Spring 2014

PHYS-2010

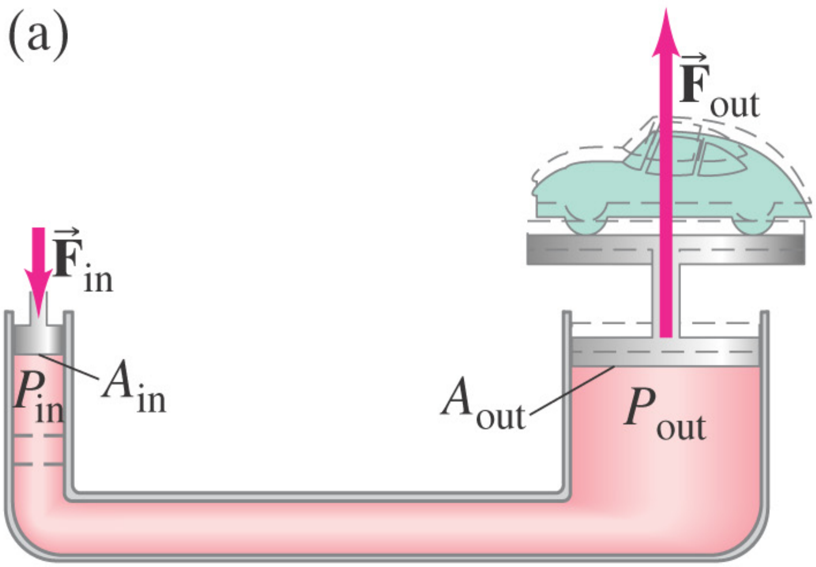
Lecture 40

Announcements

- Read **Chapter 10.**
- **Written Homework # 10** due Friday, April 25, at 4 pm.
- Special **Study Session** by Prof. Pollock and Rosemary Wulf, Tuesday, April 29, 5-6 pm in G125.
- **Next week** in sections: Review Recitation/Lab makeup.
- **FCQs** today, April 23!

Applying Outside Pressure to a Fluid

PASCAL'S PRINCIPLE: If an external pressure is applied to a *confined* fluid, the pressure *at every point* within the fluid increases by that amount.



$$P_{OUT} = P_{IN}$$

$$\frac{F_{OUT}}{A_{OUT}} = \frac{F_{IN}}{A_{IN}}$$

$$F_{OUT} = \left(\frac{A_{OUT}}{A_{IN}}\right) F_{IN}$$

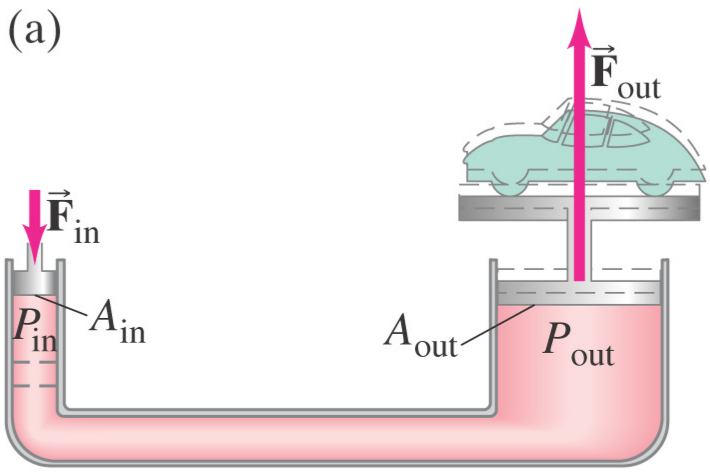
Example: Hydraulic lift

Clicker Question

Room Frequency BA

A force of 200 lbs is applied as F_{IN}. Assume that A_{IN} is 1 cm^2 and A_{OUT} is 20 cm^2. How big is P_{OUT}?

A) 200 lb/cm^2 B) 400 lb/cm^2 C) 2000 lb/cm^2 D) 4000 lb/cm^2



By Pascal's Principle, the applied pressure is the same every in the fluid (at the same depth).

