Group 11

Homework 2.3

MET 330

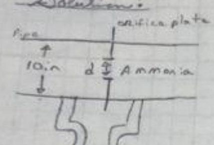
10/28/21

Fluid Mechanics | HW 2.3 | 10-27-21

Ch 15

(4) Given: A sharp-edged orifice is placed in a 10-in-diameter pipe carrying ammonia. If the volume flow rate is 25 gal/min, calculate the deflection of a water manometer (a) if the orifice diameter is 1.0 in and (b) if the orifice diameter is 7.0 in. The ammonia has a specific gravity of 0.83 and a dynamic viscosity of 2.50×10^{-6} #/ft².

Solution:



$\gamma_a = 51.79$ #/ft³

Flow Rate = 25 gal/min = 0.0557 ft³/s

$A_2 \Rightarrow 1.0\text{ in} = 0.785\text{ in}^2 = 0.00545\text{ ft}^2$

specific gravity = 0.83

dynamic viscosity = 2.5×10^{-6} #/ft²

When d = 1.0 in

$A_1 = \frac{\pi (10\text{ in})^2}{4} = 78.5\text{ in}^2 = 0.5451\text{ ft}^2$

$V_1 = C \times \sqrt{\frac{2gh\,(\gamma_w/\gamma_a) - 1}{(A_1/A_2)^2 - 1}}$

$v_1 = \frac{0.0557\text{ ft}^3/s}{0.5451\text{ ft}^2} = 0.1022\text{ ft/s}$

$\left(\frac{Q}{A_1 \times C}\right)^2 = \frac{2gh\,(\gamma_w/\gamma_a) - 1}{(A_1/A_2)^2 - 1}$

$\rho_a = 1.6102\ \frac{\text{slugs}}{\text{ft}^3}$

$\frac{\left(\left(\frac{V_1}{C}\right)^2 \left((A_1/A_2)^2 - 1\right)\right)}{(2g)\left((\gamma_w/\gamma_a) - 1\right)} = h$

$\nu = 2.5 \times 10^{-6}\,\#/\text{ft}^2 / \left(1.6102\ \frac{\text{slugs}}{\text{ft}^3}\right) = 1.55 \times 10^{-6}\ \text{ft}^2/s$

$N_R = \frac{0.1022\text{ ft/s}\,(0.83)}{1.55 \times 10^{-6}\text{ ft}^2/s} = 54\,726.452 = 5.4726 \times 10^4$

$h = \frac{\left(\frac{0.1022\text{ ft}/s}{0.59}\right)^2 \left(\frac{0.5451\text{ ft}^2}{0.00545\text{ ft}^2} - 1\right)}{2\left(32.2\,\frac{ft}{s^2}\right)\left((62.4\,\#/\text{ft}^3 / 51.79\,\#/\text{ft}^3) - 1\right)}$

$= 0.2252\text{ ft} = \boxed{2.7024\text{ in}}$

$\frac{d}{D} = \frac{1\text{ in}}{10\text{ in}} = 0.1$

* Fig. 15.7 Graph $C = 0.59$

$h = \frac{\left(\frac{0.1022\text{ ft}^3/s}{0.61}\right)^2 \left(\frac{0.5451\text{ ft}^2}{0.2671\text{ ft}^2} - 1\right)}{2\left(32.2\,\frac{ft}{s^2}\right)\left((62.4\,\#/\text{ft}^3 / 51.79\,\#/\text{ft}^3) - 1\right)}$

$= 0.0022\text{ ft} = \boxed{0.0264\text{ in}}$

$A_2 \Rightarrow 7.0\text{ in} = 38.465\text{ in}^2 = 0.2671\text{ ft}^2$

$d/D = 7.0\text{ in}/10\text{ in} = 0.7$

$C = 0.61$

Problem 15.9

Why Is there such Difference Between the angles of convergent + Divergent sections of a venturi tube?

This is mainly to reduce Energy losses in the system.

