ME 323: Mechanics of Materials ***Homework Set 4***

Fall 2023 ***Due: Friday, September 22***

Problem 4.1 (10 points)

Consider a three-member truss as shown. Members (1), (2) and (3) are pinned to the wall at H, D, and B, respectively, and pinned to each other at C. The orientations, lengths, Young's moduli and cross section areas are shown in the figure. A point force P is applied to joint C. It is desired to determine the axial load carried by the three members. Note that all members in the truss are two-force members.

a) Assuming all members are under tension, write down the equilibrium equations for joint C. Can the axial forces in the members be found from these equilibrium equations alone? Explain your reasoning.
b) Write down the force-elongation equations for the three members.
c) Write down the compatibility relations between elongation of members (1), (2), (3) and the horizontal and vertical displacements (u_C,v_C) of connector C.
d) Calculate the axial loads in the members, and horizontal and vertical displacements (u_C,v_C) of joint C. Indicate whether members are in tension or compression.

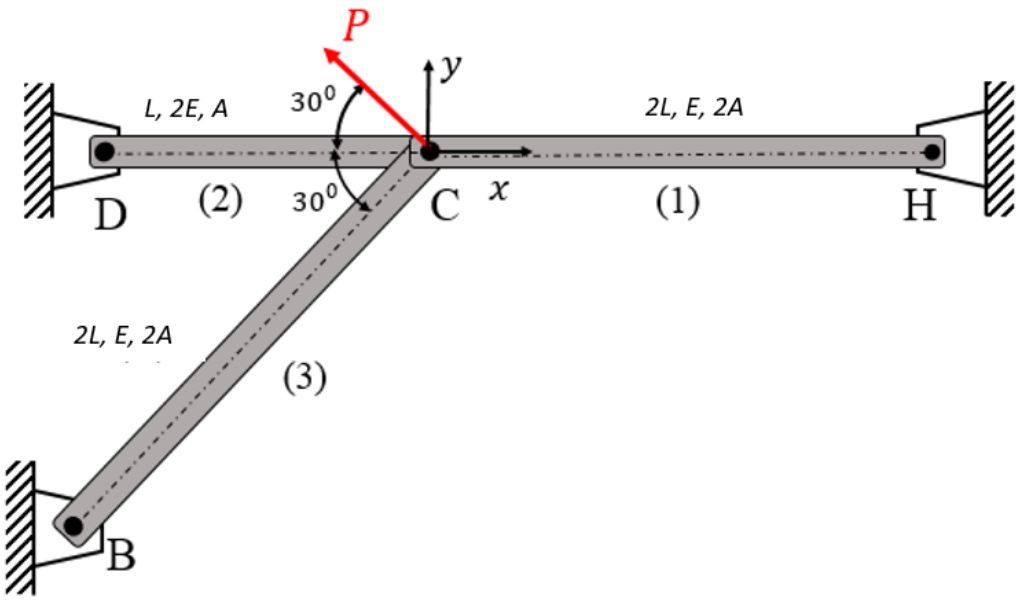

Fig. 4.1

Problem 4.2 (10 points)

A rigid block with a weight of 80×10^3lbs is supported by posts A, B, and C. The block is attached to the posts at all times. The Young's moduli for posts A and B are $E_A = E_B = 29 \times 10^3$ksi, and for post C is $E_C = 14.6 \times 10^3$ksi. All posts have the same initial length before loading with a cross-sectional area of 8sq in. After heating post C, its temperature is raised by 20°F while the temperature of A and B is held constant. The coefficient of thermal expansion for post C is $\alpha_C = 9.8 \times 10^{-6}$per °F. Determine the normal stresses in each post before and after heating post C.

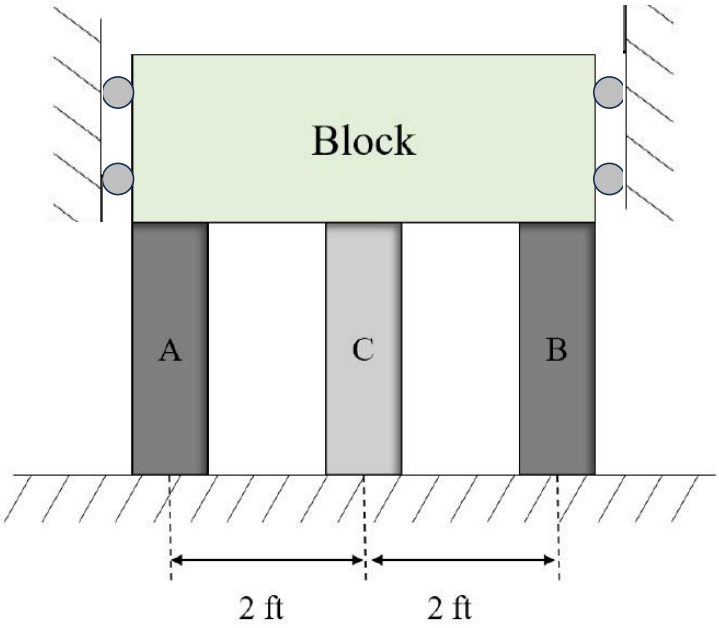

Fig. 4.2

Problem 4.3 (10 points)

The gear-shaft system shown in Fig. 4.3 is supported by frictionless bearings and transmits the torque to the fixed end A using the rigid gears at B and C. Shafts 1 and 3 are made of a material with shear moduli $\boldsymbol{G_1 = G_3 = 100\ \text{GPa}}$, and shaft 2 is made of a material with a shear modulus of $\boldsymbol{G_2 = 50\ \text{GPa}}$. The diameters of the shafts are $\boldsymbol{d_1 = 32\ \text{mm}, d_2 = 64\ \text{mm}}$, and $\boldsymbol{d_3 = 16\ \text{mm}}$. Calculate the angle of twist generated at the free ends D and E.

