

National Exams May 2016

07-Mec-B9 ADVANCED ENGINEERING STRUCTURES

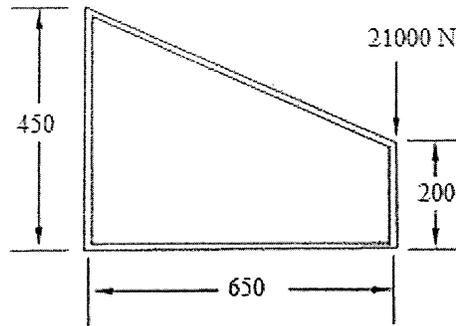
3 Hours Duration

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. Any FIVE (5) questions constitute a complete exam paper. If more than five questions are attempted, only the first five as they appear in the answer book will be marked.
4. All problems are of equal total value. Marks for individual questions are indicated within each problem.

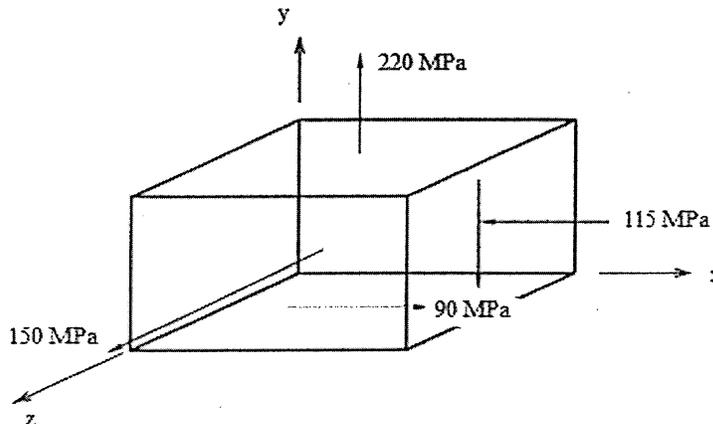
1- The thin wall beam with the cross section shown below (all dimensions are median distances in mm) has a constant wall thickness of 3 mm. The beam is subjected to a vertical force of 15000 N applied as shown. If the webs are effective in bending as well as in shear, determine:

- a. The shear flow around the section (10 marks)
- b. The bending stresses at the 4 corners of a section on the beam located 300 mm behind the one shown (10 marks)



2- An isotropic ductile solid with a yielding strength of 270 MPa is subjected to the state of stress shown below. Predict whether such stresses will cause failure according to the:

- a) maximum shear stress criterion (10 marks)
- b) Von-Mises failure criterion (10 marks)



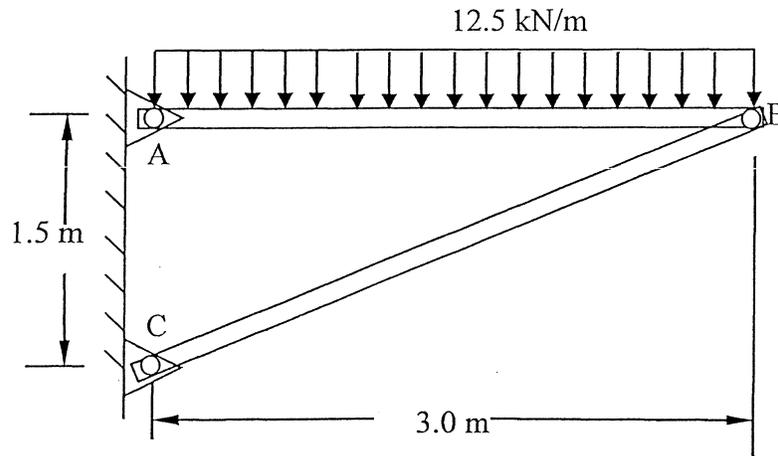
3- The following data points have been obtained from a series of mechanical strain cycling tests on an aircraft component:

Range of plastic strain $\Delta\epsilon$	Number of cycles to failure N
0.0380	230
0.0221	910
0.0150	2300
0.0080	12500

- a) Determine the coefficient C and exponent α that would best represent these results through an equation of the type: $\Delta\epsilon = CN^\alpha$. (10 marks)

- b) A component made from this material is subjected to a range of plastic strain of 0.019 for the first 350 cycles and then to a range of plastic strain of 0.011 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)

