ME2110 Mechanics of solids

(Assignment 2)

September 19, 2022

Deadline : September 26,2022, 17:00:00.

Question 1.

A bar of brass 15 mm is enclosed in a steel tube of 35 mm external diameter and 15 mm internal diameter. The bar and the tubes are initially 1.1 m long and are rigidly fastened at both ends using 2 mm diameter pin. If the temperature is raised by $60°C$, find the stresses induced in the bar, tube and pins. Given $E_s = 2.5 \times 10^5 \frac{N}{mm^2}$, $E_b = 1.5 \times 10^5 \frac{N}{mm^2}$, $\alpha_s = 10.5 \times 10^{-6}/°C$, $\alpha_b = 17.8 \times 10^{-6}/°C$. Neglect thermal expansion in the radial direction of the tubes. In Fig. 1 AA is the expansion due to the brass bar, BB is the expansion due to the steel bar, and CC is the final expansion of the combined bar.

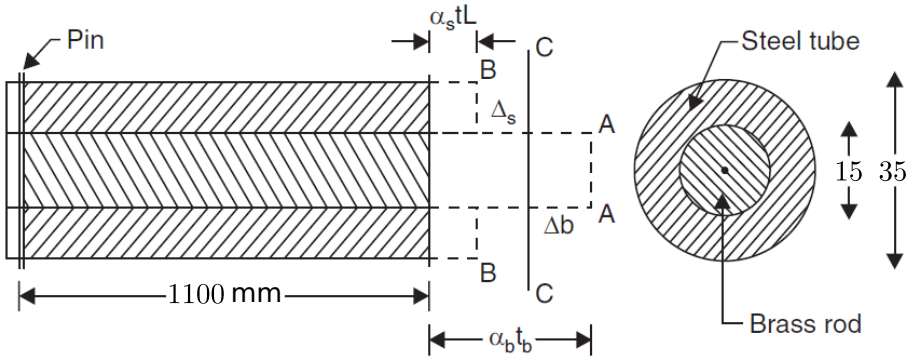

Figure 1: Question 1

Question 2.

A high-strength steel drill rod used for boring a hole in the earth has a diameter of 15 mm (see Fig. 2). The allowable shear stress in the steel is 300 MPa and the shear modulus of elasticity is 80 GPa. What is the minimum required length of the rod so that one end of the rod can be twisted 30° with respect to the other end without exceeding the allowable stress?

Question 3.

A rigid bar ABCD is pinned at point B and supported by springs at A and D(see Fig. 3).The springs at A and D have stiffnesses $k_1 = 15$ kN/m and

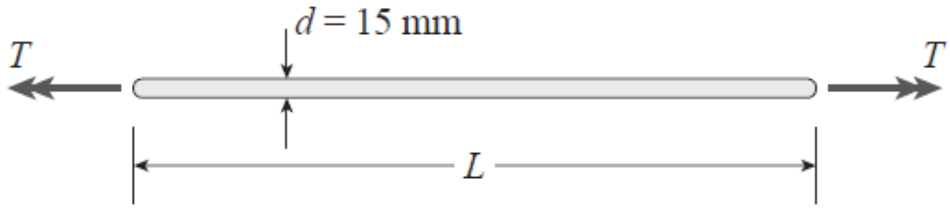

Figure 2: Question 2.

$k_2 = 30$ kN/m respectively and the distances $AB = 232$ mm, $BC = 222$ mm and $BD = 510$ mm respectively.A load P acts at point C. If the angle of rotation of the bar due to the action of the load P is limited to 7 deg. What is the maximum permissible load $P_{\max}$?

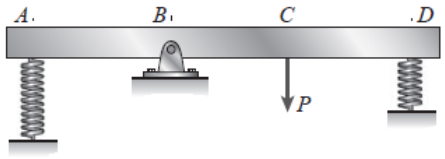

Figure 3: Question 3.

Question 4.

In the arrangement as shown in the figure, The stepped steel bar ABC is loaded by a load P. The material has young's modulus $E = 150$ GPa and the two portions. AB and BC have area of cross section 1 cm^2 and 2 cm^2 respectively.

a)The magnitude of load P required to fill up the gap of 0.75 mm is?

b)If the load P is 25 kN then what are the reactions at A and C?

c)If the load P is 25 kN then Calculate the stress in bar AB and BC in MPa?

Question 5.

(a) A Steel bar has Bulk modulus and Rigidity modulus of 160 GPa and 73 GPa respectively. Find it's poisson's ratio? (b) A Torque T is applied as shown in Fig. 5 to a solid shaft with built-in ends. Find the resisting torques at the walls are T_1 and T_2 ? How would T_1 and T_2 values change if the shaft was hollow? Explain?

