1. (14 pts) Determine the reaction (magnitude and direction) at point A. A separate, complete FBD is required for full credit.

\[ 2.86 \text{ lb} \uparrow (\text{yg}) \]

\[ \begin{align*}
  & y: A_y + 20 \text{ lb} + 13y = 0 \\
  & x: 8x - 40 \text{ lb} = 0
\end{align*} \]

\[ M_{(0)} = -A_y \cdot 14 \text{ ft} - 20 \cdot 16.8 \text{ ft} + 40 \text{ lb} \cdot 5 \text{ ft} = 0 \]

\[ \Rightarrow A_y = 2.86 \text{ lb} \]

2. (14 pts) Determine the minimum force \( P \) to keep the box from tipping over. Assume the center of mass of the box is at the middle of the sides of each box. A separate, complete FBD is required for full credit.

\[ 52.6 \text{ lb} \]

(Bottom Right Corner: \( N = 0 \))

\[ \begin{align*}
  & (z \vec{A} = 0) \\
  & \vec{M} = -P \cdot 6 \text{ ft} + 600 \text{ lb} \cdot (\sin 30^\circ) \cdot 4 \text{ ft} - 600 \text{ lb} \cdot \cos(30^\circ) \cdot 1.5 \text{ ft} \\
  & = 0
\end{align*} \]

\[ \Rightarrow P = 52.6 \text{ lb} \]

3. (14 pts) The ultimate strength of nylon is 75 MPa. Determine the minimum diameter of a nylon cable to hold up a 900 N force with a factor of safety of 2.5. Express the answer to the nearest 2 mm.

\[ F_s = \frac{US}{F/A} \]

\[ F = \frac{US}{2.5 \cdot 900 \text{ N}} \]

\[ A = 3 \cdot 10^{-5} \text{ m}^2 \]

\[ \Rightarrow A = 3 \cdot 10^{-5} \text{ m}^2 \]

\[ \Rightarrow D = 6.18 \text{ mm} \]

4. (14 pts) In 2004, Astronomers discovered a new planet orbiting very close to the a star called HD. It's orbit is 1/3 the distance of Mercury from the Sun and it takes only 3.00 days to complete one orbit (assumed circular). What is the mass of star HD (in kilograms)?

\[ 2.21 \cdot 10^{-3} \text{ kg} \]

\[ T = 3.00 \text{ days} = 2.67 \cdot 10^{-5} \text{ s} \]

\[ G = 6.67 \cdot 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2} \]

\[ \Rightarrow m_{\text{star}} = 2.21 \cdot 10^{-3} \text{ kg} \]
5. (14 pts) A hollow plastic sphere is held below the surface of a fresh water lake by a cord anchored to the bottom of the lake. The sphere has a volume of 0.65 m$^3$ and the tension in the cord is 900N. What is the mass of the sphere?

\[ m = \frac{F_b - T}{g} \]

\[ M = 0.65 \text{ m}^3 \times 9.81 \text{ m/s}^2 = 6.37 \times 10^3 \text{ N} \]

\[ F_b = 1000 \text{ kg} \times 0.65 \text{ m}^3 \times 9.81 \text{ m/s}^2 = 6.37 \times 10^3 \text{ N} \]

\[ m = \frac{F_b - T}{g} = \frac{6.37 \times 10^3 \text{ N} - 900 \text{ N}}{9.81 \text{ m/s}^2} = 558 \text{ kg} \]

6. (14 pts) At point A in a pipeline, the speed of the water is 2.5 m/s and the gauge pressure is 1.80 kPa. Find the gauge pressure at point B in the line if it is 0.5m lower than point A and the cross-sectional area at that point is twice that at the first.

\[ \rho_a = 1000 \text{ kg/m}^3, \quad A_a = 2A_b \Rightarrow V_a / A_a = V_b / A_b, \quad V_b = \frac{V_a}{2} \]

\[ P_a + \rho g h_a + \frac{1}{2} \rho V_a^2 = P_b + \rho g h_b + \frac{1}{2} \rho V_b^2 \]

\[ \Rightarrow 1.8 \times 10^3 \text{ Pa} + 1000 \text{ kg/m}^3 \times 9.81 \text{ m/s}^2 \times 0.5 \text{ m} + \frac{1}{2} \times 1000 \text{ kg/m}^3 \times (0.5 \text{ m}) \frac{2.5^2}{2} \]

\[ \Rightarrow P_b = 9.05 \text{ kPa} \]

7. (14 pts) 2.0 cm$^3$ of water is being pushed out of a syringe through a 3.5 cm long needle in 0.4 s. The interior diameter of the needle is 1.37 mm. What is the pressure difference between the tip of the needle and the end that is connected to the syringe?

\[ \Delta P = \frac{2 \pi L Q}{1000} \]

\[ \eta = \frac{dV}{dt} = \frac{2 \times 10^{-6} \text{ m}^3}{s} = 5 \times 10^{-6} \text{ m}^3/s \]

\[ \Rightarrow \Delta P = \frac{2 \times 1.03 \times 10^{-3} \text{ m} \times (0.035 \text{ m}) \times (5 \times 10^{-6} \text{ m}^3/s)}{16 \times (1.37 \times 10^{-3})^4} = 2000 \text{ Pa} \]

8. (2 pts) A ladder is leaning against a wall. If you were going to climb the ladder are you better off if there is no friction between the ladder and the wall or no friction between the ladder and the floor?

a. No friction between the ladder and the floor
b. No friction between the ladder and the wall
c. Does not matter