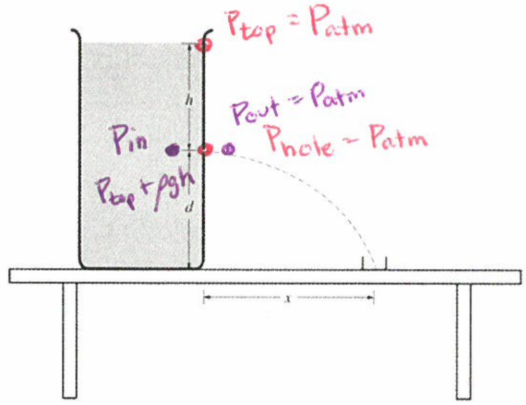
Fluids Exam Review

Directions – Complete the following problems to help prepare you for the upcoming test.

2007 AP® PHYSICS B FREE-RESPONSE QUESTIONS



4. (10 points)

The large container shown in the cross section above is filled with a liquid of density $1.1 \times 10^3\ \text{kg/m}^3$ (ρ). A small hole of area (A) $2.5 \times 10^{-6}\ \text{m}^2$ 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 (t) is $7.2 \times 10^{-4}\ \text{m}^3$ (V).

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

$2.0\text{min}\left(\frac{60\text{s}}{1\text{min}}\right) = 120\text{s}$

$Q = \frac{V}{t} = \frac{7.2 \times 10^{-4}\ \text{m}^3}{120\text{s}} = 6.0 \times 10^{-6}\ \text{m}^3/\text{s}$

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

$Q = Av \quad v = \frac{Q}{A} = \frac{6.0 \times 10^{-6}\ \text{m}^3/\text{s}}{2.5 \times 10^{-6}\ \text{m}^2} = 2.4\ \text{m/s}$

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

$P_t = P_h = P_{atm}$, $v_1 = 0\ \text{m/s}$

Top + Hole

$P_t + \frac{1}{2}\rho v_t^2 + \rho g y_2 = P_h + \frac{1}{2}\rho v_h^2 + \rho g y_1$

$v_h^2 = 2g(y_2 - y_1)$

$h = v^2/2g = (2.4\text{m/s})^2/2(9.81\text{m/s}^2) = .29\ \text{m}$

In + Out

$P_{in} + \frac{1}{2}\rho v_{in}^2 + \rho g h_{in} = P_{out} + \frac{1}{2}\rho v_{out}^2 + \rho g h_{out}$

$P_{top} + \rho g h = P_{out} + \frac{1}{2}\rho v_{out}^2$

$h = \frac{v^2}{2g}$

$h_{in} = h_{out}$, $P_{in} = P_{top} + \rho g h$

$P_{top} = P_{out} = P_{atm}$

(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

should say "container"

Justify your answer.

With less height there is a decrease in pressure at the hole, which decrease the speed the water leaves so it does not travel as far.

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 $1025\ \text{kg/m}^3$. ρ P

(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 $0.0100\ \text{m}^2$. A

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 $10.0\ \text{m/s}$ after falling for 30.0 s. t V_t

(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.

a) $P_{gauge} = P_2 - P_1 = 413\text{atm} - 1\text{atm} = \boxed{412\ \text{atm}}$

OR $413\times10^5\ \text{Pa} - 1.0\times10^5\ \text{Pa} = 412\times10^5\ \text{Pa} = \boxed{4.12\times10^7\ \text{Pa}}$

b) $P_2 = P_1 + \rho g h \qquad h = \dfrac{P_2 - P_1}{\rho g} = \dfrac{4.12\times10^7\ \text{Pa}}{(1025\ \text{kg/m}^3)(9.81\ \text{m/s}^2)} = 4097\ \text{m}$

$\boxed{4.10\times10^3\ \text{m}}$

c) $P = \dfrac{F}{A} \qquad F = PA = (4.13\times10^7\ \text{Pa})(.0100\ \text{m}^2) = \boxed{4.13\times10^5\ \text{N}}$

$F = PA = (4.12\times10^7\ \text{Pa})(.0100\ \text{m}^2) = \boxed{4.12\times10^5\ \text{N}}$

Both acceptable

d) $a = \dfrac{\Delta V}{t} = \dfrac{10.0\ \text{m/s} - 0\ \text{m/s}}{30.0\ \text{s}} = \boxed{.333\ \text{m/s}^2}$

e) $d = V_0 t + \frac{1}{2}at^2$

$= \frac{1}{2}(.333\ \text{m/s}^2)(30.0\ \text{s})^2$

$\boxed{= 150\ \text{m}}$

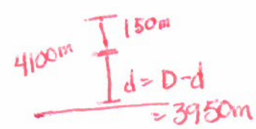
or

$V_f^2 = V_0^2 + 2ad$

$d = \dfrac{V^2}{2a} = \dfrac{(10.0\ \text{m/s})^2}{2(.333\ \text{m/s}^2)}$

$= 150\ \text{m}$

f)



① $t = \dfrac{d}{v} = \dfrac{3950\ \text{m}}{10.0\ \text{s}}$

$= 395\ \text{s}$

② $t_{tot} = t_1 + t_2$

$= 30.0\ \text{s} + 395\ \text{s}$

$\boxed{= 425\ \text{s}}$