6.15 *Assuming ideal flow in a horizontal plane, calculate the magnitude and direction of the resultant force on the stationary blade in Fig. P6.15, knowing that V_j = 50 fps and D_j = 6 in. Note that the jet is divided by the splitter so that one-third of the water is diverted toward A.*

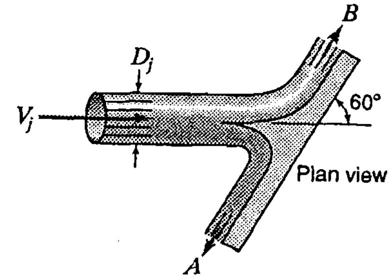


Figure P6.15

BG

$Q = \frac{\pi 0.5^2}{4}50 = 9.82$ cfs ; $Q_A = \frac{Q}{3} = 3.27$ cfs, $Q_B = 6.54$ cfs

Eq. 6.7*a* for CV: $F_x = \rho Q_A(V_{2x} - V_{1x}) + \rho Q_B(V_{2x} - V_{1x})$

$= 1.940(3.27)(-50\cos 60° - 50) + 1.940(6.54)(50\cos 60° - 50)$

$= -476 - 317 = -794$ lb $= 794$ lb ← on the CV

Eq. 6.7*b* for CV:

$F_y = \rho Q_A(V_{2y} - V_{1y}) + \rho Q_B(V_{2y} - V_{1y}) = 1.940(3.27)(-50\cos 30° - 0) + 1.940(6.54)(50\cos 30° - 0)$

$= -275 + 550 = +275$ lb $= 275$ lb ↑ on the CV.

The water acts on the blade with an opposite force $(F_{W/B})_x$ of 794 lb along the centerline to the right; and perpendicularly with an opposite force $(F_{W/B})_y$ of 275 lb (towards *A*).

Resultant force on the blade = 840 lb at 19.11° ↘ from the centerline (towards *A*) ◄

6.19 *At section P a 5-in-diameter water jet with a velocity of 28 fps is directed vertically upward against the cone shown in Fig. P6.19. Neglecting friction and assuming the streamlines at Q are parallel, find the weight of the cone if a = 1.5 ft, b = 0.6 ft, and c = 4 ft.*

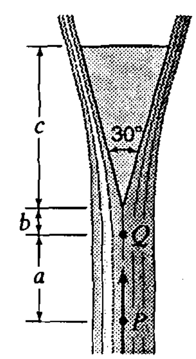


Figure P6.19

BG

Find V at section Q: Eq. 5.15: $V_P^2/2g = 1.5 + V_Q^2/2g$

$V_Q^2/2g = 28^2/2g - 1.5 = 10.67$ ft ; $V_Q = 26.2$ ft/sec

Find V_d at discharge: $V_Q^2/2g = 4.6 + V_d^2/2g$

$V_d^2/2g = 26.2^2/2g - 4.6 = 6.07$; $V_d = 19.78$ fps

From Eq. 6.10: $-(F_{C/W})_z - W_w = \rho Q(V_{2z} - V_{1z})$

where W_w = weight of water = γQ × time to flow about 4.6 ft

$\therefore$ flow time $= \frac{4.6}{(26.2 + 19.78)/2} = 0.200$ sec ;

$W_w = \gamma Q t = 62.4(\pi/4)(5/12)^2 28(0.200) = 47.7$ lb

$W_{cone} = (F_{C/W})_z = -W_w - \rho Q(V_{2z} - V_{1z})$

$W_{cone} = -47.7 - 1.940(\pi/4)(5/12)^2 28(19.78\cos 15° - 26.2) = -47.7 + 52.7 = 5.04$ lb ◄

6.22 *In Fig. P6.22 streamlines are plotted to scale in the plane of the center of a free jet impinging vertically on a horizontal circular plate. The jet diameter is 280 mm and stagnation pressure at point O is 5.5 kPa. By scaling off the pertinent dimensions determine as accurately as possible the velocity of the water as it leaves the plate and the total resultant force exerted by the water on the plate.*

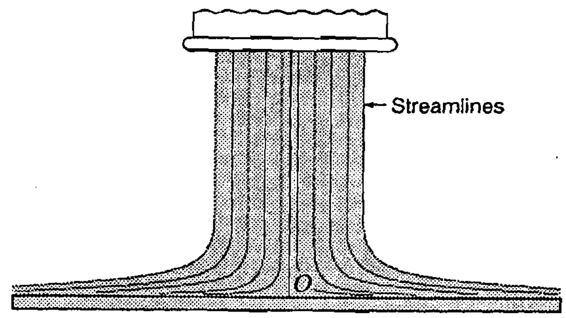


Figure P6.22

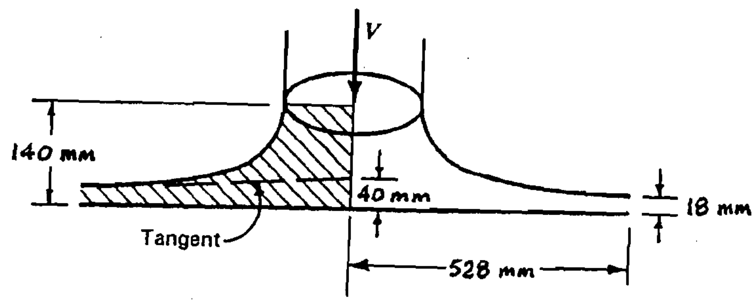
SI

Energy equation from where streamlines diverge (z = 140 mm) to stagnation point:

$$0 + 0.14 + \frac{V^2}{2g} = \frac{p_O}{\gamma} + 0 + 0 = \frac{5.5}{9.81} = 0.561 \text{ m};$$

$$\frac{V^2}{2g} = 0.421 \text{ m} \; ; \quad V = \sqrt{2(9.81)0.421} = 2.87 \text{ m/s}$$

$$Q = AV = (\pi 0.14^2)2.87 = 0.1769 \text{ m}^3\text{/s}$$



By scaling from Fig. P6.22: Water leaves the plate (r = 528 mm) at an average angle of about 1.2° and at a depth of about 18 mm, for example. (Scaling at different points will give rise to somewhat different answers.)

$V_2 = Q/A_2 \approx 0.1769/[(2\pi(0.528)0.018)] \approx 3.0$ m/s ◄

$\rho Q(\Delta V) \approx (9810/9.81)0.1769(2.87 - 2.96\sin 1.2°) = 497$ N

By scaling from Fig. P6.22, and by calculation, for water to one side of the vertical centerline and below the point where the jet first begins to widen: Area $\approx A$ = 33 300 mm^2 = 0.0333 m^2, distance from centerline to centroid = $r_c \approx$ 165.7 mm = 0.1657 m.

Using Pappus' theorem: $W = \gamma \forall = 9810(2\pi r_c A) \approx 19\,620\pi(0.1657)0.0333 = 340$ N

Total Force = $W + \rho Q(\Delta V) \approx 340 + 497 = 837$ N $\approx$ 840 N ◄

SOLUTIONS

Chapter 5 - Homework Problems

For Problem 1 through 14 draw the EL and HGL for the flow conditions shown by the sketches.