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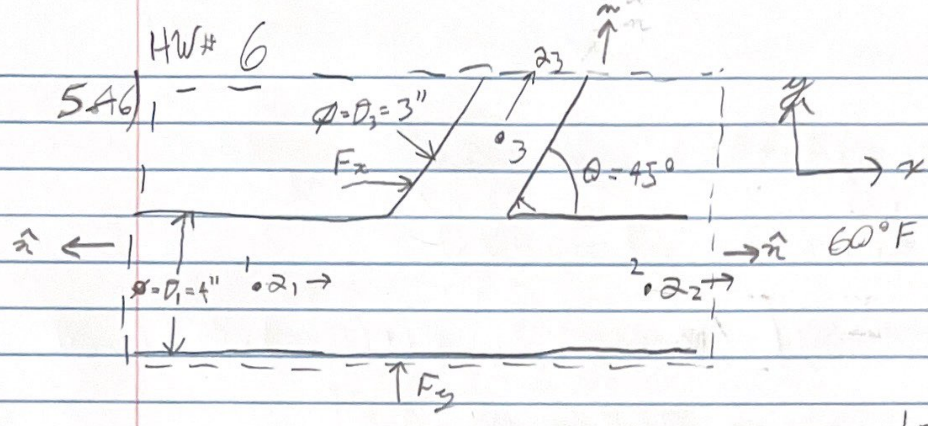
HW# 6

5.46




$Q_1 = 1.63\ ft^3/s$
$Q_2 = 1\ ft^3/s$

60°F

$P_1 = 34\ psig$
$P_2 = 35\ psig$
$P_3 = 33.5\ psig$

$1\ psig = 144\ psfg$

Find $F_x, F_y$

$Q_1 = Q_2 + Q_3 \Rightarrow Q_3 = Q_1 - Q_2 = (1.63 - 1)\ ft^3/s = .63\ ft^3/s$, exit

$Q_3 = v_3 A_3 = v_3\left(\left(\frac{D_3}{2}\right)^2 \pi\right) = \left(\frac{\pi}{4}(.25\ ft)^2\right) v_3 = \left(\frac{\pi}{64}\ ft^2\right) v_3$

$v_3$: $\Rightarrow \therefore v_3 = Q_3\left(\frac{64}{\pi}\ ft^2\right) = (.63\ ft^3/s)\left(\frac{64}{\pi}\ ft^2\right) = 12.834\ ft/s$

$v_1$: $Q_1 = v_1 A_1 \Rightarrow v_1 = Q_1/A_1 = (1.63\ ft^3/s) / \left(\frac{\pi}{4}\left(\frac{1}{3}\ ft\right)^2\right) = 18.678\ ft/s$

$v_2$: $Q_2 = v_2 A_2 \Rightarrow v_2 = Q_2/A_2 = (1\ ft^3/s) / \left(\frac{\pi}{4}\left(\frac{1}{3}\ ft\right)^2\right) = 11.459\ ft/s$

$\Sigma F$

$$\Sigma F = \underbrace{\frac{d}{dt}\left(\int_{cv} \vec{v} \cdot \rho \cdot dV\right)}_{0,\ \text{steady state}} + \int_{cs} \vec{v} \cdot \rho (\vec{v} \cdot \hat{n})\, dA = \int_{cs} \vec{v} \cdot \rho (\vec{v} \cdot \hat{n})\, dA$$

Break into components

$$\Sigma F_x = \int_{cs} \vec{v} \cdot \rho (\vec{v} \cdot \hat{n})\, dA = \int_{cs} \vec{v}_1 \cdot \rho (\vec{v}_1 \cdot \hat{n})\, dA + \int_{cs} \vec{v}_2 \cdot \rho (\vec{v}_2 \cdot \hat{n})\, dA$$
$$+ \int_{cs} \vec{v}_3 \cdot \rho (\vec{v}_3 \cdot \hat{n})\, dA$$

$$\Sigma F_y = \int_{cs} \vec{v}_3 \cdot \rho (\vec{v}_3 \cdot \hat{n})\, dA$$

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HW#6-cont'd $\qquad\qquad$ $\rho$ found in table B.1

$$\Sigma F_x = v_1 \rho(-v_1) A_1 + v_2 \rho(v_2) A_2 + v_3 \rho(v_3 \cos\theta) A_3$$

$$= \rho(-v_1^2 A_1 + v_2^2 A_2 + v_3^2 \cos(\theta) A_3)$$

$$= (1.94 \text{ slugs}/ft^3)\left[-(18.678 \text{ fps})^2\left(\tfrac{\pi}{4}\left(\tfrac{1}{5} ft\right)^2\right) + (11.459 \text{ fps})^2\left(\tfrac{\pi}{4}\left(\tfrac{1}{3} ft\right)^2\right) + (12.834 \text{ fps})^2\left(\tfrac{\pi}{4}\left(\tfrac{1}{4} ft\right)^2\right)\cos(45^\circ)\right]$$

$$F_x + P_1 A_1 - P_2 A_2 - P_3 A_3 (\cos\theta) = -25.741 \text{ lbs}$$

$$\therefore F_x = -25.741 - P_1 A_1 + P_2 A_2 + P_3 A_3 \cos(45) = (-25.741 + 180.00) \text{ lbs}$$

