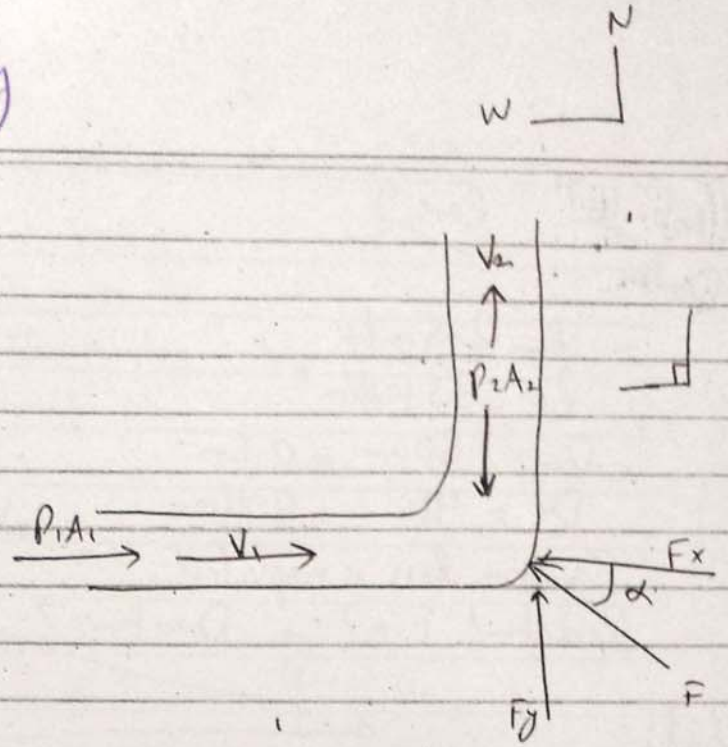
Dougherty



Prob. 6.6

Data:

$P = 450\ kN/m^2$

$V = 3\ m/s$

$d = 30cm = 0.3m$

Resultant $F = ?$

Direction $= ?$

Sol:

$a = 0.0707\ m^2$

$Q = AV = 0.0707 \times 3 = 0.2121\ m^3/s$

$$\Rightarrow \quad (\Sigma F)_x = \rho Q (V_{2x} - V_{1x})$$

$$-F_x + P_1A_1 = \rho Q (0 - V_1)$$

$$F_x = P_1A_1 + \rho Q V_1$$

$$F_x = 32452\ N$$

$$\Rightarrow \quad (\Sigma F_y) = \rho Q (V_{2y} - V_{1y})$$

$$F_y - P_2A_2 = \rho Q (+V_2 - 0)$$

$$F_y = +\rho Q V_2 + P_2A_2$$

$$F_y = 32451.3\ N$$

Resultant $F = 45.9\ kN$ Ans

$$\alpha = \tan^{-1}\left(\frac{F_y}{F_x}\right) = 45^\circ \quad \text{Ans}$$

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Prob. 6.7 Case 9

Data:

$V_1 = 2.5 m/s$

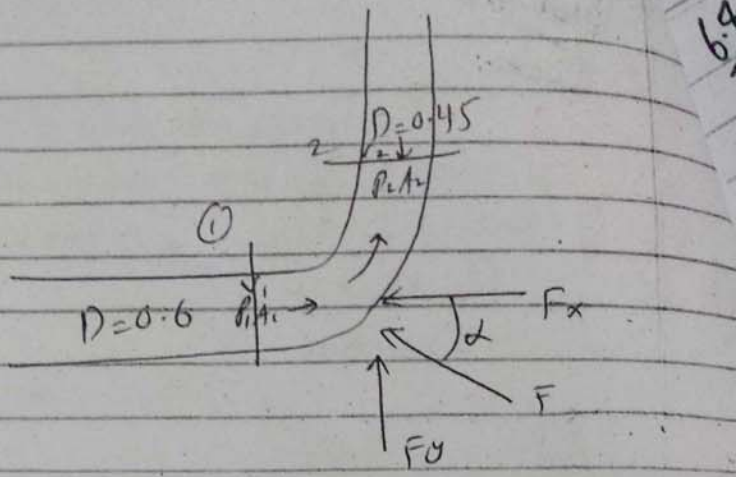
$P_1 = 35 KN/m^2$

$D_1 = 60 cm = 0.6 m$

$D_2 = 45 cm = 0.45 m$

Friction loss = neglected

Resultant F = ? + Direction = ?



