National Exams May 2003

98-Mec-B8 AIRCRAFT MATERIALS AND 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.

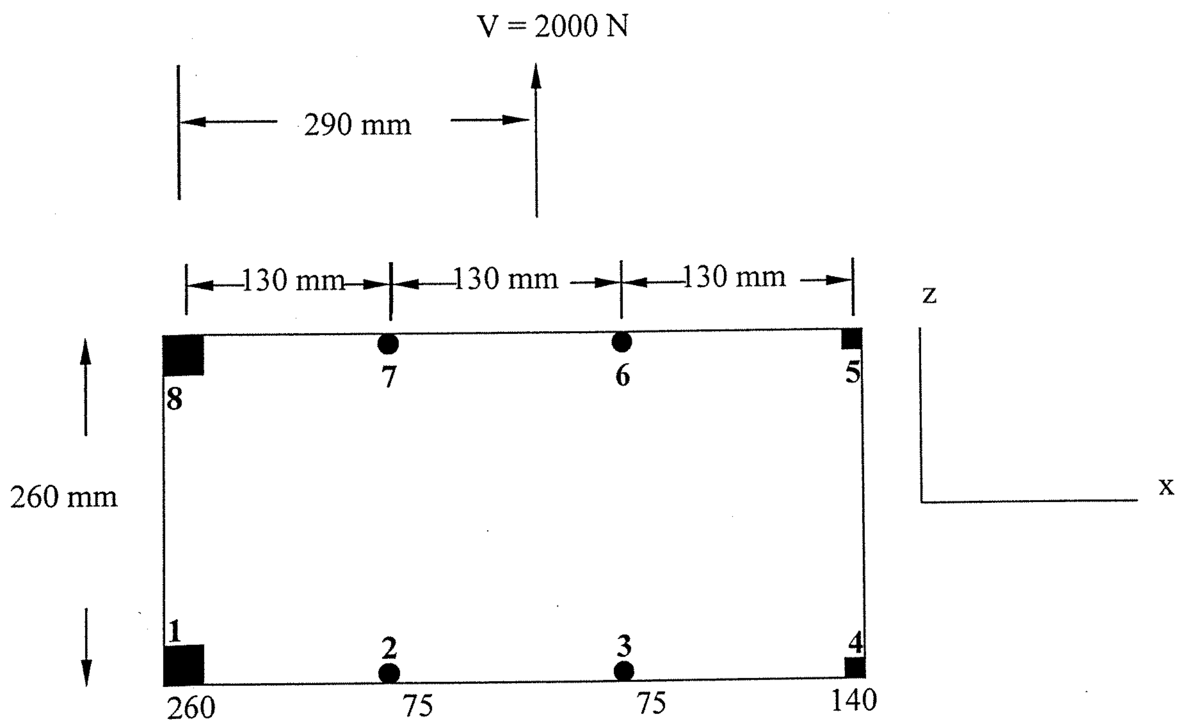
2. Any non-communicating calculator is permitted. This is an open book exam.

3. Answer **any three** of the first four questions **and any two** of the last three questions.

4. Every problem is worth 20 marks.

1- The idealized cross section shown below is that of a wing box with the black rectangles (1, 4, 5 and 8) representing spar flanges and the dark circles (2, 3, 6 and 7) representing panel stiffeners. The numbers adjacent to these boxes and circles give their areas in mm^2 (e.g. area of stringer 2 is 64.5 mm^2). The section is symmetrical with respect to the x-axis.

a. Find the shear flow around the section due to a shear load V = 1000 N applied as shown. Assume constant flow in the thin walls, i.e. assume them to be effective only in shear.
b. Determine the location of the shear centre for the box, using the method of your choice. Subsequently, substitute the load shown below with an equivalent loading at the shear centre.

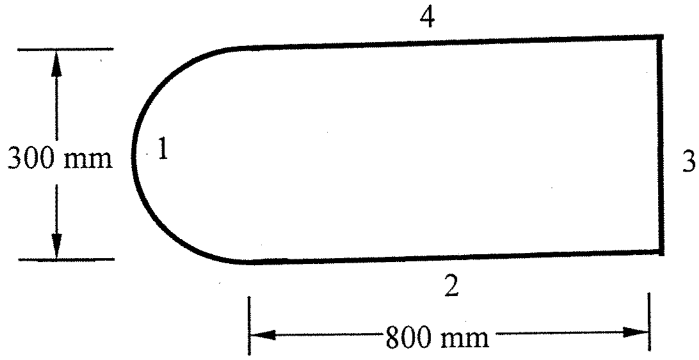


ALL DIMENSIONS SHOWN ARE MEDIAN DISTANCES

2- The torsion box shown below is symmetric with respect to the horizontal axis and is subjected to a constant torque T = 20000 N.m. acting clockwise.

