Assgnt 1

# Impact of Jets

DOUGLAS: CH=9

SEISMIC GROUP UET LHR

**Problem 1:**

**DATA:** (Case 3)

$d = 0.3m$

$V = 7.5m/s$

$u = 3.6m/s$

$F = ?$

$W.D/s = ?$

$\eta_h = ?$

**Sol:**

$$F = \rho Q (V-u)$$

$$= (1000)(0.5301)(7.5-3.6)$$

$$\boxed{F = 2067.39N}$$ Ans

$$\Rightarrow Q = AV$$

$$= (70.68\times10^{-3})(7.5)$$

$$Q = 0.530 m^3/s$$

$$\Rightarrow A = \frac{\pi d^2}{4}$$

$$A = 70.68\times10^{-3} m^2$$

$$\frac{W.D}{s} = \rho Q (V-u) u$$

$$= 2067.39 \times 3.6$$

$$\boxed{\frac{W.D}{s} = 7442 \text{ watts}}$$ Ans

$$\frac{W.D}{wt.} \text{ by wheel} = \frac{P}{\gamma Q} = \frac{7442}{(9810)(0.5301)} = 1.43 \text{ m of water}$$

$$\frac{W.D}{wt.} \text{ supplied} = \frac{V^2}{2g} = \frac{7.5^2}{2\times9.81} = 2.87 \text{ m of water}$$

$$\eta_h = \frac{WD/wt. \text{ by wheel}}{WD/wt. \text{ supplied}}$$

$$= \frac{1.43}{2.87} \times 100$$

$$\boxed{\eta_h = 49.8\%}$$

Prob. 2 ((Case 2) + (Case 1))

Data:

$d = 50mm$

$V = 18 m/s$

a) $F = ?$ when $u = 0$

b) $F = ?$ when $u = 6 m/s$

c) $\frac{WD}{s}$ by plate $= ?$ $\eta_h = ?$ in (b)

Sol:

a) $F = \rho a V^2$

$a = \frac{\pi d^2}{4} = 1.96 \times 10^{-3} m^2$

$= 1000 \times 1.96 \times 10^{-3} \times 18^2$

$\boxed{F = 635.04 N}$ Ans

b) $F = \rho a (V-u)^2$

$= 1000 \times 1.96 \times 10^{-3} (18-6)^2$

$\boxed{F = 282.24 N}$ Ans

c) $\frac{WD}{s}$ by plate $= F.u$

$= 282.24 \times 6$

$\boxed{\frac{WD}{s} = 1693.44 W}$

$\frac{WD}{wt.}$ by plate $= P/\delta Q = \frac{1693}{9810 \times (1.96 \times 10^{-3}) \times 18} = 4.89 m$ of $H_2O$

$\frac{WD}{wt.}$ supplied $= \frac{V^2}{2g} = \frac{(18)^2}{2 \times 9.81} = 16.51 m$ of $H_2O$

$\eta_h = \frac{W.D/wt. \text{ by plate}}{W.D/wt. \text{ by supplied}} = \frac{4.89}{16.51} \times 100$

$\boxed{\eta_h = 29.6\%}$

Case 1

$1\ dm^3 = 0.001\ m^3$

Prob 8:

Data:

$d = 50mm$

$Q = 85\ dm^3/s = 0.085\ m^3/s$

$F = ?$

$V$ = velocity of jet $\times 10^0$ = (velocity of water in hose)

Sol:

$$\Rightarrow a = \frac{\pi d^2}{4} = 1.96 \times 10^{-3} m^2$$

$$\Rightarrow Q = AV$$

$$V = \frac{Q}{A} = 43.37\ m/s$$

$$\rightarrow F = \rho Q V$$

$$= 1000 \times 0.085 \times 43.37$$

$$= 3686.45\ N$$

Prob. 9

Data:

$V = 4.8 m/s$ $\quad u = 1.8 m/s$

$Q = 85 dm^3/s = 0.085 m^3/s$ $\quad V = 4.8 m/s$

$F = ?$ $\quad F = ?$

Sol:

$Q = AV$

$A = 17.71 \times 10^{-3} m^2$

Force to keep tanker at rest $= \rho a V^2$

$= 1000 \times 17.71 \times 10^{-3} \times 4.8^2 = 408 N$

Force to move the tanker

$-F = \rho Q [-1.8 - 3]$

$\boxed{F = 408 N}$

Prob. 15 Case 5, 6

Data:

