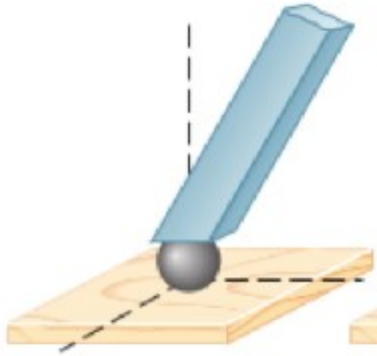
Equilibrium in 3D

$$\sum \vec{F} = \vec{0} \qquad \sum \vec{M} = \vec{0}$$

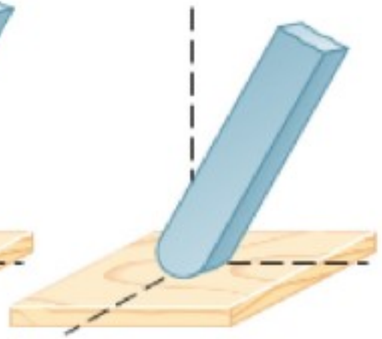
$$\sum F_x = 0 \qquad \sum M_x = 0$$

$$\sum F_y = 0 \qquad \sum M_y = 0$$

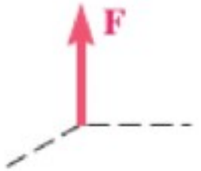
$$\sum F_z = 0 \qquad \sum M_z = 0$$



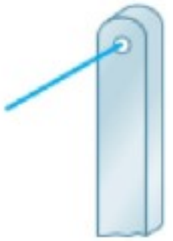
Ball



Frictionless surface

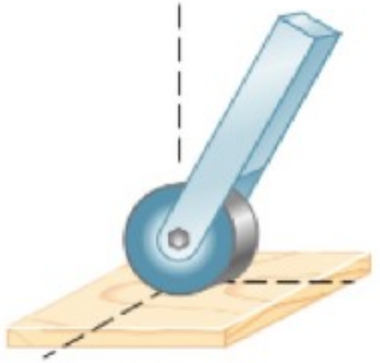


Force with known line of action, perpendicular to surface (one unknown)

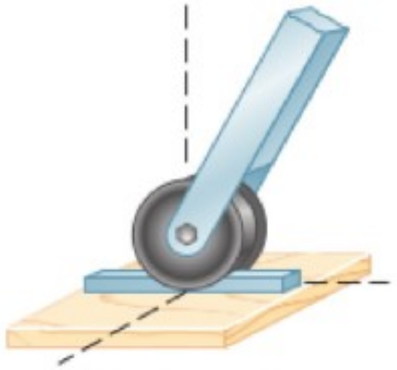


Cable

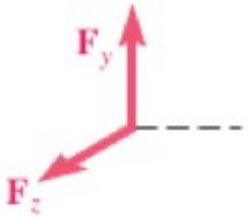
Force with known line of action, along cable (one unknown)



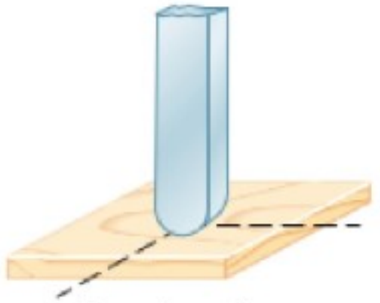
Roller on rough surface



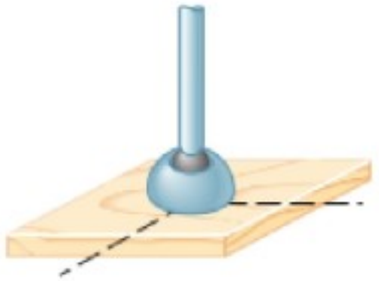
Wheel on rail



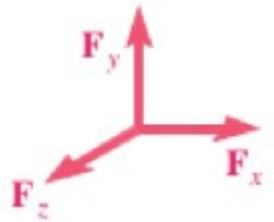
Two force components, one perpendicular to surface and one parallel to axis of wheel



