Given: Shaft rotating at 550 rpm; spur gear with 96 teeth and a diametral pitch of 6. 20° pressure angle. 30 hp transmitted to spur gear from pinion.

Find: Torque delivered to the shaft and the tangential and radial forces acting on the shaft.

Solution: Determine pitch diameter from diametral pitch information.

$$P = \frac{N}{D} \Rightarrow D = \frac{N}{P} = \frac{96}{6} = 16 \text{ inches.}$$

Determine torque

$$T = 63{,}000 \frac{P}{n} \qquad P = 30 \text{ hp}, \quad n = 550 \text{ rpm}$$

$$= \underline{3{,}440. \text{ in-lb}}$$

Determine shaft loads

$$W_t = \frac{T}{D/2} = \frac{3{,}440 \text{ in-lb}}{(16 \text{ inches})/2} = \underline{430 \text{ lb}}$$

$$W_r = W_t \cdot \tan\phi = \underline{157. \text{ lb}}$$

Given: Shaft rotating at 200 rpm with 20-in-diameter flat belt pulley. Pulley receives 10 hp from below.

Find: Torque delivered by the pulley to the shaft and the force exerted on the shaft by the pulley.

Solution:

$$T = 63{,}000 \frac{P}{n} \qquad P = 10 \text{ hp}, \quad n = 200 \text{ rpm}$$

$$\Rightarrow T = \underline{3{,}150 \text{ in-lb}}$$

Net driving force

$$F_n = \frac{T}{D/2} \qquad T = 3{,}150 \text{ in-lb}, \quad D = 20 \text{ in}$$

$$F_n = 315. \text{ lb}$$

Bend force

$$F_B = 1.5 F_n$$

$$F_B = \underline{473. \text{ lb}}$$

Given: Shaft is rotating at 650 rpm and receives 7.5 hp through a flexible coupling. Helical gear having a normal pressure angle of 20° and a 45° helix angle. The pitch diameter is 4.141 in.

Find: (a) draw free-body diagrams for the shaft in both the vertical and horizontal planes.
(b) find the magnitude of the forces.
c) draw the shearing force and bending moment diagrams for the shaft in both planes.

Solution:

$$T = 63{,}000 \frac{P}{n} \qquad P = 7.5 \text{ hp}, \quad n = 650 \text{ rpm}$$

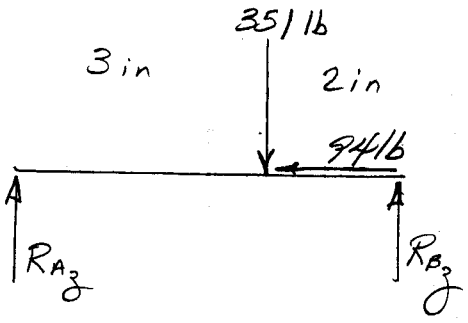
$$\Rightarrow T = \underline{727 \text{ in-lb.}}$$

