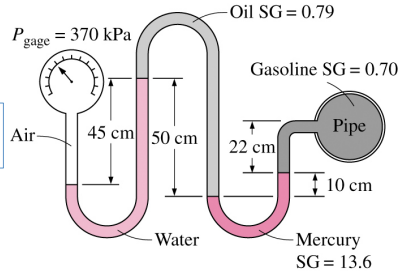
Civil Engineering Hydraulics
Mechanics of Fluids

Homework Answers

THE UNIVERSITY OF MEMPHIS
Department of Civil Engineering

Homework

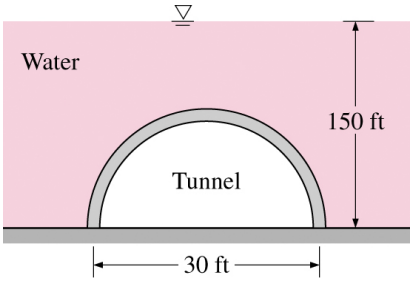
= 354.6 kPa



1. A gasoline line is connected to a pressure gage through a double-U tube manometer as shown. If the reading of the pressure gage is 370 kPa, determine the gage pressure of the gasoline line.

Homework

$= 2.07 \times 10^8$ lbf



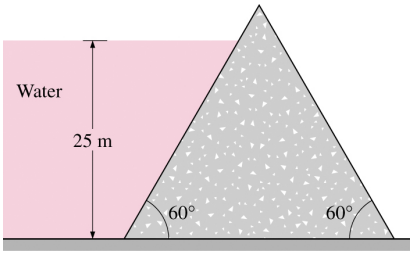
2. A semicircular 30-ft-diameter tunnel is to be built under a 150 ft deep, 800 ft long lake as shown. Determine the total hydrostatic force acting on the roof of the tunnel.

Homework

$= 9.64 \times 10^8$ N

$= 17.1$ m

$= 8.35 \times 10^8$ N



3. The water in a 25-m-deep reservoir is kept inside by a 150-m-wall whose cross section is an equilateral triangle as shown above. Determine the total force (hydrostatic+atmospheric) acting on the inner surface of the wall and its line of action and determine the horizontal component of the force.

Conservation of Mass

5–6E A garden hose attached with a nozzle is used to fill a 20-gal bucket. The inner diameter of the hose is 1 in and it reduces to 0.5 in at the nozzle exit. If the average velocity in the hose is 8 ft/s, determine (*a*) the volume and mass flow rates of water through the hose, (*b*) how long it will take to fill the bucket with water, and (*c*) the average velocity of water at the nozzle exit.

$= 0.04363 \text{ ft}^3/\text{s}$

$= 2.72 \text{ lbm/s}$

$= 61.3 \text{ s}$

$= 32 \text{ ft/s}$

Conservation of Mass

5–13 A smoking lounge is to accommodate 15 heavy smokers. The minimum fresh air requirement for smoking lounges is specified to be 30 L/s per person (ASHRAE, Standard 62, 1989). Determine the minimum required flow rate of fresh air that needs to be supplied to the lounge, and the diameter of the duct if the air velocity is not to exceed 8 m/s.

$= 0.45 \text{ m}^3/\text{s}$

$= 0.268 \text{ m}$

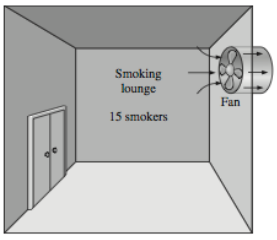


FIGURE P5–13

Homework

5–20 Electric power is to be generated by installing a hydraulic turbine–generator at a site 70 m below the free surface of a large water reservoir that can supply water at a rate of 1500 kg/s steadily. If the mechanical power output of the turbine is 800 kW and the electric power generation is 750 kW, determine the turbine efficiency and the combined turbine–generator efficiency of this plant. Neglect losses in the pipes.

77.6%

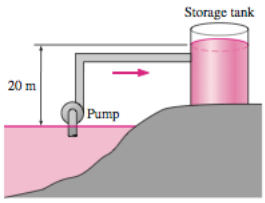
72.7%

Homework

5–24 Water is pumped from a lake to a storage tank 20 m above at a rate of 70 L/s while consuming 20.4 kW of electric power. Disregarding any frictional losses in the pipes and any changes in kinetic energy, determine (*a*) the overall efficiency of the pump–motor unit and (*b*) the pressure difference between the inlet and the exit of the pump.

67.2%

196 kPa



Homework

3.50 Linseed oil flows steadily through the system of Figure P3.50. A linseed-oil-over-water U-tube manometer between the 3- and 5-cm sections reads 6 cm. The oil is discharged through a 2-cm diameter exit. Calculate the exit velocity of the linseed oil.

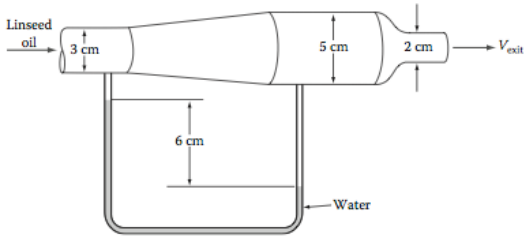
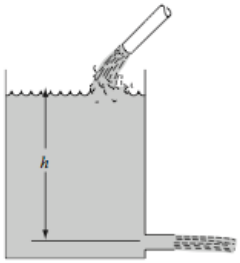


FIGURE P3.50

$V_3 = 0.72$ m/s

Homework

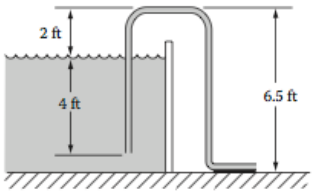
3.54 Water flows into a 1-m-diameter tank at a rate of 0.006 m^3/s, as illustrated in Figure P3.54. Water also leaves the tank through a 5-cm-diameter hole near the bottom. At a certain height h, the efflux equals the influx. Determine the equilibrium height h.



