d)$
	$\frac{2}{3}Lac$	$\frac{1}{4}Lad$	$\frac{La}{12}(5c+3d)$
	$\frac{1}{3}Lbc$	$\frac{1}{4}Lbd$	$\frac{Lb}{12}(c+3d)$
	$\frac{1}{3}Lac$	$\frac{1}{12}Lad$	$\frac{La}{12}(3c+d)$
	Lac	$\frac{1}{2}Lad$	$\frac{1}{2}La(c+d)$
	$\frac{1}{2}Lac$	$\frac{1}{6}Lad(1+\alpha)$	$\frac{1}{6}La[(1+\beta)c+(1+\alpha)d]$