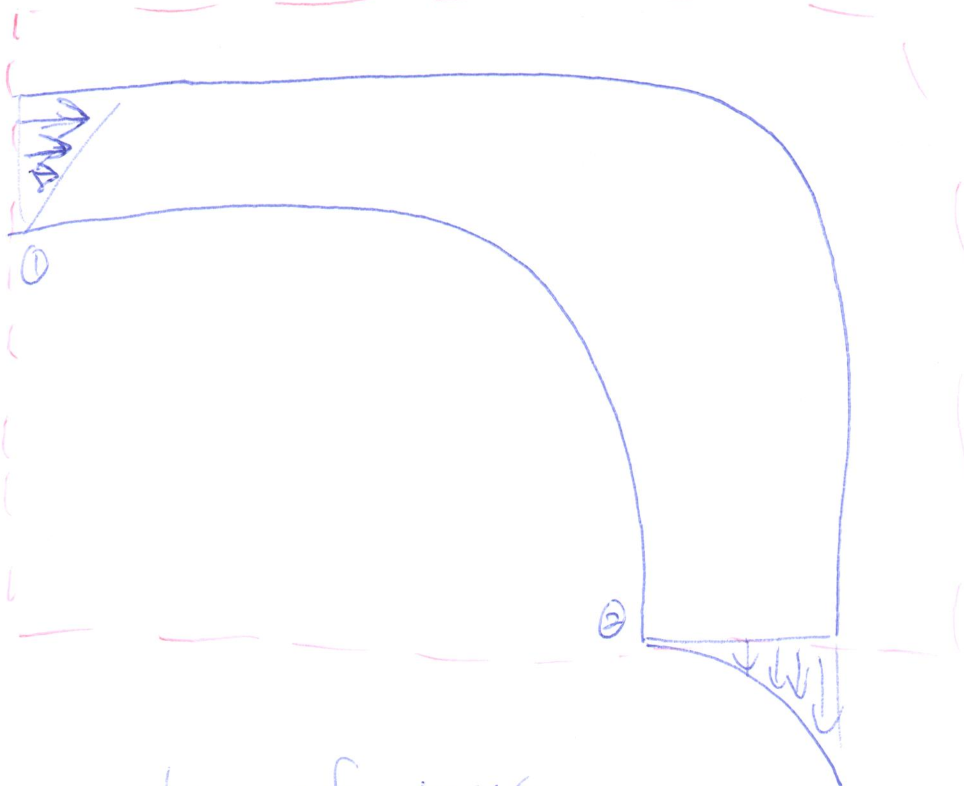


Conservation of mass

$$0 = \cancel{\frac{d}{dt}\iiint_V \rho \, dV}^{\;\to 0 \text{ s.s.}} + \iint_S \rho \vec{v}\cdot\hat{n}\, dS$$

$$\iint_{S_1} \rho \vec{v}\cdot\hat{n}\, dS + \iint_{S_2} \rho \vec{v}\cdot\hat{n}\, dS = 0$$

$$v_1 = V_a\left(\frac{y}{L}\right)\hat{\imath} \qquad v_2 = -v_b\left(\frac{x}{L}\right)^2\hat{\jmath}$$

$$\hat{n}_1 = -\hat{\imath} \qquad \hat{n}_2 = -\hat{\jmath}$$

$$\rho \iint_{S_1} -V_a\left(\frac{y}{L}\right) dS + \rho \iint v_b\left(\frac{x}{L}\right)^2 dS = 0$$

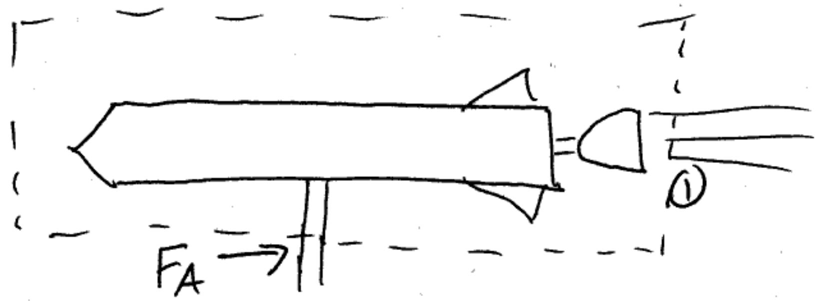
$$-\rho V_a \int_0^D \int_0^L \left(\frac{y}{L}\right) dy\, dz + \rho V_b \int_0^D \int_0^L \left(\frac{x}{L}\right)^2 dx\, dz = 0$$

