NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

INDUSTRIAL AND MANUFACTURING ENGINEERING DEPARTMENT

Bachelor of Engineering Honours Degree Industrial & Manufacturing Engineering

PART II SEMESTER 1 EXAMINATION: APRIL/MAY 2009

SOLID MECHANICS I **Course Code TIE 2103**

Examination duration 3 hours

INSTRUCTIONS TO CANDIDATE
Answer any FIVE questions out of seven.
Show all working
All Questions carry equal marks (20)

Question 1

(a) Deduce an expression for the elongation of the bar, shown in figure Q 1(a) below, consisting of two equal sections, a straight section and a tapering section. On the tapering section the diameter changes from d_A at the centre to d_B at the end B. The bar is made of material with modulus E. **[10]**

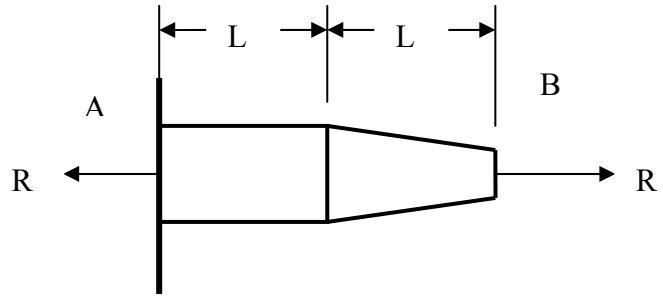


Figure Q 1(a)

(b) What is the elongation δ of the tapering bar of Figure Q 1(b), having length L and is made of material with modulus of elasticity E, and the diameter varies from D at end A to $D/2$ at end B? The bar is loaded with tensile force P. **[10]**

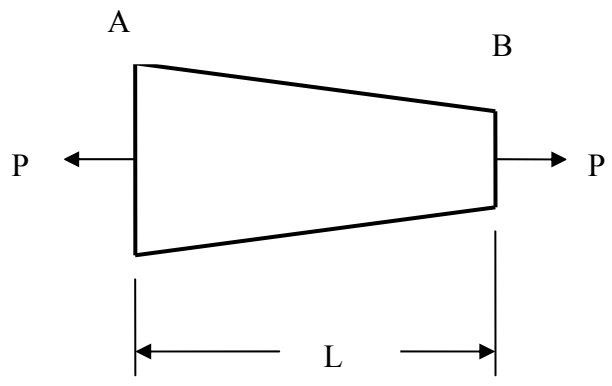


Figure Q 1(b)

Question 2

(i) Compute the shortening of the bar shown in Figure Q 2(i) under the action of the two forces P_1 and P_2, if the bar is made of material with modulus of elasticity E, and the diameter varies from a smaller diameter d1 at the free end to a larger d2 at fixed end. Evaluate the elongation δ given that $P_1 = 4.6$ KN, $P_2 = 3.4$ KN, $d_1 = 18$ mm,
$d_2 = 26$ mm, E = 70 GPa, and the two sections of the bar have equal lengths L1 = L2 = 300mm. **[10]**

(ii) Determine the elongation δ of the bar EFG under the action of the forces P1 = 3.5 KN and P2 = 6.5 KN, as shown in the figure Q 2(ii) below. The bar is made of brass of modulus of elasticity E = 100 GPa, the prismatic sections EF and have diameters of 300 mm and 22 mm respectively, and have equal lengths L = 120mm. **[10]**

Figure Q 2(i)

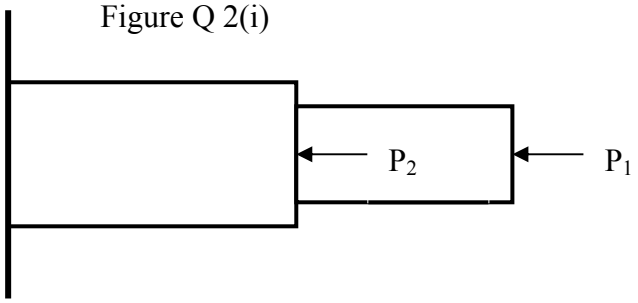
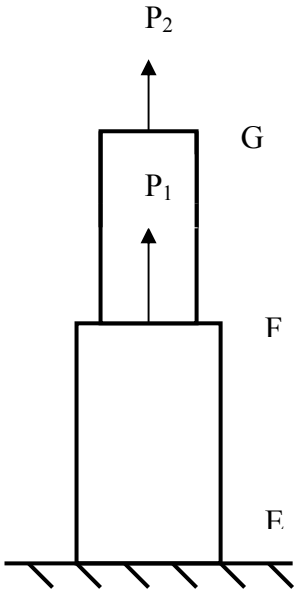


Figure Q 2(ii)



