National Exams December 2017

16-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.

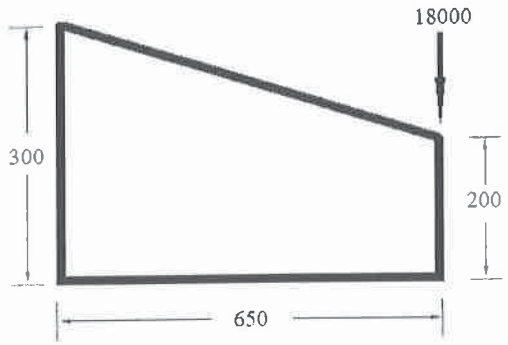
2. Any non-communicating calculator is permitted. This is an open book exam.

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 value. For problems with multiple questions, marks are allocated evenly for each question.

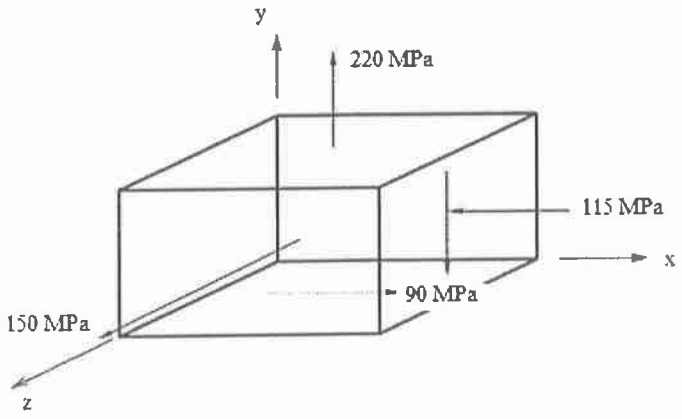
1- A cantilevered monocoque wing box with the cross section shown below (all dimensions are median distances in mm) has a constant wall thickness of 2 mm. The box is 5 meters long and is subjected to a vertical force of 18000 N applied at its free end as shown below. If the box walls are fully effective in bending as well as shear, determine:

a) The shear flow around the section
b) The bending stresses at the 4 corners of the root section on the box



2- An isotropic ductile solid with a yielding strength of 620 MPa is subjected to the state of stress shown below. Predict whether such stresses will cause yielding within a safety factor of 1.75 according to the:

a) maximum shear stress criterion
b) Von-Mises failure criterion



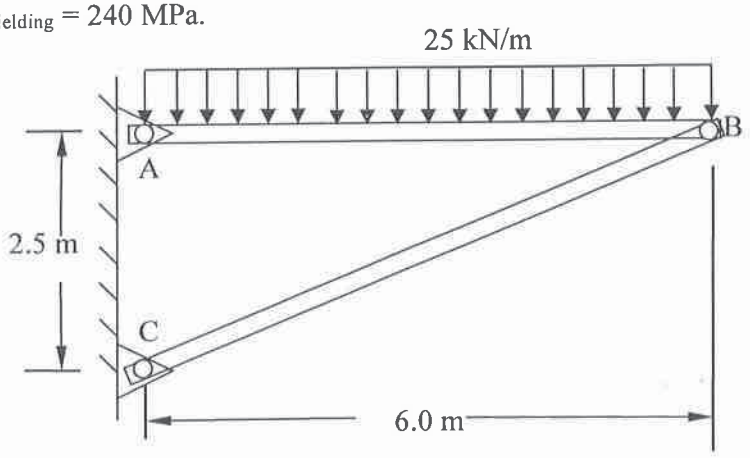
3- The following data points have been obtained from a series of mechanical strain cycling tests on an aircraft component:

Range of plastic strain $\Delta\varepsilon$	Number of cycles to failure N
0.0360	260
0.0211	990
0.0120	2700
0.0070	15500

a) Determine the coefficient C and exponent α that would best represent these results through an equation of the type: $\Delta\varepsilon = CN^{\alpha}$.

