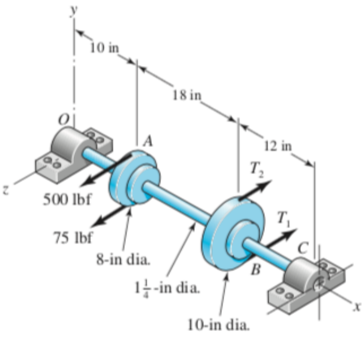
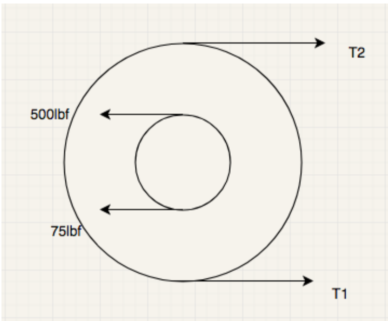
3-68 A countershaft carrying two V-belt pulleys is shown in the figure. Pulley *A* receives power from a motor through a belt with the belt tensions shown. The power is transmitted through the shaft and delivered to the belt on pulley *B*. Assume the belt tension on the loose side at *B* is 15 per- cent of the tension on the tight side.



Problem 3–68*

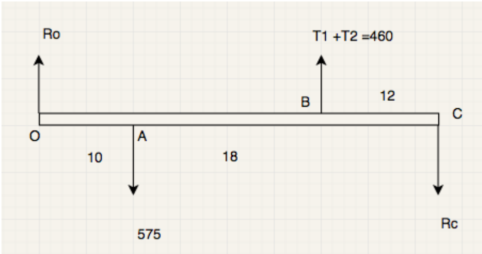
1. (*a*) Determine the tensions in the belt on pulley *B*, assuming the shaft is running at a constant speed.



#Sum of Torques
$solve(\{(500-75)\cdot(4)-(T[2]-T[1])\cdot(5)=0, 1700-(T[2]-0.15\,T[2])\cdot(5)=0\}, \{T[1], T[2]\})$

$\{T_1 = 60., T_2 = 400.\}$

2. (*b*) Find the magnitudes of the bearing reaction forces, assuming the bearings act as simple supports.



#Sum of moments at 'O'

$$R[C] := evalf\left(\frac{(-575\cdot 10+(10+18)\cdot(460))}{(12+18+10)}\right)$$

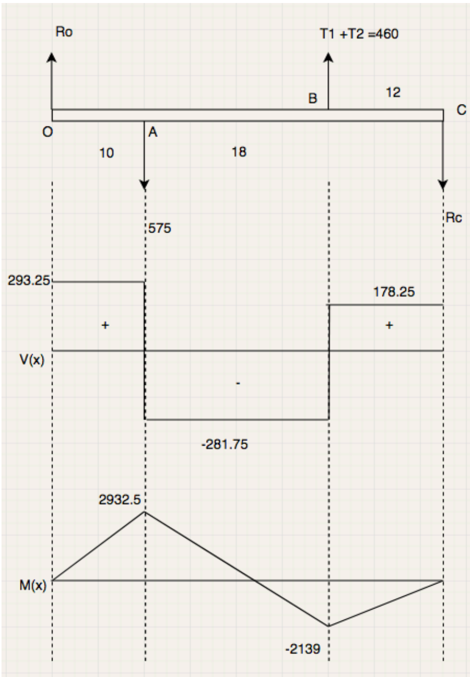
$R_C := 178.2500000$

#Sum of moments at 'C'

$$R[O] := evalf\left(\frac{(-460\cdot 12+(18+12)\cdot 575)}{10+18+12}\right)$$

$R_O := 293.2500000$

3. (*c*) Draw shear-force and bending-moment diagrams for the shaft. If needed, make one set for the horizontal plane and another set for the vertical plane.



4. (*d*) At the point of maximum bending moment, determine the bending stress and the torsional shear stress.