Question 3

(a) The EN36 main drive shaft used in a Commercial Aircraft engine has a 60mm diameter and is solid. The maximum allowable shear stress in the shaft material is 168MN/m^2. Determine the torsional strength of the shaft. If the shaft now is modified by boring a concentric hole through it axially in order to reduce weight, find the percentage reduction in the strength and mass of the drive shaft if:

(i) the hole is of diameter 45mm **[5]**

(ii) the hole is 30mm diameter **[5]**

(b) A Lathe Machine gearbox solid shaft is meant to transmit a power of 750KW at a spindle speed of 300 revs/min. If the shaft is not to twist more than 1^0 on a length of 15 diameters and the shear stress is not to exceed 50MN/m^2, compute the feasible minimum shaft diameter required on these two conditions. G=84 GN/m^2 **[10]**

Question 4

(a) A hollow steel transmission shaft on a steel milling plant has internal and external diameters respectively 150 mm and 225 mm. Determine:

(i) the maximum power this shaft can transmit at a spindle speed of 150 rev/min if the maximum shear stress is not to exceed 70 MN/m^2. **[5]**

(ii) the diameter of a solid shaft of the same material which would transmit the same maximum power at the same speed with the same stress. **[5]**

(b) A diameter 150 mm drive shaft revolves at 120 rev/min and transmits 400 kW. If the length of the shaft is 3 m and the material has G = 82.5 kN/mm^2, compute:

(i) the maximum shear stress of the material **[5]**

(ii) find the angle of twist in degrees **[5]**

Question 5

A steel shaft ABC, shown in Figure Q5 of diameter 50 mm is driven at A by a motor that transmits 50 kW to the shaft at 10 Hz. The gears at B and C drive machinery requiring power equal to 30 kW and 20 kW respectively. Compute;

(a) the maximum shear stress τ in the shaft, and

(b) the angle of twist ϕ between the motor at A and the gear at C. **[20]**

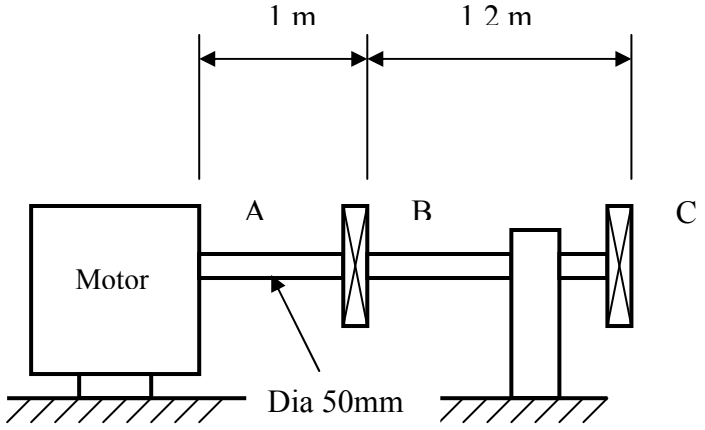


Figure Q5

Question 6

A beam ABCD, shown on Figure Q6 below, is simply supported at A and C which are 8 metres apart. A load of 30 KN/m is uniformly distributed over the portion AB which is 6 metres long. Concentrated loads of 100 KN and 70 KN act at B and D respectively where D is on an overhang 2 metres from C.

(i) Sketch the shear force and bending moment diagrams, **[10]**

(ii) Calculate the position of the maximum bending moment and the point of contraflexure. **[10]**

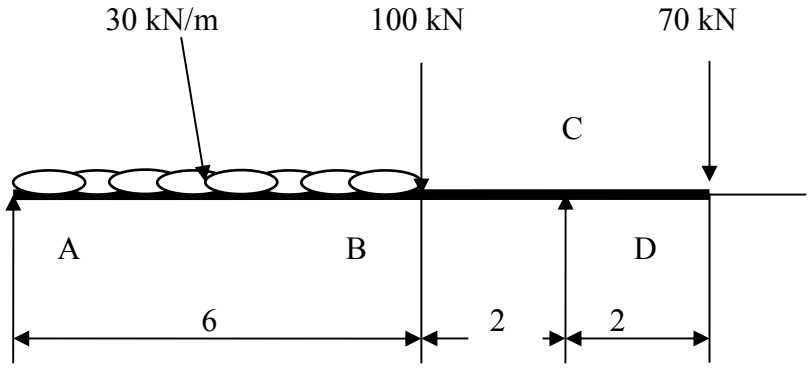


Figure Q6

Question 7

A Beam ABCDE is simply supported at B and D, and carries point loads of 100 kN and 30 kN at C and E respectively, together with uniformly distributed loads of 40 kN/m over the portion A to B and 10 kN/m over the portion C to E. AB = 1m, BC = 4m, CD = 2m and DE = 3m.

(i) Draw the shear force and bending moment diagrams and determine the magnitude and position of;

(a) the maximum shear force **[5]**

(b) maximum bending moment **[5]**

(ii) Determine the positions of the points of contraflexure. **[20]**

End of Exam