buoyant force acting on it? (e) How much does it weigh when filled with acetone? (f) Will it float when filled with acetone?

86. [II] THIS PROBLEM TREATS THE BUOYANCY OF A GAS-FILLED BALLOON IN AIR. A hovering balloon filled with hydrogen is tied to a spring scale, which is fixed to the ground. The balloon (when empty) has a mass of 30.1 kg, and now it contains 100 m^3 of gas. Take the density of the air to be 1.29 kg/m^3. (a) Draw a free-body diagram. (b) What is the weight of the balloon? (c) What is the weight of the hydrogen gas? (d) What is the buoyant force on the balloon? (e) What is the value of the force that the scale reads?

87. [II] Determine the mass of helium needed to provide enough buoyancy (in dry air at 0°C) to lift a balloon and its load having a net mass of 454 kg. The load has a negligible volume.

88. [II] A 226.7-kg polar bear standing 6-ft tall walks onto a floating sheet of ice 0.305-m thick. How big is the ice sheet if it sinks just below the surface while supporting the bear?

89. [II] Given a pine raft, of density 0.50×10^3 kg/m^3 and dimensions 3.05 m by 6.10 m by 0.305 m, how much of a load can this raft take on for each 2.54 cm it settles into fresh water? How deep does it sink into the water when unloaded?

90. [III] An object has a weight measured in air of F_{Wa}; and when immersed in water, its effective weight is F_{Ww}. It is then submerged in an unknown liquid, and its effective weight is found to be F_{Wl}. Determine the density of the unknown liquid in terms of these measured quantities and the density of water.

SECTION 9.8: THE CONTINUITY EQUATION

SECTION 9.9: BERNOULLI'S EQUATION

91. [I] Petroleum flows along a 10-cm diameter pipeline at a speed of 2.0 m/s. Determine the flow rate, assuming the liquid is ideal.

92. [I] A pipe 5.0 cm in diameter carries gasoline with a density of 0.68×10^3 kg/m^3 at a speed of 2.5 m/s. Calculate the mass-flow rate, assuming the liquid is ideal.

93. [I] Gasoline (with a density of 0.68 kg/m^3) is flowing in a pipeline having a 0.50-m diameter. Taking the fluid to be ideal, what pressure change results when the pipe descends 4.0 m down an embankment?

94. [I] Determine the blood pressure at the brain, taking its height above the heart to be 40 cm.

95. [I] Someone cuts a finger and, to control the bleeding, raises the wound 85 cm above the level where the hand was being bandaged. What is the change in the pressure of the blood? Compare that to the pressure at the heart.

96. [I] A horizontal water main with a cross-sectional area of 200 cm^2 necks down to a pipe of area 50 cm^2. Meters mounted in the flow on each side of the transition coupling show a change in gauge pressure of 80 kPa. Determine the flow rate through the system, taking the fluid to be ideal.

97. [I] Derive an expression for the speed of efflux of an ideal liquid from a hole in a large tank filled with fluid in terms of the gauge pressure at the level of the orifice and the density of the liquid. [*Hint: Use Torricelli's Result.*]

98. [I] The drain on a bath tub is 0.50 m below the level of the water when the plug is removed. At approximately what speed will the water emerge from the tub? Don't worry about the shape of the orifice.

99. [I] Water is flowing into a below-deck compartment of a ship through a hole in its side at a speed of 10.0 m/s. How far beneath the water's surface is the hole?

100. [I] A length of tubing is used as a siphon to empty a large upright cask of wine. At a given moment, the lower opening of the tube from which the wine emerges is 20 cm below the liquid level in the cask. Compute the speed at which the wine then emerges.

101. [I] A large vat of clear chicken soup is about to spring a leak from a small hole a distance h below the surface of the broth. Knowing that the hole is a height (y) above the floor, at what distance (x) away from the vat should you place a bowl on the floor to catch the flow, assuming it to be ideal?

102. [I] THIS PROBLEM EXAMINES THE FLOW OF AN INCOMPRESSIBLE LIQUID. Water moves through a horizontal pipe as shown in Fig. P102. (a) Does the fluid undergo any change in *gravitational-*PE in traveling from one section to the other? (b) If the speed of the water in the large section is 3.00 m/s, how fast is it moving in the narrow section?