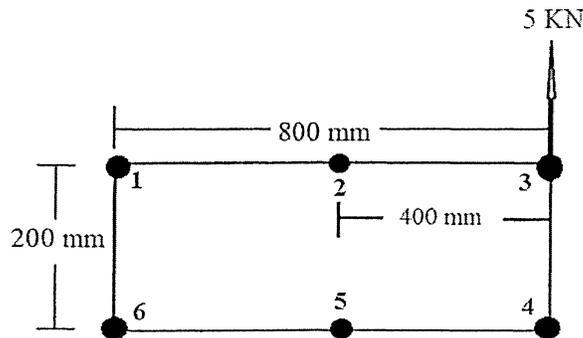
4- The steel compression strut BC of the frame ABC in the figure below is a steel tube with an outer diameter of 55 mm and a wall thickness of 5 mm. Determine the factor of safety against elastic buckling of BC if a distributed load is applied as shown below. Let $E = 200 \text{ GPa}$ and $\sigma_{\text{yielding}} = 320 \text{ MPa}$. (20 marks)



5- 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 130 N/mm^2 normal to the crack. If the panel is made from a metal alloy with fracture toughness of $2950 \text{ N/mm}^{3/2}$ and a crack growth rate of $34 \times 10^{-15} (\Delta K)^4 \text{ mm/cycle}$, determine the maintenance interval required to detect the crack before it grows to half its critical length. (20 marks)

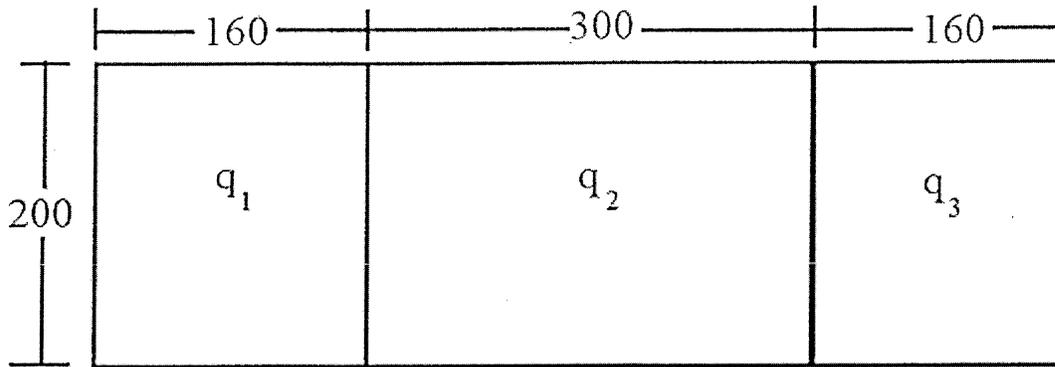
6- A stiffened thin walled wing box has been idealized into normal stress carrying booms 1 to 6 and shear only resisting thin wall panels. The box is subjected to a vertical force of 5,000 N acting upward as shown below. The boom areas are: $B_1 = B_6 = 600 \text{ mm}^2$, $B_2 = B_5 = 400 \text{ mm}^2$ and $B_3 = B_4 = 850 \text{ mm}^2$.

- a) Determine the location of the shear center with respect to boom 6 (10 marks)
 b) Determine the shear flow in the panels of the idealized box. (10 marks)



7- The figure below shows a three cell thin wall wing box made from a material whose shear modulus G is 18 GPa. The wing box is subjected to a constant clockwise torque of 12,000 N.m. The upper panels of the box have a constant thickness of 2.5 mm, while the lower panels have a thickness of 1.75 mm. All vertical panels are 1.5 mm in thickness.

- Determine the shear flows q_1 , q_2 and q_3 in the three cells (15 marks)
- Determine the magnitude and location of the maximum shear stress. (5 marks)



All dimensions shown are in mm.

8- The horizontally symmetric, constant wall thickness (1.8 mm) thin walled wing box shown below is idealized by the assumption that all direct stresses are resisted by the four booms while the thin walls are only effective in resisting shear. The leading edge (wall 2-3) of the box is semi elliptical with a major radius being twice the minor radius. Booms 1 and 4 have areas equal to 600 mm² and booms 2 and 3 equal to 450 mm².

- Determine the location of the shear center of the box (10marks)
- Determine the shear flow around the box if an upward shear force of 10,000 N is acting 100 mm to the left of the shear center. (10 marks)

