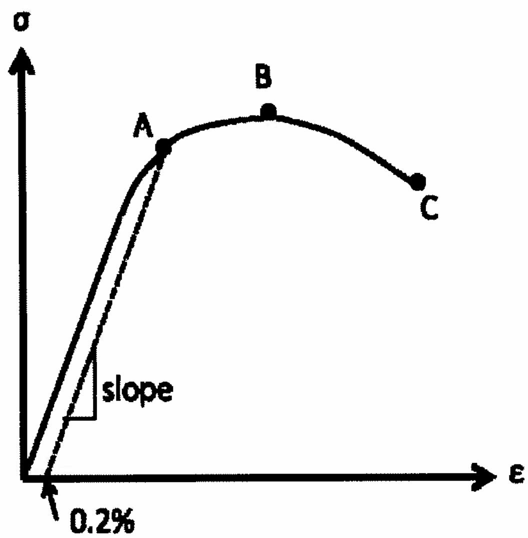
Grading Key vA Spr 2010

Problem 1 – Short Answer -- ***22 points***

[4] (a) For each term on the right, list the appropriate label on the figure below (A, B, C, slope, or none):



Breaking strength C

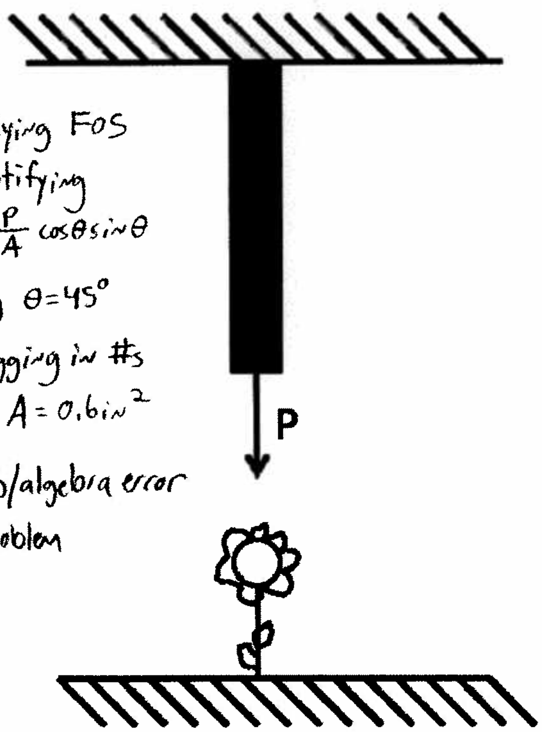
Yield strength A

Poisson's Ratio NONE

Young's Modulus Slope

1 point each

[8] (b) The structure below should be designed with a factor of safety of 3. Find the appropriate cross-sectional area of the bar such that the bar does not fail, and the flower is safe. Assume that the bar will ***fail in shear*** at a shear stress of 10 ksi. The load P = 4 kip is applied to the bar as shown.



+2 for applying FOS
+2 for identifying $\tau = \frac{P}{A}\cos\theta\sin\theta$
+2 for using $\theta = 45°$
+2 for plugging in #s to get $A = 0.6\,in^2$
-1 for math/algebra error
-1 unit problem

$$\tau_{allow} = \frac{\tau_{fail}}{FOS} = \frac{10\times10^3\,psi}{3} = 3.33\times10^3\,psi$$

$$\tau_{allow} = \frac{P}{A_o}\cos\theta\sin\theta$$

maximum at 45°, $\cos 45° \sin 45° = \frac{1}{2}$

$$\tau_{allow} = \frac{P}{2A_o} \Rightarrow A_o = \frac{P}{2\tau_{allow}} = \frac{4\times10^3\,lb}{(2)(3.33\times10^3\,psi)}$$

$$\boxed{A_o = 0.6\,in^2}$$

(c) A rope is pulled between point A (2, 5, 7) and point B (4, 0, 3). Define (write out) the unit vector, $\hat{e}_{AB}$, which points along the line from point A to point B.

