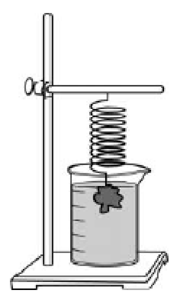
FLUIDS

2002 Q6

6. (10 points)
In the laboratory, you are given a cylindrical beaker containing a fluid and you are asked to determine the density r 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* >> ρ*)* 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

2003 Q6

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 m × 2.0 m × 0.03 m. A hoisting cable is lowered from the ship and the diver connects it to the plate. The density of aluminum is 2.7 × 103 kg/m^3. Ignore the effects of viscosity.

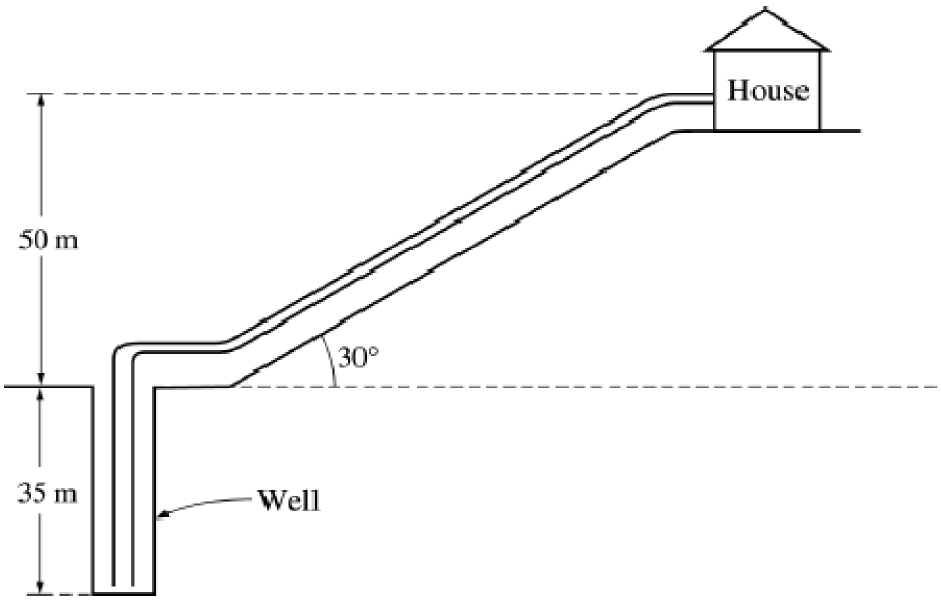
(c) Calculate the tension in the cable if it lifts the plate upward at a slow, constant velocity.

(d) Will the tension in the hoisting cable increase, decrease, or remain the same if the plate accelerates upward at 0.05 m/s2?

____ increase ____ decrease ____ remain the same

Explain your reasoning.

2003B Q6



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.

2004 Q4

2. (15 points)
While exploring a sunken ocean liner, the principal researcher found the absolute pressure on the robot observation submarine at the level of the ship to be about 413 atmospheres. The density of seawater is 1025 kg m^3 .

(a) Calculate the gauge pressure p_g on the sunken ocean liner.

(b) Calculate the depth D of the sunken ocean liner.

(c) Calculate the magnitude F of the force due to the water on a viewing port of the submarine at this depth if the viewing port has a surface area of 0.0100 m^2 .

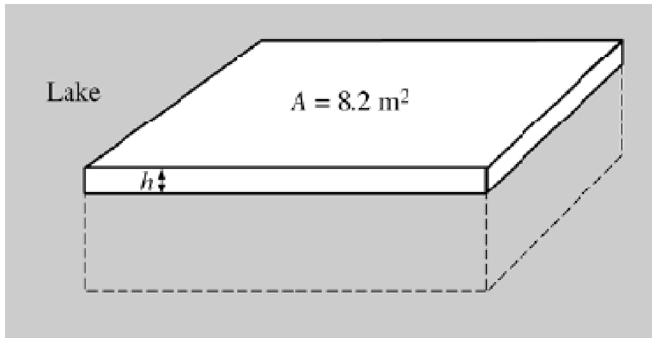
Suppose that the ocean liner came to rest at the surface of the ocean before it started to sink. Due to the resistance of the seawater, the sinking ocean liner then reached a terminal velocity of 10.0m/s after falling for 30.0 s.