#max bending moment

$$\text{sigma} = \frac{Mc}{\text{Iota}}$$

$$\sigma = \frac{Mc}{\mathrm{I}}$$

$$\text{sigma} := \frac{32 \cdot M}{\text{Pi} \cdot d^3}$$

$$\sigma := \frac{32\,M}{\pi\,d^3}$$

 # find torshinal Shear

$$\text{tau} = \frac{T \cdot r}{J}$$

$$d := 1.25$$

$$d := 1.25$$

$$\tau = \frac{T\,r}{J}$$

$$M := 2932.5$$

$$T := (500 - 75) \cdot 4$$

$$M := 2932.5$$

$$T := 1700$$

$$\text{sigma} := \frac{32 \cdot M}{\text{Pi} \cdot d^3}$$

$$\text{tau} := \frac{16 \cdot T}{\text{Pi} \cdot d^3}$$

$$\sigma := 15293.54225$$

$$\tau := 4432.910798$$

5. (*e*) At the point of maximum bending moment, determine the principal stresses and the maximum shear stress.

#Princeible stresses

$$\text{sigma}[1] := \frac{\text{sigma}[x]}{2} + \text{sqrt}\left(\left(\frac{(\text{sigma}[x])}{2}\right)^2 + \text{tau}[xy]^2\right)$$

$$\sigma_1 := 16485.53839$$

$$\text{sigma}[3] := \frac{\text{sigma}[x]}{2} - \text{sqrt}\left(\left(\frac{(\text{sigma}[x])}{2}\right)^2 + \text{tau}[xy]^2\right)$$

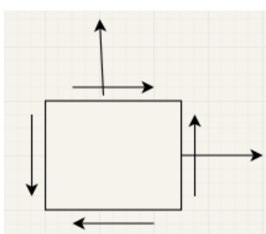
$$\sigma_3 := -1191.996141$$

$$\text{sigma}[2] := 0$$

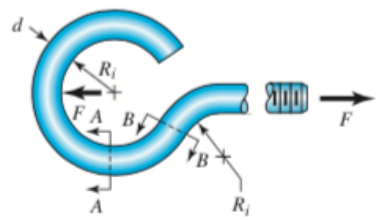
$$\sigma_2 := 0$$

$$\text{tau}[\max] := \frac{\text{sigma}[1] - \text{sigma}[2]}{2}$$

$$\tau_{\max} := 8242.769195$$



3-122 The steel eyebolt shown in the figure is loaded with a force F 5 300 N. The bolt is formed from wire of diameter d 5 6 mm to a radius R_i 5 10 mm in the eye and at the shank. Estimate the stresses at the inner and outer surfaces at section A–A.



$$d := 6$$
$$d := 6$$

$$F := 300$$
$$F := 300$$

$$R := 10$$
$$R := 10$$

$$r[In] := 10$$
$$r_{In} := 10$$

$$r[out] := 16$$
$$r_{out} := 16$$

$$r[centr] := r[In] + \frac{d}{2}$$
$$r_{centr} := 13$$

$$r[nut] := evalf\left(\left(\frac{d}{2}\right)^2 \Big/ \left(2\cdot\left(r[centr] - \text{sqrt}\left((r[centr])^2 - \left(\frac{d}{2}\right)^2\right)\right)\right)\right)$$
$$r_{nut} := 12.82455529$$

