National Exams May 2016

07-Mec-A6-2 Advanced Strength of Materials

3 Hours Duration

NOTES:

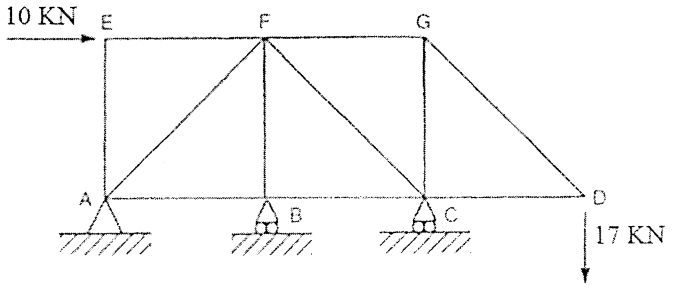
1. If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

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

3. Any five 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.

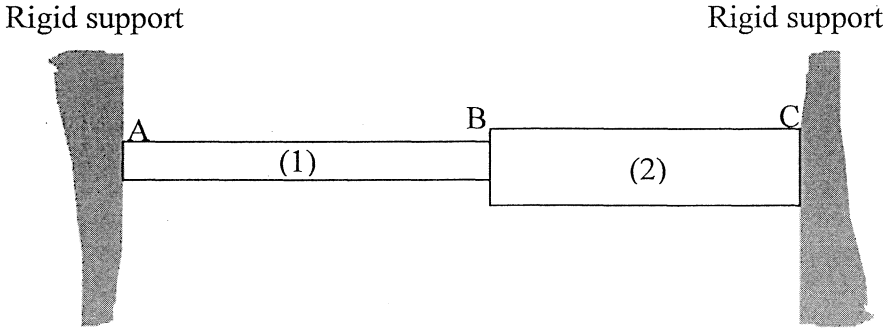
4. All problems are of equal value.

1- Calculate the forces in the members FG, GD and CD of the truss shown in the figure below using an energy method of your choice. All horizontal and vertical members are 1m long.



2- 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 $E_1 = 175$ GPa, cross-sectional area $A_1 = 530$ mm^2, length $L_1 = 175$ mm, and coefficient of thermal expansion $\alpha_1 = 8.5 \times 10^{-6}$/°C. Rod (2) has a modulus $E_2 = 100$ GPa, cross-sectional area $A_2 = 800$ mm^2, length $L_2 = 110$ mm, and coefficient of thermal expansion $\alpha_2 = 14 \times 10^{-6}$/°C.

a) Determine the axial stresses in the rods if the temperature of both is raised by 40 °C.
b) Determine whether joint B moves to the right or left and by how much?



3- A thick-walled cylinder with 0.06 m internal radius and 0.11 m external diameter is fabricated of a material whose elastic limit is 320 MPa and Poisson's ratio $\nu = 0.28$. The cylinder is subjected to an internal pressure 6.5 times greater than the external pressure. Calculate the allowable internal pressure according to:

a) the Maximum shear stress criterion
b) the Von-Mises criterion

4- A thin square plate of 1.25 m by 1.25 m is subjected to a state of plane stress represented by uniform normal stresses σ_x and σ_y. All other stresses are zero. The two stresses cause the plate to elongate by 1.95 mm in the x direction and by 0.20 mm in the y direction. If it is known that σ_x is equal to 200 MPa, and E is equal to 110 GPa and that all deformations are in the linear-elastic range, determine:

a) σ_y and the Poisson's ratio ν for the material from which the square is made, and
b) the yield strength of the material if the applied state of stress is just enough to cause yielding according to the maximum shear stress criterion

5- A pin-ended column of height 2.2 m has a circular cross-section with an external diameter of 55 mm, and a wall thickness of 2.0 mm and is converted to an open section by a narrow longitudinal slit. If the ends of the column are free to warp and the column is made from materials with E =50 GPa and G = 15 GPa, determine the values of axial load which would cause the column to buckle in:

a) pure bending mode
b) pure torsion mode

6- A two-dimensional strain field is given by:

$$\varepsilon_x = c(-4.5x^2+10.5y^2) \quad \varepsilon_y = c(1.5x^2-7.5y^2) \quad \gamma_{xy} = 1.5bxy$$

where b and c are nonzero constants.

a) What should the relationship between b and c be if this field is to satisfy the strain compatibility conditions?
b) Determine the displacements u and v corresponding to this field of strain at point (3, 7) if they are zero at point (0, 0). Use as a value of 2.5 for c.

7- A cantilevered aluminum alloy bar of solid square cross-section (**b** by **b**) is subjected to a compressive axial force of magnitude P = 75 KN acting at the centroid of the section and a torque T = 11 KN.m. This member is to be designed according to the maximum-shear-stress criterion of failure, with a safety factor of 2.

a) What is the minimum allowable cross-sectional dimension **b** if $\sigma_{yielding}$ = 330 MPa?
b) What would your answer be if the Von-Mises criterion is used?

8- The beam cross section shown below is symmetrical about the horizontal x-axis and is subjected to an upward vertical shear force of 2500 N acting at its shear centre.

a) Determine and plot the resulting flexural shear flow in the two flanges and the web.
b) Locate the shear centre of the beam.
c) Determine the location and magnitude of the maximum shear stress in the cross section.