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

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



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ARE MEDIAN DISTANCES

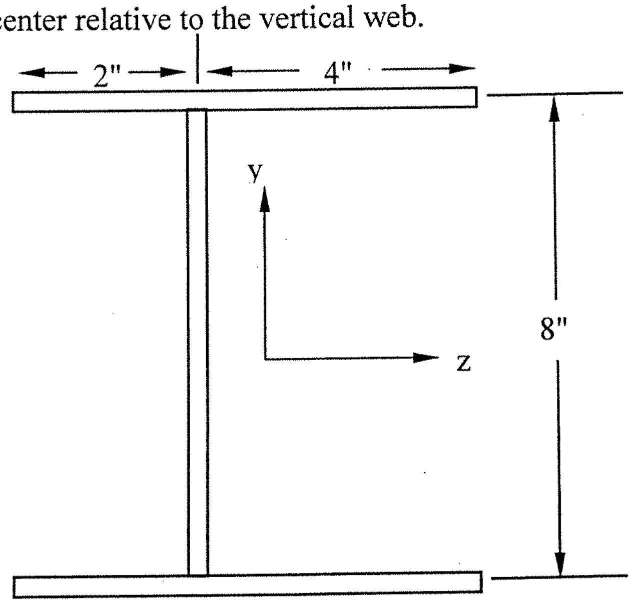
3- A cantilever bar (rigidly supported at one end) of a solid square cross-section (w by w) is subjected at its free end to a compressive axial force of magnitude P = 80 x 10^3 lb and a torque T = 30 x 10^3 lb.in. This bar is to be designed in accordance with the maximum-shear-stress criterion of failure, with a safety factor of 2.

a) What is the minimum allowable cross-sectional dimension w if $\sigma_{yielding} = 60$ ksi?

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

4- The thin-walled open section shown below is subjected to a vertical upward force of 1000 lbf acting through the shear center.

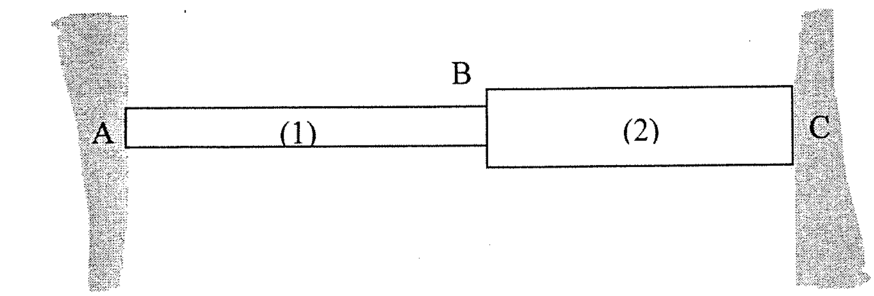
a. Find the shear flow distribution in the thin walls of the section. All of the walls have a thickness of 0.1 inch. All the dimensions are to the medians of the flanges and webs.
b. Locate the shear center relative to the vertical web.



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 = 30,000 ksi, cross-sectional area A_1 = 4.5 in^2, length L_1 = 60 in., and coefficient of thermal expansion $\alpha_1 = 7 \times 10^{-6}$/°F. Rod (2) has a modulus E_2 = 20,000 ksi, cross-sectional area A_2 = 6.0 in^2, length L_2 = 40 in., and coefficient of thermal expansion $\alpha_2 = 9 \times 10^{-6}$/°F.

a. Determine the axial stresses in the rods if the temperature of both is raised by 120 °F.

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 GPa E_{22} =25 GPa G_{12} = 15 GPa ν_{12} = 0.28

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 0.0009, 0.005 and –0.001 respectively.

7- A state of stress is characterized by the following stresses (all other stresses are zero):
σ_x = -100 MPa σ_y = 220 MPa σ_z = 60 MPa τ_{xy} = -120 MPa
Using $\sigma_{yielding}$ = 200 MPa., predict whether yielding will occur using:

a. Von-Mises criterion
b. Maximum shear stress criterion