MUEO

MOI UNIVERSITY

OFFICE OF THE DEPUTY VICE CHANCELLOR
(ACADEMICS, RESEARCH & EXTENSION)

UNIVERSITY EXAMINATIONS

2016/2017 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER EXAMINATION

FOR THE DEGREE OF

BACHELOR OF ENGINEERING

IN

MECHANICAL & PRODUCTION ENGINEERING
MANUFACTURING & INDUSTRIAL AND
TEXTILE ENGINEERING, ELECTRICAL
ENGINEERING TELECOMMUNICATION
ENGINEERING

COURSE CODE: MPE 222

COURSE TITLE: SOLID MECHANICS I

DATE: 13TH JUNE, 2017 **TIME:** 9.00 A.M. – 12.00 NOON

INSTRUCTION TO CANDIDATES

- THIS PAPER CONTAINS 7 QUESTIONS ANSWER ANY 5 QUESTIONS

THIS PAPER CONSISTS OF (7) PRINTED PAGES

PLEASE TURN OVER

QUESTION ONE

a) A hollow circular post ABC (fig. q 1) supports a load P_1 = 7.5 kN acting at the top. A second load P_2 is uniformly distributed around the cap plate at B. The diameters and thicknesses of the upper and lower parts of the post are d_{AB} = 32 mm, t_{AB} = 12 mm, d_{BC} = 57 mm, and t_{BC} = 9 mm, respectively.

i) Calculate the normal stress σ_{AB} in the upper part of the post.

ii) If it is desired that the lower part of the post have the same compressive stress as the upper part, what should be the magnitude of the load P_2?

iii) If P_1 remains at 7.5 kN and P_2 is now set at 10 kN, what new thickness of BC will result in the same compressive stress in both parts? **[6 marks]**

b) In the hollow pipe ABC (fig. q 1) load P_1 = 118 kN, load P_2 = 98 kN and modulus of elasticity is 96 GPa (the pipe dimensions remaining the same as in part a above) If the wall thickness of pipe BC increases by 5 x 10^{-3} mm when both loads are fully applied,

i) Find the increase in the inner diameter of pipe segment BC.

ii) Find Poisson's ratio for the brass.

iii) Find the increase in the wall thickness of pipe segment AB and the increase in the inner diameter of AB.

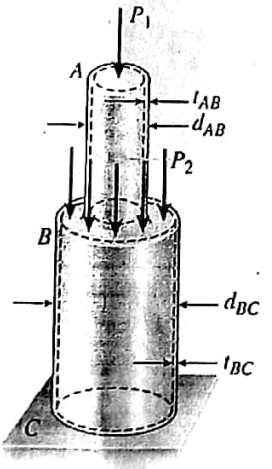

Fig. q 1 **[8 marks]**

QUESTION TWO

a) A tie-down on the deck of a sailboat consists of a bent bar bolted at both ends, as shown in the fig. q 2a. The diameter d_B of the bar is 6 mm, the diameter d_W of the washers is 22 mm, and the thickness t of the fiberglass deck is 10 mm. If the allowable shear stress in the fiberglass is 2.1

MPa, and the allowable bearing pressure between the washer and the fiberglass is 3.8 MPa, what is the allowable load P_{allow} on the tie-down?

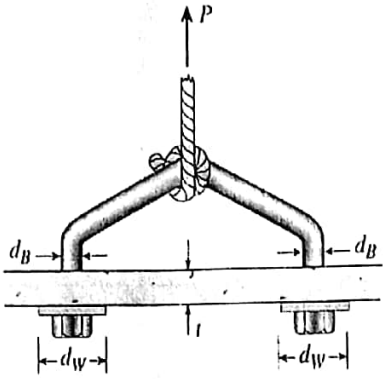

Fig. q 2a. **[5 marks]**

b) A cable and pulley system in fig. q 2b part (a) supports a cage of mass 300 kg at B. Assume that this includes the mass of the cables as well. The thickness of each the three steel pulleys is t = 40 mm. The pin diameters are d_{pA} = 25 mm, d_{pB} = 30 mm and d_{pC} = 22 mm [see fig. q 2b].

i) Find expressions for the resultant forces acting on the pulleys at A, B, and C in terms of cable tension T.

ii) What is the maximum weight W that can be added to the cage at B based on the following allowable stresses? Shear stress in the pins is 50 MPa; bearing stress between the pin and the pulley is 110 MPa.

