National Exams December 2012

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.

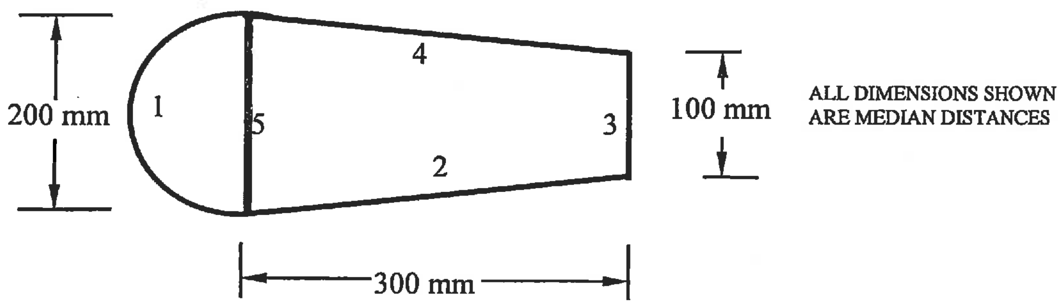
3. Answer **any** five questions.

4. All questions are of equal value. Marks for individual questions are indicated within each problem.

1- The wing torsion box shown below is symmetric with respect to the x-axis and is subjected to a constant torque T = 35000 N.m. acting clockwise.

a) Calculate the shear flow q in walls 1, 2 ,3, 4 and 5. The thickness of each wall is as follows: $t_1 = 2$ mm, $t_2 = 1$ mm, $t_3 = 2$ mm, $t_4 = 2$ mm and $t_5 = 3$ mm. <u>Wall 1 is semi-circular</u>. (15 marks)

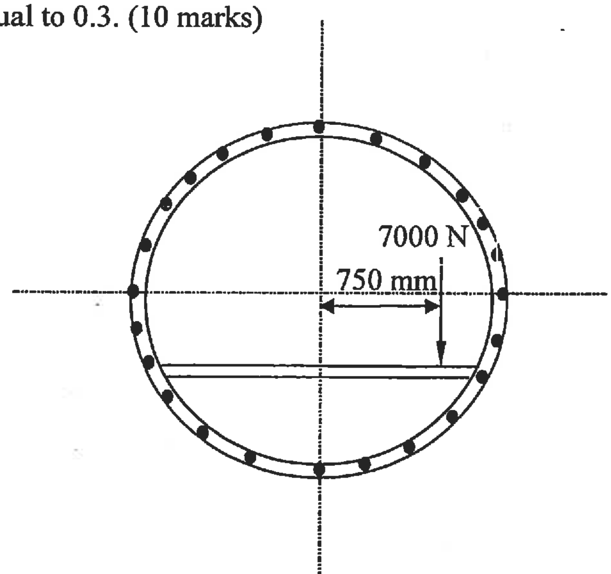
b) What is the maximum shear stress and in which wall does it occur? (5 marks)



2- The figure below shows a sketch of the idealized cross section of a 1.6 m outer-diameter circular fuselage section with a 7000 N vertical load applied to the floor beam. The 24 equally spaced stringers all have the same 105 mm^2 area.

a) Calculate the shear flow distribution around the section assuming that the skin is not effective in bending. (10 marks)

b) Determine the axial stress in the wall panels and the stringers due to an applied internal pressure of 68 KPa. Take wall thickness to be 1.0 mm. and assume Poisson's ratio of the material to be equal to 0.3. (10 marks)



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 $P = 150 \times 10^3$ N and a torque $T = 6 \times 10^3$ N.m. This bar is to be designed in accordance with the maximum-shear-stress failure criterion, with a safety factor of 3.

a) What is the minimum allowable dimension **a** if $\sigma_{yielding} = 310$ MPa? (10 marks)