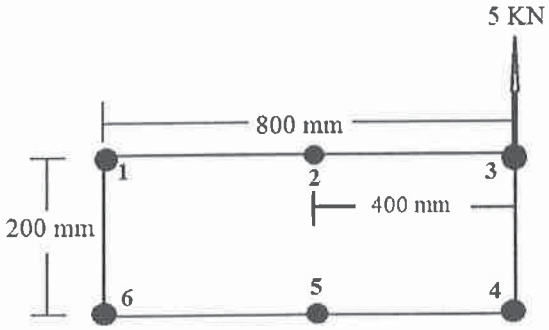
b) A component made from this material is subjected to a range of plastic strain of 0.019 for the first 390 cycles, 0.025 for the next 100 cycles, and then to a range of plastic strain of 0.010 for the rest of its service life. Calculate the total number of cycles before failure, assuming the material obeys Miner's cumulative damage law.

4- The steel compression strut BC of the frame ABC in the figure below has a tubular cross section with an outer diameter of 65 mm and a wall thickness of 3 mm. Determine the factors of safety against elastic buckling and yielding of BC given the uniformly distributed load shown below. Let E = 200 GPa and $\sigma_{yielding}$ = 240 MPa.



5- 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 7,000 N acting upward as shown below. The boom areas are: $B_1 = B_6 = 500$ mm^2, $B_2 = B_5 = 300$ mm^2 and $B_3 = B_4 = 750$ mm^2.

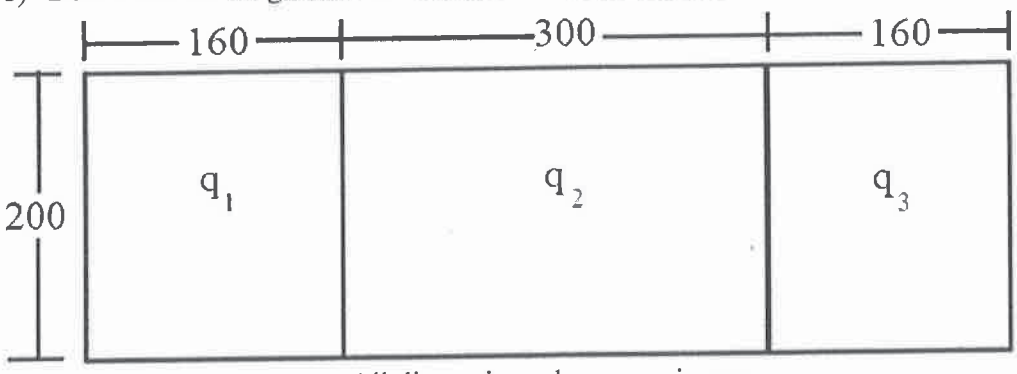
a) Determine the location of the shear center with respect to boom 6
b) Determine the shear flow in the six panels of the idealized box.



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 105 N/mm^2 normal to the crack. The panel is made from a metal alloy with fracture toughness of 2780 N/mm$^{3/2}$ and a crack growth rate of $39\times10^{-15}(\Delta K)^4$ mm/cycle. If the maintenance schedule of the panels is based on crack size tolerance, determine the required maintenance interval, in terms of number of service load cycles, to detect the crack before it grows to half its critical length.

7- The figure below shows a three cell thin wall torque box made from a material whose shear modulus G is 20 GPa. The torque box is subjected to a constant clockwise torque of 15,000 N.m. The upper panels of the box have a constant thickness of 2.0 mm, while the lower panels have a thickness of 1.5 mm. All vertical panels are 1.0 mm in thickness.

a) Determine the shear flows q_1, q_2 and q_3 in the three cells
b) Determine the magnitude and location of the maximum shear stress.



All dimensions shown are in mm.

8- The horizontally symmetric, constant wall thickness 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 mm^2 and booms 2 and 3 equal to 450 mm^2.

a) Determine the location of the shear center of the box
b) 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.