

National Exams December 2013

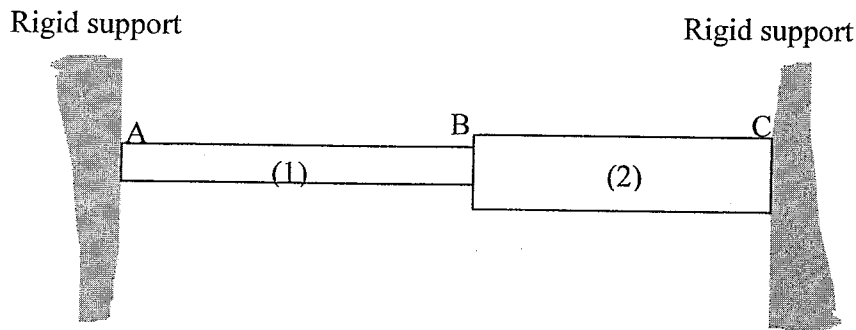
**07-Mec-A6-2** Advanced Strength of Materials

3 Hours Duration

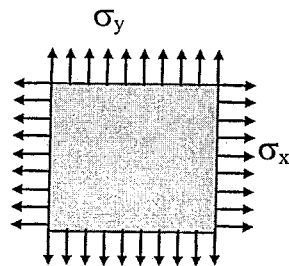
NOTES:

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 seven 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.

- 1- The two uniform linearly elastic rods shown below 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  $E_1 = 135 \text{ GPa}$ , cross-sectional area  $A_1 = 520 \text{ mm}^2$ , length  $L_1 = 120 \text{ mm}$ , and coefficient of thermal expansion  $\alpha_1 = 7.5 \times 10^{-6}/^\circ\text{C}$ . Rod (2) has a modulus  $E_2 = 85 \text{ GPa}$ , cross-sectional area  $A_2 = 950 \text{ mm}^2$ , length  $L_2 = 90 \text{ mm}$ , and coefficient of thermal expansion  $\alpha_2 = 12.5 \times 10^{-6}/^\circ\text{C}$ .
- Determine the axial stresses in the rods if the temperature of both is raised by  $60^\circ\text{C}$ .
  - Determine whether joint B moves to the right or left and by how much?



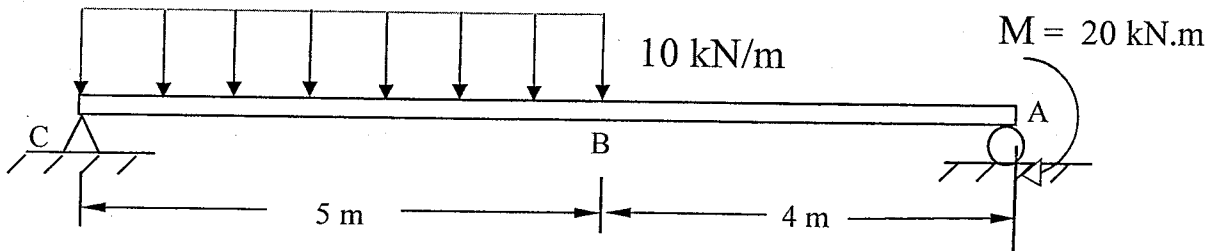
- 2- A thin square plate of 2 m by 2 m is subjected to a state of plane stress represented by uniform normal stresses  $\sigma_x$  and  $\sigma_y$  as illustrated below. All other stresses are zero. The two stresses shown cause the plate to elongate by 0.8 mm in the x direction and by 0.2 mm in the y direction. If it is known that  $\sigma_y$  is equal to 200 MPa and E is equal to 80 GPa and that all deformations are in the linear-elastic range, determine:



- $\sigma_x$
- the Poisson's ratio for the material from which the square is made, and
- the strain in the thickness direction (z-direction).

- 3- A bar of solid circular cross-section of 50 mm diameter is subjected to a torque, T, and an axial tensile load, P. A rectangular strain gauge rosette attached to the surface of the bar gives the following strain readings:  $\epsilon_0 = 500 \times 10^{-6}$ ,  $\epsilon_{45} = -100 \times 10^{-6}$  and  $\epsilon_{90} = -300 \times 10^{-6}$  with the 0 degree gauge being aligned with the axial direction of the bar. If Young's modulus, E, for the bar is 75 GPa and Poisson's ratio,  $\nu$ , is 0.3, calculate the values of T and P.

- 4- Using Castigliano's theorem, determine the displacement of point B of the beam shown below. Take  $E = 210 \text{ GPa}$ ,  $I = 285 \times 10^6 \text{ mm}^4$ .



- 5- A thick-walled cylinder with  $0.12 \text{ m}$  internal diameter and  $0.17 \text{ m}$  external diameter is fabricated of a material whose elastic limit is  $300 \text{ MPa}$  and Poisson's ratio  $\nu = 0.3$ . The cylinder is subjected to an internal pressure  $4.5$  times greater than the external pressure. Calculate the allowable internal pressure according to:

- the Von-Mises criterion
- the maximum shear stress criterion

- 6- A  $1.75 \text{ m}$  long pin-ended column has a hollow circular cross-section  $50 \text{ mm}$  in diameter, with a wall thickness  $2.0 \text{ mm}$  and is converted to an open section by a narrow longitudinal slit; the ends of the column are free to warp. If the column is made from materials with  $E = 70 \text{ GPa}$  and  $G = 15 \text{ GPa}$ , determine the values of axial load which would cause the column to buckle in:

- pure bending mode
- pure torsion mode

- 7- Calculate the forces in the members FG, GD and CD of the truss shown in the figure below using the principle of virtual work. All horizontal and vertical members are  $1 \text{ m}$  long.

