Name ___________________________________ Date ____________________ Period ______

<u>Fluids</u>

Density

$\rho = m/V$

- ρ: density (kg/m^3)
- m: mass (kg)
- V: volume (m^3)

<u>Pressure</u>

$p = F/A$

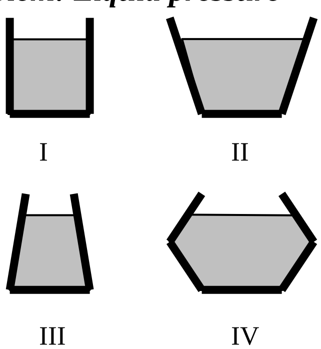
- p : pressure (Pa)
- F: force (N)
- A: area (m^2)

<u>The Pressure of a Liquid</u>

$p = \rho gh$

- p: pressure (Pa)
- ρ: density (kg/m3)
- g: acceleration constant (9.8 m/s^2)
- h: height of liquid column (m)

Problem: Liquid pressure



The glasses shown are each filled to a depth *d* with water. The surface area of the bottom of each glass is the same. Rank the downward force experienced by the bottom of the glasses in order, from greatest to least.

(A) I, III, II, IV
(B) I, IV, III, II
(C) II, III, IV, I
(D) IV, III, I, II
(E) None of the above; the forces are the same.

Explain your reasoning:

<u>Absolute Pressure</u>

$p = p_o + \rho gh$

- p: pressure (Pa)
- p_o: atmospheric pressure (Pa)
- ρgh: liquid pressure (Pa)

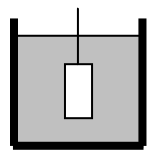
<u>Buoyant Force</u>

The upward force exerted on a submerged or partially submerged body.

$F_{buoy} = \rho Vg$

- F_{buoy}: the buoyant force exerted on a submerged or partially submerged object.
- V: the volume of displaced liquid.
- ρ: the density of the displaced liquid.

Problem: Buoyant Force



A 2.0 kg mass is suspended in a liquid on a string, as shown above. If the tension in the string is found to be 15 Newtons, the buoyant force the fluid is exerting on the mass is most nearly

(A) 5 Newtons
(B) 13 Newtons
(C) 15 Newtons
(D) 20 Newtons
(E) 25 Newtons

Show your work:

Fluid Flow Continuity

Conservation of Mass results in continuity of fluid flow.

The volume per unit time of water flowing in a pipe is constant throughout the pipe.

$A_1v_1 = A_2v_2$

A_1, A_2: cross sectional areas at points 1 and 2

v_1, v_2: speed of fluid flow at points 1 and 2

$V = Avt$

V: volume of fluid (m^3)

A: cross sectional area of pipe (m^2)

v: speed of fluid flow in the pipe (m/s)

t: time (s)

Problem: Fluid Flow Continuity

A water pipe of varying diameter is 1 cm in internal diameter at point A, where the speed of the water is observed to be 4.0 m/s. At point B, the internal diameter is 4 cm. At what speed is the water flowing at point B?

A. ¼ m/s B. ½ m/s C. 2.0 m/s
D. 4.0 m/s E. None of the above.

Show your work:

Problem: Fluid Flow Continuity

In a pipe with a 1.0 m^2 cross-section, the flow rate is observed to be ½ m^3/s. What is the speed of the water?

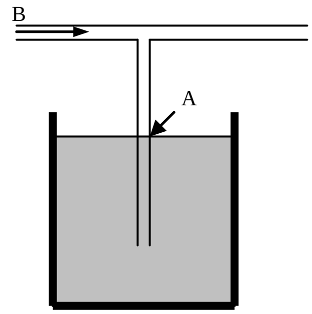
A. 0 B. ¼ m/s C. ½ m/s
D. 2.0 m/s E. 4.0 m/s

Show your work:

Bernoulli's Theorem

The faster a fluid moves, the lower the pressure it exerts on surfaces parallel to the velocity.

Problem: Bernoulli's Theorem



The bottom of the t-tube that is open on all ends is placed in a glass of water as shown. The level of the water rises to point A inside the tube. A student blows through a t-tube in the direction indicated. What happens?

(A) The water level in the tube drops below point A.
(B) The water level in the tube rises above point A.
(C) The water level in the tube remains at point A.
(D) Air bubbles out of the bottom of the tube into the glass of water
(E) Cannot be predicted without knowing how hard the student blows.

Explain your reasoning:

<<ADVANCED TOPIC>>

Bernoulli's Theorem

$p + \rho g h + \frac{1}{2} \rho v^2 = \text{Constant}$

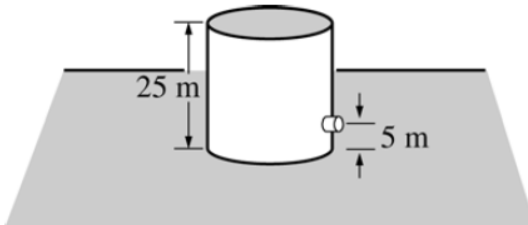
p : pressure (Pa)

ρ : density of fluid (kg/m^3)

g: gravitational acceleration constant (9.8 m/s^2)

h: height above lowest point (m)

v: speed of fluid flow at a point in the pipe (m/s)



5. (10 points)

A large tank, 25 m in height and open at the top, is completely filled with saltwater (density 1025 kg/m^3). A small drain plug with a cross-sectional area of $4.0 \times 10^{-5}\ \text{m}^2$ is located 5.0 m from the bottom of the tank. The plug breaks loose from the tank, and water flows from the drain.

