1) In words: As radius gets smaller volume goes to zero faster than the circumference. Since: weight \( = \text{volume and force due to surface tension} \times \text{circumference} \), there must exist a radius where surface tension is sufficient to balance the weight (gravity). This ignores buoyancy, which also acts but is insufficient on its own as S.G. \( > 1 \).

Math: \[
\frac{2}{3} \pi R^3 \rho g = \frac{4}{3} \pi R^3 \gamma \cos \theta
\]

\[
R = \left( \frac{3}{2} \frac{\gamma \cos \theta}{\rho g} \right)^{\frac{1}{3}}
\]

where \( R \) is the radius of the sphere that can be supported by fluid with surface tension \( \gamma \) and contact angle \( \theta \).

2) \[
T = \int_A r \cdot \mathbf{t} \, dA = R \int \frac{\partial R}{\partial \theta} \mathbf{t} \cdot \frac{d}{d\theta} \left( \frac{R}{\sin \theta} \right) \, d\theta
\]

\[
= 2\pi R^3 \left[ \frac{\partial R}{\partial \theta} \left( \frac{2h}{a} + \frac{R}{2b} \right) \right] = 2\pi R^3 \left( \frac{2ab + Ra}{2ab} \right)
\]

\[
\therefore \quad m = \frac{T}{\pi R^3 R} \left( \frac{2ab}{4bh + Ra} \right)
\]
3) \( F_x = P_c \cdot A = \gamma \left( \frac{H + D}{2} \right) \frac{R^2}{P_c} \)

\[ F_x = 62.4 \frac{\text{lb}}{\text{ft}^2} \left( \frac{7 \text{ ft} + 2 \text{ ft}}{2} \right) \frac{1}{4} \text{ ft}^2 \]

\[ F_x = 1,760 \text{ lb} \]

\( \text{ii) } \text{Let} \ y_r = \text{distance below centroid of conical plug face} \)

\[ y_r = \frac{\text{InC} \cdot \gamma \sin \theta}{P_c \cdot A} = \frac{\gamma (Rr)^4}{\gamma} \cdot \frac{644}{4} \cdot \frac{1}{1,760 \text{ lb}} = 0.45 \text{ ft} = y_r \]

\( \text{iiii) } \text{The net force of the fluid system on the conical plug in the vertical, } F_z, \text{ is the buoyant force, } \)

\[ F_z = F_{z3} = \frac{1}{3} \left[ \frac{14 \gamma (2R)^2}{4} \left( \frac{2L}{4} - \frac{4R^2}{4} \right) \right] \gamma \]

\[ = \frac{14 \gamma}{12} R^2 L (8 - 1) \gamma = \frac{77}{12} \gamma R^2 L \gamma \]

\[ x_1 = \frac{F_z}{12} = \frac{77}{12} \gamma \left( \frac{2 \text{ ft}}{2 \text{ ft}} \right)^2 \frac{62.4 \text{ lb}}{\text{ft}^3} = 915 \text{ lb} = F_z \]

\( \text{iv) } \)

\[ x_2 = x_1 \frac{R}{R} - x_2 \frac{R}{R} \]

\[ x_2 = \frac{14}{4} \frac{1}{5} = \frac{11}{28} \frac{1}{2} \frac{L}{2} \text{ ft} \]

\[ \therefore x_2 = 0.79 \text{ ft to right of face of plug} \]
4) Choose a moving C.U. at speed of cart, \( V_C \)

**Cons mass:**

\[ m = \text{mass} \]

\[ V_{in} \Delta x_{in} = V_{ax} \Delta A \]

\[ V_{in} = V_j - V_C \]

**Cons linear momentum in \( x \)-dir:**

\[ \sum F_{ext} = F_{brane} = m \Delta V_{ax} - m \Delta V_{in} = -m (V_j - V_C) \]

\[ = -\rho \frac{\pi D_x^2}{4} (V_j - V_C)^2 \Rightarrow V_j = \frac{\rho}{\rho} \frac{4 \pi}{D_x^2} \]

\[ = -998 \left( \frac{9 \pi (0.1 \text{m})}{4} \right)^2 \left[ \frac{4 \pi (0.1 \text{m})^3}{4 \pi (0.1 \text{m})^2} - 2 \left( \frac{\pi (0.1 \text{m})}{5} \right)^2 \right] \]

\[ \therefore F_{brane} = -789 \text{ lbf} \]