5pts

$$r_{AB} = 2\hat{i} - 5\hat{j} - 4\hat{k} \text{ m} \quad 2\text{pts}$$

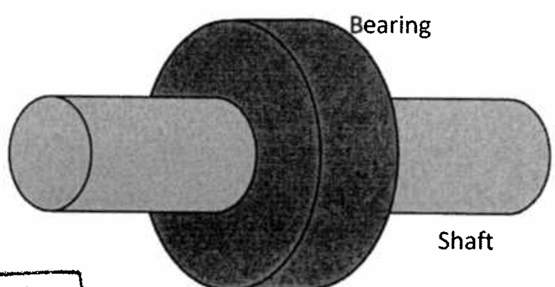
$$|r_{AB}| = \sqrt{(2)^2 + (5)^2 + (4)^2} \text{ m} \quad 2\text{ pts}$$

$$\hat{e}_{AB} = \frac{r_{AB}}{|r_{AB}|}$$

$$= 0.298\hat{i} - 0.745\hat{j} - 0.596\hat{k} \quad 1\text{ pt}$$

no units

(d) A steel roller bearing needs to be placed on the outside of a shaft, as seen in the assembly image below. At room temperature (25°C), the inner diameter of the bearing is 10.25 cm and the outer diameter of the shaft is 10.3 cm, therefore the bearing needs to be heated to assemble the two components. Assuming the shaft remains at room temperature, to what minimum temperature does the bearing need to be heated to make this assembly possible? The coefficient of thermal expansion for the bearing is 17.3×10^{-6} /°C.



5pts

$$\Delta d = 10.3\text{ cm} - 10.25\text{ cm} \quad 2\text{pts}$$

$$\Delta d = \alpha \Delta T d$$

$$\Delta T = \frac{\Delta d}{\alpha d} = \frac{0.05\text{ cm}}{(17.3\times10^{-6}/^\circ C)(10.25\text{ cm})}$$

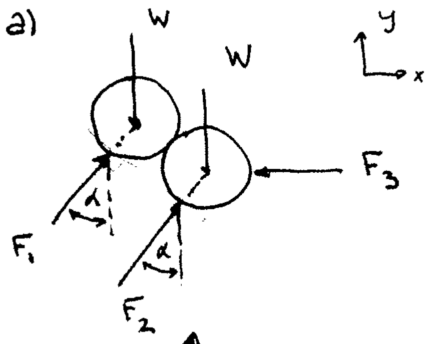
$$= 282^\circ C \quad 2\text{ pts}$$

$$T_{final} = T_{initial} + \Delta T$$

$$= 25^\circ C + 282^\circ C = 307^\circ C \quad 1\text{ pt}$$

EXAM 1 SP 09-10 PROBLEM 2

a)



F.B.D.

EQUILIBRIUM:

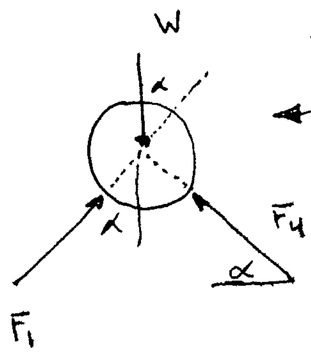
$\uparrow \sum F_y = 0$

$$\overset{?}{F_1} \cos\alpha + \overset{?}{F_2} \cos\alpha - W - W = 0 \qquad (1)$$

$\rightarrow \sum F_x = 0$

$$F_1 \sin\alpha + F_2 \sin\alpha - \overset{?}{F_3} = 0 \qquad (2)$$

2 EQUATIONS, 3 UNKNOWNS. NEED ANOTHER FBD.



FBD PIPE 1

$\rightarrow \sum F_x = 0$

$$F_1 \sin\alpha - \overset{?}{F_4} \cos\alpha = 0 \qquad (3)$$

$\uparrow \sum F_y = 0$

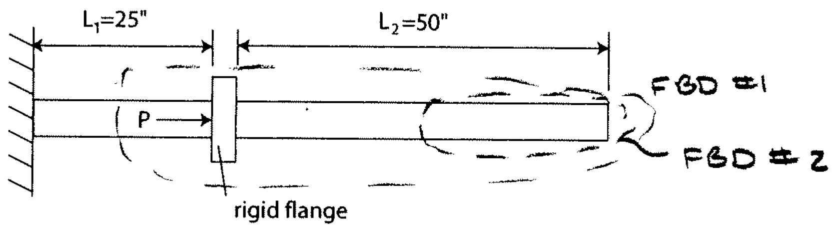
$$F_1 \cos\alpha + F_4 \sin\alpha - W = 0 \qquad (4)$$

