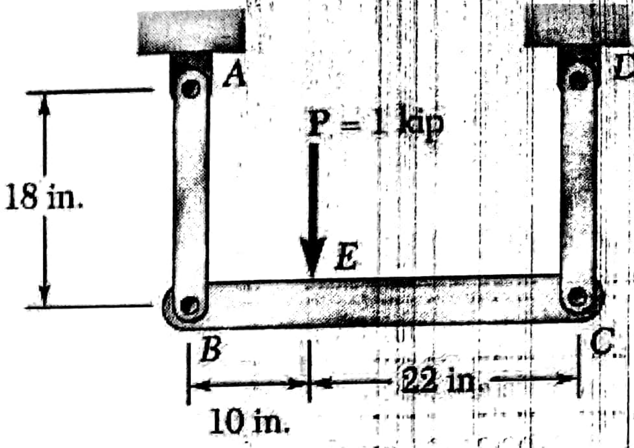
First Midterm

Mansoura University		level 100
Faculty of Engineering		Strength of Materials
BME	Time Allowed:1 Hours	Mid-Term Exam - 2018/2019

Name: Department/ Sec.:

PROBLEM 1:

Each of the links AB and CD is made of Aluminum ($E = 10.9 \times 10^6$ psi) and has a cross-sectional area of 0.2 in.^{2}. Knowing that they support the rigid member BC. Determine the deflection of point E.



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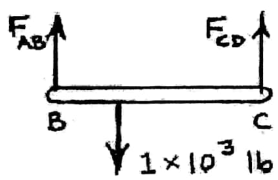
SOLUTION

Free body BC:



$$+\circlearrowleft \Sigma M_C = 0: -(32)F_{AB} + (22)(1\times10^3) = 0$$

$$F_{AB} = 687.5 \text{ lb}$$ 1

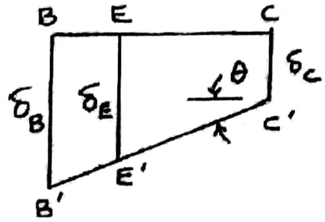
$$+\uparrow \Sigma F_y = 0: \; 687.5 - 1\times10^3 + F_{CD} = 0$$

$$F_{CD} = 312.5 \text{ lb}$$ 1

$$\delta_{AB} = \frac{F_{AB}L_{AB}}{EA} = \frac{(687.5)(18)}{(10.9\times10^6)(0.2)} = 5.6766\times10^{-3} \text{ in} = \delta_B$$ 2

$$\delta_{CD} = \frac{F_{CD}L_{CD}}{EA} = \frac{(312.5)(18)}{(10.9\times10^6)(0.2)} = 2.5803\times10^{-3} \text{ in} = \delta_C$$ 2

Deformation diagram:



$$\text{Slope } \theta = \frac{\delta_B - \delta_C}{L_{BC}} = \frac{3.0963\times10^{-3}}{32}$$

$$= 96.759\times10^{-6} \text{ rad}$$

$$\delta_E = \delta_C + L_{EC}\theta$$

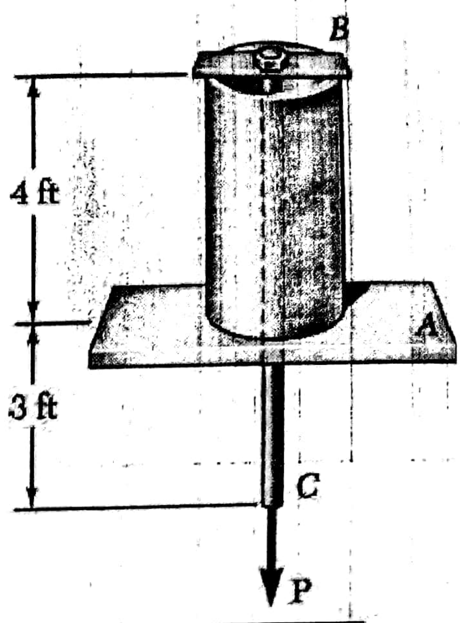
$$= 2.5803\times10^{-3} + (22)(96.759\times10^{-6})$$

$$= 4.7090\times10^{-3} \text{ in}$$ 1

$$\delta_E = 4.71\times10^{-3} \text{ in} \downarrow$$

PROBLEM 2:

A 4 ft section of aluminum pipe of cross-sectional area 1.75 in^2 rests on a fixed support at A. The 58 in. diameter steel rod BC hangs from a rigid bar that rests on the top of the pipe at B. Knowing that the modulus of elasticity is 29×10^6 psi for steel, and 10.4×10^6 psi for aluminium.
Determine the deflection of point C when a 15 kip force is applied at C.



