National Examinations December 2019

16-Mec-B9, Advanced Engineering Structures

3 Hours Duration

Notes:

1. If doubt 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.

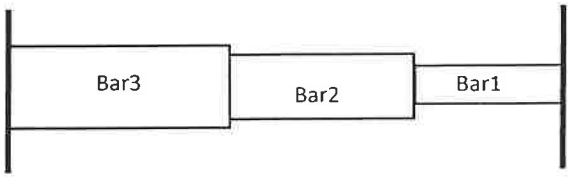
3. Any five problems constitute a complete paper. If you choose to attempt more than five problems, only the first five problems as they appear in your answer book will be marked.

4. All problems are of equal value.

Q1. Three round bars are connected together and held between rigid walls on both end as shown.

Bar 1: $E_1 = 70$ GPa	$\alpha_1 = 23.6 \times 10^{-6}$ /°C	$L_1 = 0.6$m	$D_1 = 0.1$m
Bar 2: $E_2 = 120$ GPa	$\alpha_2 = 18.7 \times 10^{-6}$ /°C	$L_2 = 0.5$m	$D_2 = 0.075$m
Bar 1: $E_3 = 190$ GPa	$\alpha_3 = 17.3 \times 10^{-6}$ /°C	$L_3 = 0.5$m	$D_3 = 0.05$m

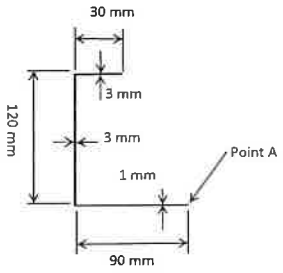
The temperature rises from 21°C to 45 °C, determine force in each member.

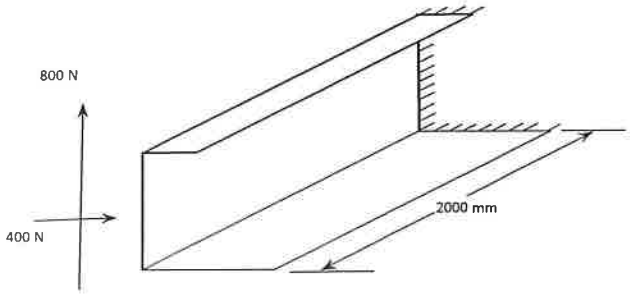


Q2. A solid made of mild steel is subjected to the following state of stress, $\sigma_x = 150$ MPa, $\sigma_y = 260$ MPa, $\sigma_z = -190$ MPa. Determine if stresses cause failure if maximum allowable stress is 350 MPa:

a) Based on maximum shear theory
b) Based on maximum distortion theory

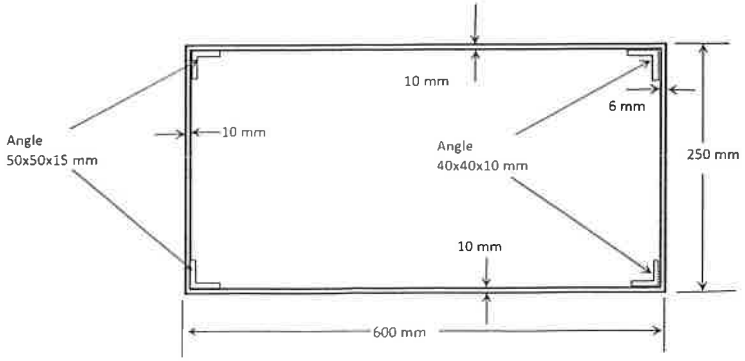
Q3. A thin-walled, cantilever beam of unsymmetrical cross-section support shear load at its free end, see the figure. Determine the value of direct stress at point A at mid span of the beam if loads are applied at shear center.





Q4. Idealize the box section shown here to direct stress carrying booms at four corners and shear stress carrying panels.

A) Determine the shear center of the section
B) If a shear load of 10 kN is applied at shear center, determine the shear flow in each panel.

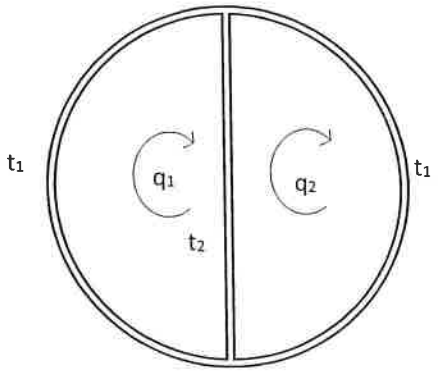


Q5. A semi-infinite plate has edge crack of 0.4 mm length. The plate experiences a cyclic repeated stress of 150 N/mm^2, its fracture toughness is 180 N/mm^3 and the rate of crack growth is $28.5 \times 10^{-15} (\Delta K)^4$ mm/cycle. Determine:

a) Crack length at failure
b) Number of cycle to failure

Q6. For the two segment torsion box, determine the maximum torque and maximum angle of twist per unit length. If shear modulus is G = 80 GPa and Max shear stress is τ = 20 MPa
The radius is 200 mm

t_1 = 10 mm & t_2 = 5 mm
Note
The thickness t_2 is only applied to the vertical wall between the two boxes.



Q7. The curved beam shown here has a rectangular cross sectional area that has the dimensions **50 mm** by **30 mm** and inner radius of **150 mm**. If **G = 200 GPa** and a load of **N= 200 kN** and moment of **150kN-m** is applied.
Determine the stress $\sigma_{\theta\theta}$ σ_{rr}.
If the yield strength is **250MPa**, determine the whether or not the beam yielded and if not, determine the actor of safety