Ch 15

15. $T = 80°F$ $h = 0.24$ in or 0.02 ft

$V_1 = \sqrt{2gh(\gamma_g - \gamma)/\gamma}$

$\gamma = 0.0736$ lb/ft^3

$\gamma_g = 62.4$ lb/ft^3 1 in $= 0.083$ ft

$V_1 = \sqrt{2(32.2)(0.02)(62.4 - 0.0736)/0.0736}$

$\boxed{V_1 = 33.03 \text{ ft/s}}$

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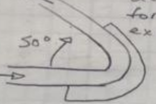
Ch 16

(6.) Given: The figure shows a free stream of water at 180°F being deflected by a stationary vane through a 130° angle. The entering stream has a velocity of 22.0 ft/s. The cross-sectional area of the stream is constant at 2.95 in² throughout the system. Compute forces in the horizontal and vertical directions exerted on the water by the vane.



$2.95 in^2 = 0.020 ft^2$

Solution:

$Q = 0.020 ft^2 (22 ft/s)$

$= 0.44 ft^3/s$

ρ_w @ 180°F = 1.883 slugs/ft³

$(v_2)_x = 22 ft/s \times \cos(180° - 130°)$

$= 14.14 ft/s$

$(v_2)_y = 22 ft/s \times \sin(180° - 130°)$

$= 16.85 ft/s$

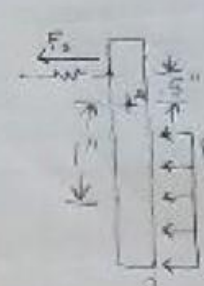
$F_x = 1.883 \frac{slugs}{ft^3} (0.44 ft^3/s)(14.14 ft/s + 22 ft/s)$

$= 29.9427\# = \boxed{29.94\#}$

$F_y = 1.883 slugs/ft^3 (0.44 ft^3/s)(16.85 ft/s)$

$= 13.9605\# = \boxed{13.96\#}$

Problem 16.11



$Q = 100 \frac{gal}{min} = 0.22 \frac{ft^3}{s}$

$\rho_{water} = 1.94 \frac{slug}{ft^3}$

$V_{water} = \frac{Q}{A_{pipe}} = \frac{0.22 \frac{ft^3}{s}}{0.00545 ft^2} = 40.85 \frac{ft}{s}$

$F_{WATER} = \rho Q(\cancel{V_2} - V_1) = \rho Q(-V_{WATER})$

$\therefore F_{WATER} = 1.94 \frac{slug}{ft^3} \cdot 0.22 \frac{ft^3}{s} \cdot (-40.85 \frac{ft}{s}) = \boxed{-17.43 lb}$

$\circlearrowleft \Sigma M_A = 0 \quad F_s d_s - F_{WATER} d_w = 0$

$F_s (\frac{0.5}{12}) ft = -17.43 lb (\frac{1}{12}) ft \quad \boxed{F_s = -34.87 lb}$

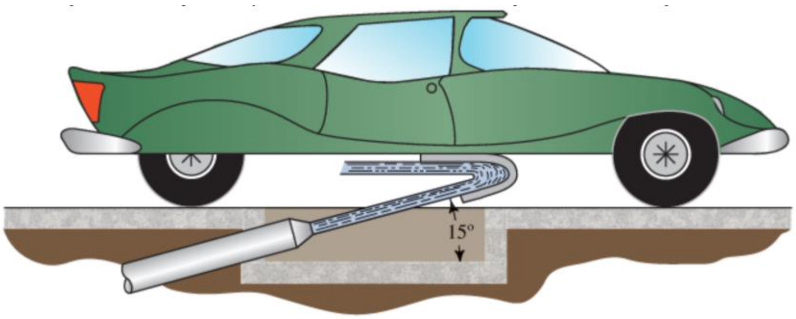
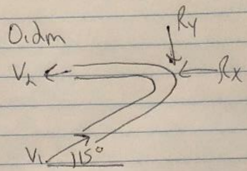


Figure 16.18
Problem 16.20.