$d = 75mm$ $\quad$ $V = 21 m/s$ $\quad$ $\phi = 120°$ $\quad$ $F = ?$

$u = 10.5 m/s$

a) $F = ?$

b) $W.D/s = ?$

c) $\eta_h = ?$

$\phi = 180° - \theta_2$

$\theta_2 = 180° - 120°$

$\therefore \theta_2 = 60°$

Sol:

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

$$Q = AV = 4.42 \times 10^{-3} \times 21 = 0.09282 \, m^3/s$$

$$\Rightarrow F_N = \rho Q (V_2 \cos\theta_2 + V_1 \; .)$$

$$= 1000 \times 0.09282 (21 \cos 60° + 21 \; .)$$

$$= 2923.83 N$$

$\Rightarrow V_1 = V_2$ assuming no friction loss

$$\Rightarrow F_T = \rho Q (\; . \; - V_2 \sin\theta_2)$$

$$= 1000 \times 0.09282 (\; . \; - 21 \sin 60°)$$

$$= -1688 N$$

$$F = \sqrt{F_N^2 + F_T^2}$$

$$\boxed{F = 3376 N}$$

$\Rightarrow$ Direction:

$$\alpha = \tan^{-1} \frac{F_T}{F_N}$$

$$= \tan^{-1} \left( \frac{1688}{2924} \right)$$

$$\boxed{\alpha = 40°}$$

a)

$$F = \rho Q (V_{R_1} + V_{R_2} \cos\theta_2)$$

$$= 1000 \times 0.0928 (10.5 + 10.5 \cos 60^\circ)$$

$$F = 1461.9 \text{ N}$$

$\therefore V_{R_1} = V_1 - u_1$

$= 21 - 10.5$

$V_{R_1} = 10.5 \text{ m/s}$

$V_{R_2} = V_2 - u_2$

b) $\frac{WD}{s}$ by $\frac{1}{2}$ pelton wheel $= F \times u$

$= 1461.9 \times 10.5$

$= 15350 \text{ W}$

c) $\frac{WD}{wt.}$ by $\frac{1}{2}$ pelton wheel $= \frac{P}{\gamma Q} = \frac{15350}{(9810)(0.0928)}$

$= 16.86 \text{ m of } H_2O$

$\frac{WD}{wt.}$ supplied $= \frac{K.E}{wt} = \frac{V^2}{2g} = \frac{(21)^2}{2 \times 9.81} = 22.48$ m of water

$$\eta_h = \frac{16.86}{22.48} \times 100$$

$$\boxed{\eta_h = 75\%}$$

**Prob. 17** (Case 5, 6)

$d = 50\,mm$

$V = 24\,m/s$

$\phi = 120°$

a) $F_N = ?$ when stationary

b) $F_N = ?$ when $u = 9\,m/s$

$\frac{WD}{s} = ?$ $\quad \eta_h = ?$

**Sol:**

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

$Q = AV = 0.04704\,m^3/s$

a) $F_N = \rho Q (V_2 \cos\theta_2 + V_1)$

$= 1000 \times 0.04704 (24 \cos 60° + 24)$

$\boxed{F_N = 1694\,N}$

$\Rightarrow (V_1 = V_2$ assuming no friction loss)

$\phi = 180° - \theta_2$

$\theta_2 = 180° - 120°$

$\theta_2 = 60°$

$V_{R_1} = V_1 - u_1$

$= 24 - 9 = 15$

b) $F_N = \rho Q (V_{R_1} + V_{R_2} \cos\theta_2)$

$= 1000 \times 0.04704 (15 + 15 \cos 60°)$

$= 1058.4\,N$

$\frac{WD}{s} = F u = 1058.4 \times 9 = \underline{9526\,W}$

$\frac{WD}{wt.}$ by wheel $= \frac{P}{\delta Q} = \frac{9526}{9810 \times 0.04704} = 20.64\,m\,of\,H_2O$

$\frac{WD}{wt.}$ supplied $= \frac{K.E}{wt.} = \frac{V^2}{2g} = \frac{24^2}{2 \times 9.81} = 29.36\,m\,of\,H_2O$

$\eta_h = \frac{20.64}{29.36} \times 100$

$\boxed{\eta_h = 70.29\,\%}$

Case 6

Prob. 19

Data:

$Q = 85\ dm^3/s = 0.085\ m^3/s$ — Friction losses = 0.80

$V_1 = 36\ m/s$ — Resultant F = ?

