SOLUTION

ME 323: Mechanics of Materials ***Homework Set H06***

Summer 2025 ***Assigned/Due: June 23/June 26***

A rod is made up of segments (1) and (2), where the same material, having a modulus of elasticity E, is used for each segment. Segments (1) and (2) have circular cross-sections of diameters $2d$ and d, respectively, and lengths of $2L$ and L, respectively. The segments are joined by a rigid connector at C, and second rigid connecter is located at D, with the weights of the connectors at C and D being $2W$ and W, respectively. A vertical load of $P = 2W$ is applied to connector D. The weights of segments (1) and (2) are to be considered to be negligible.

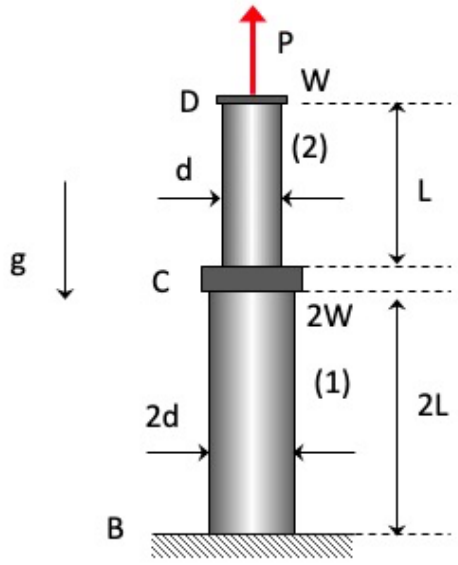
a) Draw individual free body diagrams (FBDs) of connectors C and D.

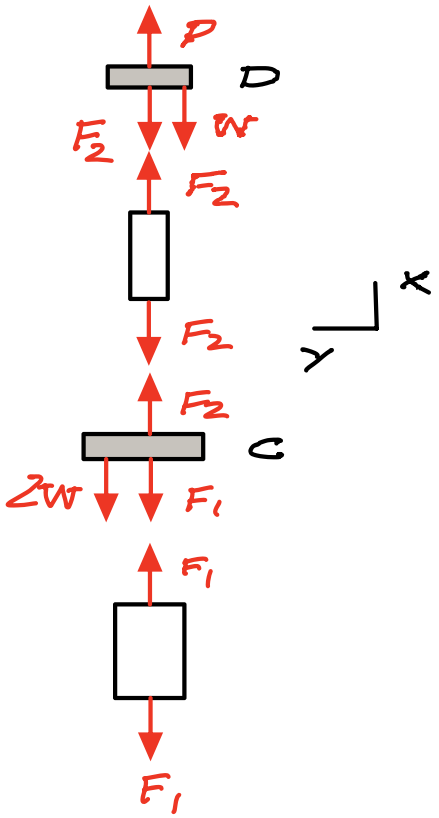
b) Write down the equilibrium equations for the connectors from the FBDs above, and from these, determine the load carried by each of the two segments of the rod.

c) Write down the force/elongation equations for segments (1) and (2).

d) Determine the displacements of connectors C and D.

Leave your answers in terms of the given parameters of, at most: E, d, W and L. Verify that your answers have appropriate units.





1. Equilibrium

(1) C: $\Sigma F_x = -F_1 + F_2 - 2W = 0$

(2) D: $\Sigma F_x = \underbrace{P - W}_{W} - F_2 = 0$

(2) $\Rightarrow F_2 = W$ ← F_2

(1) $\Rightarrow F_1 = F_2 - 2W = -W$ ← F_1

2. Force/elongation

$$e_1 = \frac{F_1(2L)}{E\pi(2d/2)^2} = \frac{2}{\pi}\frac{F_1 L}{Ed^2} = -\frac{2}{\pi}\frac{WL}{Ed^2}$$

$$e_2 = \frac{F_2 L}{E\pi(d/2)^2} = \frac{4}{\pi}\frac{F_2 L}{Ed^2} = \frac{4}{\pi}\frac{WL}{Ed^2}$$

3. Compatibility

$$V_C = \cancel{V_B^{\,0}} + e_1 = -\frac{2}{\pi}\frac{WL}{Ed^2} \longleftarrow V_C$$

$$V_D = V_C + e_2 = e_1 + e_2 = \frac{2}{\pi}\frac{WL}{Ed^2} \longleftarrow V_D$$

Unit check: $\frac{WL}{Ed^2} = \frac{(N)(m)}{\left(\frac{N}{m^2}\right)(m^2)} = m$ ✓ (checks)