National Exams December 2011

07-Mec-A6-2 Advanced Strength of Materials

3 Hours Duration

NOTES:

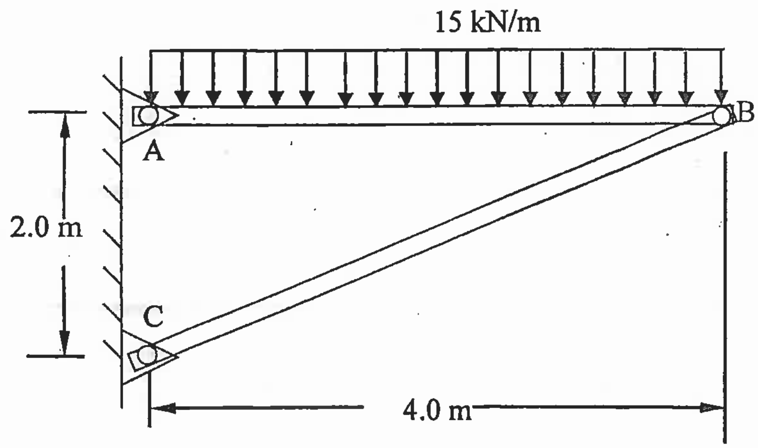
1. If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

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

3. Any five of the eight problems constitute a complete paper. If you chose 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.

1- 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 6 mm. Determine the factor of safety against elastic buckling of BC if a distributed load is applied as shown below. Let E = 205 GPa and $\sigma_{yielding} = 350$ MPa.



2- A two-dimensional strain field is given by

$$\varepsilon_x = 3c(-x^2+2y^2) \qquad \varepsilon_y = c(x^2-5y^2) \quad \gamma_{xy} = 16cxy$$

where c is a nonzero constant.

a) Confirm whether or not this set of strains satisfies the compatibility conditions.
b) If it does, determine the displacements u(x,y) and v(x,y) corresponding to this field of strain. If it does not, propose a modification to the strain field to make it satisfy the compatibility conditions then determine the displacements u(x,y) and v(x,y).

3- A three element rosette is mounted on a metallic component with a Young's modulus of 105 GPa and a Poisson's ratio of 0.3. The rosette provides the following readings along its 0, 45 and 90 degree directions respectively:

$$\varepsilon_0 = 200\ \mu \qquad \varepsilon_{45} = 0\ \mu \qquad \varepsilon_{90} = 500\ \mu$$

a) From these readings, calculate ε_x, ε_y and γ_{xy}.
b) Determine the principal stresses at the rosette location.

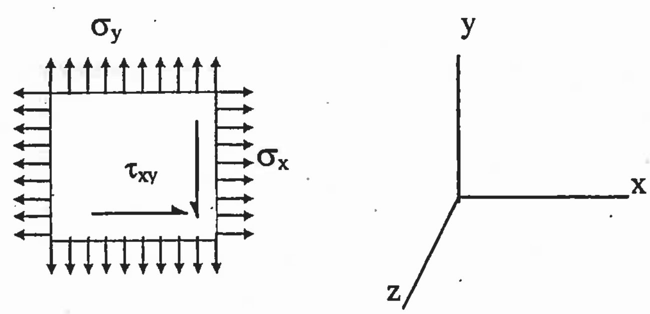
4- The state of plane stress shown below is defined by the following stresses:

$\sigma_x = 207$ MPa $\qquad \sigma_y = 70$ MPa $\qquad$ and $\qquad \tau_{xy} = -77$ MPa

a) Show this stress state on a Mohr's circle and use the circle to estimate the magnitude of the principal stresses and the maximum shear stress.

b) Will the above stress condition cause yielding according to the maximum shear stress theory? Assume $\sigma_{yielding} = 295$ MPa.

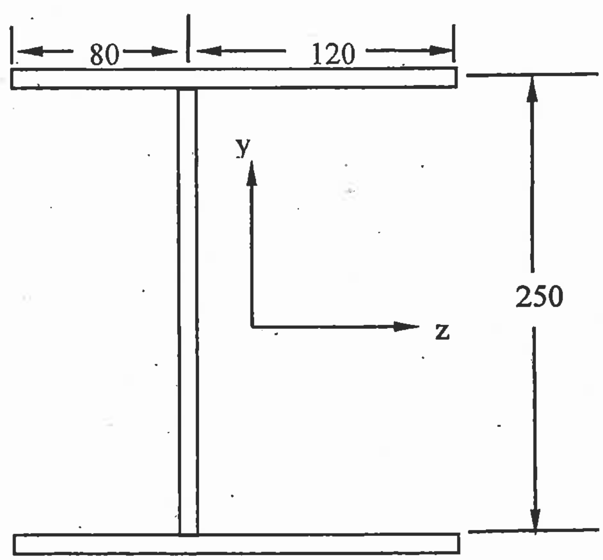
c) Determine the normal and shear stresses on an element rotated 60 degrees clockwise from the x-axis.



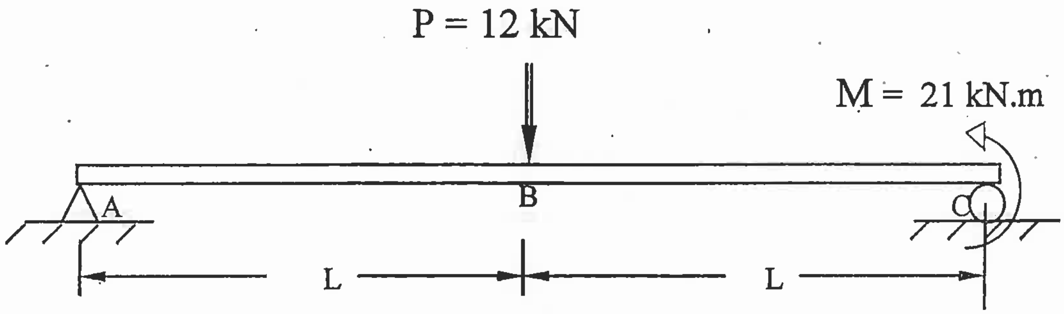
5- The thin-walled open section shown below is subjected to a vertical upward force of 55000 N acting through the shear center.

a) Find the shear flow distribution in the thin walls of the section. All of the walls have a thickness of 8 mm. All the dimensions shown are in mm and are to the medians of the flanges and webs.

b) Locate the shear center relative to the vertical web.



6- Using Castigliano's second theorem, determine the slope at the point of support C and the displacement of point B of the simply supported beam shown below. Take $E = 210$ GPa, $I = 250 \times 10^6$ mm^4, $L = 2.5$ m .



7- A thick-walled cylinder with 0.18 m internal diameter and 0.28 m external diameter is fabricated of a material whose elastic limit is 330 MPa and Poisson's ratio $\nu = 0.30$. The cylinder is subjected to an internal pressure two times greater than the external pressure. Calculate the allowable internal pressure according to:

a) the maximum shear stress theory, and
b) the Von-Mises theory.

8- The figure below shows a steel ring of 280 mm mean radius and a uniform rectangular section of 100 mm wide and 25 mm thick. A rigid bar is fitted horizontally as shown. Assuming an allowable stress of 175 MPa, determine the maximum tensile force P that can be carried by the ring.