(d) Determine the magnitude *a* of the average acceleration of the ocean liner during this period of time.

(e) Assuming the acceleration was constant, calculate the distance *d* below the surface at which the ocean liner reached this terminal velocity.

(f) Calculate the time *t* it took the ocean liner to sink from the surface to the bottom of the ocean.

2005 Q5



Note: Figure not drawn to scale.

5. (10 points)

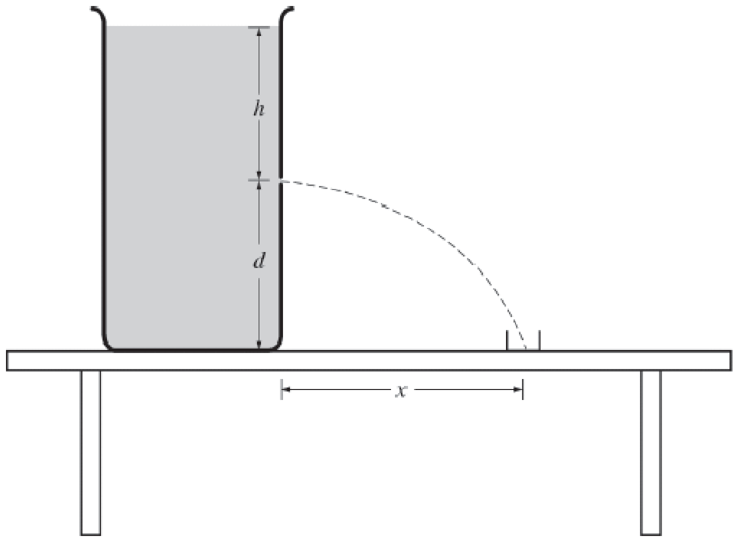
A large rectangular raft (density 650 kg/m^3) is floating on a lake. The surface area of the top of the raft is 8.2 m^2 and its volume is 1.80 m^3. The density of the lake water is 1000 kg/m^3.

(a) Calculate the height *h* of the portion of the raft that is above the surrounding water.

(b) Calculate the magnitude of the buoyant force on the raft and state its direction.

(c) If the average mass of a person is 75 kg, calculate the maximum number of people that can be on the raft without the top of the raft sinking below the surface of the water. (Assume that the people are evenly distributed on the raft.)

2007 Q4



4. (10 points)
The large container shown in the cross section above is filled with a liquid of density 1.1×10^3 kg/m^3. A small hole of area 2.5×10^{-6} m^2 is opened in the side of the container a distance *h* below the liquid surface, which allows a stream of liquid to flow through the hole and into a beaker placed to the right of the container. At the same time, liquid is also added to the container at an appropriate rate so that *h* remains constant. The amount of liquid collected in the beaker in 2.0 minutes is 7.2×10^{-4} m^3.

(a) Calculate the volume rate of flow of liquid from the hole in m^3/s.

(b) Calculate the speed of the liquid as it exits from the hole.

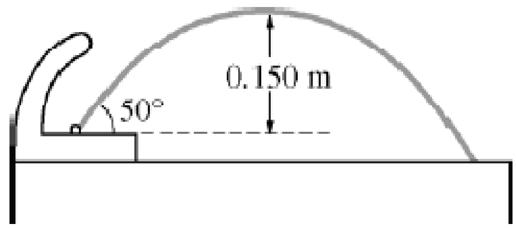
(c) Calculate the height h of liquid needed above the hole to cause the speed you determined in part (b).

(d) Suppose that there is now less liquid in the beaker so that the height h is reduced to $h/2$. In relation to the beaker, where will the liquid hit the tabletop?

____ Left of the beaker ____ In the beaker ____ Right of the beaker

Justify your answer.

2008 Q4



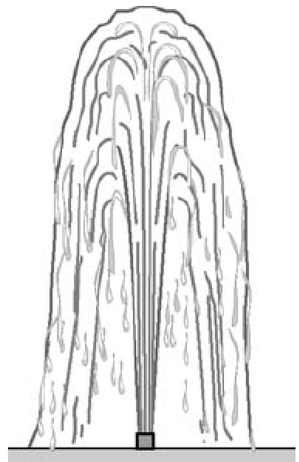
4. (10 points)
A drinking fountain projects water at an initial angle of 50° above the horizontal, and the water reaches a maximum height of 0.150 m above the point of exit. Assume air resistance is negligible.

