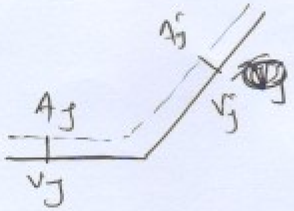
P3.60 Tutorial



x-momentum balance

$$-F_x = 0 + \int u \rho (V\cdot n)\, dA$$

$$= \underbrace{(V_j - V_c)}_{\cos\theta}\, \rho (V_j - V_c) A_j + (V_j - V_c)(V_j - V_c)(-) A_j\, \rho =$$

$$+F_x = \rho A_j (V_j - V_c)^2 (1 - \cos\theta)$$

(b) $P = V_c F_x = \rho A_j V_c (V_j - V_c)^2 (1 - \cos\theta)$

(c) $F_{x\,max} \Rightarrow V_c = 0$

(d) $\frac{dP}{dV_c} = 0 \qquad \cancel{-2(V_j - V_c) V_c} + (V_j - V_c)^2 = 0$

$$V_j - V_c = +2 V_j$$

$$-2V_c + V_j - V_c = 0$$

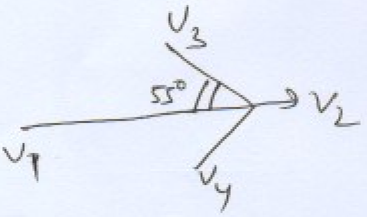
$$3V_c = V_j$$

$$V_c = V_j/3$$

P3.68

$\dot{m}g = 1960$ N/s

$\dot{m} = 200$ kg/s



x-momentum balance

$$-F = \int u \underbrace{\rho (V.n) dA}_{\dot{m}}$$

$\rho A_1 V_1 = 200$

$1000 \times 0.04 \times 1 \times V_1 = 200 \quad V_1 = 5\,m/s = V_2 = V_3 = V_4$

$$-F = 5 \times (200 \times 0.3) + (200)(0.35)\, 5 \cos(180-55) + 200 \times 0.35 (5) \cos(180-55)$$

$$- 200 \times 5$$

$$= 300 - 401.5 - 1000$$

$F = 1101.5$ N

P3.84

$\rho V A = 0.3 \text{ kg/s}$

$PV = nRT$

$P = \frac{\rho}{m} RT \qquad \rho = \frac{Pm}{RT} = \frac{1.01325 \times 10^5 \times 28.8}{8314 \times 293} = 1.2 \text{ kg/m}^3$

$1.2 \times V \times \frac{\pi}{4}(0.1)^2 = 0.3$

$V = 31.83 \text{ m/s}$

x momentum

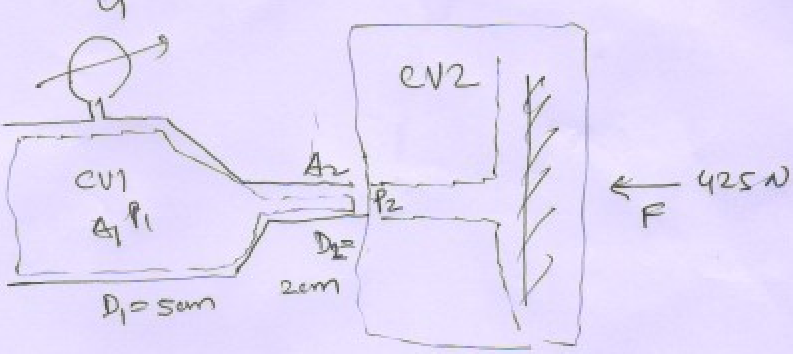
$-W = V \cos 42.5\, \dot{m} - V \dot{m}$

$= 31.83 \cos 42.5 \times 0.3 - 31.83 \times 0.3$

$= -2.5 \text{ N}$

$W = 2.5 \text{ N}$

P3.119



$\rho = 0.79 \times 1000 = 790\ kg/m^3$

mass balance on CV1

$$0 = \cancel{\frac{d}{dt}}^{0}\int \rho\, d\forall + \int \rho (V \cdot n)\, dA$$

Steady state

Assuming uniform velocity profile at section 1 & 2

$$0 = 0 + \rho V_2 A_2 - \rho V_1 A_1 \quad \text{— } (1')$$

V_1 & V_2 are unknown $\rightarrow$ we need another equation

x-momentum balance on CV_2

$$\Sigma F_x = \cancel{\frac{d}{dt}}^{0}\int u \rho\, d\forall + \int u \rho (V \cdot n)\, dA$$

S.S.

$$-425 = 0 + 0 - \rho V_2^2 A_2$$

$$425 = 790 \times V_2^2 \times \frac{\pi}{4}(0.02)^2$$

$$V_2 = 41.38\ m/s$$

from (1') $\quad V_1 = V_2 \dfrac{D_2^2}{D_1^2} = \dfrac{41.38 \times (0.02)^2}{(0.05)^2} = 6.62\ m/s$

To find $P_1 \Rightarrow$ energy balance on CV1

$$\frac{p_1}{\rho g} + \frac{1}{2g}\alpha_1 V_1^2 + z_1 = \frac{p_2}{\rho g} + \frac{1}{2g}\alpha_2 V_2^2 + z_2 + h_f - h_p + h_t \quad \text{— } (1)$$

Assume frictionless $h_f = 0$

no pump or turbine $h_p = 0, h_t = 0$

$z_1 = z_2$

Assume turbulent flow $\alpha_1 = \alpha_2 = 0$

$P_2 = 1 \text{ atm} = 101325 \text{ N/m}^2$

from (ii)

$$\frac{p_1}{790 \times 9.81} + \frac{1}{2 \times 9.81}(6.62)^2 = \frac{101325}{790 \times 9.81} + \frac{1}{2 \times 9.81} \times (41.38)^2$$

$$= 13.074 + 87.273$$

$$\frac{p_1}{790 \times 9.81} + 2.234$$

$$P_1 = 760374.6 \text{ Pa}$$