(a) Calculate the force exerted by the water on the plug before the plug breaks free.

(b) Calculate the speed of the water as it leaves the hole in the side of the tank.

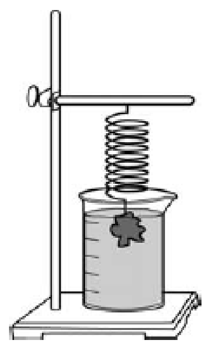
(c) Calculate the volume flow rate of the water from the hole.

6. (10 points)

In the laboratory, you are given a cylindrical beaker containing a fluid and you are asked to determine the density ρ of the fluid. You are to use a spring of negligible mass and unknown spring constant k attached to a stand. An irregularly shaped object of known mass m and density D ($D >> \rho$) hangs from the spring. You may also choose from among the following items to complete the task.

- A metric ruler
- A stopwatch
- String

(a) Explain how you could experimentally determine the spring constant k.

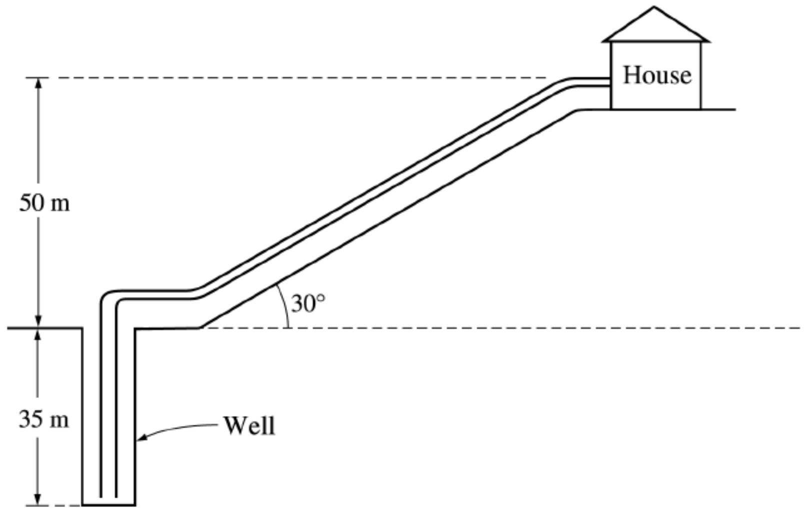


(b) The spring-object system is now arranged so that the object (but none of the spring) is immersed in the unknown fluid, as shown above. Describe any changes that are observed in the spring-object system and explain why they occur.

(c) Explain how you could experimentally determine the density of the fluid.

(d) Show explicitly, using equations, how you will use your measurements to calculate the fluid density ρ. Start by identifying any symbols you use in your equations.

Symbol	Physical quantity



6. (10 points)

A pump, submerged at the bottom of a well that is 35 m deep, is used to pump water uphill to a house that is 50 m above the top of the well, as shown above. The density of water is 1,000 kg/m^3. All pressures are gauge pressures. Neglect the effects of friction, turbulence, and viscosity.

(a) Residents of the house use 0.35 m^3 of water per day. The day's pumping is completed in 2 hours during the day.

i. Calculate the minimum work required to pump the water used per day

ii. Calculate the minimum power rating of the pump.

(b) The average pressure the pump actually produces is 9.20×10^5 N/m^2. Within the well the water flows at 0.50 m/s and the pipe has a diameter of 3.0 cm. At the house the pipe diameter is 1.25 cm.

i. Calculate the flow velocity when a faucet in the house is open.

ii. Explain how you would calculate the minimum pressure at the faucet.

6. (10 points)

A diver descends from a salvage ship to the ocean floor at a depth of 35 m below the surface. The density of ocean water is 1.025×10^3 kg/m^3.

(a) Calculate the gauge pressure on the diver on the ocean floor.

(b) Calculate the absolute pressure on the diver on the ocean floor.

The diver finds a rectangular aluminum plate having dimensions $1.0 \text{ m} \times 2.0 \text{ m} \times 0.03 \text{ m}$. A hoisting cable is lowered from the ship and the diver connects it to the plate. The density of aluminum is 2.7×10^3 kg/m^3. Ignore the effects of viscosity.

(c) Calculate the tension in the cable if it lifts the plate upward at a slow, constant velocity.

(d) Will the tension in the hoisting cable increase, decrease, or remain the same if the plate accelerates upward at 0.05 m/s^2?

____ increase ____ decrease ____ remain the same

Explain your reasoning.