Spring 2014

PHYS-2010

Lecture 39

Clicker Question

Room Frequency BA

Large cube *B* is made up of 8 identical smaller wooden cubes *A*, as shown. Each side of cube *B* is twice as long as each side of cube *A*. How do the densities of cubes *A* and *B* compare?

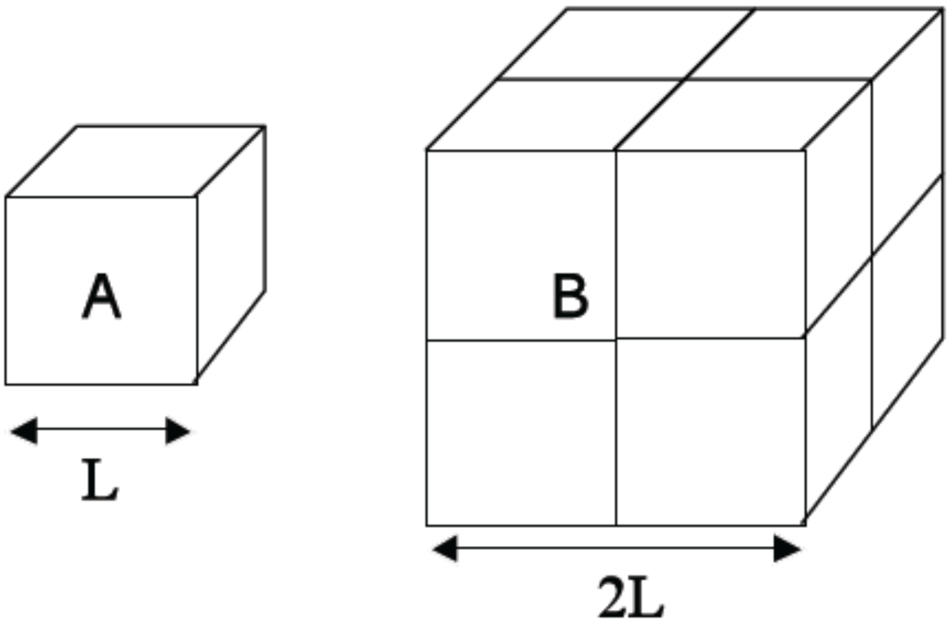
A) $\rho_A = 4\ \rho_B$

B) $\rho_A = 2\ \rho_B$

C) $\rho_A = \rho_B$

D) $\rho_A = \frac{1}{2}\ \rho_B$

E) $\rho_A = \frac{1}{4}\ \rho_B$



Clicker Question

Room Frequency BA

Large cube *B* is made up of 8 identical smaller wooden cubes *A*, as shown. Each side of cube *B* is twice as long as each side of cube *A*. How do the densities of cubes *A* and *B* compare?