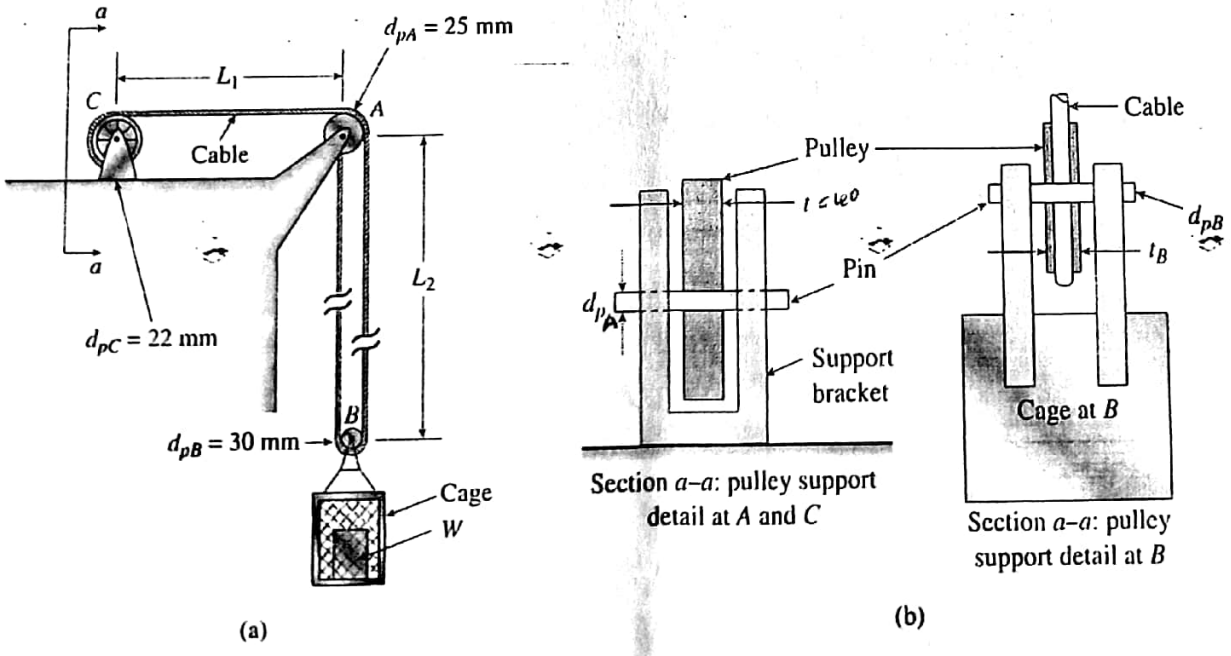

Fig. q 2b **[9 marks]**

QUESTION THREE

a) A hollow, circular, cast-iron pipe (E_c= 83 GPa) supports a brass rod (E_b= 96 GPa) and weight W = 9 kN, as shown in fig. q 3a. The outside diameter of the pipe is d_c= 150 mm.

i) If the allowable compressive stress in the pipe is 35 MPa and the allowable shortening of the pipe is 0.5 mm, what is the minimum required wall thickness $t_{c,min}$? (take γ_{steel} = 77 kN/m^3 and γ_{brass} = 84 kN/m^3.)

ii) What is the elongation of the brass rod d_r due to both load W and its own weight?

iii) What is the minimum required clearance h?

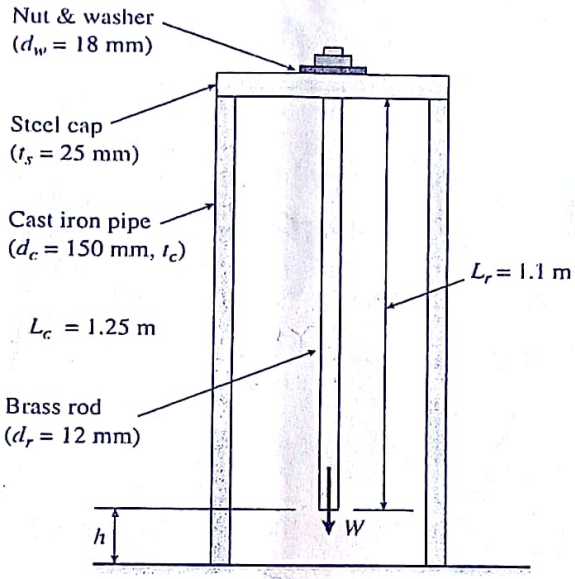

Fig. q 3a **[9 marks]**

b) A long, rectangular copper bar under a tensile load P hangs from a pin that is supported by two steel posts (see figure). The copper bar has a length of 2.0 m, a cross-sectional area of 4800 mm^2, and a modulus of elasticity E_c= 120 GPa. Each steel post has a height of 0.5 m, a cross-sectional area of 4500 mm^2, and a modulus of elasticity E_s= 200 GPa.

i) Determine the downward displacement d of the lower end of the copper bar due to a load P = 180 kN.

ii) What is the maximum permissible load P_{max} if the displacement d is limited to 1.0 mm?