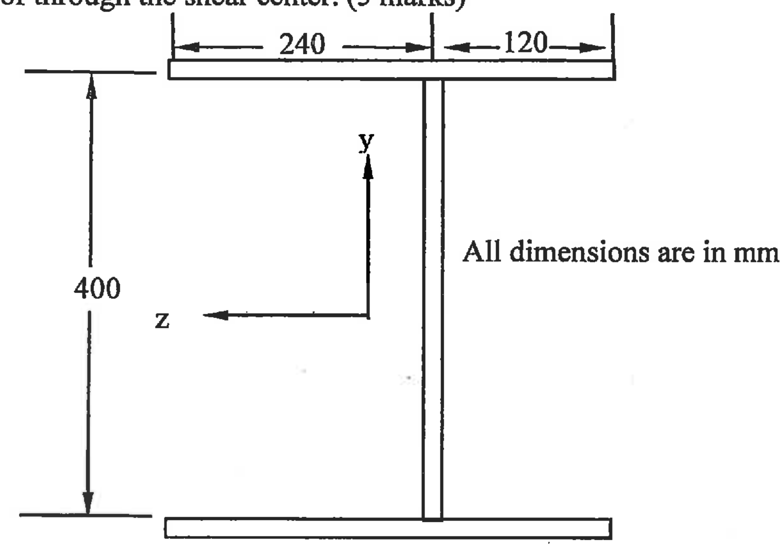
b) What would your answer be if the Von-Mises stress criterion is used? (10 marks)

4- The thin-walled open section shown below (symmetric about the z-axis), is subjected to an upward vertical force of 10 KN acting through the shear center.

a) Find the shear flow distribution in the thin walls of the section. All of the walls have the same thickness of 3 mm. All dimensions are to the mid-planes of the walls. (10 marks)

b) Locate the shear center relative to the vertical web. (5 marks)

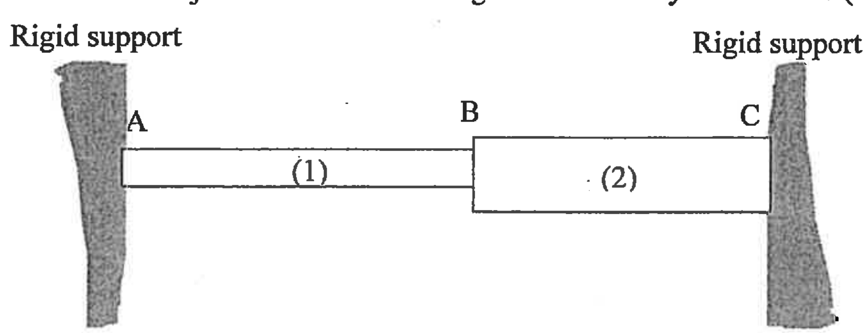
c) Calculate the maximum shear stress in the section if the shear force acts through the vertical web instead of through the shear center. (5 marks)



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 $E_1 = 250$ MPa, cross-sectional area $A_1 = 10$ cm^2, length $L_1 = 120$ cm, and coefficient of thermal expansion $\alpha_1 = 10 \times 10^{-6}$/°C. Rod (2) has a modulus $E_2 = 200$ MPa, cross-sectional area $A_2 = 25$ cm^2, length $L_2 = 100$ cm, and coefficient of thermal expansion $\alpha_2 = 19 \times 10^{-6}$/°C.

a) Determine the axial stresses in the rods if their temperature is raised by 55 °C. (15 marks)

b) Determine whether joint B moves to the right or left and by how much? (5 marks)



6- An aircraft wing skin panel which can be modeled as a semi-infinite plate, has an edge crack of length 0.25 mm and is subjected to typical cyclic service loads. The component of those loads that act to propagate the crack can be simplified to constant amplitude stress loading of 200 N/mm^2 normal to the crack. If the panel is made from a metal alloy with fracture toughness of 2100 $N/mm^{3/2}$ and a crack growth rate of $35\times10^{-15}(\Delta K)^4$ mm/cycle, determine if a maintenance interval equivalent to 6,000 cycles is adequate to detect the crack before it grows to a critical length leading to panel fracture.

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. (10 marks)

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. (10 marks)

8- An isotropic ductile solid with a yielding strength of 200 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 (10 marks)

b) energy of distortion theory. (10 marks)