$h = 0.477$ m $= 47.7$ cm

Homework

3.58 A garden hose is used as a siphon to empty a pool, as shown in Figure P3.58. The inside diameter of the hose is $\frac{1}{2}$ in. and the pool diameter is 12 ft. Find the rate of water discharge through the hose.



$$Q = 0.023 \text{ ft}^3/\text{s}$$

FIGURE P3.58

Homework

3.51 Water flows steadily through the system shown in Figure P3.51. The 4-in. section leads to a 3-in. throat, followed by a divergent section and, finally, a nozzle whose exit diameter is 2 in. An air-over-water manometer is connected between the 4-in. and 3-in. sections. Determine the expected reading Δh on the manometer if the velocity at the exit is 8 ft/s.

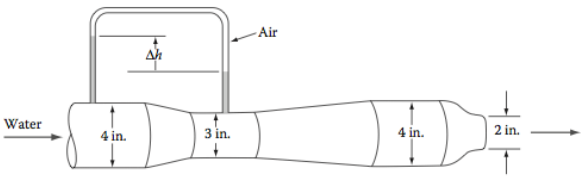


FIGURE P3.51

$$\Delta h = 0.269 \text{ ft} = 3.23 \text{ in.}$$

Homework

3.60 A siphon is used to drain a tank of water, as shown in Figure P3.60. The siphon tube has an inside diameter of 3 in., and at the exit there is a nozzle that discharges liquid in a 2-in.-diameter jet. Assuming no losses in the system, determine the volume flow rate through the siphon. Also calculate the flow velocity in the 3-in.-ID tube.

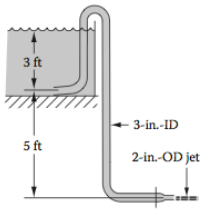


FIGURE P3.60

$\boxed{Q = 0.50\ ft^3/s}$

$\boxed{V = 10.1\ ft/s}$

Homework

3.63 Figure P3.63 shows a water nozzle attached to a 3-in.-ID hose. The nozzle discharges a 1-in.-OD jet, and the pressure in the hose just upstream of the nozzle is 15 psig. Determine the volume flow rate through the nozzle if it is held horizontally.

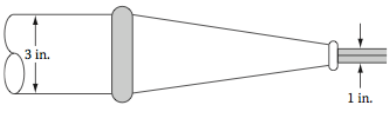
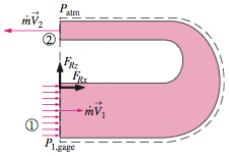


FIGURE P3.63

$\boxed{Q = 0.26\ ft^3/s}$

Homework

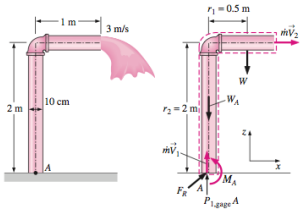
1. A reversing elbow is placed such that the fluid makes a 180° U-turn before it is discharged. The elevation difference between the centers of the inlet and the exit sections is 0.3 m. Determine the anchoring force needed to hold the elbow in place. The water flows at a rate of 14 kg/s. The elbow discharges water into the atmosphere. The cross-sectional area of the elbow is 113 cm^2 at the inlet and 7 cm^2 at the outlet. The weight of the elbow is negligible.



-2951 N

Example

Underground water is pumped to a sufficient height through a 10-cm-diameter pipe that consists of a 2-m-long vertical and 1-m-long horizontal section, as shown in Fig. 6–37. Water discharges to atmospheric air at an average velocity of 3 m/s, and the mass of the horizontal pipe section when filled with water is 12 kg per meter length. The pipe is anchored on the ground by a concrete base. Determine the bending moment acting at the base of the pipe (point A) and the required length of the horizontal section that would make the moment at point A zero.



-82.5 N-m
2.40 m

Homework

6–47 Water is flowing through a 12-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. P6–47, in the vertical direction. Water discharges to atmospheric air at a velocity of 4 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?

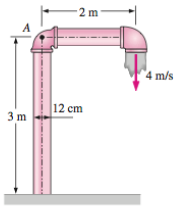


FIGURE P6–47

$= -70.0\ \text{N} \cdot \text{m}$

$= 659\ \text{N} \cdot \text{m}$

Homework

6–48 A large lawn sprinkler with two identical arms is used to generate electric power by attaching a generator to its rotating head. Water enters the sprinkler from the base along the axis of rotation at a rate of 8 gal/s and leaves the nozzles in the tangential direction. The sprinkler rotates at a rate of 250 rpm in a horizontal plane. The diameter of each jet is 0.5 in, and the normal distance between the axis of rotation and the center of each nozzle is 2 ft. If the rotating head is somehow stuck, determine the moment acting on the head.

$= 1409\ \text{lbf} \cdot \text{ft}$