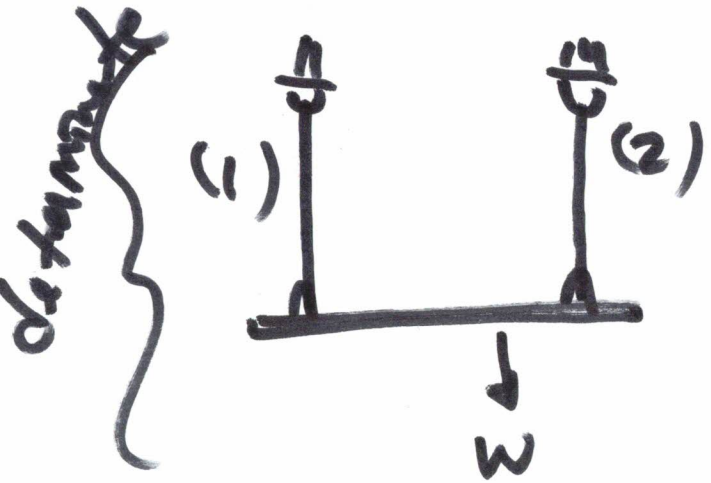
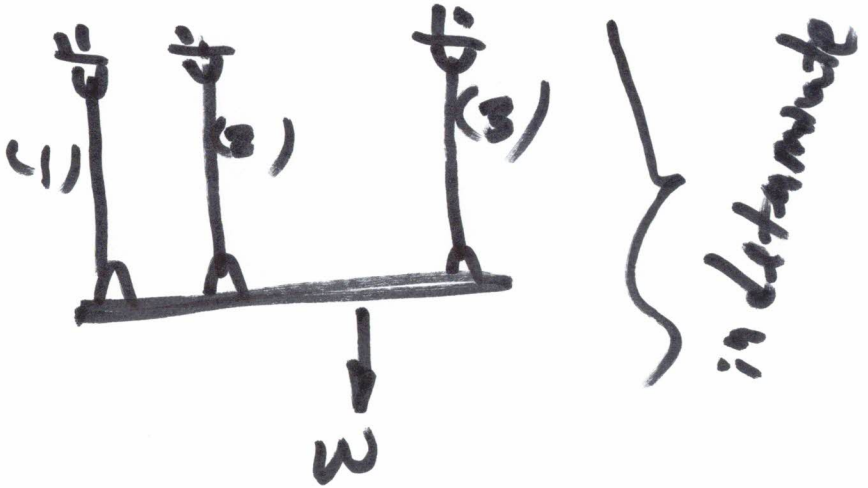
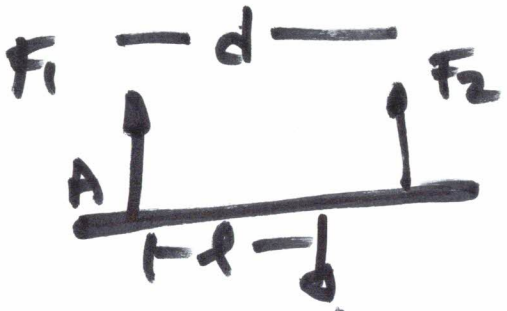
C. Statically Indeterminate

If the forces / reactions for the structure cannot be determined by statics alone, the structure is statically indeterminate.

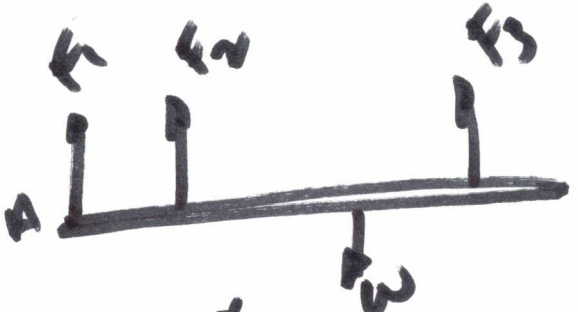






$\Sigma F_y \uparrow \quad F_1 + F_2 - W = 0$

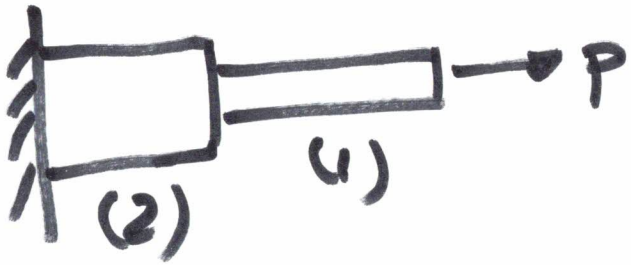
$\circlearrowleft \Sigma M_A \quad F_2 \cdot d - W\ell = 0$