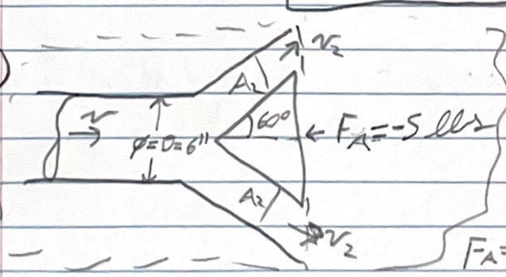
$$\boxed{F_x = 154.259 \text{ lbs } \hat{x}}$$

$$\Sigma F_y = v_3 \rho (v_3 \sin(45)) A_3 = v_3^2 \rho \sin(45) A_3 = 11.09 \text{ lbs}$$

$$F_y - P_3 A_3 \sin(\theta) = 11.09 \Rightarrow F_y = 11.09 + 167.44$$

$$\boxed{F_y = 178.53 \text{ lbs } \hat{y}}$$

5.51)




$$\Sigma F_x = \underbrace{\frac{d}{dt}\left(\int_{CV} \vec{v} \cdot \rho \, d\forall\right)}_{0,\ \text{steady state}} + \int_{CS} \vec{v} \cdot \rho (\vec{v} \cdot \hat{n}) \, dA$$

$$F_A = \int_{A_1} v_1 \rho(-v_1) \, dA_1 + 2\int_{A_2} (v_2 = v_3) \rho (v_2 \cos(\theta)) \, dA_2$$

$$F_A = -v_1^2 \rho A_1 + 2 v_2^2 \rho \cos\theta A_2$$

each $v_1 = v_2 = v_3$, so $\Rightarrow F_a = v_1^2 \rho\left(-A_1 + (2A_2)\cos(60^\circ)\right)$ $\quad A_1$

$\hookrightarrow A_1 v_1 = A_2 v_1 + A_3 v_1 \Rightarrow A_1 = 2A_2 = 2A_3$

$$F_a = v_1^2 \rho A_1 \left(-1 + \tfrac{1}{2}\right) = -\frac{v_1^2 \rho A_1}{2} \Rightarrow -\frac{2F_a}{\rho A_1} = v_1^2$$

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HW#6 - cont

$\rho$ from table B.3

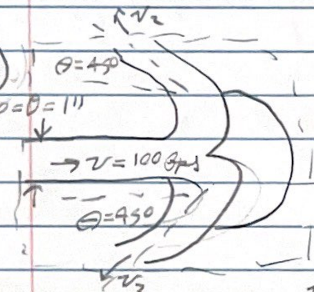
$$\therefore v_1 = \sqrt{\frac{-2(-5)}{(2.329e\text{-}3)\left(\frac{\pi}{4}\left(\frac{1}{2}'\right)^2\right)}} = 147.877 \text{ fps}$$

$$Q = A_1 v_1 = v_1\left(\frac{\pi}{4}\left(\frac{1}{2}'\right)^2\right)$$

$$\boxed{Q = 29.036 \text{ ft}^3/\text{s}}$$

5.70)

~~5.5~~ a)




$$\Sigma F_x = \underbrace{\cancel{\frac{d}{dt}\left(\int_{cv} v_x \rho \, d\forall\right)}}_{0,\text{ steady state}} + \int_{cs} \vec{v}_x \rho (\vec{v}_x \cdot \hat{n})\, dA$$

$y$, $x$

$$F_x = -v_1^2 \rho A_1 + 2 v_2^2 \rho A_2 \cos(45°)$$

$v_1 = v_2 = v_3$, so $Q = v_1 A_1 = v_2 A_2 + v_3 A_3 \Rightarrow A_1 = 2A_2$

$$-F_x = v_1^2 \rho A_1 (-1 + \cos(45)) = \left(\sqrt{2}/2 + 1\right) v_1^2 \rho A_1$$

$$-F_x = \left(\sqrt{2}/2 + 1\right)(100 \text{ fps})^2 \left(1.936 \frac{\text{slug}}{\text{ft}^3}\right)\left(\frac{\pi}{4}\left(\frac{1}{12}'\right)^2\right) = 180.258 \text{ lbs}$$

$$\boxed{F_x = -180.257 \text{ lbs } \hat{x}}$$

b) same procedure, but use $v_R = v_1 - 10 \text{ fps} = 90 \text{ fps}$

$$\Rightarrow -F_x = \left(\sqrt{2}/2 + 1\right) v_R^2 \rho A_1$$

$$\boxed{F_x = -146.009 \text{ fps } \hat{x}}$$

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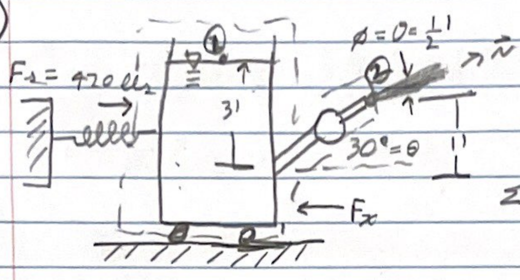
HW#6