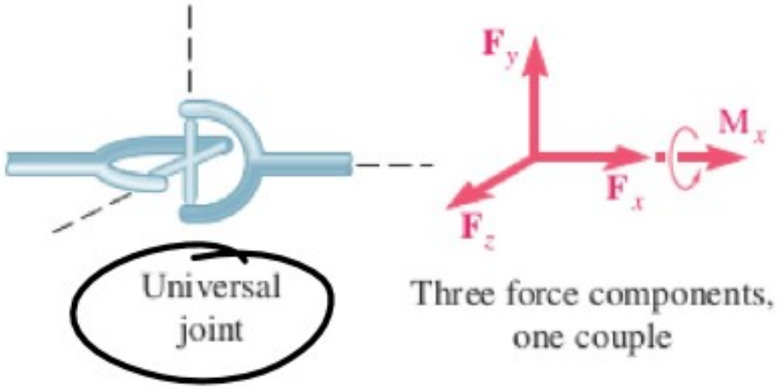
Rough surface



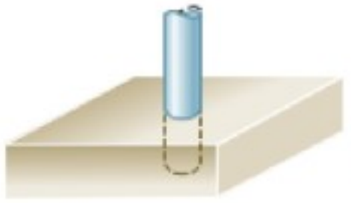
Ball and socket



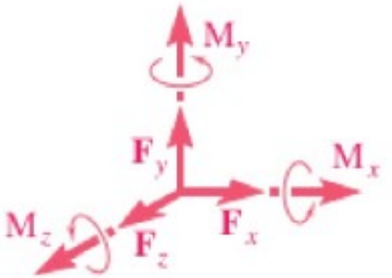
Three force components, mutually perpendicular at point of contact



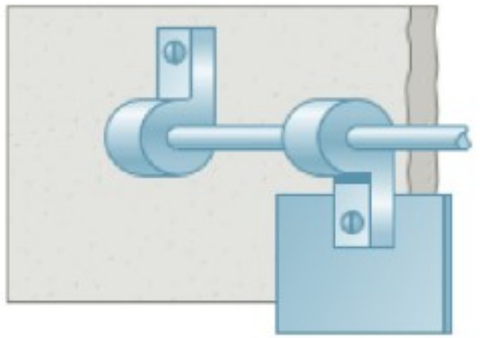
Three force components, one couple

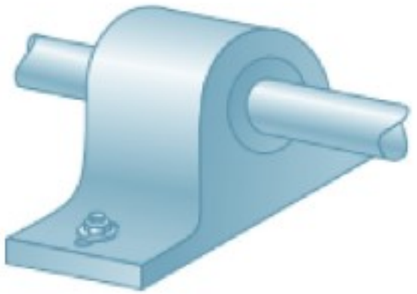


Fixed support

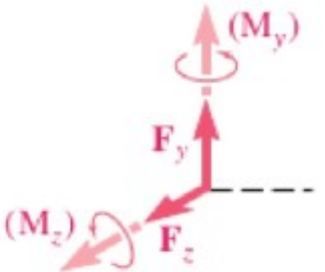


Three force components, three couples (no translation, no rotation)

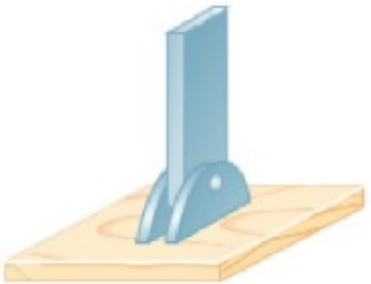




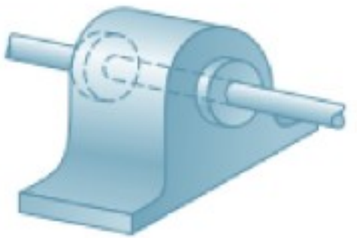
Hinge and bearing supporting radial load only



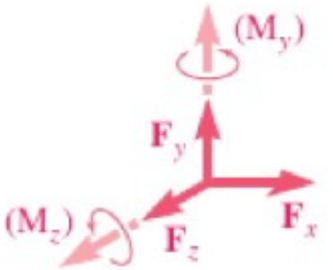
Two force components and up to two couples