$u = 18\ m/s$ — $\eta_h = ?$

$\alpha = 135°$ — Assumption = water enters without shock.

Sol:

$V_{R1} = V_1 - u_1$

$= 36 - 18 = 18\ m/s$

$V_2 = 0.8 V_1$

$= 0.8\ (36)$

$V_2 = 28.8\ m/s$

$\vec{V}_{R2} = \vec{V}_2 - \vec{u}_2$

$= 28.8 - 18$ $\quad \because u_1 = u_2$

$V_{R2} = 10.8\ m/s$

Also

$\theta_2 = 180° - 135° = 45°$

$F_N = \rho Q (V_{R1} + V_{R2} \cos\theta_2)$

$F_N = 2179.12\ N$

$F_T = -\rho Q V_{R2} \sin\theta_2$

$= -649.1$

$$F = \sqrt{F_N^2 + F_T^2}$$

$$= \sqrt{2179.12^2 + 649^2}$$

$$= 2274\ N$$

$$\frac{WD}{s} = Fu = 2274 \times 18 = 40932 \text{ watts}$$

$$\frac{WD}{wt.} \text{ by machine} = \frac{45838.6}{9810 \times 0.085} = 55 \text{ m of } H_2O \quad (49)$$

$$\frac{W.D}{wt.} \text{ supplied} = \frac{V^2}{2g} = \frac{36^2}{2 \times 9.81} = 66 \text{ m of } H_2O$$

$$\eta_n = \frac{49}{66} \times 100$$

$$\eta = 74\ \%$$

Prob.20 Case 1

Data:

$M = \rho Q = 20 kg/s$

$V = 25 m/s$

$u = 12 m/s$

$\beta_1 = 25°$

$\theta_1 = ?$

If $\theta_2 = 150°$ means $180° - 150° = 30°$

$F_N = ?$

$P = ?$

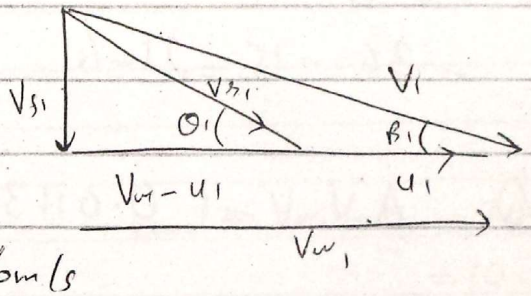
Friction = 20%

$V_{R_2} = 0.8 V_{R_1}$

Sol:

$V_{w_1} = V_1 \cos\beta_1$

$= 25 \cos 25 = 22.66 m/s$




$V_{f_1} = V_1 \sin\beta_1 = 25 \sin 25 = 10.56 m/s$

$V_{w_1} - u_1 = 10.66$

$V_{R_1} = \sqrt{(V_{f_1})^2 + (V_{w_1} - u_1)^2} = 15 m/s$

$V_{R_2} = 0.8(15) = 12 m/s$

$\theta_1 = \tan^{-1}\left(\frac{V_{f_1}}{V_{w_1} - u_1}\right) = 44.73°$ Ans

$F_N = \rho Q (V_{R_2} \cos\theta_2 + V_{R_1} \cos\theta_1)$

$\boxed{F_N = 420.97 N}$

$P_{owr} = \frac{WD}{t}$ by $T \cdot W = F_N u$

$= 420.97 \times 12 = 5052 W$

Ans.

Case 6

Prob 21

Data:

$d = 20\,mm$ Frictional resistance = 12%.

$V = 36\,m/s$ a) F resultant = ? Direction = ?

$u = 15\,m/s$ b) Power = ?