Sol:

$A_1 = 0.2827 m^2$ $\quad Q = 0.7068 m^3/s$

$A_2 = 0.159 m^2$ $\quad = 0.707 m^3/s$

$A_1V_1 = A_2V_2$

$V_2 = \frac{A_1V_1}{A_2} = 4.44 m/s$

Applying energy equation

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g}$$

$$\frac{35000}{9810} + \frac{2.5^2}{2\times 9.81} = \frac{P_2}{9810} + \frac{4.44^2}{2\times 9.81}$$

$P_2 = 28268.2 N/m^2$

$\Rightarrow -F_x + P_1A_1 = \rho Q(\beta_2 V_2 - V_1)$

$\Rightarrow F_x = P_1A_1 - P_2A_2\cos\phi - \rho Q(V_2\cos\phi - V_1)$

$= 35000 \times 2827 - 1000\times 0.159 \times \cos 90 - 1000 \times 0.707 (4.44\cos 90 - 2.5)$

$F_x = 11662 N$

$\Rightarrow F_y = \sin\phi (P_2A_2 + \rho Q V_2)$

$= \sin 90 (28268.2 \times 0.159 + 1000 \times 0.707 \times 4.44) = 7634 N$

$\Rightarrow F_y - P_2A_2 = \rho Q(+V_2)$

$F_y = 7633.8 N$

$\Rightarrow F$ (Resultant) $= 13938 N$ Ans

$\alpha = \tan^{-1}\left(\frac{F_y}{F_x}\right) = 33.2°$ Ans

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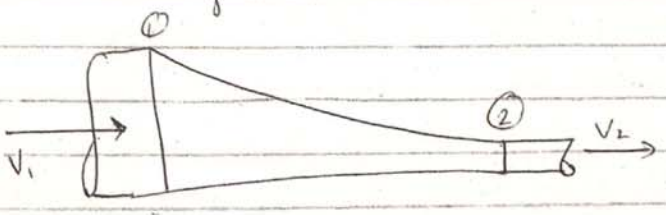
6.8 Case 9

Data:

$D_1 = 90cm = 0.9m$ $\quad P_1 = 700 kN/m^2$ $\quad V_1 = 2.5 m/s$

$D_2 = 60cm = 0.6m$ $\quad \theta = 0°$

Resultant $F = ?$ $\quad$ Friction = neglected.



Sol:

$A_1 = 0.6362 m^2$

$A_2 = 0.2827 m^2$

$A_1 V_1 = A_2 V_2$

$V_2 = \frac{A_1 V_1}{A_2} \Rightarrow V_2 = 5.63 m/s$

Applying energy equation

$\cancel{Z_1} + \frac{P_1}{\rho} + \frac{V_1^2}{2g} = \cancel{Z_2} + \frac{P_2}{\rho} + \frac{V_2^2}{2g}$

$P_2 = 687277 N/m^2 = 687.277 kN/m^2$

Also

$Q = A_1 V_1 = A_2 V_2 = 1.5905 m^3/s$

a) From left to right

$F_x = P_1 A_1 - P_2 A_2 \cos\theta - \rho Q (V_2 \cos\theta - V_1)$

$F = 700000 \times 0.6362 - 687277 \times 0.2827 - 1000 \times 1.5905 (5.63 - 2.5)$

$F = 246 kN$

b) from right to left $\quad F = -246 kN$

Equation

$P_1 A_1 - P_2 A_2 - F = \rho Q (V_2 - V_1)$

$F = 246 kN$

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Prob. 6.9

Data:

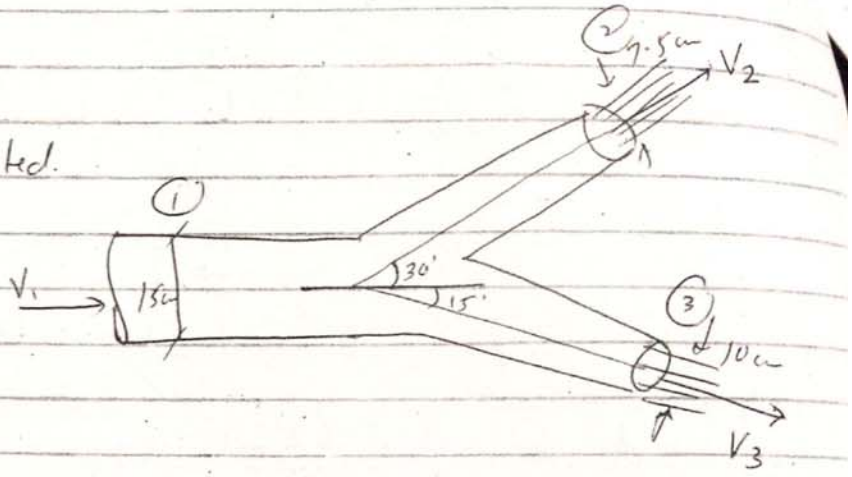
Magnitude and direction of force = ?

$V_2 = V_3 = 12 \text{ m/s}$

$Z_1 = Z_2 = Z_3$

$\gamma = 9810 \text{ N/m}^3$

Friction = neglected.



Sol.

