Announcements

1. Third hour test on Chapters. 13-15 – Wednesday, Nov. 6th; practice tests available:
   http://www.wfu.edu/~natalie/f02phy113/extrapractice
   Problem solving sessions?   Monday evening?

   Tuesday evening?

2. Today's lecture –

   Physics of fluids

   Newton's second law & gravity

   ➔ $dP/dy = -\rho g$

   Energetics – Bernoulli's equation

Application of Newton's second law to fluid (near Earth's surface)

$$\frac{dP}{dy} = -\rho g$$

Incompressible fluid: $P = P_0 - \rho g(y - y_0)$

example: $\rho = 1000\text{kg/m}^3$ (water)

Compressible fluid: $P = P_0 e^{-\frac{\rho_0 g}{P_0}(y-y_0)}$

$$\approx P_0 - \rho_0 g(y - y_0) \;\; (\text{for } \frac{\rho_0 g}{P_0}(y - y_0) << 1)$$

example: $\rho = 1.29\text{kg/m}^3$ (air)

Example: Instrument to measure pressure P:

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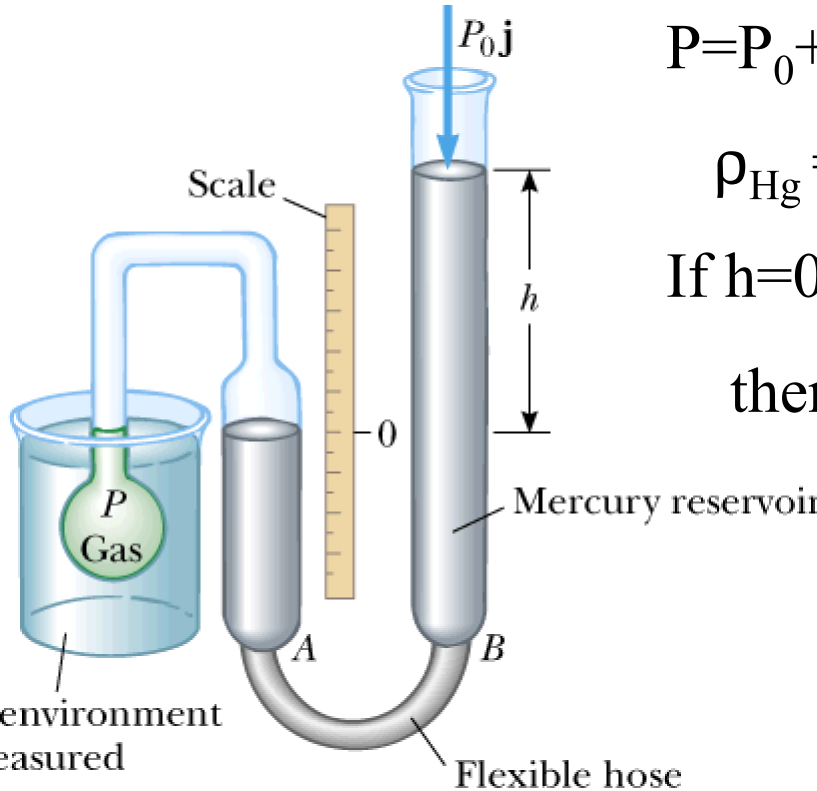
Figure 19.2



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$P=P_0+\rho_{Hg}gh$

$\rho_{Hg} = 13600\ kg/m^3$

If h=0.4m

then $P=P_0+53300$ Pa

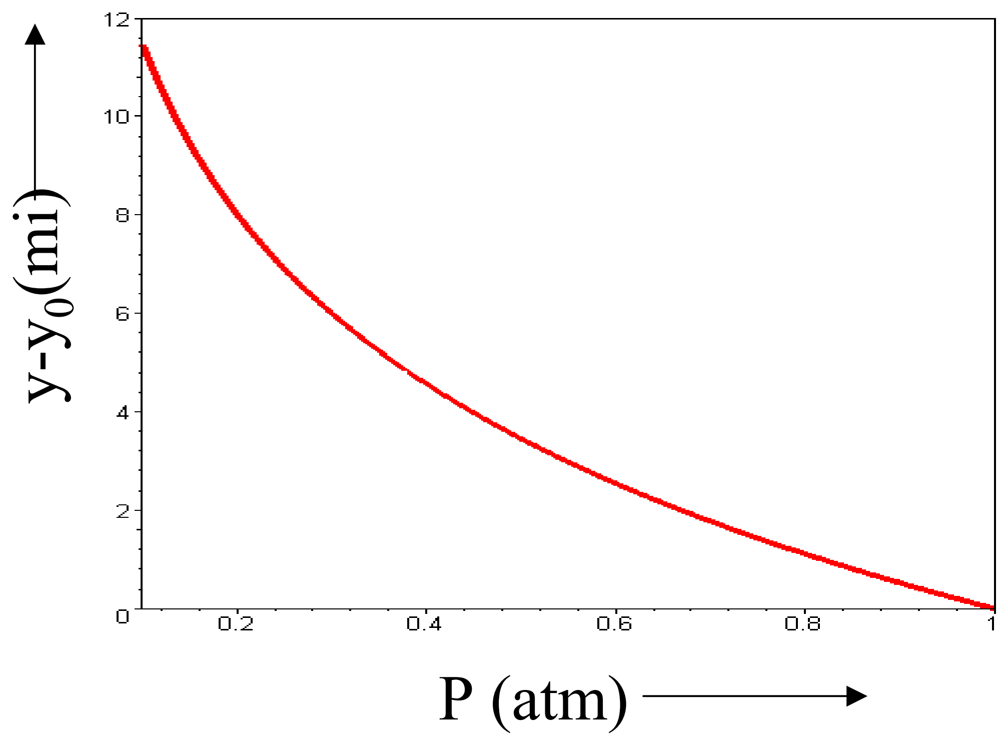
Effects of the weight of a "compressible" fluid on pressure.

