Foundations of Solid Mechanics

E2: Axial load

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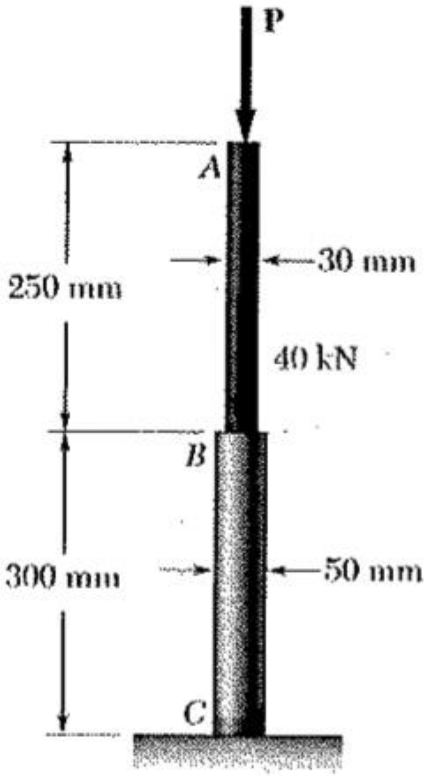
Foundations of Solid Mechanics

Exercise-1

1. Two solid cylindrical rods are jointed at B and loaded as shown. Rod AB is made of steel (E = 200 GPa) and rod BC of brass (E = 105 GPa). Determine (a) the load P for which the total deformation of the rod is -0.2 mm, (b) the corresponding deflection of point B.



$$\delta_{total} = \delta_{AC} = \delta_{AB} + \delta_{BC} = -0.2\ mm$$

$F_{AB} = P$ (compression)

$F_{BC} = P + 40$ (compression)

$$\delta_{total} = \delta_{AB} + \delta_{BC}$$

$$= \frac{P \cdot l_{AB}}{E_{AB} \cdot A_{AB}} + \frac{(P+40) \cdot l_{BC}}{E_{BC} \cdot A_{BC}} = 0.2\ mm$$

$\rightarrow P = 44.0\ kN$

$\delta_B = \delta_{BC} = \delta_B - \delta_C$ ($\delta_C = 0$, C is fixed)

$= 0.1222\ mm$ ($\downarrow$)

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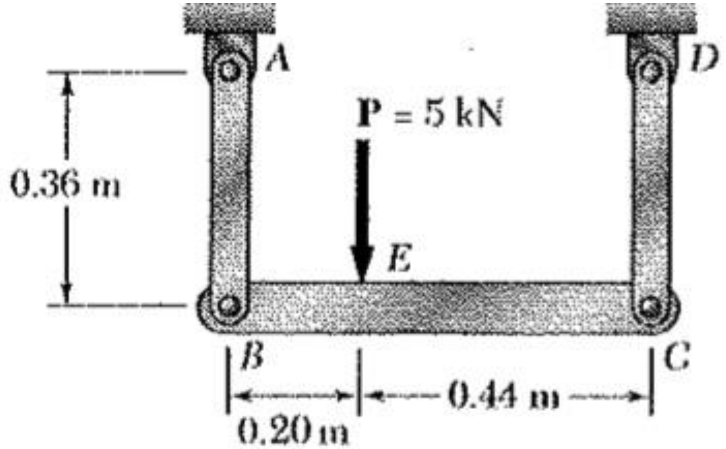
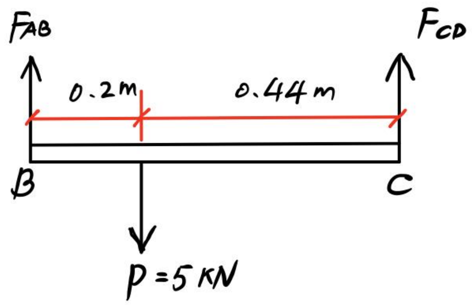
Exercise-2

2. Each of the link AB and CD is made of aluminum (E = 75 GPa) and has a cross-sectional area of 125 mm^2. Knowing that they support the rigid member BC, determine the deflection of point E.





