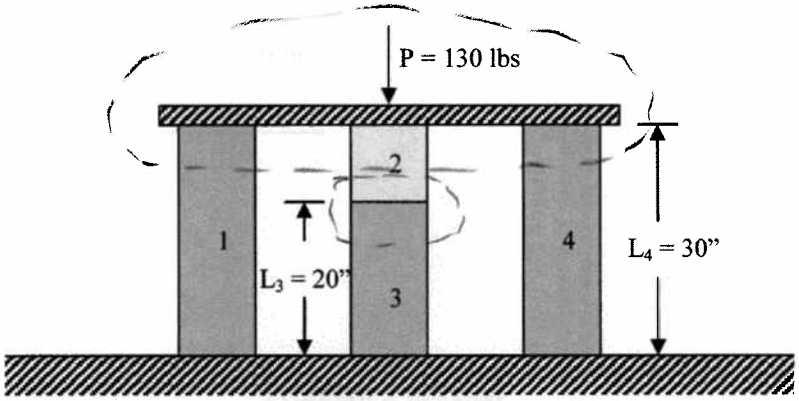
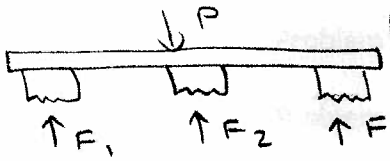
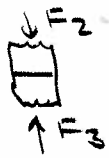
Problem 4 – *33 points*

We are supporting a rigid plate with blocks of metal, as shown in the figure below. Blocks 1 and 4 are steel, and they are the same size. Block 3 is also steel, but it wasn't tall enough so we cut an aluminum block (Block 2) to fit under the plate. The elastic modulus of steel is $E_S = 30\text{x}10^6$ psi and the elastic modulus of aluminum is $E_A = 10\text{x}10^6$ psi. All of the blocks have the same cross-sectional area. What are the internal forces in each of the four blocks? You may assume that both the internal forces and the deflections of Blocks 1 and 4 are the same.



FBD: 

6 pts



6 pts, even if no FBD and if only implied

Equilibrium: $P = F_1 + F_2 + F_4$ 6pts

$F_2 = F_3$

(If Equil follows from FBD give 6pts)

Geometry: $\delta_1 = \delta_2 + \delta_3 = \delta_4$ 6pts

Force-Deflection: $\delta_1 = \frac{F_1 L_1}{E_S A}$ $\delta_2 = \frac{F_2 L_2}{E_a A}$ $\delta_3 = \frac{F_3 L_3}{E_S A}$ 6pts

(Give the 6pts generously)

Solve: $\frac{F_1 L_1}{E_S A} = \frac{F_2 L_2}{E_a A} + \frac{F_3 L_3}{E_S A} = F_2\left(\frac{L_2}{E_a} + \frac{L_3}{E_S}\right)$ 3 pts if solve some reasonable system.

$F_1 = F_2\left(\frac{E_S}{E_a}\frac{L_2}{L_1} + \frac{L_3}{L_1}\right) = F_2\left(3\frac{1}{3} + \frac{2}{3}\right) = \frac{5}{3}F_2$

$P = 2F_1 + F_2 = 2\left(\frac{5}{3}F_2\right) + F_2 = \frac{13}{3}F_2$ $\quad F_2 = \frac{3}{13}(130) = 30\text{lbs}$

$F_1 = \frac{5}{3}F_2 = 50\text{ lbs}$

$F_1 = F_4 = 50\text{lbs} \quad F_2 = F_3 = 30\text{lbs}$