Figure P102

103. [II] THIS PROBLEM EXAMINES THE RATE OF FLOW OF AN INCOMPRESSIBLE LIQUID. A rectangular open tank is 152 cm wide, 305 cm deep, and 610 cm long. We wish to fill the tank using a 2.54-cm diameter hose that delivers water at a speed of 305 cm/s. (a) Determine the volume of the tank in cm^3. (b) What is the cross-sectional area of the hose in cm^2. (c) Compute the volume of water delivered per second by the hose. (d) How long will it take to fill the tank?

104. [II] Refer to Fig. 9.43 on p. 315. Suppose a person standing erect or sitting upright is accelerated upward at a rate a. Write an expression for the resulting blood pressure in the brain in terms of the pressure at the heart and discuss your results.

105. [II] A Texas pipeline carrying natural gas ($\rho = 0.90$ kg/m^3) with a mass-rate of flow of 1.0 kg/s is 35 cm in diameter. Determine the average speed at which the gas is moving along.

106. [II] THIS PROBLEM EXAMINES LAMINAR FLOW OF AN INCOMPRESSIBLE LIQUID. Water moves through a horizontal pipe as shown Fig. P102, but this time the gauge on the left reads 130 kPa and the one on the right is broken. The cross-sectional areas of the pipe are 4.49 cm^2 and 1.00 cm^2. If the speed of the water in the large section is 2.00 m/s, (a) how fast is it moving in the narrow section? (b) What is the pressure in the narrow section?

107. [II] THIS PROBLEM EXAMINES LAMINAR FLOW OF AN INCOMPRESSIBLE LIQUID. A pipe carries glycerine (having a density of 1.26

$P_i + \frac{1}{2}\rho v_i^2 + \rho g h_i = P_f + \frac{1}{2}\rho v_f^2 + \rho g h_f$

g/cm³) under pressure from the floor of a processing plant up 20 m to a bottling machine. The liquid enters the pipe, which has a cross-sectional area of 6.25×10^{-2} m², at 14.0×10^5 Pa. Up at the bottling machine, the end of the pipe necks down and attaches to a horizontal delivery tube that has a cross-sectional area of 100 cm². Assume there is little or no friction impeding the flow. (a) Draw a diagram showing streamlines from the lower pipe up into the delivery tube. (b) If the liquid initially enters the pipe at 5.00 m/s, at what speed is it traveling in the delivery tube? (c) What is the pressure inside the delivery tube?

108. [II] The pressure of blood in a main artery at the level of the heart (Table 9.6) reaches a maximum of about 120 mm Hg. Suppose the artery is cut, how high will blood spurt vertically? [*Hint: Take the speed of the blood in the artery to be essentially zero.*]

109. [II] THIS PROBLEM EXAMINES LAMINAR FLOW OF AN INCOMPRESSIBLE LIQUID. A large open vertical tank containing a liquid, springs a small leak 2.0 m beneath the surface of the fluid. (a) Draw a diagram showing streamlines from the open surface, down though the hole into the exiting stream. (b) What is the pressure at points at the start and end of each of these lines? (c) Use Bernoulli's Equation to determine the speed at which the fluid leaves the tank.

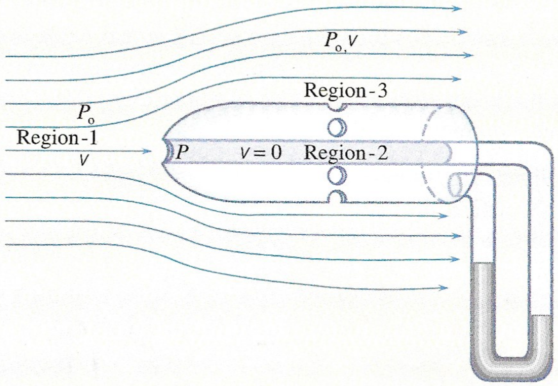
110. [II] A cylindrical water tank 2.0 m in diameter has a spigot with a hole whose area is 5.0 cm² located 4.0 m below the surface. Show that for a point at the surface the $\frac{1}{2}\rho v^2$ term in Bernoulli's Equation is properly ignorable compared to the corresponding term outside of the spigot in the escaping water jet. Assume no contraction of the stream as it leaves the tank.

