National Exams December 2011

07-Mec-B9 ADVANCED ENGINEERING STRUCTURES

3 Hours Duration

NOTES:

1. If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. Any non-communicating calculator is permitted. This is an open book exam.

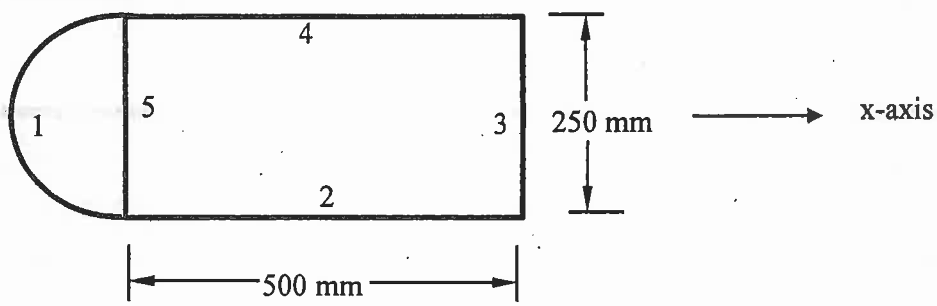
3. Answer **any** five questions.

4. All questions and sub-questions are of equal value.

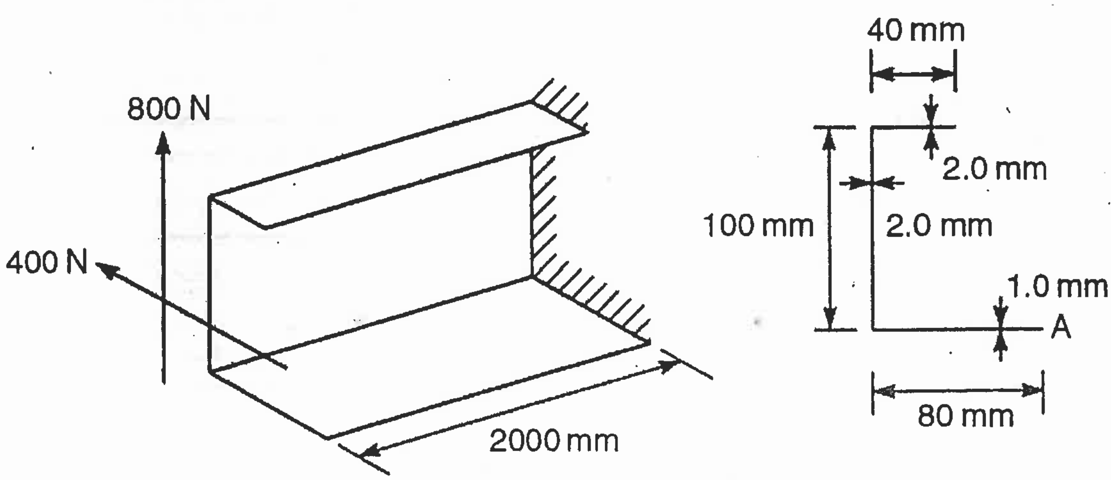
1- The wing torsion box shown below is symmetric with respect to the x-axis and is subjected to a constant torque T = 55000 N.m acting clockwise.

a) Calculate the maximum shear stress in the section. The thickness of each wall is as follows: t_1 = 3 mm, t_2 = 2 mm, t_3 = 4 mm, t_4 = 3 mm and t_5 = 5 mm. Wall 1 is semi-circular and the dimensions shown below are median distances.

b) Determine the location of the shear centre with respect to wall # 3, if wall # 5 was not there.



2- A thin-walled, cantilever beam supports two loads at its free end as shown below. Calculate the bending stress at the extremity of the lower flange (point A) at a section 1000 mm away from where the loads are applied. Assume the applied loads are acting at the shear center of the section.



3- A cantilever bar (rigidly supported at one end) of solid square cross-section (**a** by **a**) is subjected at its free end to a compressive axial force of magnitude P = 250 x 10^3 N and a torque T = 9 x 10^3 N.m. This bar is to be designed in accordance with the maximum-shear-stress criterion of failure, with a safety factor of 3.