Step 1

$\circlearrowleft \Sigma M_c = 0 \longrightarrow$

$-0.64 \cdot F_{AB} + P \cdot 0.44 = 0$

$\longrightarrow F_{AB} = 3.4375 \text{ kN}$

$\circlearrowleft \Sigma M_B = 0 \longrightarrow$

$0.64 \cdot F_{CD} - 0.2 \cdot P = 0$

$\longrightarrow F_{CD} = 1.5625 \text{ kN}$

Step 2

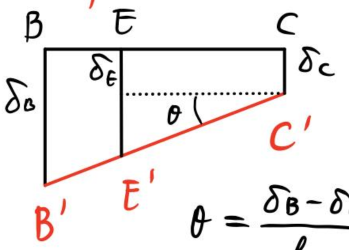
$$\delta_B = \frac{F_{AB} \cdot l}{EA} = \frac{3.4375 \times 10^3 \times 0.36}{75 \times 10^9 \times 125 \times 10^{-6}}$$

$$= 132 \times 10^{-6} \text{ m}$$

$$\delta_C = \frac{F_{CD} \cdot l}{EA} = \frac{1.5625 \times 10^3 \times 0.36}{75 \times 10^9 \times 125 \times 10^{-6}}$$

$$= 60 \times 10^{-6} \text{ m}$$

Step 3



$$\theta = \frac{\delta_B - \delta_C}{l_{BC}}$$

$$\delta_E = \delta_C + l_{CE} \cdot \theta$$

$$= \delta_C + \frac{l_{CE}}{l_{BC}} \cdot (\delta_B - \delta_C)$$

$$= 109.5 \times 10^{-6} \text{ m}$$

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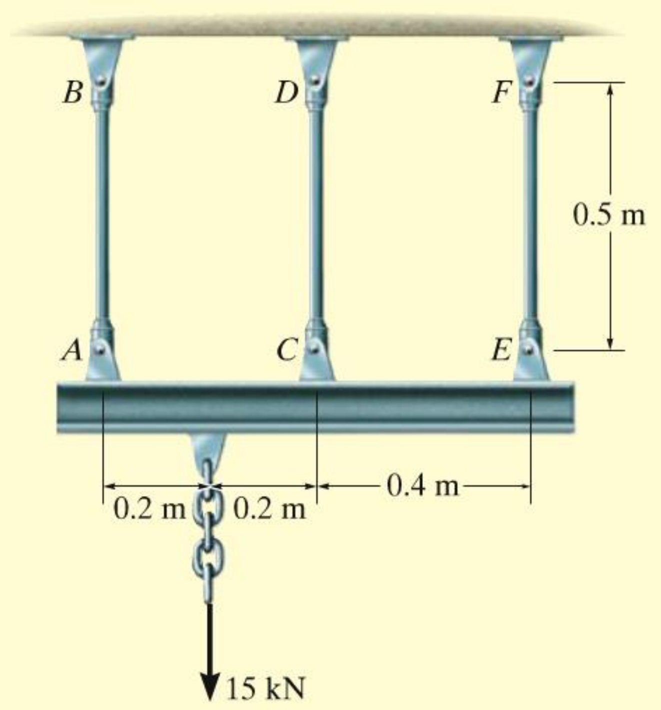
Exercise-3

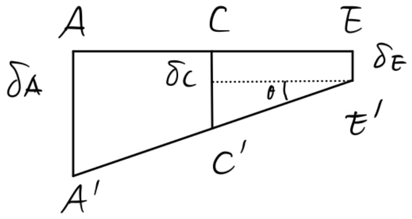
3. The steel bars shown in below are pin connected to a rigid member. If the applied load on the member is 15kN, determine the force developed in each bar. Bars *AB* and *EF* each have a cross-sectional area of 50mm^2, and the bar *CD* has a cross-sectional area of 30mm^2.



- 3 unknowns : F_{AB}, F_{CD}, F_{EF}
- we need 3 indepent equations to solve them
- equilibrium equations can only provide 2 independ equations, which are:

$\boxed{\Sigma F_y = 0}$ (1), $\boxed{\Sigma M_C = 0}$ (2) (or you can use $\Sigma M_A = 0$, $\Sigma M_E = 0, \cdots$)

- compatibility condition can provide 1 equation



$$\theta = \frac{\delta_A - \delta_E}{l_{AE}} = \frac{\delta_C - \delta_E}{l_{CE}}$$

$$\longrightarrow \boxed{\delta_C = \frac{\delta_A + \delta_E}{2}} \quad (3)$$

$F_A = 9.52$ kN, $F_C = 3.46$ kN, $F_E = 2.02$ kN