Question 6.

A square plate (L x L) rigidly held at three edges but free to move along the

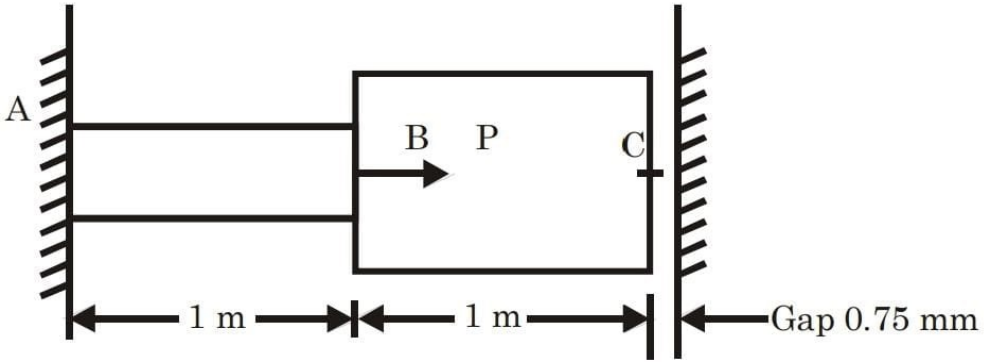

Figure 4: Question 4.

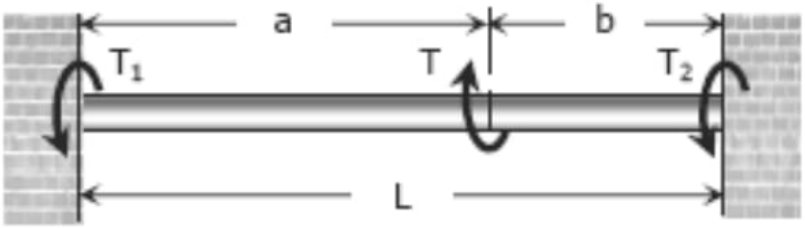

Figure 5: Question 5(b).

fourth edge. If temperature of the plate is raised by temperature $T°C$, , then find the percentage change in surface area of plate. Given modulus of elasticity of material= E and Poisson's ratio, $\nu = 0.25$, coefficient of thermal expansion of the material $\alpha = (1/T) \times 10^{-2}/°C$.

Question 7.

Two shafts of the same material and of same lenghths are subjected to the same torque, if the first shaft is of a solid circular section and the second shaft is of hollow circular section, whose internal diameter is 3/4 of the outside diameter and the maximum shear stress developed in each shaft is the same, compare the weights of the shafts.

Question 8.

The solid circular shaft has a linear taper from r_a at one end to r_b at the other. Derive an equation that gives the maximum shear stress in the shaft at a location x along the shaft axis?

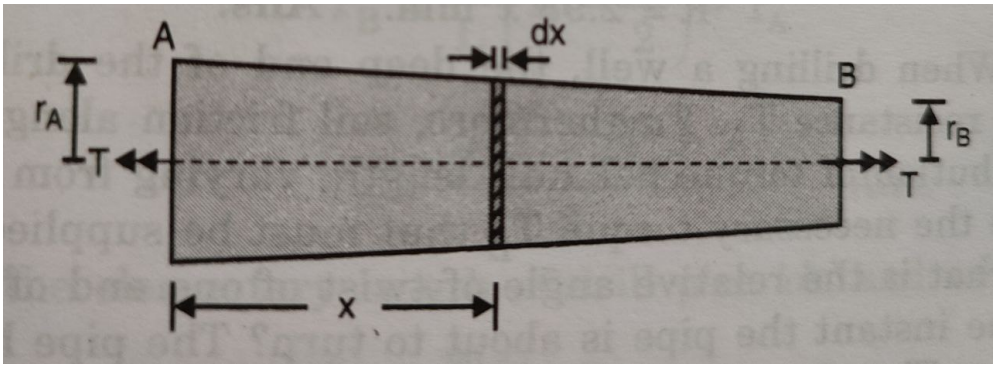

Figure 6: Question 8

Question 9.

A uniform metal bar has a cross-sectional area of 600 mm^2 and a length of 1.5m. If the stress at the elastic limit is 160 Gpa, what will be its proof resilience ? Determine also the maximum value of an applied load, which may be suddenly applied applied without exceeding the elastic limit. Calculate the value of the gradually applied load which will produce the same extension as that produced by the suddenly applied load above.

Question 10.

Define the following:

- Creep and relaxation
- Modulus of resilience
- Modulus of toughness
- Fatigue
- St.Venant's principle