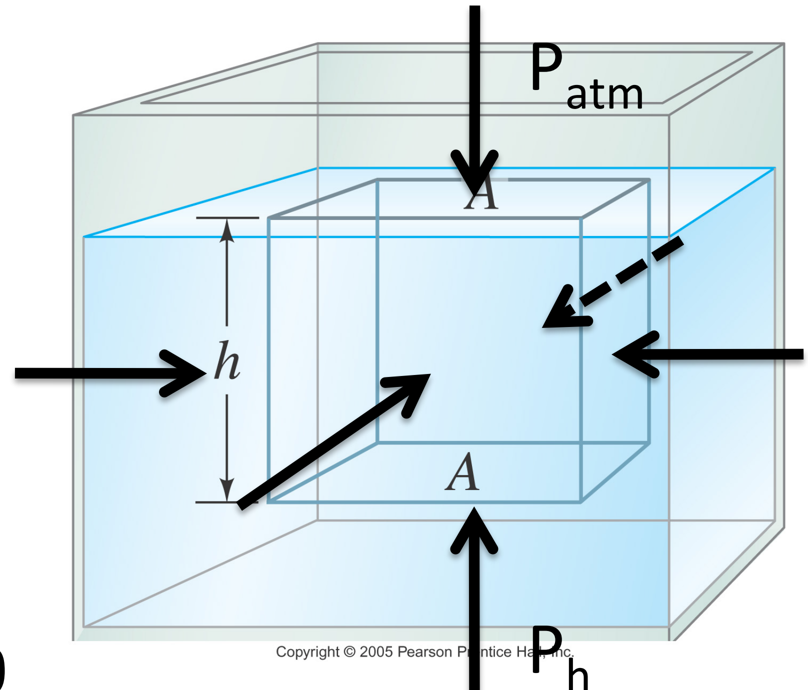
PRESSURE IN FLUIDS

For our first application of Newton's 2nd Law on Fluids, let's consider the result of gravity on the pressure in a fluid.

Consider an imaginary cube with each side of area A, the top at the surface and the bottom at depth h.

Each of the six faces contributes to the net force!

Four side faces cancel each other; what about top and bottom faces?



$$F_{net} = F_{top} + F_{bottom} - M_{water}g = 0$$

$$F_{net} = -P_{atm}A + P_hA - M_{water}g = 0$$

PRESSURE IN FLUIDS

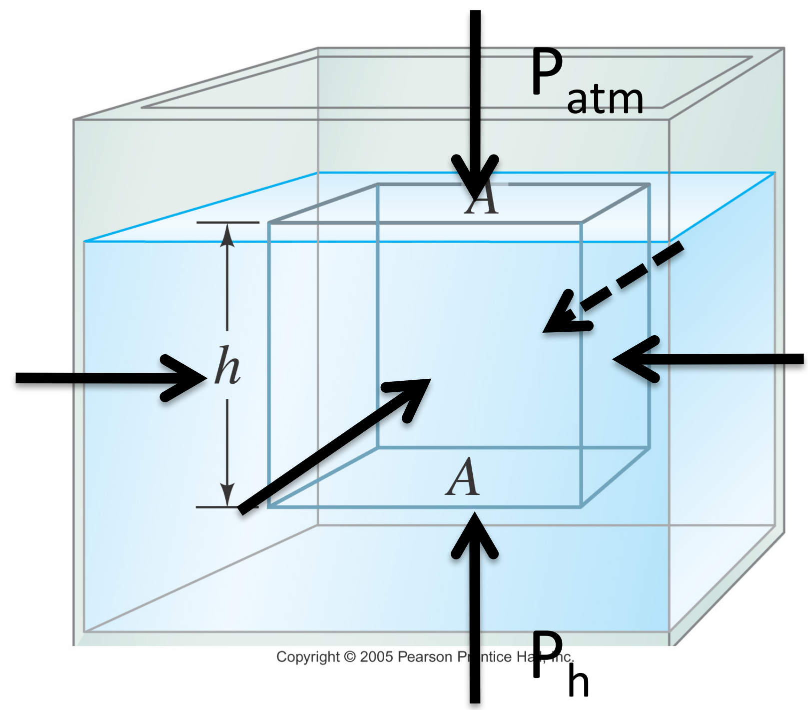
$$F_{net} = -P_{atm}A + P_hA - M_{water}g = 0$$