(a) Calculate the speed at which the water leaves the fountain.

(b) The radius of the fountain's exit hole is 4.00×10^{-3} m. Calculate the volume rate of flow of the water.

(c) The fountain is fed by a pipe that at one point has a radius of 7.00×10^{-3} m and is 3.00 m below the fountain's opening. The density of water is 1.0×10^{-3} kg/m^3. Calculate the gauge pressure in the feeder pipe at this point.

2008B Q4



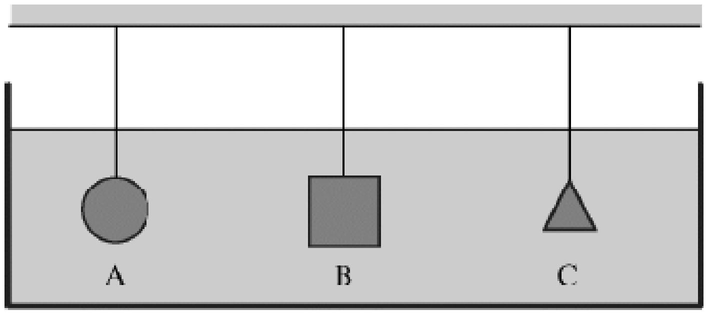
4. (10 points)
A fountain with an opening of radius 0.015 m shoots a stream of water vertically from ground level at 6.0 m/s. The density of water is 1000 kg m^3.

(a) Calculate the volume rate of flow of water.

(b) The fountain is fed by a pipe that at one point has a radius of 0.025 m and is 2.5 m below the fountain's opening. Calculate the absolute pressure in the pipe at this point.

(c) The fountain owner wants to launch the water 4.0 m into the air with the same volume flow rate. A nozzle can be attached to change the size of the opening. Calculate the radius needed on this new nozzle.

2009 Q5



5. (10 points)
Three objects of identical mass attached to strings are suspended in a large tank of liquid, as shown above.

(a) Must all three strings have the same tension?

____ Yes ____ No

Justify your answer.

Object A has a volume of 1.0×10^{-5} m^3 and a density of 1300 kg/m^3. The tension in the string to which object A is attached is 0.0098 N.

(b) Calculate the buoyant force on object A.

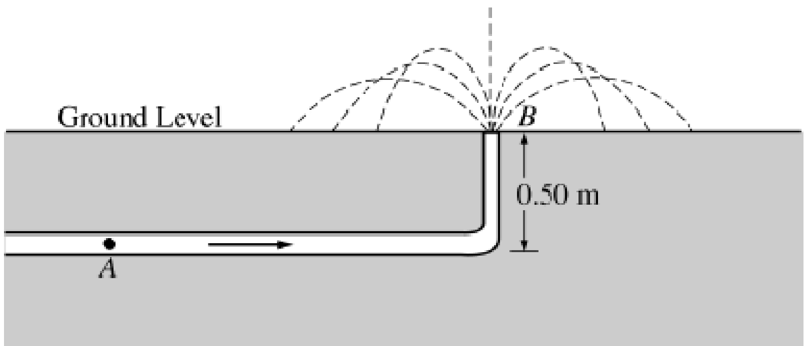
(c) Calculate the density of the liquid.

(d) Some of the liquid is now drained from the tank until only half of the volume of object A is submerged. Would the tension in the string to which object A is attached increase, decrease, or remain the same?

____ Increase ____ Decrease ____ Remain the same

Justify your answer.

2009B Q3



3. (15 points)
An underground pipe carries water of density 1000 kg/m3 to a fountain at ground level, as shown above. At point *A*, 0.50 m below ground level, the pipe has a cross-sectional area of 1.0×10^{-4} m^2. At ground level, the pipe has a cross-sectional area of 0.50×10^{-4} m^2. The water leaves the pipe at point *B* at a speed of 8.2 m/s.

(a) Calculate the speed of the water in the pipe at point *A*.

(b) Calculate the absolute water pressure in the pipe at point *A*.

(c) Calculate the maximum height above the ground that the water reaches upon leaving the pipe vertically at ground level, assuming air resistance is negligible.

(d) Calculate the horizontal distance from the pipe that is reached by water exiting the pipe at 60° from the level ground, assuming air resistance is negligible.