ORDRE DES INGÉNIEURS DU QUÉBEC

NOVEMBER 2019 SESSION

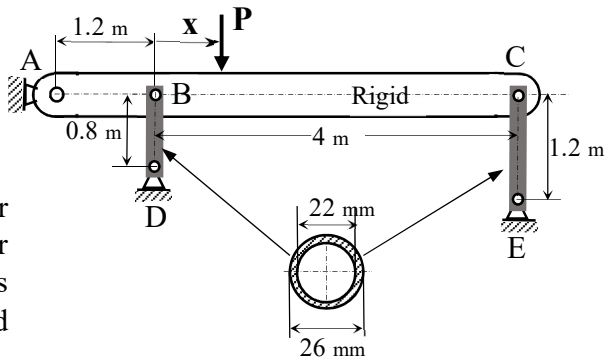
Open book examination Calculators: Models allowed only Duration of the examination: 3 hours

16-MC-A6 Advanced Strength of Materials

There are four (4) questions presented on two pages.

Question 1 (25 points)

The rigid beam ABC show in the figure 1 is supported by two columns BD and CE.
The joint A is supported in both directions.
The columns BD and CE have a section of the circular tube with outer diameter d_{ext} = 26 mm and inner diameter d_{int} = 22 mm. The material of BD and CE has a modulus of elasticity E = 200000 MPa and a yield stress S_Y = 250 MPa.
A load **P** is applied at distance **x** from column BD.



Cross section BD and CE

Figure 1

a) If the distance x = 1.0 m, calculate the critical load **P**.

b) If the distance **x** can be varied between **B** and **C**, calculate the maximum value of **P** and the corresponding value of the distance **x**.

Question 2 (25 points)

The beam ABCD having a section of the square tube 50.8×50.8×6.35 mm, is fixed at point D and simply supported in the horizontal direction at point A.

A horizontal load P = 12 kN is applied at point C as show in figure 2.

The material has a modulus of elasticity E = 200000 MPa.

By neglecting the energies due to shear force and the axial force, calculate the horizontal displacement at point C.

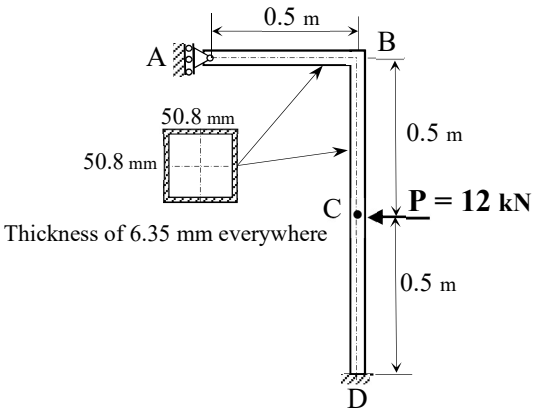


Figure 2

Question 3 (25 points)

A 60° strain rosette is glued to the outer surface of a thin-walled closed cylindrical tank as shown in figure 3.

The cylindrical tank has an inner radius $R_{int} = 40$ mm and a thickness $e = 4$ mm and is made from an unknown material.

By applying an internal pressure $p = 10$ MPa and a torsional moment $T = 2$ kNm, the gauges indicate the following deformations: $\varepsilon_a = 100*10^{-6}$, $\varepsilon_b = 597*10^{-6}$ et $\varepsilon_c = 90*10^{-6}$.

Determine the modulus of elasticity **E** and the Poisson's ratio **ν** of the cylindrical tank.

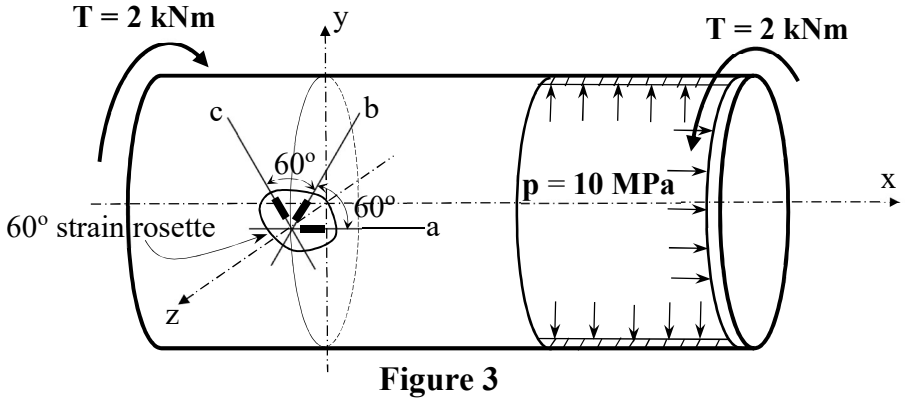


Figure 3

Question 4 (25 points)

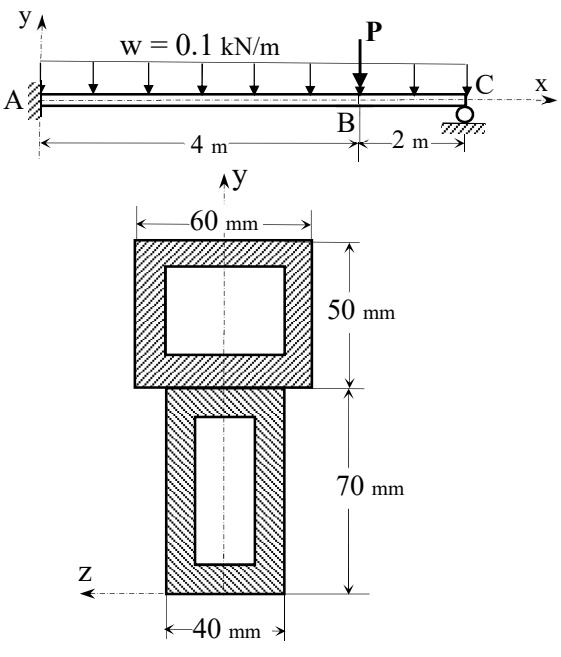
The beam ABC is fixed at point A and simply supported at point C.

The beam is subjected to a load **P** downward at B and a uniform distributed load $w = 0.1$ kN/m downward.

The dimensions of the cross section of the beam are given in figure 4.

The material of the beam is elastic perfectly plastic with the yield stress $S_Y = 250$ MPa.

Calculate the fully plastic load **P** of this beam (P_P).



Thickness of 10 mm everywhere

Figure 4