Pin and bracket



Hinge and bearing supporting axial thrust and radial load

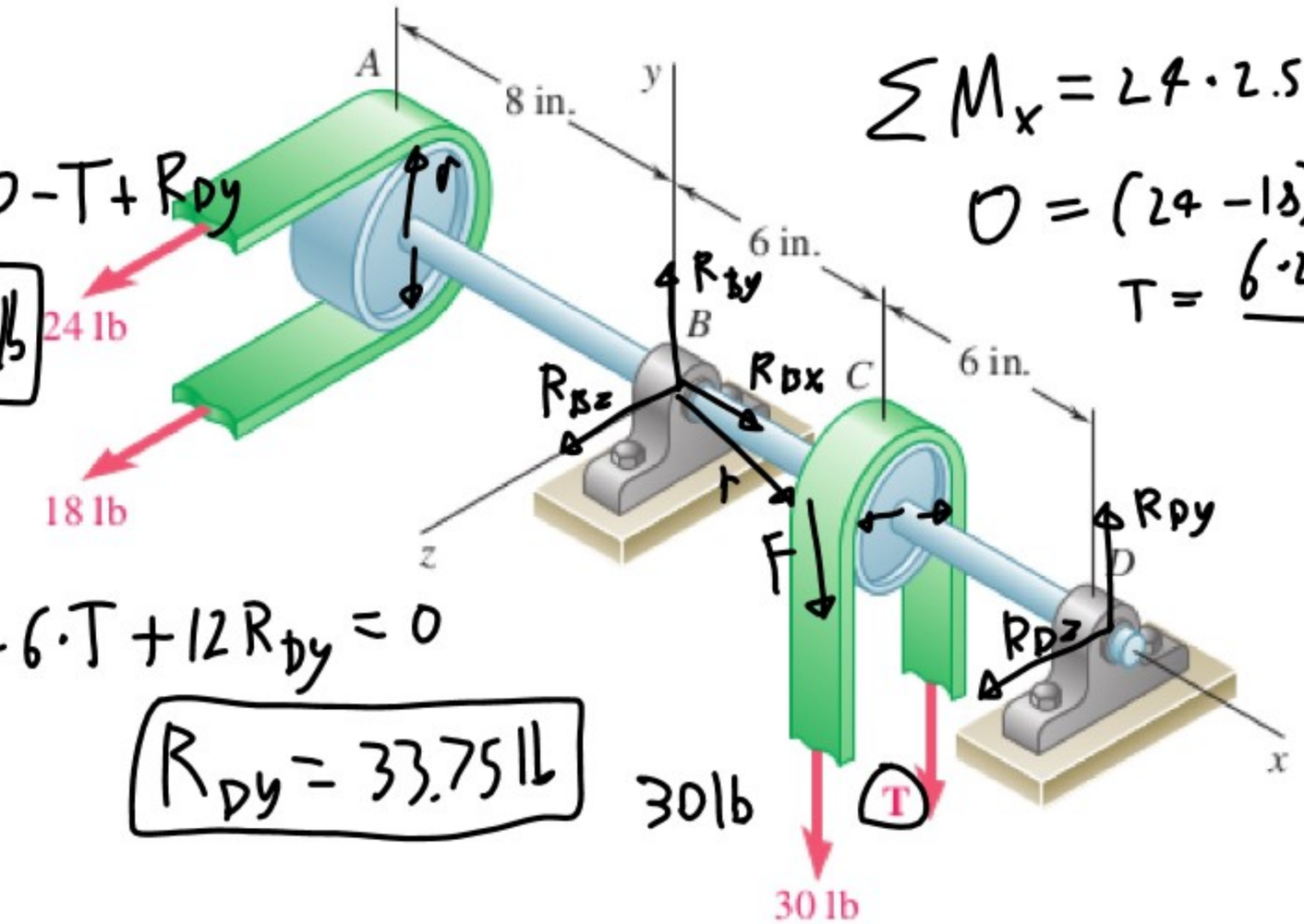


Three force components and up to two couples

4.94 Two transmission belts pass over sheaves welded to an axle supported by bearings at B and D. The sheave at A has a radius of 2.5 in., and the sheave at C has a radius of 2 in. Knowing that the system rotates at a constant rate, determine (a) the tension T, (b) the reactions at B and D. Assume that the bearing at D does not exert any axial thrust and neglect the weights of the sheaves and axle.

$$\Sigma F_x = R_{Dx}$$

$$0 = R_{Bx}$$



$$\Sigma F_y = R_{By} - 30 - T + R_{Dy}$$

$$\Sigma M_x = 24 \cdot 2.5 - 18 \cdot 2.5 + 30 \cdot 2 - 2T$$

$$0 = (24 - 18)2.5 + 60 - 2T$$

$$T = \frac{6 \cdot 2.5 + 60}{2} = 37.5 \text{ lb}$$

$$M_z = r_x F_y - r_y F_x$$

$$\Sigma M_z^B = -6 \cdot 30 - 6 \cdot T + 12 R_{Dy} = 0$$

$$R_{By} = 33.75 \text{ lb}$$

$$R_{Dy} = 33.75 \text{ lb}$$

4.94 Two transmission belts pass over sheaves welded to an axle supported by bearings at B and D. The sheave at A has a radius of 2.5 in., and the sheave at C has a radius of 2 in. Knowing that the system rotates at a constant rate, determine (a) the tension T, (b) the reactions at B and D. Assume that the bearing at D does not exert any axial thrust and neglect the weights of the sheaves and axle.

$$\sum F_z = 24 + 18 + R_{Dz} + 28 = 0$$

$$-(24+18+28) = R_{Bz}$$

$$\boxed{R_{Bz} = -70}$$

$$\sum M_y^B = 8 \cdot 24 + 8 \cdot 18 - 12 \cdot R_{Dz} = 0$$

$$12 R_{Dz} = 8(24+18)$$

$$R_{Dz} = \frac{8(24+18)}{12} = \boxed{28\ \text{lb}}$$