$$A := evalf\left(\frac{\text{Pi}}{4}d^2\right)$$
$$A := 28.27433389$$

$$e := r[centr]-r[nut]$$
$$e := 0.17544471$$

$$C[o] := r[out] - r[nut]$$
$$C_o := 3.17544471$$

$$C[i] := r[nut] - r[In]$$
$$C_i := 2.82455529$$

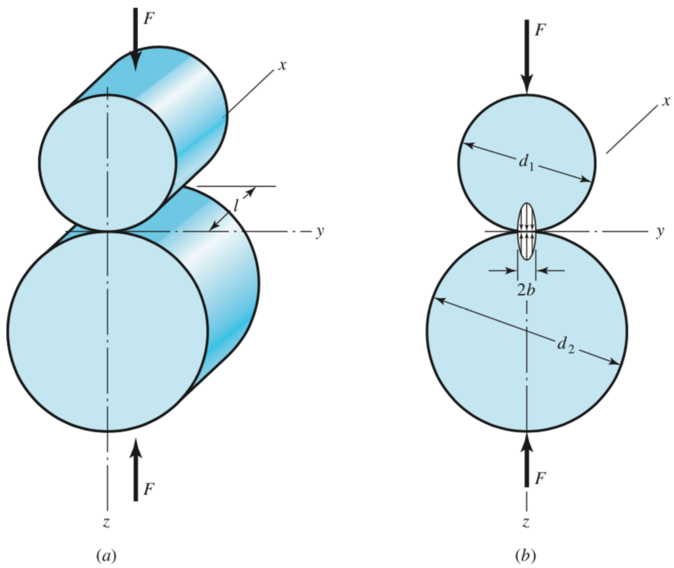
$$M := 300\cdot 13$$
$$M := 3900$$

$$\sigma_o := 260.2631645$$

$$\text{sigma}[i] := \frac{F}{A} + \frac{M\cdot C[i]}{A\cdot e\cdot r[In]}$$
$$\sigma_i := 232.6763077$$

$$\text{sigma}[o] := \frac{F}{A} - \frac{M\cdot C[o]}{A\cdot e\cdot r[out]}$$
$$\sigma_o := -145.4226924$$

3-138 An aluminum alloy cylindrical roller with diameter 1.25 in and length 2 in rolls on the inside of a cast-iron ring having an inside radius of 6 in, which is 2 in thick. Find the maximum contact force F that can be used if the shear stress is not to exceed 4000 psi.



$$b := \mathrm{sqrt}\left(\frac{2\cdot F}{\mathrm{Pi}\cdot L}\cdot\frac{\frac{(1-\mathrm{nu}[1]^2)}{E[1]}+\frac{(1-\mathrm{nu}[2]^2)}{E[2]}}{\frac{1}{d[1]}-\frac{1}{d[2]}}\right)$$

$$b := \sqrt{2}\sqrt{\frac{F\left(\frac{-v_1^2+1}{E_1}+\frac{-v_2^2+1}{E_2}\right)}{\pi L\left(\frac{1}{d_1}-\frac{1}{d_2}\right)}}$$

$P := 4000$

$P := 4000$

$L := 2$ # in

$L := 2$

nu[1] := .333 #Al

$v_1 := 0.333$

nu[2] := .211 #cast iron

$v_2 := 0.211$

$E[1] := 10.4\cdot 10^6$

$E_1 := 1.04000000\ 10^7$

$E[2] := 14.5\cdot 10^6$

$E_2 := 1.45000000\ 10^7$

$d[1] := 1.25$

$d_1 := 1.25$

$d[2] := 6\cdot 2$

$d_2 := 12$

evalf(b)

$0.0002593045282\sqrt{F}$

$$solve\left(P=\frac{2\,F}{\mathrm{Pi}\cdot b\cdot L}, F\right)$$

10.61793176

$$\frac{112.7404749}{.3}$$

375.8015830

$$\frac{112.7404749}{.322}$$

350.1256984

$$\left(\frac{4000}{.3}\right)^2$$

$1.777777777\ 10^8$

$solve\left(\{4000 = 0.322\sqrt{F}\}, \{F\}\right)$

$$\left(\frac{4000}{.322}\right)^2$$

$1.543150342\ 10^8$

$$b = \sqrt{\frac{2F}{\pi l}\,\frac{(1-\nu_1^2)/E_1 + (1-\nu_2^2)/E_2}{1/d_1 + 1/d_2}}$$

The maximum pressure is

$$p_{\max} = \frac{2F}{\pi b l}$$

$$\sigma_x = -2\nu p_{\max}\left(\sqrt{1+\frac{z^2}{b^2}} - \left|\frac{z}{b}\right|\right) \tag{3–75}$$

$$\sigma_y = -p_{\max}\left(\frac{1+2\frac{z^2}{b^2}}{\sqrt{1+\frac{z^2}{b^2}}} - 2\left|\frac{z}{b}\right|\right) \tag{3–76}$$

$$\sigma_3 = \sigma_z = \frac{-p_{\max}}{\sqrt{1+z^2/b^2}} \tag{3–77}$$