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SOLUTION

Rod BC:

$$L_{BC} = 7 \text{ ft} = 84 \text{ in.} \quad E_{BC} = 29\times10^6 \text{ psi}$$

$$A_{BC} = \frac{\pi}{4}d^2 = \frac{\pi}{4}(0.625)^2 = 0.30680 \text{ in}^2$$

$$\delta_{C/B} = \frac{PL_{BC}}{E_{BC}A_{BC}} = \frac{(15\times10^3)(84)}{(29\times10^6)(0.30680)} = 0.141618 \text{ in.}$$ 3

Pipe AB:

$$L_{AB} = 4 \text{ ft} = 48 \text{ in.} \quad E_{AB} = 10.4\times10^6 \text{ psi}$$

$$A_{AB} = 1.75 \text{ in}^2$$

$$\delta_{B/A} = \frac{PL_{AB}}{E_{AB}A_{AB}} = \frac{(15\times10^3)(48)}{(10.4\times10^6)(1.75)} = 39.560\times10^{-3} \text{ in.}$$ 3

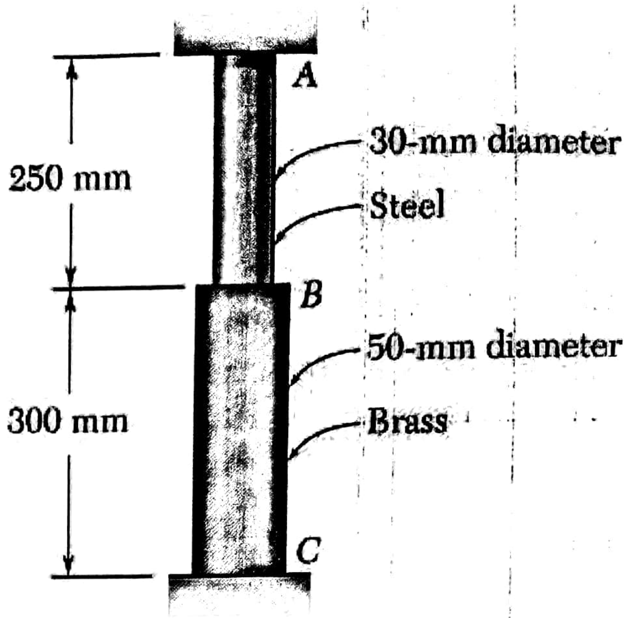
Total:

$$\delta_C = \delta_{B/A} + \delta_{C/B} = 39.560\times10^{-3} + 0.141618 = 0.181178 \text{ in.}$$ 2

$$\delta_C = 0.1812 \text{ in.} \blacktriangleleft$$

PROBLEM 3:

A rod consisting of two cylindrical portions AB and BC is restrained at both ends. Portion AB is made of steel (E_s = 200 GPa, α_s = 11.7 $\times 10^{-6}$/ °C), and portion BC is made of brass (E_b =105 GPa, α_b = 20.9$\times 10^{-6}$/ °C). Knowing that the rod is initially unstressed.
Determine the compressive force induced in ABC when there is a temperature rise of 50°C.



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SOLUTION

$$A_{AB} = \frac{\pi}{4} d_{AB}^2 = \frac{\pi}{4}(30)^2 = 706.86 \text{ mm}^2 = 706.86\times 10^{-6}\text{m}^2$$

$$A_{BC} = \frac{\pi}{4} d_{BC}^2 = \frac{\pi}{4}(50)^2 = 1.9635\times 10^{3}\text{mm}^2 = 1.9635\times 10^{-3}\text{m}^2$$

Free thermal expansion:

2 2

$$\delta_T = L_{AB}\alpha_s(\Delta T) + L_{BC}\alpha_b(\Delta T)$$

$1.4625*10^{-4}$ $3.135*10^{-4}$

$$= (0.250)(11.7\times 10^{-6})(50) + (0.300)(20.9\times 10^{-6})(50)$$

$$= 459.75\times 10^{-6}\text{m}$$

Shortening due to induced compressive force P:

2 2

$$\delta_P = \frac{PL}{E_s A_{AB}} + \frac{PL}{E_b A_{BC}}$$

$1.768*10^{-9}$ P $1.455*10^{-9}$ P

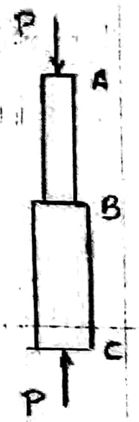
$$= \frac{0.250P}{(200\times 10^9)(706.86\times 10^{-6})} + \frac{0.300P}{(105\times 10^9)(1.9635\times 10^{-3})}$$

$$= 3.2235\times 10^{-9} P$$

For zero net deflection, $\delta_P = \delta_T$ 2

$$3.2235\times 10^{-9} P = 459.75\times 10^{-6}$$

$$P = 142.62\times 10^{3}\text{N}$$



P=142.6 kN ◄

Best Wishes
Ass.Prof.Dr.Noha Fouda