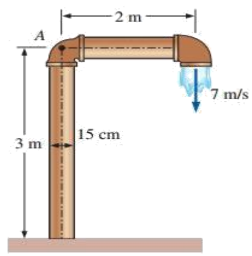
Sheet No 2.1

1- Water is flowing through a 15-cm-diameter pipe that consists of a 3-m-long vertical and 2-m-long horizontal section with a 90° elbow at the exit to force the water to be discharged downward, as shown in Fig. in the vertical direction. Water discharges to atmospheric air at a velocity of 7 m/s, and the mass of the pipe section when filled with water is 15 kg per meter length. Determine the moment acting at the intersection of the vertical and horizontal sections of the pipe (point A). What would your answer be if the flow were discharged upward instead of downward?

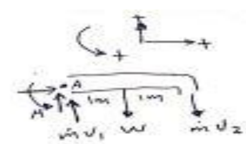


Solution

Solution

$\dot{m} = \rho A V = 1000 * 9.81 * \frac{\pi}{4}(0.15)^2$

$= 123.7 \ kg/s$



$W = mg = 15 * 2 * 9.81 = 294.3 \ N$

(a) downward discharge

$\sum M_A = \sum_{out} r\dot{m}V - \sum_{in} r\dot{m}V$ ($r = 0$)

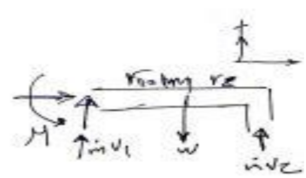
$M_A - r_1 W = -r_2 \dot{m} V_2$

$M_A = r_1 W - r_2 \dot{m} V_2 = 1 * 294.3 - 2 * 123.7 * 7$

$= -1438 \ N \cdot m$

. negative sign indicates that the assumed direction for M_A is wrong

(b) upward discharge direction



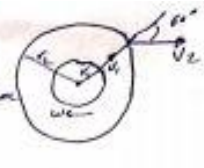
$M_A - r_1 W = r_2 \dot{m} V_2$

$M_A = r_1 W + r_2 \dot{m} V_2$

$= 2026 \ N \cdot m$

3- The impeller of a centrifugal pump has inner and outer diameters of 13 and 30 cm, respectively, and a flow rate of 0.15 m^3/s at a rotational speed of 1200 rpm. The blade width of the impeller is 8 cm at the inlet and 3.5 cm at the outlet. If water enters the impeller in the radial direction and exits at an angle of 60° from the radial direction, determine the minimum power requirement for the pump

<u>Sol</u>



$$V_{1n} = \frac{Q}{2\pi r_1 b_1} = \frac{0.15}{2\pi(0.13/2) \times 0.08} = 4.59\ m/sec$$

$$V_{2n} = \frac{Q}{2\pi r_2 b_2} = \frac{0.15}{2\pi(0.3/2) \times 0.035} = 4.547\ m/sec$$

$\alpha_1 = 0° \longrightarrow V_{t1} = V_{n1} \tan 0 = \text{zero}$

$\alpha_2 = 60° \rightarrow V_{t2} = V_2 \tan 60 = 7.876\ m/sec$

$\cdot\ \dot{m} = \rho Q = 150\ kg/sec$

$$T = \dot{m}(r_2 V_{2t} - r_1 V_{t1})$$
$$= 150\,(0.3 \times 7.876 - 0) = 354.43\ N$$

$\cdot$ Power $= T\omega$

$$\omega = \frac{2\pi n}{60} = 125.7\ rad/sec$$

$$\dot{W} = 125.7 \times 354.43 = 44551.3\ W$$
$$= \underline{44.55\ kW}$$