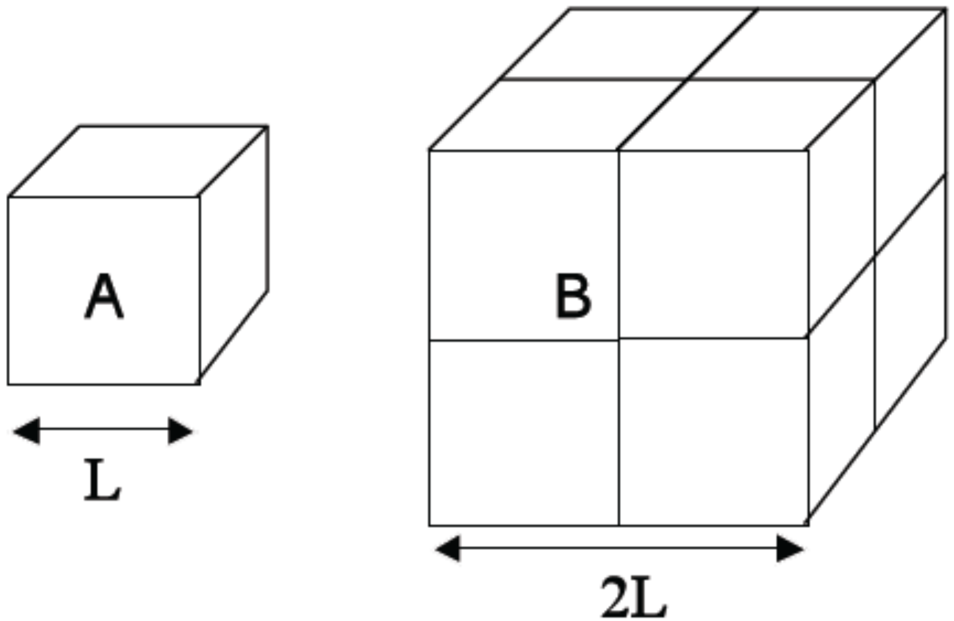
A) $\rho_A = 4\ \rho_B$

B) $\rho_A = 2\ \rho_B$

C) $\rho_A = \rho_B$

D) $\rho_A = ½\ \rho_B$

E) $\rho_A = ¼\ \rho_B$



Announcements

- Read **Chapter 10.**
- **CAPA # 13** due next tomorrow, Tuesday, April 22.
- **Written Homework # 10** due Friday, April 25, at 4 pm.
- This week: **Lab # 8** "Buoyancy" (with prelab)
- **FCQs** this Wednesday, April 23!