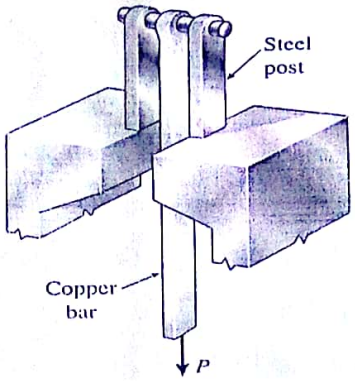

Fig q 3b **[5 marks]**

QUESTION FOUR

a) Calculate the overall change in length of the tapered rod shown in fig. q 4a. It carries a tensile load of 10 kN at the free end, and at the step change in section a compressive load of 2 MN/m evenly distributed around a circle of 30 mm diameter. E = 208 GN/m^2.

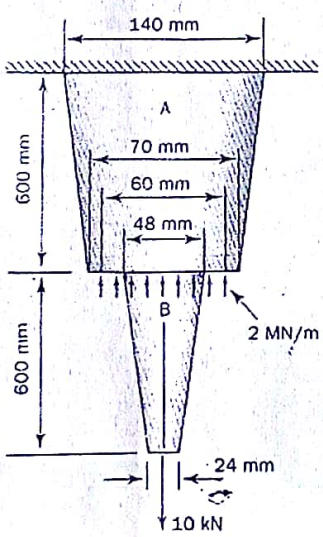

Fig. q 4a **[10 marks]**

b) The steel axle of a large winch on an ocean liner is subjected to a torque of 1.65 kN.m (see fig. q 4b). What is the minimum required diameter d_{min} if the allowable shear stress is 48 MPa and the allowable rate of twist is 0.75°/m? (Assume that the shear modulus of elasticity is 80 GPa.)

Fig. q 4b **[4 marks]**

QUESTION FIVE

a) A gun-metal sleeve is fixed securely to a steel shaft and the compound shaft is subjected to a torque. If the torque on the sleeve is twice that on the shaft , find the ratio of external diameter of sleeve to diameter of shaft. If the limits of shearing stress in the gun – metal and steel are 45 and 80 N/mm^2 respectively, find the torque that may be transmitted by the compound shaft when the steel shaft diameter is 50 mm, $G_{steel} = 2.5\ G_{gun}$ and $L_{steel} = L_{gun}$. **[10 marks]**

b) A ship's propeller shaft has external and internal diameter of 25 cm and 15 cm. What power can be transmitted at 110 rpm with a maximum shearing stress of 75 MPa. What will be the twist in degrees of a 10 m length of the shaft? G = 80 GPa. **[4 marks]**

QUESTION SIX

Draw the shear force and bending moment diagrams for the beam in fig. q 6. Find the maximum shear force, the maximum bending moment and the position of the point of contraflexure.

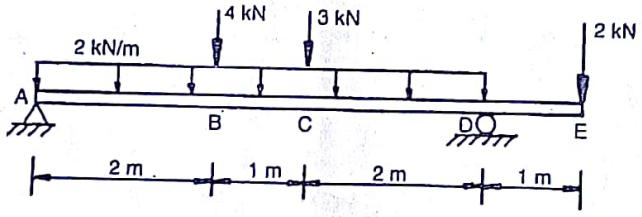

Fig. q 6 **[14 marks]**

QUESTION SEVEN

The angle section shown in fig. q 7 is subjected to a bending moment of 2 kN.m about the z-axis. Determine the bending stress distribution.

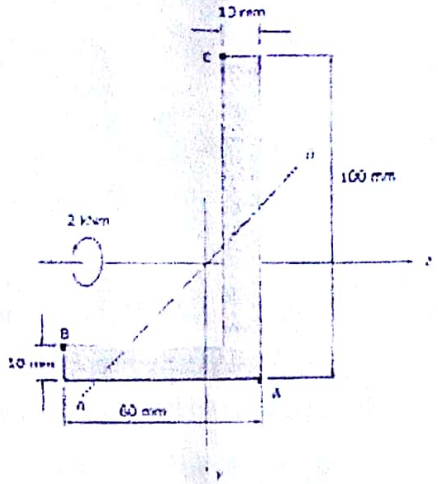

Fig. q 7 **[14 marks]**

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