$$W_t = \frac{T}{D/2} = \frac{727}{(4.141/2)} = \underline{351.1\text{b}}$$

$$W_r = W_t \tan\phi / \cos\psi$$

$$= \underline{133.1\text{b}}$$

$$W_x = W_t \tan\psi = \underline{94\,1\text{b}}$$



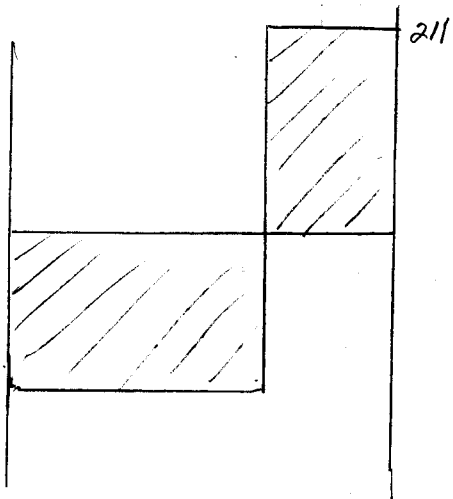
Looking Down

$$\Sigma M_A = 0 = R_{B_z}(5) - 351(3)$$

$$\Rightarrow R_{B_z} = \underline{\underline{211.\ lb}}$$

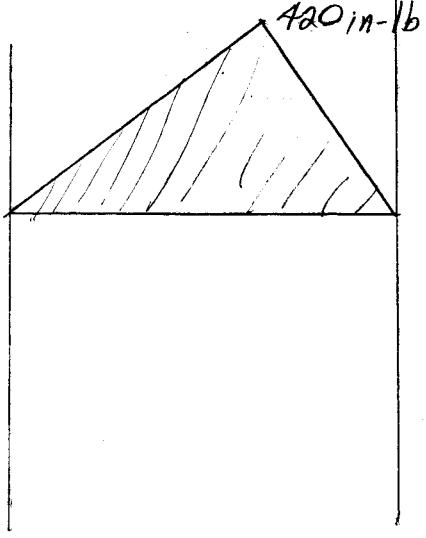
$$\Sigma F_z = 0 = R_{A_z} - 351 + 211 \Rightarrow R_{A_z} = \underline{\underline{140\ lb}}$$

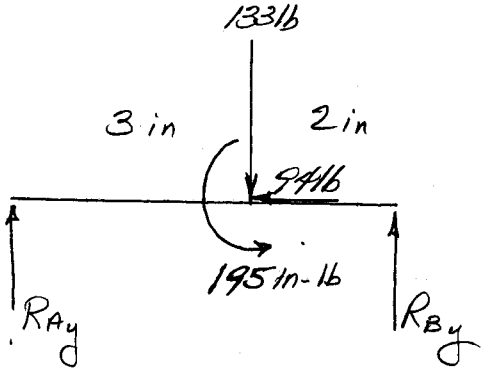
Shear Diagram



Tensor sign convention used.

Moment Diagram





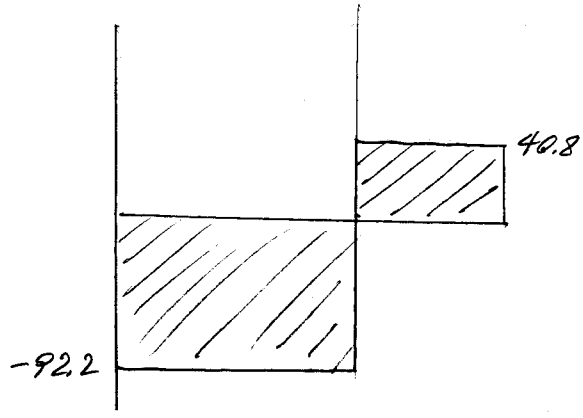
Looking from side

$$\Sigma M_A = 0 = 195 + R_{By}(5) - 133(3)$$

$$\Rightarrow R_{By} = 40.8 \text{ lb.}$$

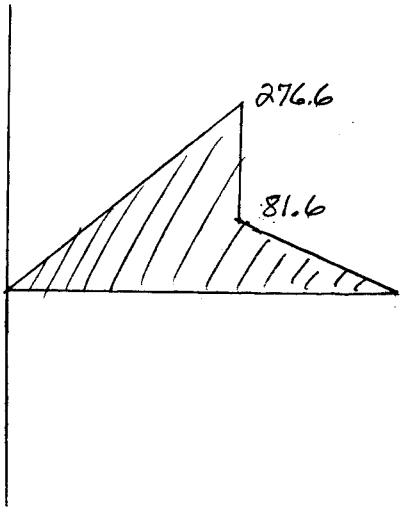
$$\Sigma F_y = 0 = R_{Ay} - 133 + 40.8 \Rightarrow R_{Ay} = 92.2 \text{ lb}$$

Shear Diagram



Tensor sign convention used.

Bending Moment Diagram.



Given: Shaft with chain sprocket rotating at 480 rpm carries 10" sprocket that receives 11 hp.

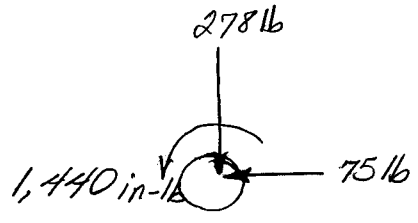
Find: Torque delivered to the shaft by the sprocket and total force exerted on the shaft by the sprocket. Resolve force into horizontal and vertical components and show components acting on the shaft.

Solution:

$$T = 63{,}000\frac{P}{n} \qquad P = 11 \text{ hp}, \quad n = 480 \text{ rpm}$$

$$T = 1{,}440 \text{ in-lb}$$

$$F = \frac{T}{D/2} = \frac{1{,}440 \text{ in-lb}}{(10 \text{ in}/2)} = 288 \text{ lb}.$$



Looking from left to right.