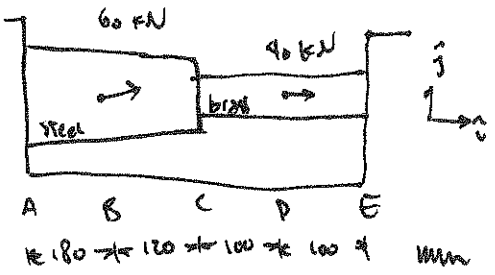
9.30. SOLUTION

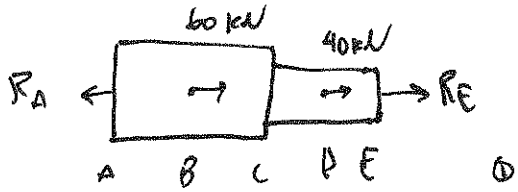


steel: $E_s = 200$ GPa, diam. = 40 mm

brass: $E_b = 105$ GPa, diam = 30 mm

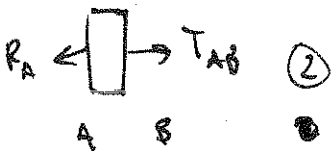
Find R_A, R_E, δ_C.

FBD of whole structure:

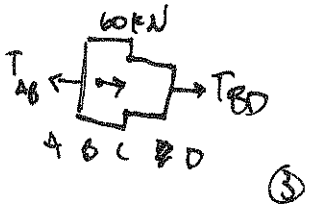


① : $\{\Sigma \vec{F} = \vec{0}\} \cdot \hat{i} \Rightarrow R_E + 100\,kN = R_A$

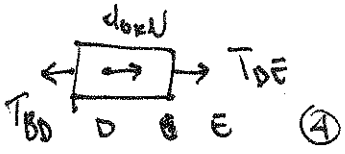
Partial FBDs



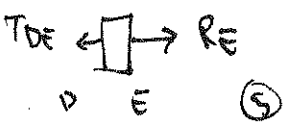
② : $\{\Sigma \vec{F} = \vec{0}\} \cdot \hat{i} \Rightarrow T_{AB} = R_A$



③ : $\{\Sigma \vec{F} = \vec{0}\} \cdot \hat{i} \Rightarrow T_{BD} + 60\,kN = T_{AB}$



④ : $\{\Sigma \vec{F} = \vec{0}\} \cdot \hat{i} \Rightarrow T_{DE} + 40\,kN = T_{BD}$



⑤ : $\{\Sigma \vec{F} = \vec{0}\} \cdot \hat{i} \Rightarrow R_E = T_{DE}$

→

9.30 cont.

Combine 5 eqns. to get:

$$T_{AB} = R_E + 100\,kN$$

$$T_{BD} = R_E + 40\,kN$$

$$T_{DE} = R_E$$

This is all we can get from statics, so let's look at material properties + geometry.

Material properties:

$$\delta_{AB} = \frac{T_{AB} L_{AB}}{E_S A_S} = \frac{(R_E + 100\,kN)(.18\,m)}{(200\,GPa)(\pi(.02\,m)^2)} = 7.16\cdot10^{-10}\,\frac{kg}{ms^2} R_E + 1.91\cdot10^{-5}\,m$$

$$\delta_{BC} = \frac{T_{BD} L_{BC}}{E_S A_S} = \frac{(R_E + 40\,kN)(.12\,m)}{(200\,GPa)(\pi(.02\,m)^2)} = 4.7\cdot10^{-10}\,\frac{kg}{ms^2} R_E + 1.91\cdot10^{-5}\,m$$

$$\delta_{CD} = \frac{T_{BD} L_{BC}}{E_b A_b} = \frac{(R_E + 40\,kN)(.1\,m)}{(100\,GPa)(\pi(.015\,m)^2)} = 1.35\cdot10^{-9}\,\frac{kg}{ms^2} R_E + 5.39\cdot10^{-5}\,m$$

$$\delta_{DE} = \frac{T_{DE} L_{DE}}{E_b A_b} = \frac{R_E\ (.1\,m)}{(105\,GPa)(\pi(.015\,m)^2)} = 1.35\cdot10^{-9}\,\frac{kg}{ms^2} R_E$$

→

9.30. cont.

From geometry:

$$\delta_{AB} + \delta_{BC} + \delta_{CD} + \delta_{DE} = 0$$

because ends are fixed.

Combine w/ material properties to get:

$$38.9 \cdot 10^{-10} \frac{kg}{mN^2} R_E + 14.96 \cdot 10^{-5} m = 0$$

$$\boxed{R_E = -37.3\ kN}$$

so since $R_E + 100\ kN = R_A$,

$$\boxed{R_A = 62.7\ kN}$$

and since $\delta_C = \delta_{AB} + \delta_{BC}$,

$$\delta_C = 1.19 \cdot 10^{-9} \frac{kg}{mN^2} (-37.3\ kN) + 9.07 \cdot 10^{-5} m$$

$$\boxed{\delta_C = 1.35 \cdot 10^{-4} m}$$