ORDRE DES INGÉNIEURS DU QUÉBEC

SESSION IN MAY 2017

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 beam ABCDE is simply supported at three points A, C and E. The beam is subjected to a load **P** downward at B and a load **2·P** downward at D.

The dimensions of the cross section of the beam are given in Figure 1. Note that the areas of rectangular and annular sections area equal.

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).

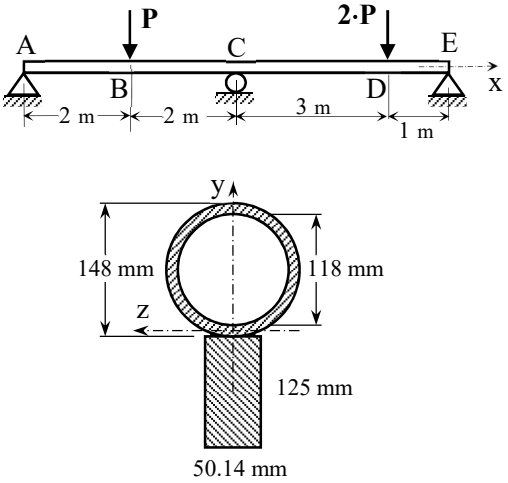

Figure 1

Question 2 (25 points)

The truss members in Figure 2 are made of the same material with Young's modulus $E = 200000$ MPa and have the same cross section area of 1200 mm^2.

The node B is supported in both directions. The node O is simply supported in a horizontal direction.

Two forces $P = 200$ kN and $Q = 150$ kN are applied at point A.

Using an energy method, determine:

a) the displacement of A along x axis ($u_{x,A}$).

b) the displacement of A along y axis ($u_{y,A}$).

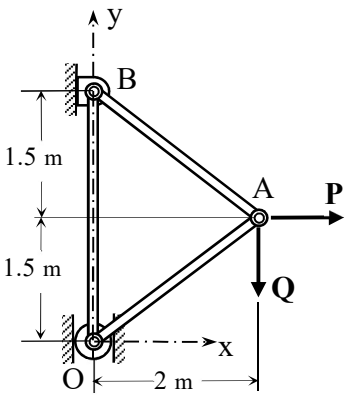

Figure 2

Question 3 (25 points)

The shaft OAB of the diameter $d_{OA} = 50.8$ mm and $d_{AB} = 38.1$ mm is fixed at points O and B and subjected to a torque T_A at A as show in Figure 3.

If the recorded strain of the gauge glued to the outer surface at point J is $\varepsilon_J = 120*10^{-6}$ and assuming elastic behaviour, determine:

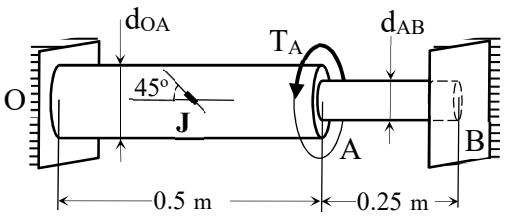

Figure 3

a) the magnitude of torque T_A knowing that the shear modulus of elasticity of the material is $G = 80$ GPa;

b) the strain energy of the shaft due to the torque T_A.

Question 4 (25 points)

The beam OAB illustrated in Figure 4 is fixed at B and simply supported at O in a vertical direction.

The flexural modulus of rigidity is $E \cdot I = 4*10^6$ Nmm^2 (E is the modulus of elasticity and I is the second moment of cross section area).

A horizontal force **P** is applied at A.

By neglecting the effect of shear force and the axial force, calculate the reaction at point O in function of **P**.

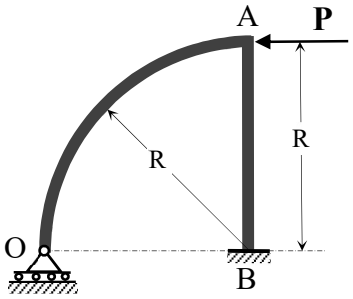

Figure 4