$\Sigma F_y \uparrow$ } 2 eqn 3 unknowns

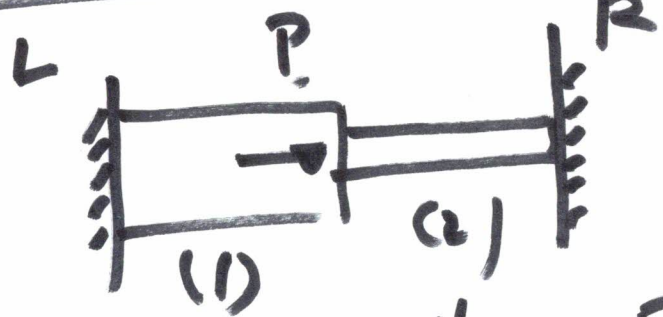
$\circlearrowleft \Sigma M_A$

1. Materials in series



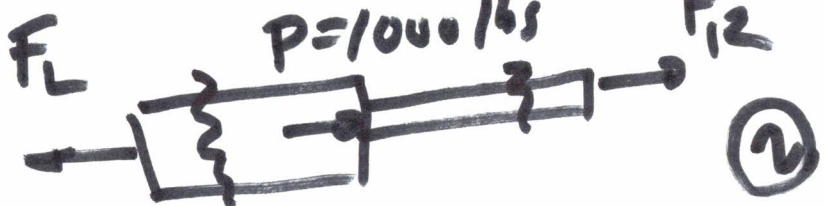
$$\delta_{total} = \delta_1 + \delta_2$$

$$= \frac{F_1 L_1}{A_1 E_1} + \frac{F_2 L_2}{A_2 E_2}$$



$$\delta_{total} = \delta_1 + \delta_2 = 0$$

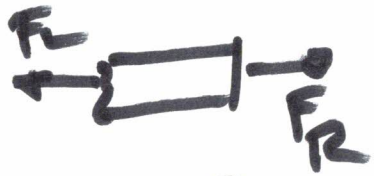
① $$\frac{F_1 L_1}{A_1 E_1} + \frac{F_2 L_2}{A_2 E_2} = 0$$



②

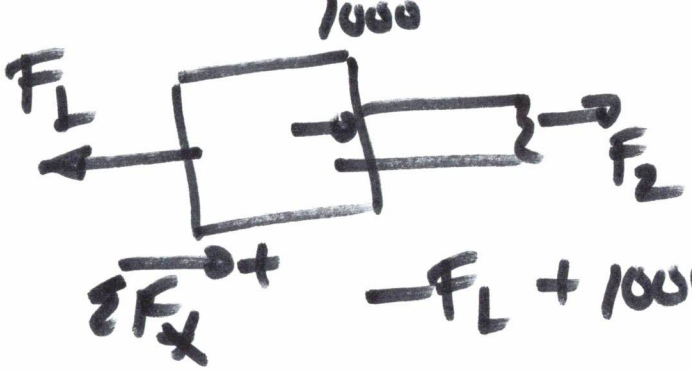
$$\Sigma F_y \quad -F_L + 1000 + F_R = 0$$