5.121)




$$\Sigma F_x = \cancel{\frac{d}{dt}\left(\int_{cv} \vec{v}\cdot\rho\, d\forall\right)}^{0,\ \text{quasi steady}} + \int_{cs} \vec{v}\cdot\rho(\vec{v}\cdot\hat{n})\,dA$$

$$\Sigma F_x = \int_{cs} \vec{v}_2\,\rho(\vec{v}\cdot\hat{n})\,dA = v_2^2\rho\cos(30°)A_2$$

$$\Rightarrow F_s = v_2^2\underbrace{\rho}_{1.936\ \text{slug/ft}^3}\cos(30°)A_2 \Rightarrow v_2 = \left(\frac{F_s}{\rho\cos(30°)A}\right)^{1/2} \quad \text{w/ } A_2 = \left(\frac{\pi}{4}\left(\frac{1'}{2}\right)^2\right)$$

$\therefore v_2 = 35.718$ ~~ft/s~~ & $Q_2 = v_2 A_2$ so

$$\boxed{Q_2 = 7.013\ \text{ft}^3/\text{s}}$$

Know power is $\dot{W}_p = \rho g Q h_p$, & $h_p$ is found from BE.

BE 1-2

$P_{atm} = P_2$ $\qquad$ $P_{atm} = P_1$

$$\cancel{P_1} + \rho g z_1 + \rho g h_p + \cancel{\tfrac{1}{2}\rho v_1^2}^{0} = \cancel{P_2} + \rho g z_2 + \tfrac{1}{2}\rho v_2^2 + \cancel{\rho g h_L}^{0}$$

$$\Rightarrow g z_1 + g h_p = g z_2 + \frac{1}{2}v_2^2 \Rightarrow h_p = \frac{v_2^2}{2g} + z_2 - z_1$$

$\Rightarrow g = 32.2$ ft/s² $\quad \therefore h_p = 17.8106$ ft

$$\Rightarrow \therefore \dot{W}_p = \rho g Q h_p = (1.936\ \text{slugs/ft}^3)(32.2\ \text{ft/s}^2)(7.013\ \text{ft}^3/\text{s})(17.8106\ \text{ft})$$

$$\Rightarrow \dot{W}_p = 7786.84\ \frac{\text{lbs ft}}{\text{s}}\left(\frac{.0018433\ldots\ \text{hp}}{1\ \text{lbs ft/s}}\right)$$

$$\boxed{\dot{W}_p = 14.354\ \text{hp}}$$

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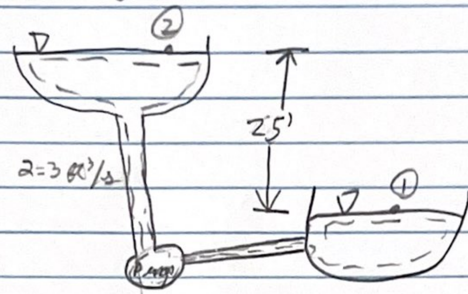
HW # 6 - cont

5.B)




$h_L = 10\,ft$

$P_1 = P_{atm} = P_2$
working w/ gauge pressure)
so $P_{atm} = 0$

a) $\dot{W}_P = \rho g Q h_P$ ← need $h_P$

BE b/w 2 & 1
← no $P_1$ or $P_2$ b/c gauge pressure

$$\frac{\cancel{v_1^2}^{0}}{2g} + z_1 + h_P = \frac{\cancel{v_2^2}^{0}}{2g} + z_2 + h_L$$

$v_1 = 0 = v_2$, surfaces don't change

$\Rightarrow h_P = h_L + (z_2 - z_1) = 10\,ft + 25\,ft = 35\,ft$

$\dot{W}_P = \rho g Q h_P = (1.94\,slugs/ft^3)(32.1741\,ft/s^2)(3\,ft^3/s)(35\,ft)$

$= 187.253(35)\,\frac{lbs\,ft}{s} = 6553.86\,\frac{lbs\,ft}{s}\left(\frac{.0018433994\,hp}{lbs\,ft/s}\right)$

$$\boxed{\dot{W}_P = 12.0814\,hp}$$

b) $\dot{W}_L = \rho g Q h_L = 187.253(10\,ft)\,\frac{lbs}{s}\left(\frac{.0018433994\,hp}{lbs\,ft/s}\right)$

$$\boxed{\dot{W}_L = 3.4518\,hp}$$