$$M_{Water} = \rho_{Water}V = \rho_{Water}(Ah)$$

$$P_hA = P_{atm}A + M_{Water}g$$

$$P_h\cancel{A} = P_{atm}\cancel{A} + \rho_{Water}\cancel{A}h\,g$$

$$\boxed{P_h = P_{atm} + \rho_{Water}hg}$$

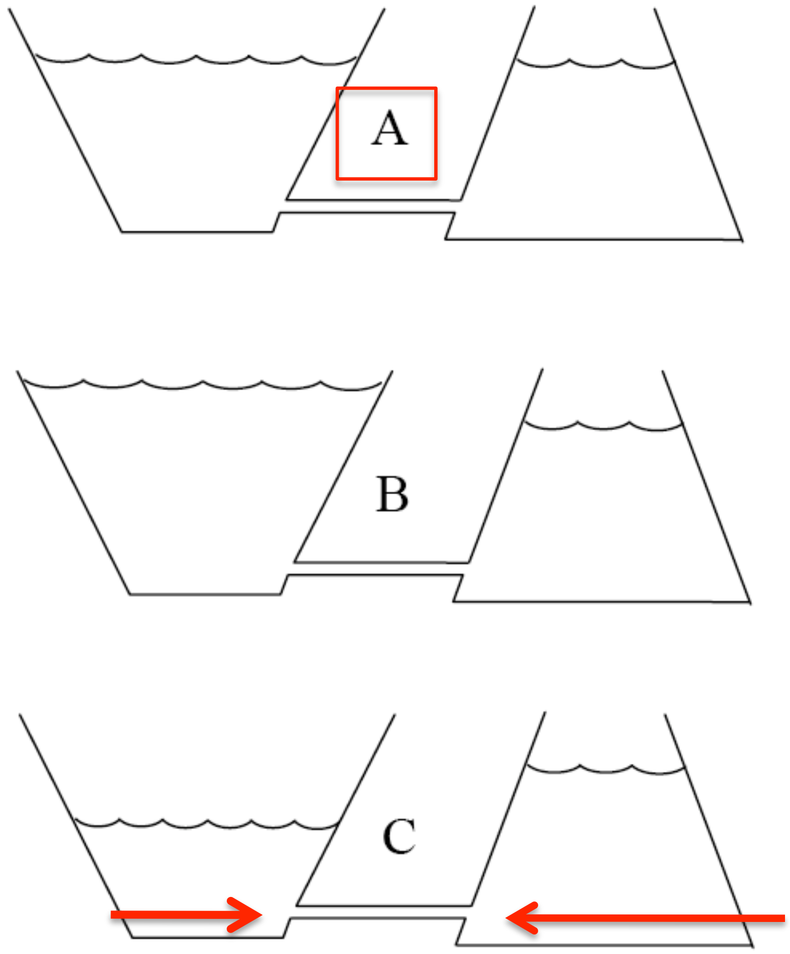


Pressure increases linearly with depth, proportional to g and ρ!

Clicker Question

Room Frequency BA

As shown, two containers are connected by a hose and are filled with water. Which picture correctly depicts the water levels?



Different depths would give different pressures! The net force on the fluid at the connection tube would not be zero and there would be flow!

$$P = P_{atm} + \rho g h$$

More on Gravity and Pascal's Principle

$$P_h = P_{atm} + \rho_{Water} g h$$

- Pressure only depends on the depth *h*; at a given depth the pressure is the same.
- Water pressure at depth *h* is literally the weight per unit area of a fluid column of height *h*!