$\theta_2 = 150^\circ$ mean $180^\circ - 150^\circ = 30^\circ$

Sol:

$V_{R_1} = V_1 - u_1 = 36 - 15 = 21\,m/s$ and $V_{R_2} = 0.88 \times 21 = 18.48\,m/s$

Also

$Q = AV = 0.0113\,m^3/s$

$\Rightarrow F_N = \rho Q (V_{R_2} \cos\theta_2 + V_{R_1} \cos\theta_1)$

$= 1000 \times 0.0113 (18.48 \cos 30^\circ + 21 \cos 0)$

$F_N = 418.14\,N$

$\Rightarrow F_T = \rho Q (V_{R_1} \sin\theta_1 - V_{R_2} \sin\theta_2)$

$= 1000 \times 0.0113 (21 \sin 0 - 18.48 \sin 30^\circ)$

$F_T = -104.4\,N$

$\Rightarrow F = \sqrt{F_N^2 + F_T^2}$

$\boxed{F = 431\,N}$ Ans

$\Rightarrow \alpha = \tan^{-1} \frac{F_T}{F_N}$

$\boxed{\alpha = 14^\circ}$ Ans

Power $= \frac{WD}{t}$ by fixed wheel $= F_N \cdot u$

$= 418.14 \times 15$

$= 6272.1$ Watts Ans.

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**Prob. 22** Case 7

**Data:**

$M = 13.6$ kg/s
$V = 24$ m/s
$\beta_1 = 30°$
$u = 10.5$ m/s
$\theta_2 = 20°$

a) $\theta_1 = ?$
b) $\frac{WD}{t} = ?$

**Sol:**

$V_{w_1} = V_1 \cos\beta_1$

$V_{w_1} = V_1 \cos 30°$

$= 24 \cos 30° = 20.78$ m/s

and $V_{w_1} - u = 20.78 - 10.5$

$= 10.28$ m/s

$V_{f_1} = V_1 \sin\beta_1$

$= 24 \sin 30° = 12$ m/s

Hence $\theta_1 = \tan^{-1}\left(\frac{V_{f_1}}{V_{w_1} - u_1}\right) = \tan^{-1}\left(\frac{12}{10.28}\right) = 49°25'$ Ans

$\Rightarrow F_N = \rho Q (V_{R_2}\cos\theta_2 + V_{R_1}\cos\theta_1)$

$F_N = 13.6 (15.8 \cos 20 + 15.8 \cos 49°25')$

$F_N = 341.7$ N

$\therefore V_{R_1} = \sqrt{V_{f_1}^2 + (V_{w_1} - u)^2}$

$V_{R_1} = 15.8$ m/s

$V_{R_2} = V_{R_1}$ as no friction loss

Power $= \frac{WD}{t} = \frac{F_N \cdot u}{t} = 341.7 \times 10.5$

$= 3587.97$ Watts

$= 3.58$ KW

Ans

Prob 24 Case 8

Data:

$D_1 = 0.9\,m$

$D_2 = 0.6\,m$

$P_1 = 414\,KN/m^2$

$V_1 = 2.1\,m/s$

$F = ?$

$h_L = 1.5\,m$

Sol:

$A_1 = 0.636\,m^2$ $\qquad A_2 = 0.283\,m^2$

Applying continuity eq:

$$A_1V_1 = A_2V_2$$

$$V_2 = \frac{A_1V_1}{A_2} = 4.72\,m/s$$

Applying energy equation

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

$$P_2 = 390.35\,KN/m^2$$

Writing IME in x-direction

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

$$P_1A_1 - P_2A_2 - F = \rho Q (V_2 - V_1)$$

$$\boxed{F = 149.4\,KN}$$ Ans

Prob. 25 Case 9

Data:

$D_1 = 600\,mm$

$D_2 = 300\,mm$

$\phi = 60^\circ$

$P_1 = 172\,KN/m^2$

$F = ?$ (Resultant + direction)

a) when no flow

b) when $Q = 0.85\,m^3/s$

Sol:

$A_1 = 0.2827\,m^2$ $\quad A_2 = 0.0707\,m^2$

$$z_1 + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} = z_2 + \frac{P_2}{\gamma} + \frac{V_2^2}{2g}$$

$$P_1 = P_2$$

$$P_2 = 172\,KN/m^2$$

When $Q = 0$

$$\Rightarrow \quad F_x = P_1 A_1 - P_2 A_2 \cos\phi$$

$$= 172(0.2827) - 172(0.0707)\cos 60^\circ$$

$$F_x = 42.54\,KN$$

$$\Rightarrow \quad F_y = \sin\phi\, P_2 A_2$$

$$= \sin 60^\circ \; 172(0.0707)$$

$$F_y = 10.53\,KN$$

$$\text{Resultant } F = \sqrt{42.54^2 + 10.53^2}$$

$$F = 43.82\,KN \quad \text{Ans}$$

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

$$= \tan^{-1}\left(\frac{10.53}{42.54}\right)$$

$$\alpha = 13^\circ 54' \quad \text{Ans.}$$

When $Q = 0.85 m^3/s$

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

$$= 172000 \times 0.2827 - 104259.8 \times 0.0707 \cos 60^\circ - 1000 \times 0.85 (12.02 \cos 60^\circ - 3)$$