16.20 A vehicle is to be propelled by a jet of water impinging on a vane as shown in **Fig. 16.18**. The jet has a velocity of 30 m/s and issues from a nozzle with a diameter of 200 mm. Calculate the force on the vehicle (a) if it is stationary and (b) if it is moving at 12 m/s.

16.20) $V = 30\ m/s$ $D = 200\ mm = 0.2\ m$



$Q = VA$
$= \pi/4(0.2)^2(30) = 0.943\ m^3/s$

$\rho = 1000\ kg/m^3$

X direction
$R_x = \rho Q(V_2 - (-V_1\cos 15°))$
$= \rho QV(1+\cos 15°)$
$R_x = 1000(0.943)(30)(1+\cos 15°)$
$R_x = 55616\ N$

Y direction $R_y = \rho Q(0 - (-V_1 \sin 15))$
$= \rho QV(\sin 15°)$
$= 1000(0.943)(30)(\sin 15°)$
$R_y = 7322\ N$

$F_R = \sqrt{(55616)^2 + (7322)^2} = \underline{56095.9\ N}$

b) $V_x = 30\cos 15 = 28.98\ m/s$
$V_y = 30\sin 15 = 7.765\ m/s$

$V'_x = 28.98 - 12 = 16.98\ m/s$

$V_R = \sqrt{(16.98)^2 + (7.765)^2} = 18.67\ m/s$

$Q = 1000(0.0314)(18.67)$
$Q = 586.2\ kg/s$

$\alpha = \tan^{-1}(7.765/16.98) = 24.6°$
$\beta = 24.6 - 15 = 9.6°$
$V_c = 18.67\cos 9.6 = 18.41\ m/s$

$R_x = 586.2(18.41 - 16.98)$
$R_x = 838.3\ N$

$R_y = 586.2(0 + 7.765)$
$R_y = 4551.8\ N$

$F_R = \sqrt{(838.3)^2 + (4551.8)^2}$

$F_R = 4,551.8\ N$

@ 12 m/s

Ch 18

29. $d = 7.5\text{ mm} = 0.0075\text{ m}$

$V = 25\text{ m/s}$

$Q = AV \qquad V_1 = V_2 = 25\text{ m/s}$

$$A = \frac{\pi d^2}{4} = \frac{\pi (0.0075)^2}{4} = 4.418 \times 10^{-5}\text{ m}^2$$

$$Q = (4.418 \times 10^{-5})(25) = 1.1045 \times 10^{-3}\text{ m}^3/\text{s}$$

$$R_x = \rho Q[(V_2 \cos 60^\circ) + (V_1 \cos 10^\circ)]$$

$$R_x = (1000)(1.1045 \times 10^{-3})[(25 \cos 60) + (25 \cos 10)]$$

$$\boxed{R_x = 40.99\text{ N}}$$

$$R_y = \rho Q[(V_2 \sin 60^\circ) - (V_1 \sin 10^\circ)]$$

$$R_y = (1000)(1.1045 \times 10^{-3})[(25 \sin 60) - (25 \sin 10)]$$

$$\boxed{R_y = 19.12\text{ N}}$$

The examples we were given discussed impulse theorem and instrumentation. The first impulse theorem problem used velocity, density, friction, and diameter to determine the heaviest object that can be moved by the air jet. Numerous free body diagrams were drawn to get to the conclusion that the object must weight less than 0.0307 lb in order to be moved by the air. The second impulse theorem problem asked to calculate the force on a plate due to a moment. Diameter, velocity, density, and specifics given in a drawing were used to determine that the force was 67.437 lb and the moment was 11.205 lb*ft. The instrumentation example asked us to determine the appropriate diameter of the orifice. Flow rate, manometer height, and area were all used. The diameter of the orifice was determined to be 8.938 in after all of the calculations were completed.