$A_1 = 0.0177 \text{ m}^2$

$A_2 = 4.42 \times 10^{-3} \text{ m}^2$

$A_3 = 7.85 \times 10^{-3} \text{ m}^2$

$$\Rightarrow \quad A_1V_1 = A_2V_2 + A_3V_3$$

$$V_1 = 8.32 \text{ m/s}$$

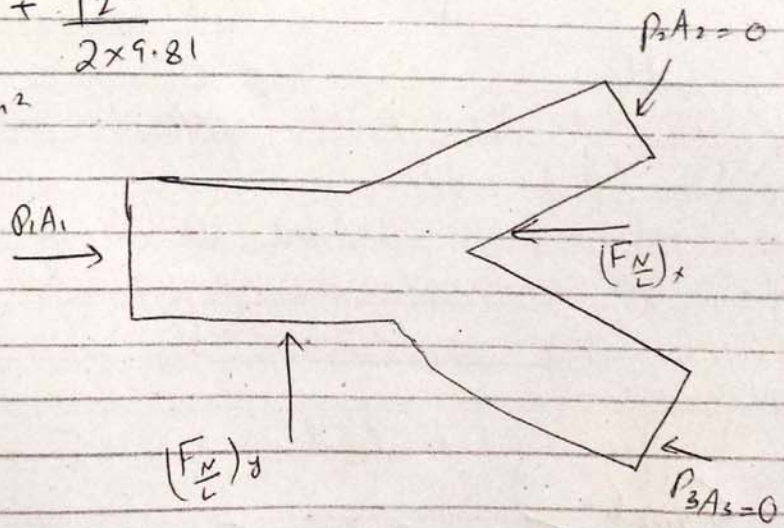
$Q = 0.1473 \text{ m}^3/\text{s}$ $\quad Q_2 = 0.053 \text{ m}^3/\text{s}$ $\quad Q_3 = 0.0942 \text{ m}^3/\text{s}$

Energy equation

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g}$$

$$\frac{P_1}{9810} + \frac{8.32^2}{2\times 9.81} = 0 + \frac{12^2}{2\times 9.81}$$

$$P_1 = 37388.8 \text{ N/m}^2$$



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$\rho Q (V_{2x} - V_{1x})$

$\rho Q (V_{2x} + V_{3x} - V_{1x})$

$$\Sigma F_x = P_1 A_1 - (F_R)_x = (\rho Q_2 V_{2x} + \rho Q_3 V_{3x}) - \rho Q_1 V_{1x}$$

$$P_1 A_1 - F_x = (\rho Q_2 V_{2x} + \rho Q_3 V_{3x}) - \rho Q_1 V_{1x}$$

$V_{1x} = V_1 = 8.32 \text{ m/s}$

$V_{2x} = V_2 \cos 30^\circ$

$= 12 \cos 30^\circ = 10.4 \text{ m/s}$

$F_x = $ ~~206~~ N

243.4 N

$V_{3x} = V_3 \cos 15^\circ \quad 11.6$

$= 12 \cos 15^\circ = $ [redacted] m/s

$\Sigma F_y = \rho Q (V_{2y} - V_{1y})$

$F = \rho Q (V_{2y} + V_{3y} - V_1)$

$\Sigma F_y = F_y = (\rho Q_2 V_{2y} + \rho Q_3 V_{3y}) - \rho Q_1 V_{1y}$

$V_{1y} = 0$

$V_{2y} = V_2 \sin 30^\circ$

$= 6 \text{ m/s}$

$F_y = $ ~~25.038~~ N

$V_{3y} = -V_3 \sin 15^\circ$

$= -3.11 \text{ m/s}$

$$F = \sqrt{F_x^2 + F_y^2}$$

$$\boxed{F = 244.68 \text{ N}}$$

$$\theta = \tan^{-1} \frac{F_y}{F_x}$$

$\theta =$

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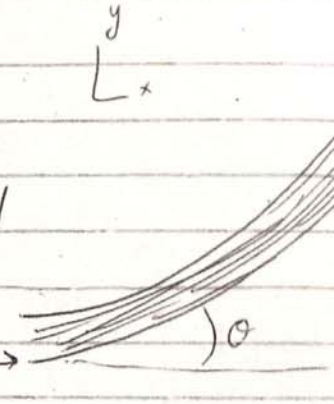
6.15

Data:



$\theta = 120°$ Friction loss = neglected

$V_1 = 30 m/s$

$d = 5 cm$

a) $F_x = ?$

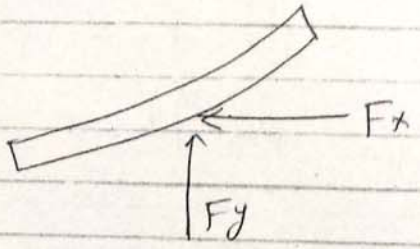
b) $F_y = ?$

c) $F = ?$ $\alpha = ?$

Sol:

$A = 1.96 \times 10^{-3} m^2$

$Q = AV = 0.0588 m^3/s$



a) $-F_x = \rho Q (V_{2x} - V_{1x})$

$= 1000 \times 0.0588 (-15 - 30)$

$\boxed{F_x = 2646 N}$

$V_{1x} = V_1 \cos 0° = 30 m/s$

$V_{2x} = V_2 \cos 120° = -15 m/s$

b) $F_y = \rho Q (V_{2y} - V_{1y})$

$= 1000 \times 0.0588 (26 - 0)$

$\boxed{F_y = 1529 N}$

$V_{2y} = V \sin 120° = 26 m/s$

Resultant $F = \sqrt{2646^2 + 1529^2} = 3056 N$

$\alpha = \tan^{-1}\left(\frac{1529}{2646}\right)$

$\boxed{\alpha = 30°}$

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Prob 6.16

Data: Same problem 6.15 but friction losses as $V_2 = 25 m/s$

a) $-F_x = \rho Q (V_{2x} - V_{1x})$

$= 1000 \times 0.0588 (-12.5 - 30)$

$V_{1x} = 30 m/s$

$V_{2x} = 25 \cos 120° = -12.5 m/s$

$F_x = 2499 N$

b) $F_y = \rho Q (V_{2y} - V_{1y})$

$= 1000 \times 0.0588 (21.65 - 0)$

$F_y = 1273.02 N$

$V_{2y} = V_2 \sin 120° = 21.65$

$= 25 \sin 120° = 21.65 m/s$

Resultant force $= 2804 N$ Ans

$\alpha = \tan^{-1} \frac{1273.02}{2499}$

$\boxed{\alpha = 27°}$

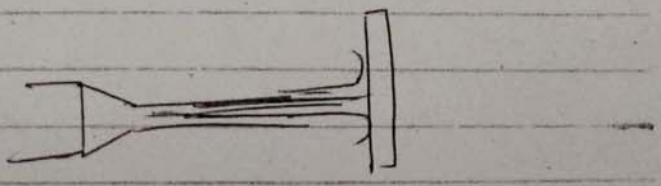
Prob 6.17

Data: Same problem 6.15

$V = 30 m/s$

$A = 1.96 \times 10^{-3} m^2$

$Q = AV = 0.0588 m^3/s$



Force of jet on plate $= \rho a V^2$

$= 1000 \times 1.96 \times 10^{-3} \times 30^2$

$= 1764 N$

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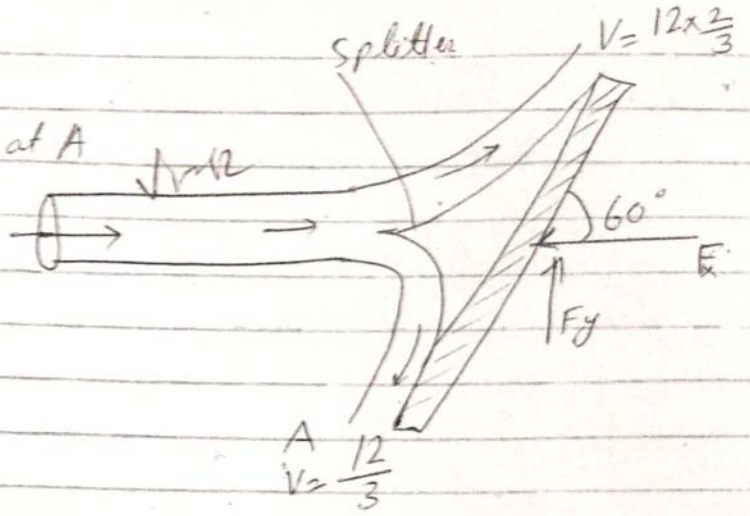
6.33

Data:

$d = 15cm \Rightarrow \frac{1}{3}$ discharge at A

$V = 12 m/s$

Magnitude and direction of F = ?



Sol:

$A = 0.0177 m^2$

$Q = AV = 0.2124 m^3/s$

$\Rightarrow \quad \Sigma F_x = M[V_{2x} - V_{1x}]$

$-F_x = \rho Q (V_2 \cos\theta - V_1 \cos\theta)$

$-F_x = 1000 \times 0.2124 \left(12 \times \frac{2}{3} \cos 60^\circ - \frac{12}{3} \cos 60^\circ - 12 \cos 0^\circ\right)$

$\boxed{F_x = 2124 N}$

$\Rightarrow \quad \Sigma F_y = \rho Q (V_{2y} - V_{1y})$

$= 1000 \times 0.2124 \left(12 \times \frac{2}{3} \sin 60^\circ - \frac{12}{3} \sin 60^\circ - 0\right)$

$F_y = 736 N$

Resultant $F = 2248 N$

$\alpha = 19.11^\circ$

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