$$-\rho V_a \frac{L}{2} D + \rho V_b \frac{L}{3} D = 0$$

$$V_b \frac{L}{3} = V_a \frac{L}{2}$$

$$\boxed{V_b = \frac{3}{2} V_a}$$

3)



$$0 = \frac{\partial}{\partial t}\iiint_{C.V.} \rho \, dV + \oiint_S \rho \, \vec{V}\cdot\hat{n} \, dS$$

$$\frac{\partial}{\partial t}\iiint_{C.V.} \rho \, dV = -0.5 \text{ kg/s} \quad \boxed{\text{stated in problem}}$$

$$0 = -0.5 \text{ kg/s} + \oiint_S \rho \, \vec{V}\cdot\hat{n} \, dS$$

$$0.5 \text{ kg/s} = \rho_{exit} V_{exit} S_{exit}$$

$$\rho_{exit} = \frac{0.5 \text{ kg/s}}{(1970 \text{ m/s})(7\times10^{-4} \text{ m}^2)} = 0.363 \text{ kg/m}^3$$

Assume momentum in control volume constant

$$\sum \vec{F} = \cancel{\frac{\partial}{\partial t}\iiint_{C.V.} \rho \vec{V} \, dV} + \oiint_S \rho \vec{V} \, \vec{V}\cdot\hat{n} \, dS$$

x - dir :

$$F_A = \iint_{S_1} \rho \vec{U}\, \vec{V} \cdot \hat{n}\, dS$$

$$= \rho_{exit} V_{exit}^2 S_{exit}$$

$$= (0.363\ kg/m^3)(1970\ m/s)^2(7 \times 10^{-4}\ m^2)$$

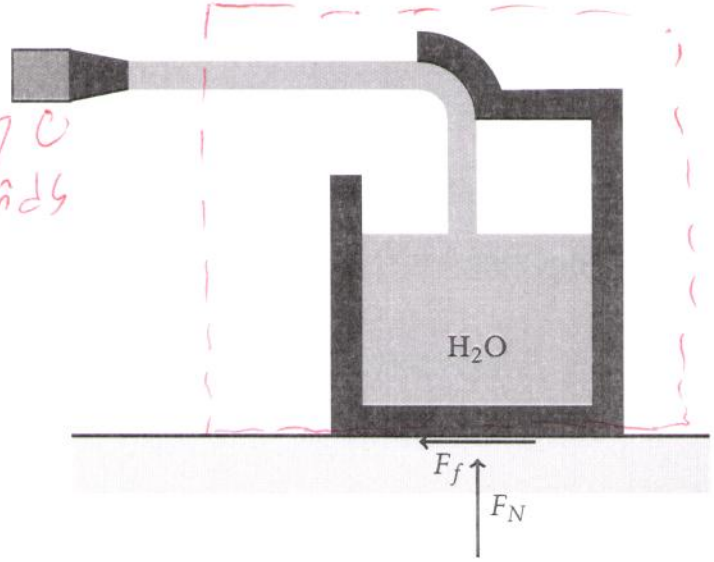
$$\boxed{= 985\ N}$$

Name:

2) A jet of water with a diameter of 5 cm and velocity of 15 m/s strikes an object and is redirected into an attached container, as illustrated.

   a) When the container and contained water have a mass of 100 kg, what must be the normal force, F_N exerted by the ground?

   b) What is the minimum coefficient of static friction, μ_s, between the container and the ground such that the container does not move?



y dir:

a) $\sum F_y = \frac{d}{dt}\iiint_V \cancel{\rho v_y \, dV} + \oiint_S \cancel{\rho v_y \vec{v} \cdot \hat{n} \, dS}$ 0 0

$\sum F_y = 0$

$F_N = -F_g = \boxed{981\,N}$

x-dir

b) $\sum F_x = \frac{d}{dt}\iiint_V \rho v_x \, dV + \oiint_S \rho V_x \vec{V} \cdot \hat{n} \, dS$