DENSITY DEMONSTRATIONS

Specific Gravity (SG) of substance X $\equiv \dfrac{\rho_X}{\rho_{Water}}$

$SG_{Water} = 1$

$SG_{Concrete} \approx 2.3$

$SG_{Iron} \approx 8$

$SG_{lead} \approx 12$

$SG_{Gold} \approx 19$

$SG_{Ice} \approx 0.9$

$SG_{Oil} \approx 0.8$

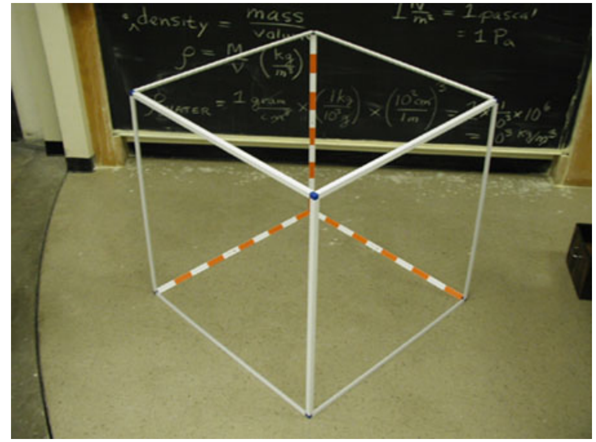
$\rho(H_2O) = 1\ g/cm^3$

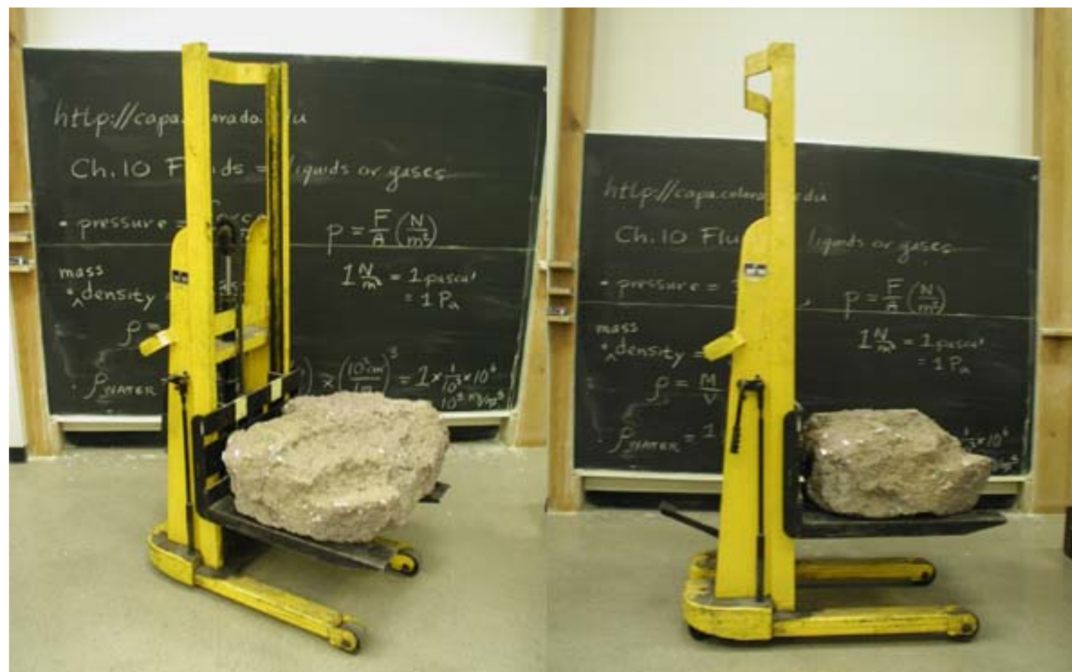
Gold Bars - Federal Reserve

Measurements: 7 x 3.625 x 1.75 inches

1 standard (7"x 3.625"x 1.75")
gold bar = 31 lb !!

DENSITY DEMONSTRATIONS



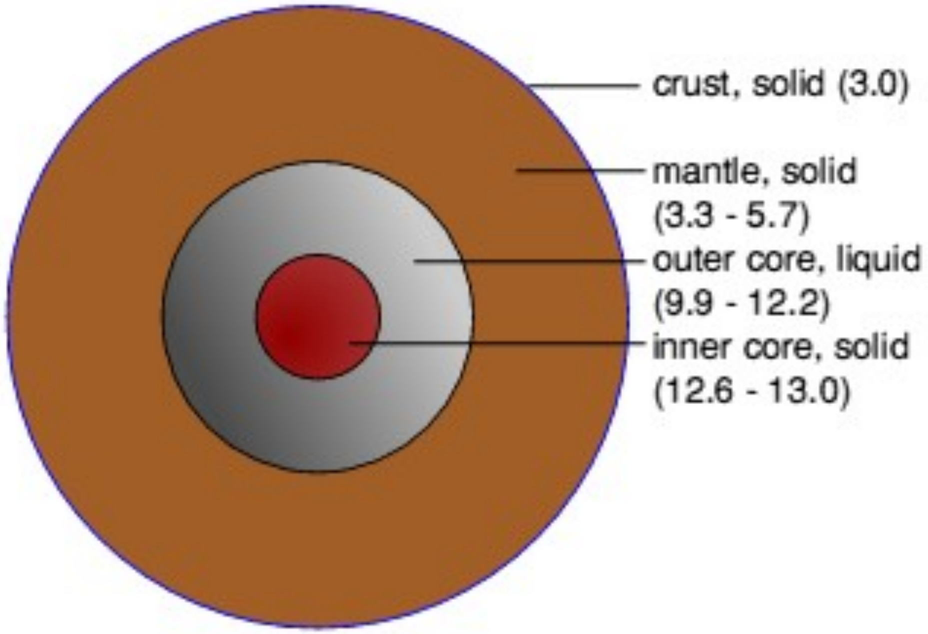


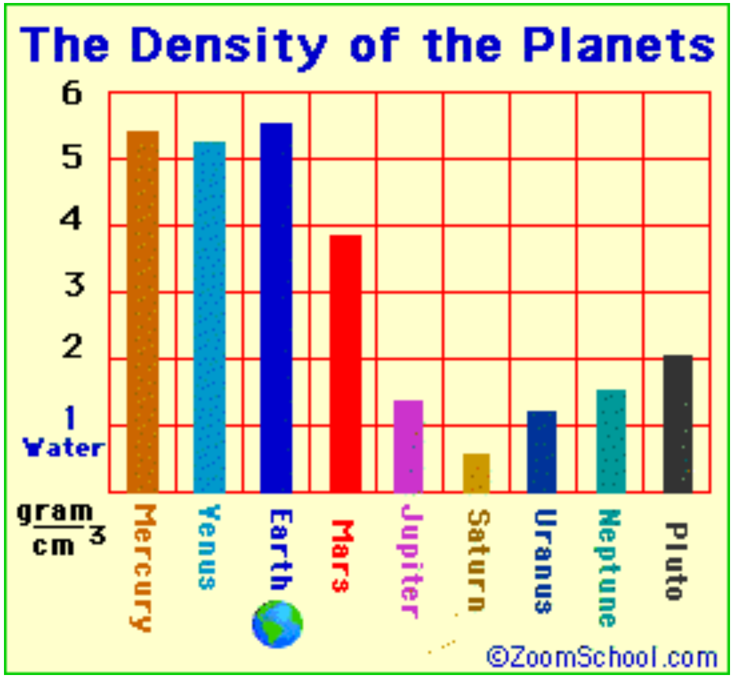
Density of the Earth

What is the average density of the Earth?