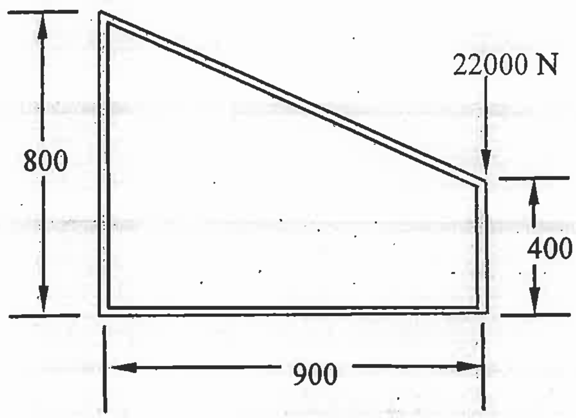
a) What is the minimum allowable dimension **a** if $\sigma_{yielding}$ = 350 MPa?

b) What would your answer be if the Von-Mises stress criterion is used?

4- The closed thin wall beam with the cross section shown below (all dimensions are median distances in mm) and a wall thickness of 5 mm is subjected to the vertical force shown. If the webs are effective in bending as well as in shear, determine:

a) The shear flow around the section

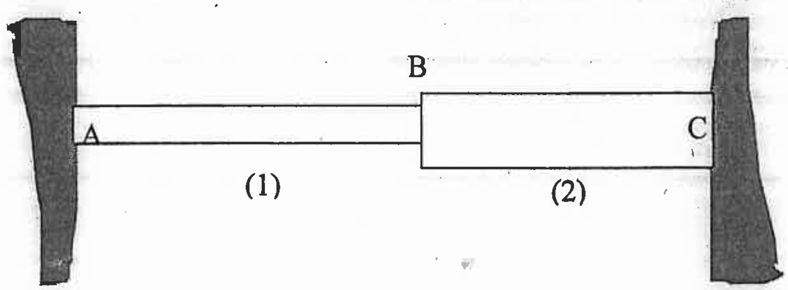
b) The bending stresses at the 4 corners of a section on the beam located 300 mm behind the one shown



5- Two uniform linearly elastic rods are welded together at B, and the resulting two-segment rod is attached to rigid supports at A and C. Rod (1) has a modulus $E_1 = 200$ GPa, cross-sectional area $A_1 = 5\ cm^2$, length $L_1 = 120$ cm, and coefficient of thermal expansion $\alpha_1 = 12 \times 10^{-6}/°C$. Rod (2) has a modulus $E_2 = 100$ MPa, cross-sectional area $A_2 = 15\ cm^2$, length $L_2 = 100$ cm, and coefficient of thermal expansion $\alpha_2 = 17 \times 10^{-6}/°C$.

a) Determine the axial stresses in the rods if their temperature is raised by 80 °C.

b) Determine whether joint B moves to the right or left and by how much?



6- An orthotropic composite material system has the following lamina properties:

$$E_{11} = 180 \text{ GPa}$$
$$E_{22} = 18 \text{ GPa}$$
$$G_{12} = 10 \text{ GPa}$$
$$\nu_{12} = 0.3$$

a) Determine the various entries in the 0° lamina stiffness matrix [C]. Recall ([σ] = [C][ε])

b) Evaluate the transform stiffness matrix [Q] for a 90° ply.

c) Evaluate the transform stiffness matrix [Q] for a 45° ply.

d) Determine σ_x, σ_y, τ_{xy} for a 90° ply if ε_x, ε_y, γ_{xy} are given by 0.0008, 0.005 and –0.001 respectively.

7- The following data points have been obtained from a series of mechanical strain cycling tests:

Range of plastic strain $\Delta\varepsilon$	Number of cycles to failure N
0.0400	100
0.0211	500
0,0160	1000
0.0084	5000

a) Show that these results can be represented by an equation of the type: $\Delta\varepsilon = CN^{\alpha}$
Where C and α are material constants.

b) A component made from this material is subjected to a range of plastic strain of 0.02 for the first 300 cycles and then to a range of plastic strain of 0.01 for the rest of its service life. Calculate the total number of cycles before failure, assuming the material obeys Miner's cumulative damage law.

8- An isotropic ductile solid with a yielding strength of 340 MPa is subjected to the state of stress shown below. Predict whether such stresses will cause failure according to the:

a) maximum shear stress theory

b) energy of distortion theory.