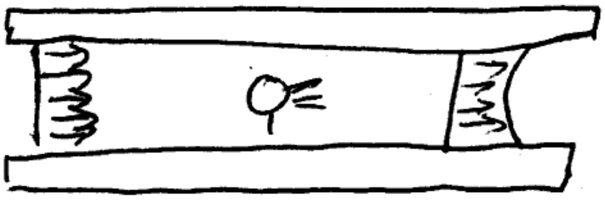
$F_f = \rho V_x(-U_x)S$

$S = \frac{\pi D^2}{4} = 0.00196\,m^2$

$-100\,kg\,(9.81\,m/s^2)\,\mu_s = -1000\,kg/m^3\,(15\,m/s)^2\,(0.00196\,m^2)$

$\boxed{\mu_s = 0.45}$

Assgn #4 #2



$\rho = 1.225 \, kg/m^3$ $\qquad R = 0.5m$

$V_A = 20 m/s \qquad V_B = a + 2a\left(\frac{r}{R}\right)^2 \qquad P_A - P_B = 100 Pa$

conservation of mass

$$0 = \cancelto{0}{\frac{\partial}{\partial t}\iiint_V \rho \, dV} + \iint_S \rho \vec{V} \cdot n \, dS$$

$$0 = -\rho V_A S + \iint_{S_B} \rho\left[a + 2a\left(\frac{r}{R}\right)^2\right] dS$$

$$\rho V_A S = \int_0^{2\pi}\int_0^R \rho\left[a + 2a\left(\frac{r}{R}\right)^2\right] r \, dr \, d\theta$$

$$\rho V_A \pi R^2 = 2\pi\rho a \int_0^R \left[1 + 2\left(\frac{r}{R}\right)^2\right] r \, dr$$

$$= 2\pi\rho a \int_0^R \left[r + 2\frac{r^3}{R^2}\right] dr$$

$$= 2\pi\rho a \left[\frac{r^2}{2} + \frac{r^4}{2R^2}\right]_0^R$$

$$= 2\pi\rho a \left[R^2\right]$$

$$\cancel{\rho} V_A \cancel{\pi} \cancel{R^2} = 2 \cancel{\pi} \cancel{\rho} a \cancel{R^2}$$

$$\boxed{a = \frac{V_A}{2}}$$

$$\sum F_x = \frac{\partial}{\partial t}\cancel{\iiint_V \rho V_x \, dV} + \iint_S \rho V_x \vec{V}\cdot n \, dS$$

$$= -\rho V_A^2 \pi R^2 + \int_0^{2\pi}\int_0^R \rho \left(\frac{V_A}{2}\right)^2 \left[1 + 2\left(\frac{r}{R}\right)^2\right]^2 r \, dr \, d\theta$$

$$= -\rho V_A^2 \pi R^2 + \frac{\rho V_A^2}{\cancel{4}} (2\pi) \int_0^R \left[1 + 2\left(\frac{r}{R}\right)^2\right]^2 r \, dr$$ [redacted]

$$= -\rho V_A^2 \pi R^2 + \frac{\rho V_A^2}{2} \pi \int_0^R \left[1 + 4\frac{r^2}{R^2} + 4\frac{r^4}{R^4}\right] r \, dr$$ [redacted]

$$= -\rho V_A^2 \pi R^2 + \frac{\rho V_A^2}{2} \pi \int_0^R \left[r + 4\frac{r^3}{R^2} + 4\frac{r^5}{R^4}\right] dr$$

$$= -\rho V_A^2 \pi R^2 + \frac{\rho V_A^2}{2} \pi \left[\frac{r^2}{2} + 4\frac{r^4}{4R^2} + \frac{4}{6}\frac{r^6}{R^4}\right]_0^R$$

$$= -\rho V_A^2 \pi R^2 + \frac{\rho V_A^2}{2} \pi \left[\frac{R^2}{2} + R^2 + \frac{2}{3}R^2\right]$$

$$= -\rho V_A^2 \pi R^2 + \frac{\rho V_A^2}{2} \pi \left[\frac{13}{6} R^2\right]$$

$= \rho V_A^2 \pi R^2$ [redacted] $\frac{1}{12}$

$F_R + F_p = \rho V_A^2 \pi R^2$ [redacted] $\frac{1}{12}$

$F_R + [P_A - P_B]\pi R^2 = \rho V_A^2 \pi R^2$ [redacted] $\frac{1}{12}$

$F_R = \left[\rho V_A^2\right.$ [redacted] $\left.\left(\frac{1}{12}\right) - (P_A - P_B)\right]\pi R^2$

$\boxed{-46 N \uparrow}$

$F_R = \left[(1.225 \, kg/m^3)(20 \, m/s)^2 \left(\frac{1}{12}\right) - (100 \, Pa)\right]\pi(0.5 \, m)^2 =$ [redacted]