$$\frac{dP}{dy} = -\rho g$$

Solution :

For a gas, $\rho = P\frac{\rho_0}{P_0}$

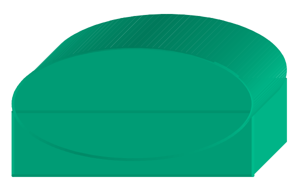
$$P(y) = P_0 e^{-\frac{\rho_0 g}{P_0}(y-y_0)} \approx P_0 e^{-\frac{y-y_0}{8000m}} \approx P_0 e^{-\frac{y-y_0}{5mi}}$$



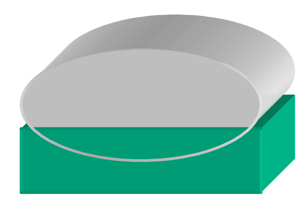
Peer instruction question

Suppose that a caterer packed some food in an air tight container with a flexible top at sea-level. This food was loaded on to an airplane with a cruising altitude of ~6 mi above the earth's surface. Assuming that the airplane cabin is imperfectly pressurized, what do you expect the container to look like during the flight?

(A)



(B)



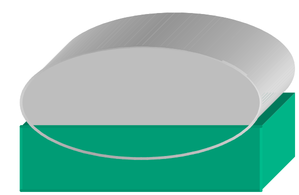
(C)

Peer instruction question

Suppose that a caterer packed some food in an air tight container with a flexible top at sea-level. This food was loaded on to a submarine which typically submerges at 200m below sea level. Assuming that the submarine cabin is imperfectly pressurized, what do you expect the container to look like during the submersion?

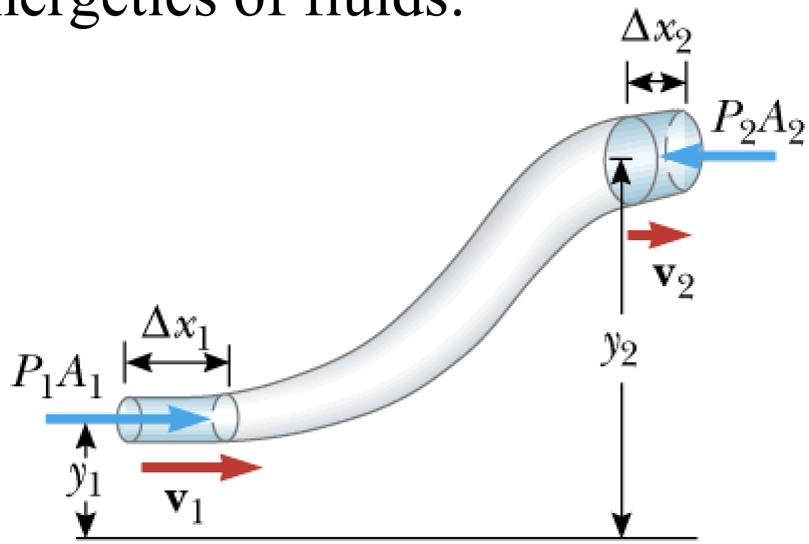
(A)

(B)



(C)

Energetics of fluids:



