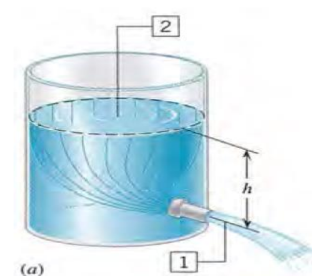
Physics 05-06 The Most General Applications of Bernoulli's Equation **Name: ____________________________**

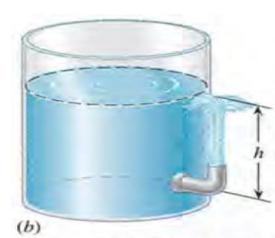
The Most General Applications of Bernoulli's Equation

Water circulates throughout a house in a hot-water heating system. If the water is pumped at a speed of 0.50 m/s through a 4.0-cm-diameter pipe in the basement under a pressure of 3.0 atm, what will be the flow speed and pressure in a 2.6-cm-diameter pipe on the second floor 5.0 m above? Assume the pipes do not divide into branches.

The tank is open to the atmosphere at the top. Find an expression for the speed of the liquid leaving the pipe at the bottom.



Since Bernoulli's Equation is conservation of ________________, the water would ________________ up to the same ________________ as the ________________ in the tank.



Power in Fluid Flow

$$Power = \left(\Delta P + \Delta \frac{1}{2}\rho v^2 + \Delta \rho g h\right) Q$$

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Homework	

1. Have you ever had a large truck pass you from the opposite direction on a narrow two-lane road? You probably noticed that your car was pulled toward the truck as it passed. What can you conclude about the speed of the air between your car and the truck compared to that on the opposite side of the car? Provide a reason for your answer.
2. Based on Bernoulli's equation, what are three forms of energy in a fluid? (Note that these forms are conservative, unlike heat transfer and other dissipative forms not included in Bernoulli's equation.)
3. Water that has emerged from a hose into the atmosphere has a gauge pressure of zero. Why? When you put your hand in front of the emerging stream you feel a force, yet the water's gauge pressure is zero. Explain where the force comes from in terms of energy.
4. Water pressure inside a hose nozzle can be less than atmospheric pressure due to the Bernoulli effect. Explain in terms of energy how the water can emerge from the nozzle against the opposing atmospheric pressure.
5. Hoover Dam on the Colorado River is the highest dam in the United States at 221 m, with an output of 1300 MW. The dam generates electricity with water taken from a depth of 150 m and an average flow rate of 650 m^3/s. (a) Calculate the power in this flow. (b) What is the ratio of this power to the facility's average of 680 MW? (OpenStax 12.25) $\mathbf{9.56 \times 10^8}$ **W, 1.4**
6. A frequently quoted rule of thumb in aircraft design is that wings should produce about 1000 N of lift per square meter of wing. (The fact that a wing has a top and bottom surface does not double its area.) (a) At takeoff, an aircraft travels at 60.0 m/s, so that the air speed relative to the bottom of the wing is 60.0 m/s. Given the sea level density of air to be 1.29 kg/m^3, how fast must it move over the upper surface to create the ideal lift? (b) How fast must air move over the upper surface at a cruising speed of 245 m/s and at an altitude where air density is one-fourth that at sea level? (Note that this is not all of the aircraft's lift—some comes from the body of the plane, some from engine thrust, and so on. Furthermore, Bernoulli's principle gives an approximate answer because flow over the wing creates turbulence.) (OpenStax 12.26) **71.8 m/s, 257 m/s**
7. The left ventricle of a resting adult's heart pumps blood at a flow rate of 83.0 cm^3/s , increasing its pressure by 110 mmHg, its speed from zero to 30.0 cm/s, and its height by 5.00 cm. (All numbers are averaged over the entire heartbeat.) Calculate the total power output of the left ventricle. Note that most of the power is used to increase blood pressure. (OpenStax 12.27) **1.26 W**
8. A sump pump (used to drain water from the basement of houses built below the water table) is draining a flooded basement at the rate of 0.750 L/s, with an output pressure of 3.00×10^5 N/m^2. (a) The water enters a hose with a 3.00-cm inside diameter and rises 2.50 m above the pump. What is its pressure at this point? (b) The hose goes over the foundation wall, losing 0.500 m in height, and widens to 4.00 cm in diameter. What is the pressure now? You may neglect frictional losses in both parts of the problem. (OpenStax 12.28) $\mathbf{2.76 \times 10^5}$ $\mathbf{N/m^2}$**,** $\mathbf{2.81 \times 10^5}$ $\mathbf{N/m^2}$
9. The Ludington Pumped Storage Power Plant is a reservoir by Lake Michigan. To store the extra electric energy produced by the nearby windmill farm on windy days, water is pumped up from the lake into the reservoir 111 m higher. Then at during calm, the water is released through turbines to generate electrical energy. (a) If the maximum flow rate is 1.2×10^5 m^3/min, what is the maximum power produced by the falling water? (b) The power plant actually can only produce 1872 MW of power. What percentage of the power is lost? (RW) **2200 MW, 15%**