$$F_x = 42380 N = 42.38 kN$$

$$F_y = \sin\phi (P_2 A_2 + \rho Q V_2)$$

$$= \sin 60^\circ (104259.8 \times 0.0707 + 1000 \times 0.85 \times 12.02)$$

$$F_y = 15231.8 N = 15.231 kN$$

$\because Q = A_1 V_1$

$$V_1 = \frac{Q}{A_1} = 3 m/s$$

$$V_2 = \frac{Q}{A_2} = 12.02 m/s$$

$$\Rightarrow F = \sqrt{42.38^2 + 15.232^2}$$

$$\boxed{F = 45 kN} \quad \text{Ans}$$

Since

By energy equation

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

$$\frac{172000}{9810} + \frac{3^2}{2g} = \frac{P_2}{89810} + \frac{12.02^2}{2 \times 9.81}$$

$$P_2 = 104259.8 N/m^2$$

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

$$= \tan^{-1} \left( \frac{15.231}{42.38} \right)$$

$$\boxed{\alpha = 19^\circ 46'} \quad \text{Ans}$$

Dougherty

Prob. 6.6

Data:

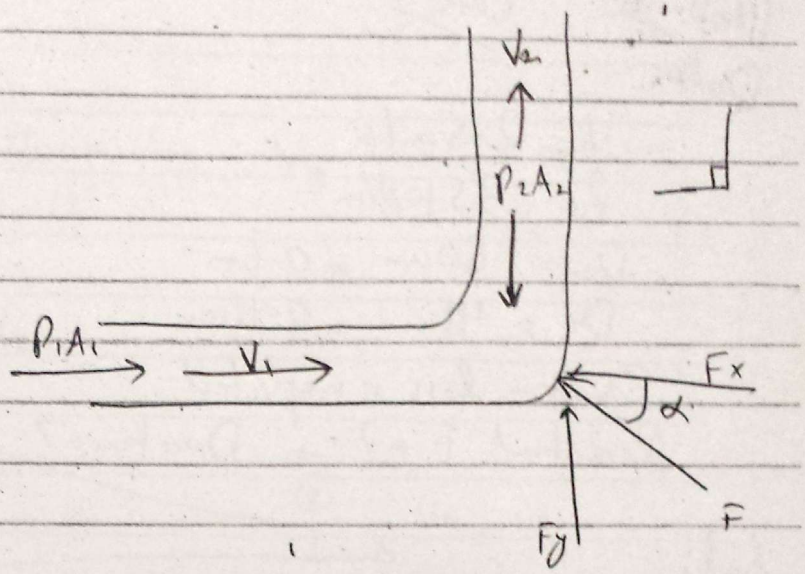
$P = 450\ kN/m^2$

$V = 3\ m/s$

$d = 30cm = 0.3m$

Resultant $F = ?$

Direction $= ?$




Sol:

$a = 0.0707\ m^2$

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

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

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

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

$$F_x = 32452\ N$$

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

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

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

$$F_y = 32451.3\ N$$

Resultant $F = 45.9\ kN$ Ans

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

Prob. 6.7 Case 9

Data:

$V_1 = 2.5 m/s$

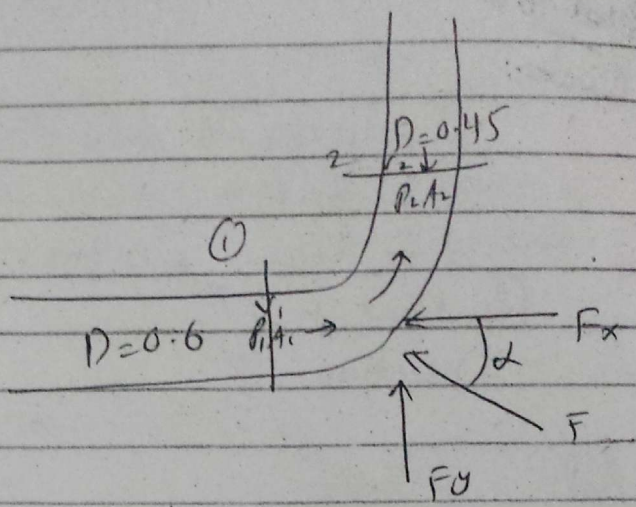
$P_1 = 35 KN/m^2$

$D_1 = 60cm = 0.6m$

$D_2 = 45cm = 0.45m$

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

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

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

$P_2 = 28268.2 N/m^2$

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

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

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

$F_x = 11662 N$

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

$F_y = 7633.8 N$

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

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

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

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

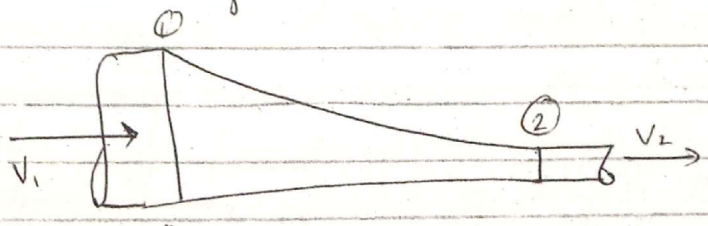
6.8 Case 9

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:

$A_1 = 0.6362 m^2$

$A_2 = 0.2827 m^2$

$A_1V_1 = A_2V_2$

$V_2 = \frac{A_1V_1}{A_2} \Rightarrow V_2 = 5.63 m/s$

Applying energy equation

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

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

Also

$Q = A_1V_1 = A_2V_2 = 1.5905 m^3/s$

a) From left to right

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

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

$\boxed{F = 246 kN}$

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

Equation

$P_1A_1 - P_2A_2 - F = \rho Q(V_2 - V_1)$

$F = 246 kN$

Prob. 6.9

Data:

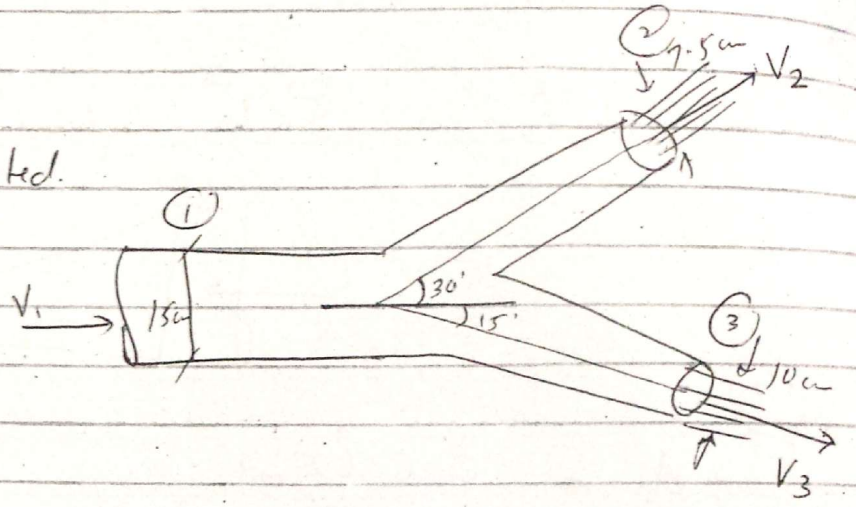
Magnitude and direction of force = ?

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

$Z_1 = Z_2 = Z_3$

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

Friction = neglected.




Sol.

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

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

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

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

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

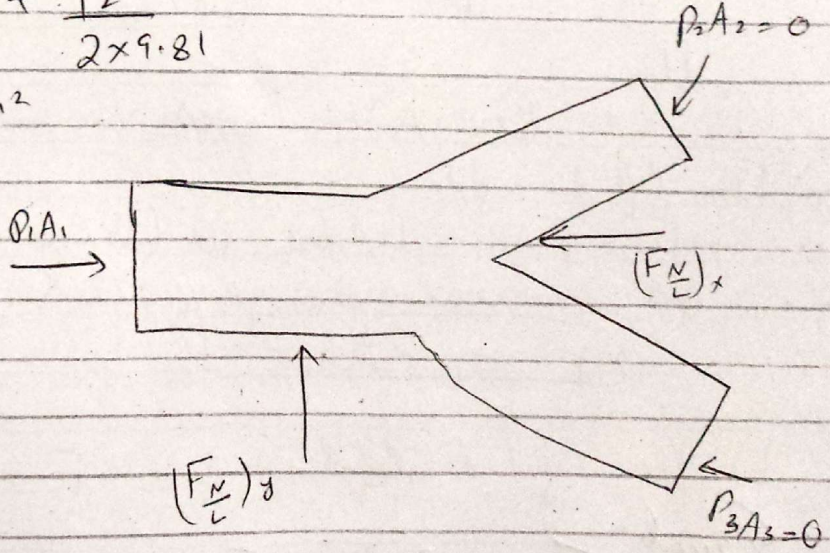
$Q = 0.1473 \text{ m}^3/\text{s} \quad Q_2 = 0.053 \text{ m}^3/\text{s} \quad Q_3 = 0.0942 \text{ m}^3/\text{s}$