Use $\boldsymbol{L = 1\ \text{m}}$, $\boldsymbol{d_c = 150\ \text{mm}}$, $\boldsymbol{d_b = 90\ \text{mm}}$, and $\boldsymbol{T_0 = 5\ \text{N}\cdot\text{m}}$

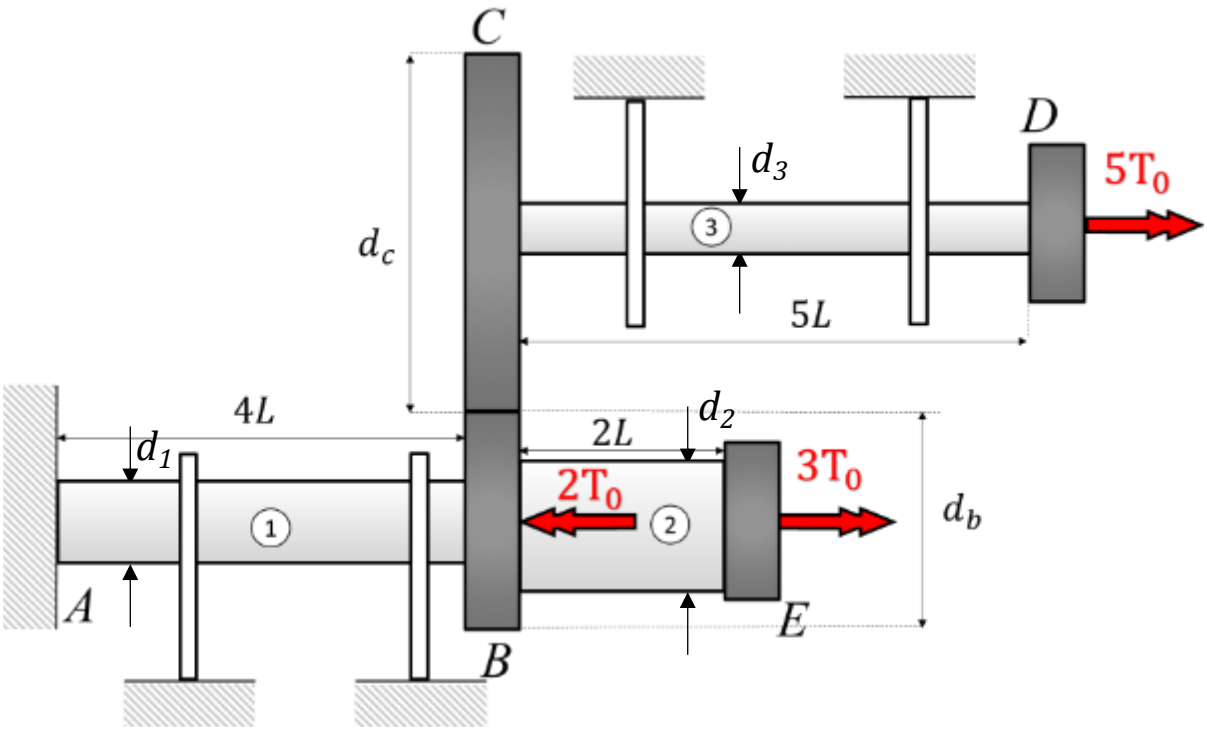

Fig. 4.3

Problem 4.4 - Conceptual (5 points)

Consider a circular shaft of radius R and length L composed of a material with shear modulus G fixed at one end. The shaft is subjected to a torque T at the other end. Determine the effect the following changes would have on the shear stress and angle of rotation.

(1) If the shaft radius R is increased, the maximum shear stress in the rod (a) increases (b) decreases (c) does not change.
(2) If the shaft length L is increased, the maximum shear stress in the rod (a) increases (b) decreases (c) does not change.
(3) If the shaft shear modulus G is increased, the maximum shear stress in the rod (a) increases (b) decreases (c) does not change.
(4) If the shaft radius R is increased, the maximum angle of rotation in the rod (a) increases (b) decreases (c) does not change.
(5) If the shaft length L is increased, the maximum angle of rotation in the rod (a) increases (b) decreases (c) does not change.

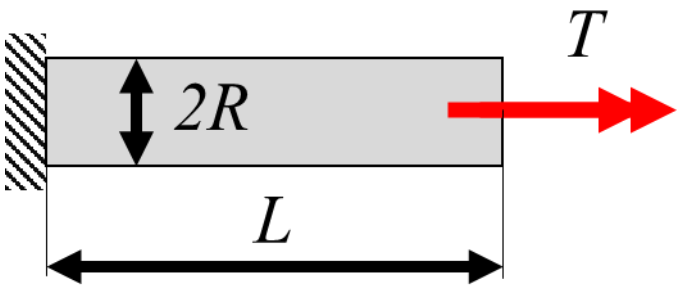

Fig. 4.4