NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

INDUSTRIAL AND MANUFACTURING ENGINEERING DEPARTMENT

PART II END OF SEMESTER I FINAL EXAMINATION: FEBRUARY 2010

SOLID MECHANICS I **Course Code 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) Determine the shortening δ of the bar shown in figure Q1, below, under the action of two forces P_1 and P_2 if the bar is made up of material with modulus of elasticity E and the diameter varies from small diameter d_1 at the free end to a larger d_2 at the fixed end.

[10]

(b) Evaluate δ, for figure Q1, 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 $L_1 = L_2$ = 300 mm

[10]

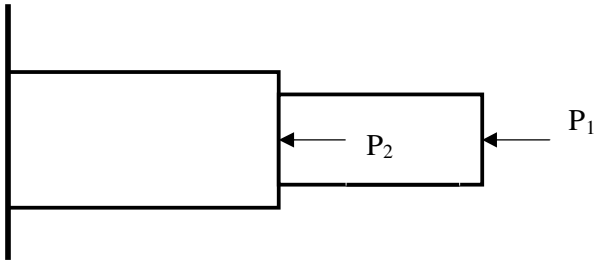

Figure Q 1

QUESTION 2

(a)Deduce the expression for the elongation δ of the tapering bar of figure Q 2(a), 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. **[7]**

(b) Determine the angle of rotation of one of the ends of the bar shown if figure Q2(b) below relative to the other end when the bar is acted on by a torque T = 12 000 Nm, and is made up of two sections, one prismatic and of length L_1 = 480 mm and having diameter d_1 = 32 mm,

the other section tapers to a diameter $d_2 = 44$ mm, has length $L_2 = 200$ mm. The bar is made of material with a shear modulus of elasticity
G = 80 GPa. **[13]**

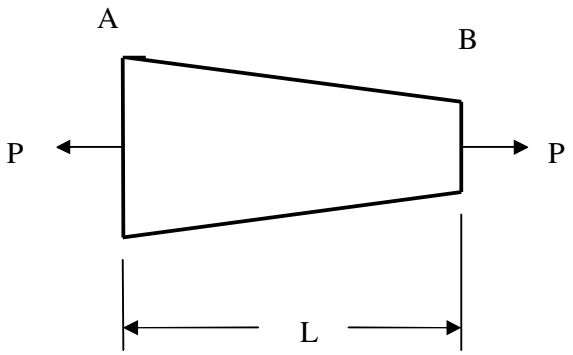

Figure Q 2(a)

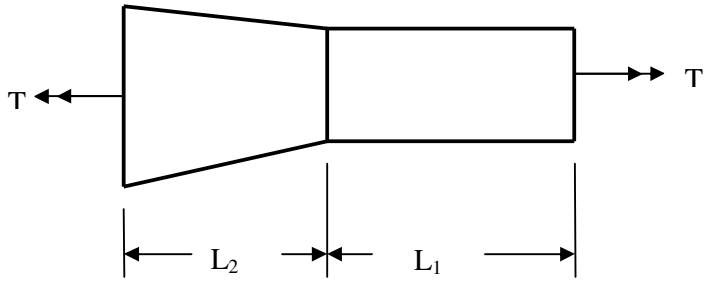

Figure Q 2(b)

QUESTION 3

As shown in figure Q3, below, a prismatic solid bar AB, of length L and CSA.A is acted on by a force P acting at a point C which is a distance (2L)/3 along AB. If the bar is made of material with modulus of elasticity E;

(a) determine the support reactions at A and B **[12]**

(b) what is the displacement δ of point C? **[8]**

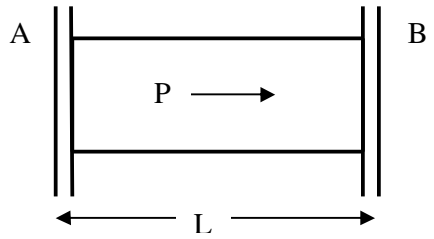

Figure Q3

QUESTION 4

Figure Q4 shows a solid bar consisting of two sections of equal lengths L = 160 mm with larger diameter being 60 mm and the smaller diameter being 40 mm, and is fixed between rigid supports. The bar is made of material with modulus of elasticity E = 74 GPa and a coefficient of thermal expansion $\alpha = 19 \times 10^{-6}/^{o}C$. If the bar is heated uniformly with a temperature increase $\Delta T = 20^{o}C$. What are the reactions at the supports A and B?

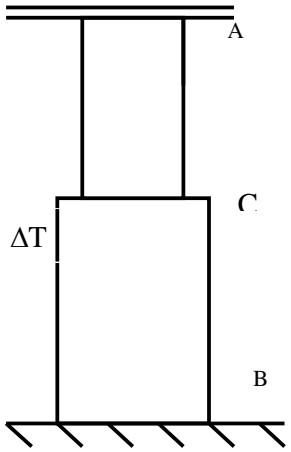

Figure Q4

[20]

QUESTION 5

A beam 10m long rests on two supports placed 5m apart, and overhangs at the right hand support by 3m. It carries a load of 40 kN/m run between the supports. In addition, it carries isolated loads of 50 kN at the left hand end, 20 kN at a point 1m from left-hand end, and 40 kN at the right-hand end.

(a) Sketch the bending moment diagram showing salient values of BM. **[8]**

(b) Sketch the shear-force diagram showing salient values of SM. **[6]**

(c) State the value and location of the maximum bending moment **[6]**

QUESTION 6

Two tubes, one of copper and one of steel, are of equal length, and rigidly connected together at their ends, so that under all conditions they are of equal length. The copper tube has internal and external diameters of 100mm and 125 mm respectively, whilst the internal and external diameters of the steel tube are 75 mm and 100 mm respectively. If the original length of the tubes was 375 mm;

(i) Calculate the stresses set up in them when there is a temperature rise of $22^{o}C$ **[15]**

(ii) What is the final length of the tubes? **[5]**

($E_{steel} = 207 \times 10^{3} N/mm^{2}$, $E_{copper} = 110 \times 10^{3} N/mm^{2}$. Coefficients of expansion per degree Celsius – steel 0.000 012, copper 0.000 019)

QUESTION 7

A support column is made up of a steel tube, 70 mm inside diameter, filled with concrete. If the maximum stress in the concrete is not to exceed 21 N/mm^2 and the column is to carry a compressive load of 195 kN, calculate the minimum outside diameter of the tube? For concrete, E = 20 kN/mm^2 and for steel E = 200 kN/mm^2.

20]

End of Examination