$F_1 = F_L$



$F_L = F_R$

statically indeterminate



$$-F_L + 1000 + F_2 = 0$$

$$F_2 = F_L - 1000 = F_R$$

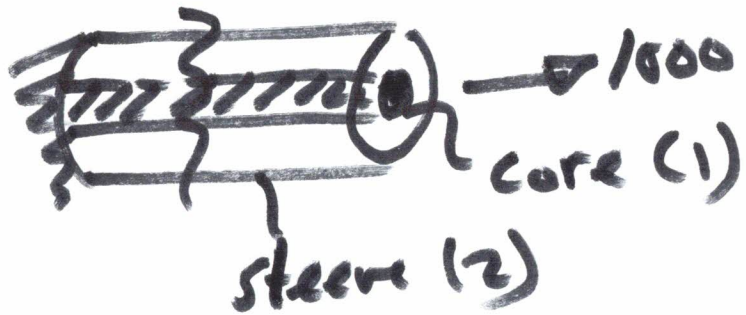
$$F_R = F_L - 1000$$

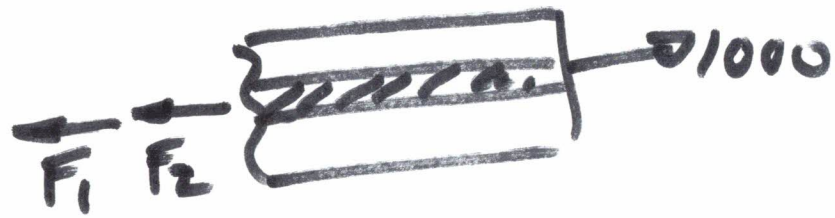
Solve ① & ② For F_L & F_R

or

F_1 & F_2

2. materials in parallel





① $F_1 + F_2 = 1000$

$e_1 = e_2$

② $\frac{F_1 L_1}{A_1 E_1} = \frac{F_2 L_2}{A_2 E_2}$

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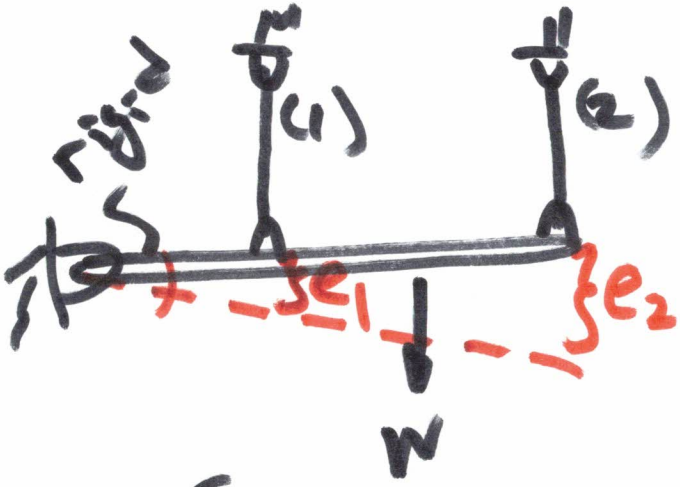
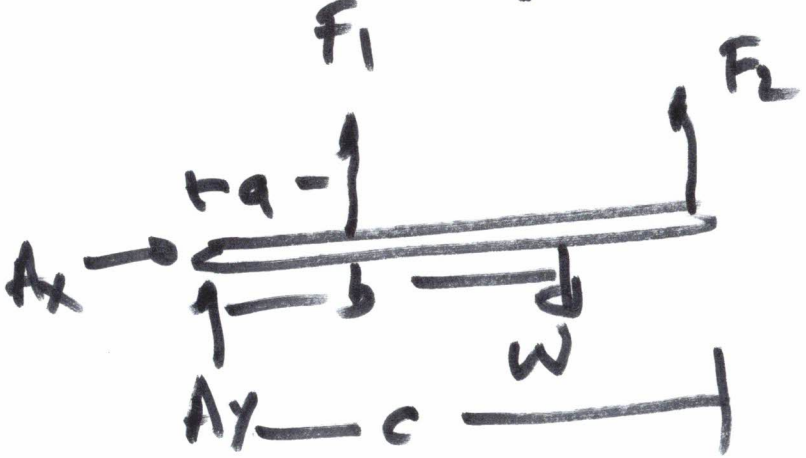
③ Similar Triangles





