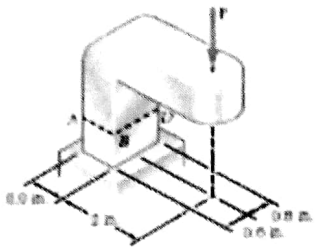
Mid Term Exam
Strength of materials PDE181
Time: 1 hrs

Please, solve all the following problems with clear net sketch and force analysis diagrams

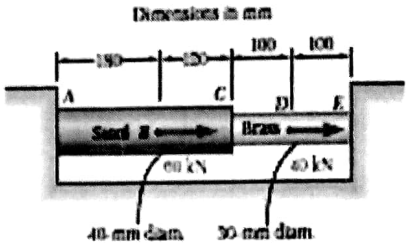
Problem 1: (15 marks)

Knowing that the allowable stress in section ABD is 10 ksi, determine the largest force P that can be applied to the bracket shown.E.



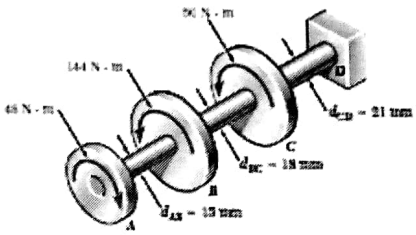
Problem 2: (10 marks)

Two cylindrical rods, one of steel and the other of brass, are joined at *C* and restrained by rigid supports at *A* and *E*. For the loading shown and knowing that *Es* 5 200 GPa and *Eb* 5 105 GPa, determine:(*a*) the reactions at *A* and *E*, (*b*) the deflection of point *C*.



Problem 3: (15 marks)

Knowing that each of the shafts *AB*, *BC*, and *CD* consists of a solid circular rod, determine (*a*) the shaft in which the maximum shearing stress occurs, (*b*) the magnitude of that stress.

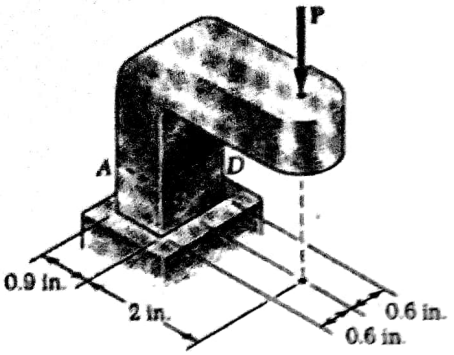


Wish you the Best of Luck

Dr./ Mona Abou-Eleaz

Problem 1

4.109 Knowing that the allowable stress in section *ABD* is 10 ksi, determine the largest force **P** which can be applied to the bracket shown.



$A = (1.2)(0.9) = 1.08 \text{ in}^2$

$I = \frac{1}{12}(1.2)(0.9)^3 = 72.9 \times 10^{-3} \text{ in}^4$

$c = \frac{1}{2}(0.9) = 0.45 \text{ in.}$

$e = 2 + 0.45 = 2.45 \text{ in.}$

$$\sigma = \frac{P}{A} + \frac{Mc}{I} = \frac{P}{A} + \frac{Pec}{I} = PK$$

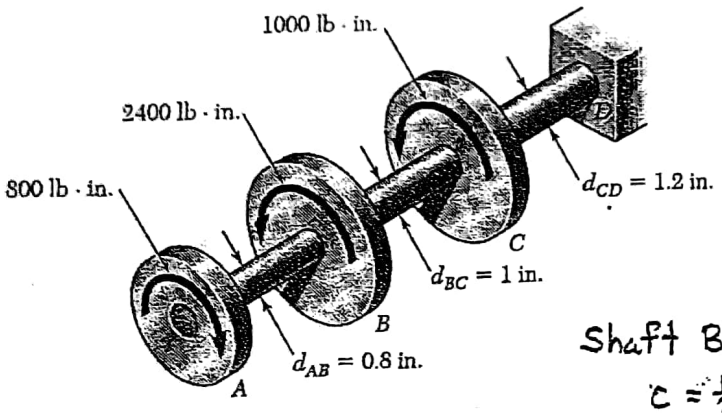
$$K = \frac{1}{A} + \frac{ec}{I} = \frac{1}{1.08} + \frac{(2.45)(0.45)}{72.9 \times 10^{-3}} = 16.049 \text{ in}^{-2}$$

$$P = \frac{\sigma}{K} = \frac{10}{16.049} = 0.623 \text{ kip}$$

$P = 623 \text{ lb}$

Problem 3

3.9 Knowing that each of the shafts *AB*, *BC*, and *CD* consist of solid circular rods, determine (*a*) the shaft in which the maximum shearing stress occurs, (*b*) the magnitude of that stress.