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$\Delta x_1 = v_1 \Delta t$

$\Delta x_2 = v_2 \Delta t$

$A_1 \Delta x_1 = A_2 \Delta x_2$

$m = \rho A_1 \Delta x_1$

$K_2 + U_2 = K_1 + U_1 + W_{12}$

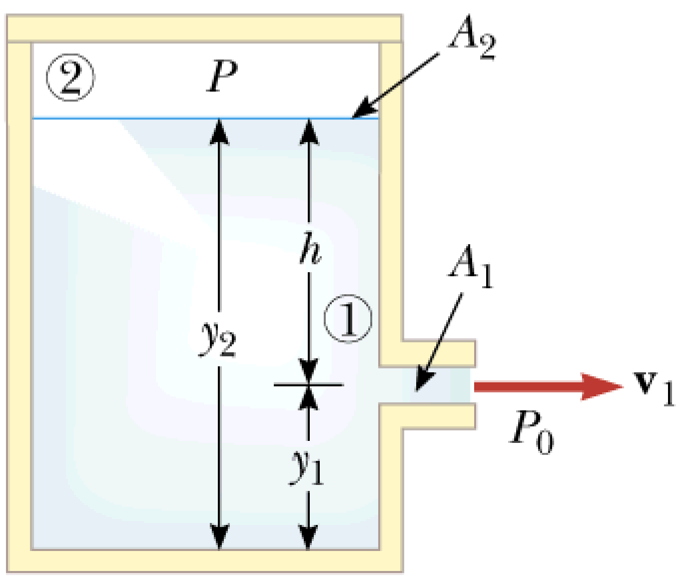
$\frac{1}{2} m v_2^2 + mgh_2 = \frac{1}{2} m v_1^2 + mgh_1 + (P_1 A_1 \Delta x_1 - P_2 A_2 \Delta x_2)$

$\rightarrow P_2 + \frac{1}{2} \rho v_2^2 + \rho g h_2 = P_1 + \frac{1}{2} \rho v_1^2 + \rho g h_1$

Bernoulli's equation:

$$P_2 + \tfrac{1}{2}\rho v_2^2 + \rho g h_2 = P_1 + \tfrac{1}{2}\rho v_1^2 + \rho g h_1$$

Examples:



$$P + \tfrac{1}{2}\rho v_2^2 + \rho g y_2 =$$

$$P_0 + \tfrac{1}{2}\rho v_1^2 + \rho g y_1$$

$$v_1 = \sqrt{\frac{2\left(gh - (P_0 - P)/\rho\right)}{1 - \left(A_1/A_2\right)^2}}$$

Streamline flow of air around an airplane wing:

$$P_2 + \tfrac{1}{2}\rho v_2^2 + \rho g h_2 = P_1 + \tfrac{1}{2}\rho v_1^2 + \rho g h_1$$

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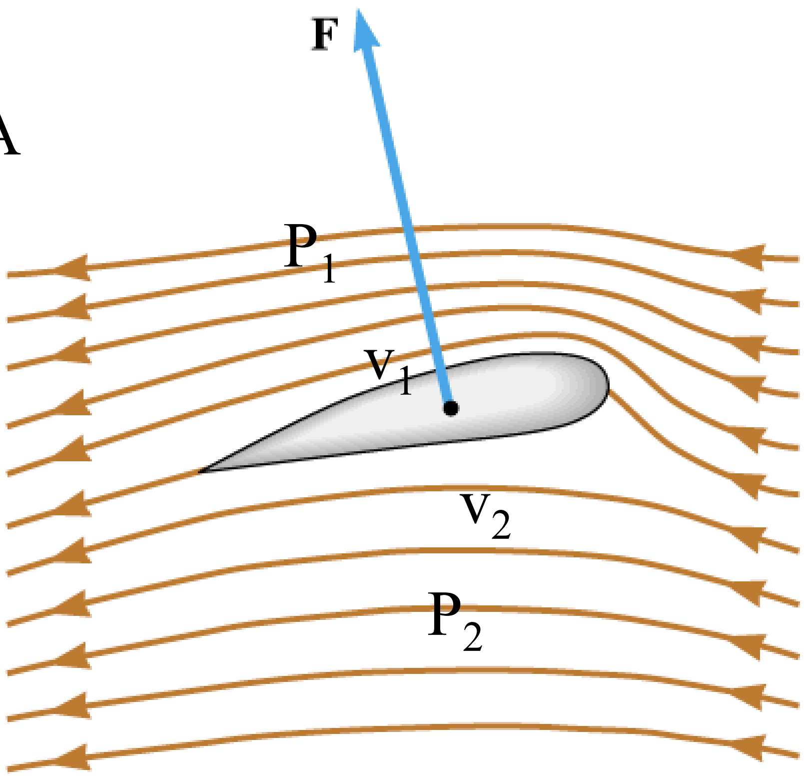
Figure 15.24

$$F_{lift}=(P_2-P_1)A$$



$$h_1 \approx h_2$$

$$v_1 > v_2$$

$$P_2 = P_1 + \tfrac{1}{2}\rho\left(v_1^2 - v_2^2\right)$$

Example:

$v_1 = 270$ m/s

$v_2 = 260$ m/s

$\rho = 0.6$ kg/m^3

$A = 40$ m^2

$F_{lift} = 63{,}600$ N

Peer instruction question

Suppose you see a tornado coming toward your house. Assuming that you have enough time, which of the following should you do before entering your shelter?

(A) Open all of the windows and doors.

(B) Make sure that all of the windows and doors are tightly shut.

Homework problem: A hypodermic syringe contains a medicine with the density of water. The barrel of the syringe has a cross-sectional area $A=2.5\text{x}10^{-5}\text{m}^2$, and the needle has a cross-sectional area $a= 1.0\text{x}10^{-8}\text{m}^2$. In the absence of a force on the plunger, the pressure everywhere is 1 atm. A force F of magnitude 2 N acts on the plunger, making the medicine squirt horizontally from the needle. Determine the speed of the medicine as leave the needle's tip.