$\circlearrowleft + \sum M_A$ $F_2 \cdot c + F_1 a - W(b) = 0$ ①

$\frac{e_1}{a} = \frac{e_2}{c}$

$\frac{F_1 L_1}{A_1 E_1} = \frac{a}{c} \frac{F_2 L_2}{A_2 E_2}$ ②

$E_1 = 6.5 \times 10^3$ ksi

$E_2 = 15 \times 10^3$ ksi

$L_1 = L_2 = 20$ in

$d_1 = 1$ in

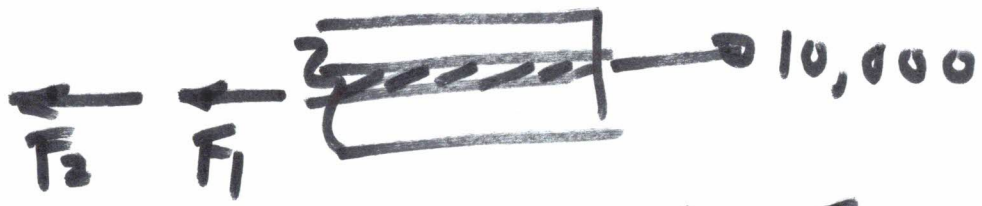
$d_{2o} = 1.5$ in

$d_{2i} = 1.0$ in

same

$$\varepsilon_1 = \varepsilon_2$$

$$\frac{F_1 L_1}{A_1 E_1} = \frac{F_2 L_2}{A_2 E_2}$$

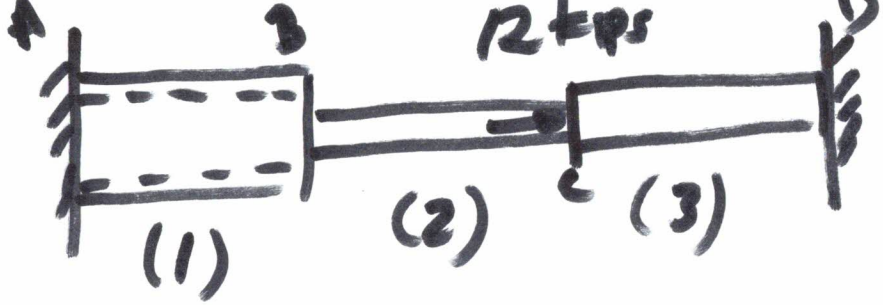


$$F_1 + F_2 = 10{,}000 \text{ lbs}$$

$$F_1 = F_2 \frac{L_2}{L_1} \frac{A_1}{A_2} \frac{E_1}{E_2} = F_2 (1) \frac{\frac{\pi}{4}(1)^2}{\frac{\pi}{4}[1.5^2 - 1.0^2]} \frac{6.5}{15}$$

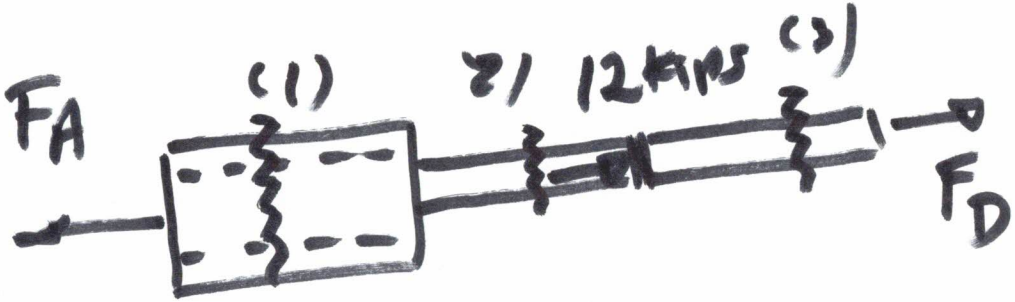
$$\sigma_1 = \frac{F_1}{A_1} \qquad \sigma_2 = \frac{F_2}{A_2}$$

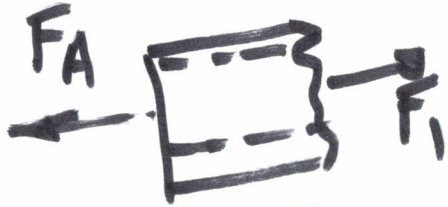
ε_1 , ε_2



$$\delta_1 + \delta_2 + \delta_3 = 0$$

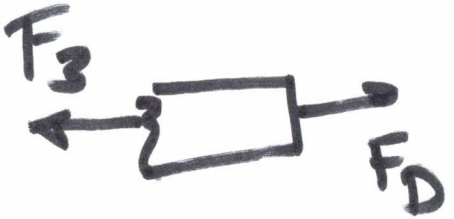
$$\frac{F_1 L_1}{A_1 E_1} + \frac{F_2 L_2}{A_2 E_2} + \frac{F_3 L_3}{A_3 E_3} \quad (1)$$





$F_1 = F_A$

$F_2 = F_A$



$F_3 = F_D$

$$\sum F_x \quad -F_A + 12{,}000 + F_D = 0 \quad (2)$$

D. Thermal with +Thermal ($\Delta T > 0$)

ΔT_1 ΔT_2 ΔT_3

$$e = \frac{FL}{AE} + \alpha \Delta T L$$

$$e_{total} = \sum_{i=1}^{3} \left(\frac{FL}{AE} + \alpha \Delta T L \right)_i$$