This also applies to air itself!

Atmospheric pressure at sea level:

P_{atm} = 1 atm ≈ $\rho_{air} g H$ ≈ (1.3 kg /m^3) x g x 8 km ≈

(1.3 kg /m^3) x (8x10^3 m) x g ≈(1x10^4 kg/m^2)x(10 m/s^2) ≈ 10^5 Pa

Also: P_{atm}= 1 atm ≈ (1x10^4 kg/m^2) g = (1 kg /cm^2) g

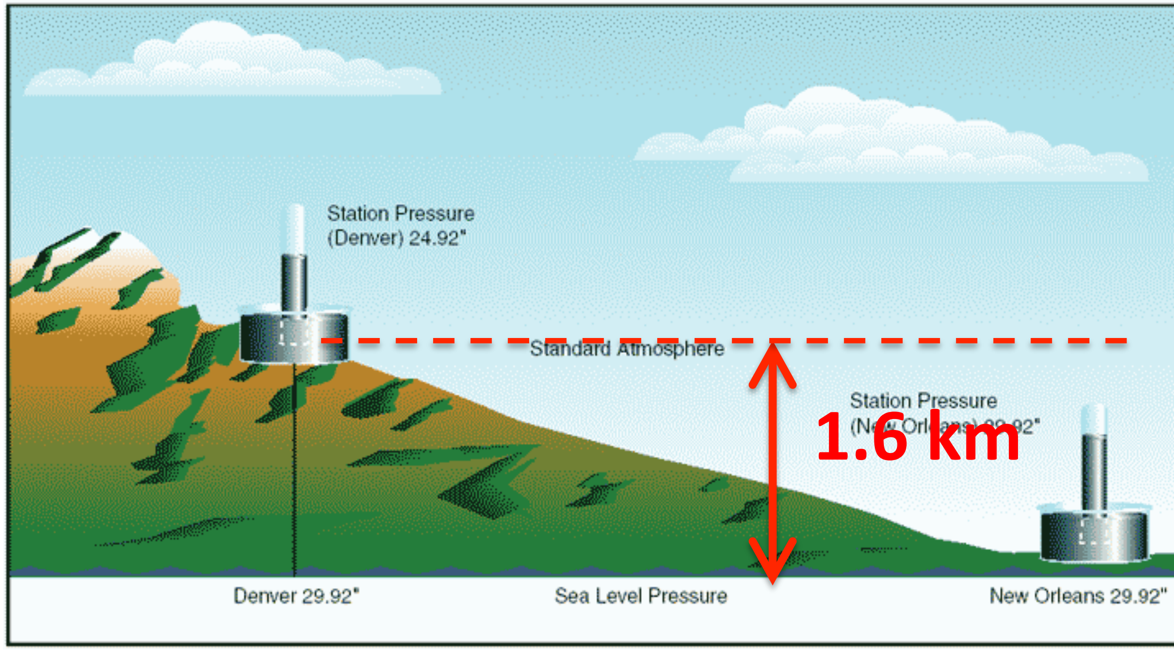
-- weight of 1 kg on every cm^2 !

Atmospheric Pressure in Boulder

Why is atmospheric pressure is lower in Boulder/Denver?

("Mile-high city": 1 mile above sea level)

Air pressure at sea level is higher than in Boulder by the weight of the extra air:



$$\Delta P = P_{sea} - P_{Boulder} =$$

$$\rho_{air} g H_{Boulder} \approx \rho_{air} g \times (1\, mile) \approx \rho_{air} g \times (1.6\, km) =$$

$$\rho_{air} g \times (8\, km)\, \frac{1.6\, km}{8\, km} = 0.2\, P_{sea} = 0.2\, atm$$

MAGDEBURG HEMISPHERES

Experimental demonstration of air pressure by Otto von Guericke:

- Regensburg 1654, 30 horses;
- Magdeburg 1656, 16 horses.