Energy equation

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

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

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



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

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

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

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

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

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

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

$F_x =$ ~~206~~ N

$243.4 \text{ N}$

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

$= 12 \cos 15^\circ =$ [illegible] 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

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

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

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

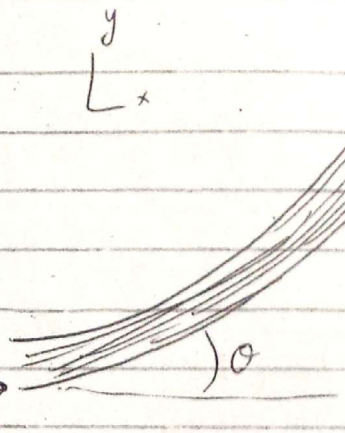
$$F = 244.68 \text{ N}$$

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

$\theta =$

6.15

Data:




$\theta = 120°$ Friction loss = neglected

$V_1 = 30 m/s$

$d = 5 cm$

a) $F_x = ?$

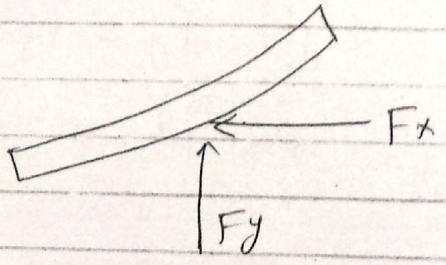
b) $F_y = ?$

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

Sol:

$A = \frac{\pi}{4} d^2 = 1.96 \times 10^{-3} m^2$

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




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

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

$\boxed{\alpha = 30°}$

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

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

$\boxed{\alpha = 27°}$

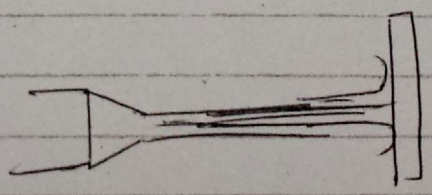
Prob 6.17

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 $= \rho a V^2$

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

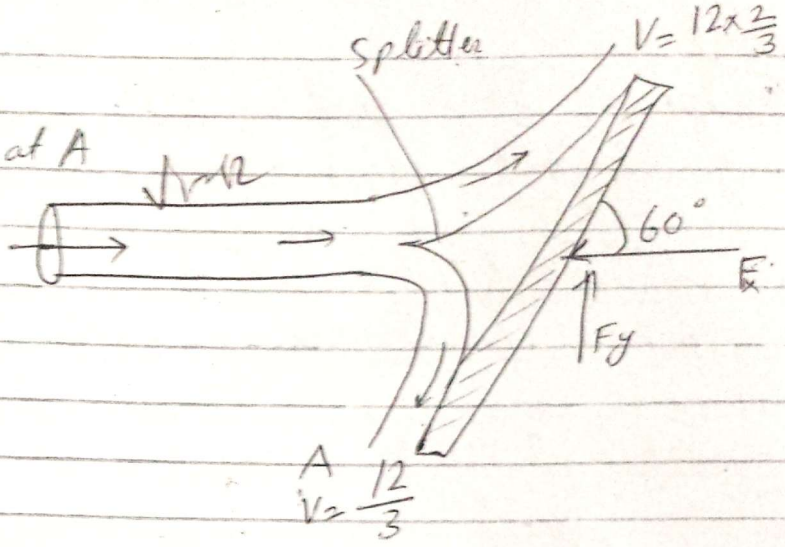
$= 1764 N$

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 $F = 2248 N$

$\alpha = 19.11^\circ$