Shaft AB: $T = 800 \text{ lb-in}$

$c = \frac{1}{2}d = 0.4 \text{ in.}$

$$\tau_{max} = \frac{Tc}{J} = \frac{2T}{\pi c^3}$$

$$\tau_{max} = \frac{(2)(800)}{\pi (0.4)^3} = 7957 \text{ psi}$$

Shaft BC: $T = -800 + 2400 = 1600 \text{ lb-in}$

$c = \frac{1}{2}d = 0.5 \text{ in.}$

$$\tau_{max} = \frac{(2)(1600)}{\pi (0.5)^3} = 8149 \text{ psi (largest)}$$

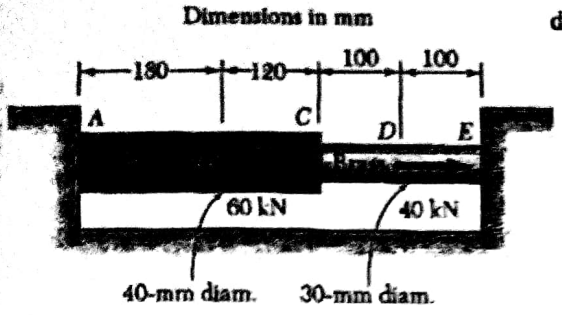
Shaft CD: $T = -800 + 2400 + 1000 = 2600 \text{ lb-in}$ $\quad c = \frac{1}{2}d = 0.6 \text{ in.}$

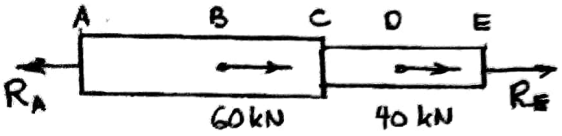
$$\tau_{max} = \frac{(2)(2600)}{\pi (0.6)^3} = 7663 \text{ psi}$$

Answers: (a) Shaft BC (b) 8.15 ksi

Problem 2.

2.39 Two cylindrical rods, one of steel and the other of brass, are joined at C and restrained by rigid supports at A and E. For the loading shown and knowing that E_s = 200 GPa and E_b = 105 GPa, determine (*a*) the reactions at A and E, (*b*) the deflection of point C.





A to C: $E = 200\times10^9$ Pa

$A = \frac{\pi}{4}(40)^2 = 1.25664\times10^3\ mm^2 = 1.25664\times10^{-3}\ m^2$

$EA = 251.327\times10^6$ N

C to E: $E = 105\times10^9$ Pa

$A = \frac{\pi}{4}(30)^2 = 706.86\ mm^2 = 706.86\times10^{-6}\ m^2$

$EA = 74.220\times10^6$ N

A to B: $P = R_A$ $\quad L = 180\ mm = 0.180\ m$

$$\delta_{AB} = \frac{PL}{EA} = \frac{R_A(0.180)}{251.327\times10^6} = 716.20\times10^{-12}\,R_A$$

B to C: $P = R_A - 60\times10^3$ $\quad L = 120\ mm = 0.120\ m$

$$\delta_{BC} = \frac{PL}{EA} = \frac{(R_A - 60\times10^3)(0.120)}{251.327\times10^6} = 447.47\times10^{-12}\,R_A - 26.848\times10^{-6}$$

C to D: $P = R_A - 60\times10^3$ $\quad L = 100\ mm = 0.100\ m$

$$\delta_{BC} = \frac{PL}{EA} = \frac{(R_A - 60\times10^3)(0.100)}{74.220\times10^6} = 1.34735\times10^{-9}\,R_A - 80.841\times10^{-6}$$

D to E: $P = R_A - 100\times10^3$ $\quad L = 100\ mm = 0.100\ m$

$$\delta_{DE} = \frac{PL}{EA} = \frac{(R_A - 100\times10^3)(0.100)}{74.220\times10^6} = 1.34735\times10^{-9}\,R_A - 134.735\times10^{-6}$$

A to E: $\delta_{AE} = \delta_{AB} + \delta_{BC} + \delta_{CD} + \delta_{DE} = 3.85837\times10^{-9}\,R_A - 242.424\times10^{-6}$

Since point E cannot move relative to A, $\delta_{AE} = 0$

(a) $3.85837\times10^{-9}\,R_A - 242.424\times10^{-6} = 0$ $\quad R_A = 62.831\times10^3$ N $\quad$ 62.8 kN ←

$R_E = R_A - 100\times10^3 = 62.8\times10^3 - 100\times10^3 = -37.2\times10^3$ N $\quad$ 37.2 kN ←

(b) $\delta_C = \delta_{AB} + \delta_{BC} = 1.16367\times10^{-9}\,R_A - 26.848\times10^{-6}$

$= (1.16369\times10^{-9})(62.831\times10^3) - 26.848\times10^{-6}$

$= 46.3\times10^{-6}$ m $\quad$ 46.3 μm →