SOLUTION: Point-1 is at the surface of the water, point-2 is at the hole. At the surface $A_1 = \frac{1}{4}\pi D^2 = 3.142$ m². At the hole $A_2 = 5.0 \times 10^{-4}$ m². Since $A_1 v_1 = A_2 v_2$; $v_1 = (A_2/A_1)v_2 = 1.6 \times 10^{-4} v_2$. And $v_1^2 = 2.5 \times 10^{-8} v_2^2$, hence $\frac{1}{2}\rho v_1^2$ is ignorable compared to $\frac{1}{2}\rho v_2^2$.

111. [II] A Pitot tube, shown in Fig. P111, is a fluid-speed measuring device that has applications in many fields, including physiology. Often used on airplanes to measure the airspeed of the craft, it can be seen mounted on the wings or fuselage. At the front opening, the streamlines part and there is a **stagnation point** there. The fluid rushes away from that point in all directions, and *its speed there is zero*. Accordingly, the pressure (P) there and all along the inner tube is relatively high. On the other hand, the speed of the fluid over any of the small holes in the outer cylinder is the undisturbed freestream speed (v). Derive an expression for v in terms of the pressure difference indicated by the attached manometer, keeping in mind that the air within the device is at rest. By the way, the device was first used by Henri Pitot to measure water speeds in the Seine River (1730).

112. [II] A small plane, having a mass of 3000 kg, is flying in air of density 1.0 kg/m³. Air moves over the top and bottom surfaces of the wings at 160 m/s and 130 m/s, respectively. What is the net minimum wing area needed? Use the results of Problem 103.

113. [II] The instrument depicted in Fig. P113 is inserted in a pipeline to determine flow rates and speed. Known as a Venturi meter, it consists of a throat and two open manometer tubes. Derive an expression for the speed of flow in the pipe in terms of Δy, the difference in the column heights, and the known cross-sectional areas of pipe and throat. In actuality, the manometer tubes are quite narrow and short, and the fluid within them is at rest.



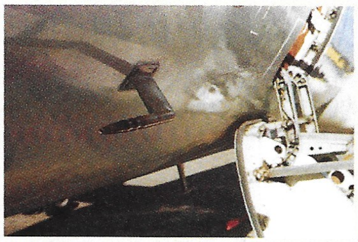


Figure P111

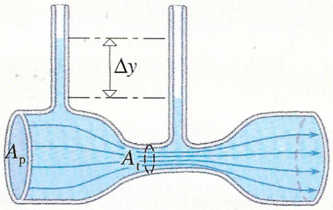


Figure P113

114. [II] The flowmeter in Fig. P113 shows a difference in height of 5.0 cm on an oil pipeline 200 cm² in cross section. If the throat of the device has a diameter of 10 cm, what is the pipeline flow rate? (Assume the liquid to be ideal.)

115. [II] A vaccination gun forces vaccine through a small aperture a few thousandths of an inch in diameter, at high pressures (550 psi), and so does away with the need for hypodermic needles. Compute the speed at which the fluid leaves the gun. Take the flow speed of the vaccine ($\rho = 1.1 \times 10^3$ kg/m³) in the reservoir within the body of the gun to be negligible.

116. [II] A cardboard milk container has two holes, one above the other, punched in its side. At a given moment, the two escaping streams of milk strike the table the container is standing on, at the same point. If the heights of the upper and lower holes are, respectively, y_u and y_l, write an expression for y, the level of milk at that instant, in terms of these heights.

117. [II] A large-diameter open cylindrical storage tank stands on a high platform. It has a small horizontal spigot at its very bottom, a height Y above the ground and a depth h below the surface of the water. Use Bernoulli's Equation to follow a tube of flow from point-1 at the surface, to point-2 just outside the spigot, to point-3 at the point of impact with the ground. Write expressions for v_2 and for v_3 (the speeds at the spigot and at the point of impact with the ground) in terms of g, h, and Y. Did you expect these results?