SOLVE 4 EQNS [(1) - (4)] FOR 4 UNKNOWNS (F_1, F_2, F_3 & F_4)

POINTS:

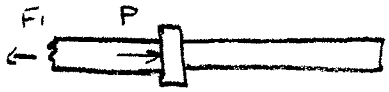
FBD 2 PIPES	5	PTS
FBD 1 PIPE	5	PTS
EQUIL. EQNS @ 6 PTS EA.	24	PTS
	34	PTS.

Problem 3 – *44 points*



(11 pts) (a) Consider the rod shown in the diagram above. We apply a force P=1000 lb to the rigid flange. If the rod has a cross-sectional area A=1 in^2, and a Young's modulus of E = 10,000 ksi, how far does the flange move when the force is applied?

FBD #1



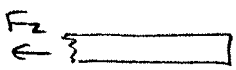
$F_1 = P$

(4 pts) $\delta = \frac{P L_1}{EA} = \frac{(1000\ lb)(25'')}{(10^7\ psi)(1'')^2}$

(FBDs 5 pts) Might only get one.

(2 pts) $\delta = .0025$ in

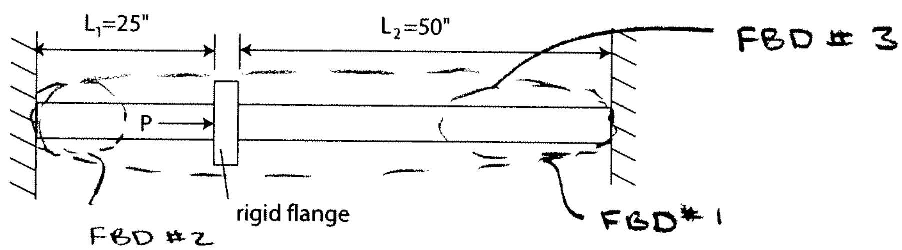
FBD #2



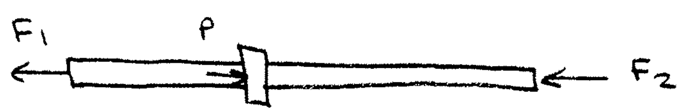
$F_2 = 0$

so net deflection is

(33 pts) (b) Now suppose that the far end of the rod is touching a wall, as shown in the diagram below. (Before the force was applied, the rod just barely touched the wall.) For this new configuration, how far does the rigid flange move when the force is applied?



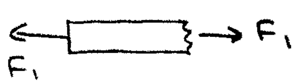
FBD #1



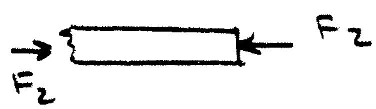
(FBD's 15 pts)

$-F_1 + P - F_2 = 0$ $P = F_1 + F_2$ (5 pts)

FBD #2



FBD #3



Geometry: $\delta_1 + \delta_2 = 0$ (5 pts)

Force - Deflection:

$$\delta_1 = \frac{-F_1 L_1}{EA}$$

(6 pts total)

$$\delta_2 = \frac{F_2 L_2}{EA}$$

Solving: (2 pts)

$$\frac{F_1 L_1}{\cancel{EA}} = \frac{F_2 L_2}{\cancel{EA}} \qquad F_1 = F_2 \frac{L_2}{L_1} = 2F_2$$

$$P = (2F_2) + F_2 = 3F_2$$

$F_2 = P/3 = 333$ lbs (compression)

$F_1 = 2F_2 = 667$ lbs (tension)