$\rho_{Earth} = M_E / V_E$

Density of Earth = 5.5 g/cm^3





FLUIDS

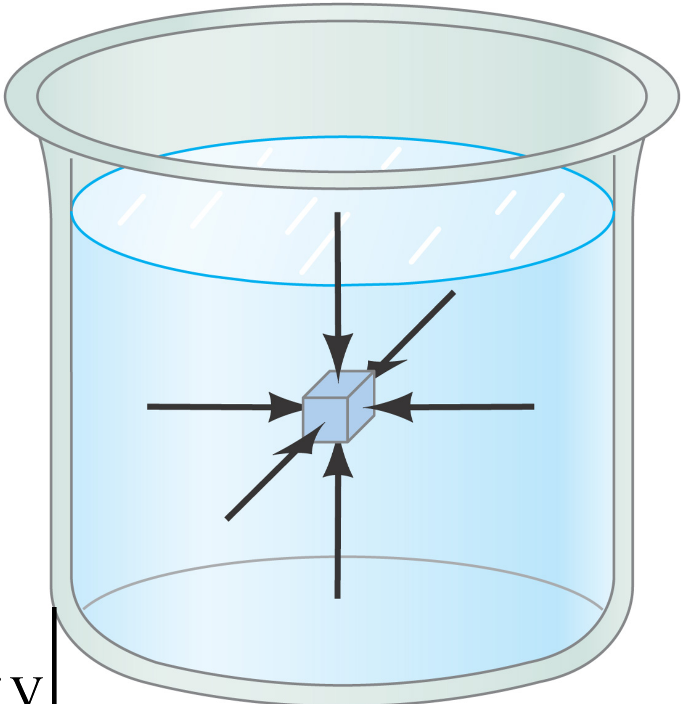
Back to Square 2: Fluid "Forces"

When we try to apply Newton's Laws to Fluids what do we use for the ***force***?

Again, consider a "small" imaginary volume or box inside the body of fluid – a fluid element.

To find the force on the imaginary volume *V*, we use the concept of *pressure P:*

The magnitude of the force *F* on each side of the fluid element divided by the *area A* of that side:



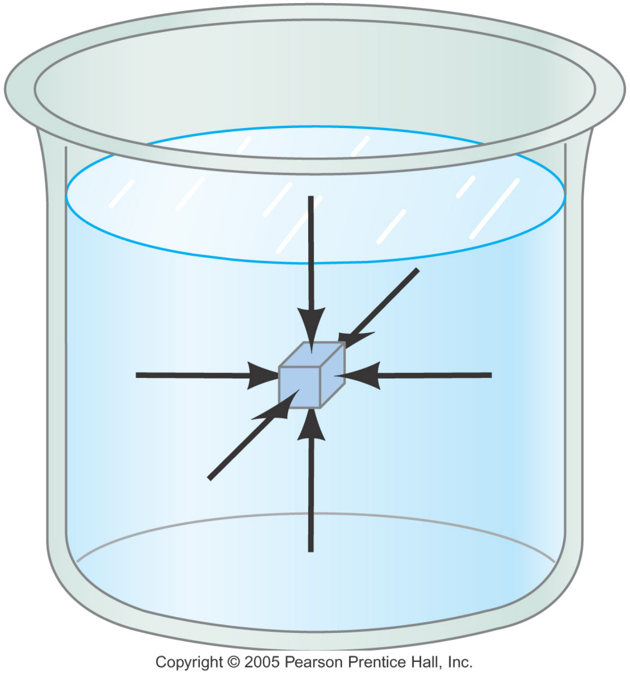
$$P_{\text{at side of V}} = \frac{\left|\vec{F}_{\text{on side of V}}\right|}{A_{\text{of side V}}}$$

Direction of Fluid Forces

Newton's law deals with forces which are *vectors!*
What is the direction of the force from fluid pressure?

*For static fluids (no flow) the force is **perpendicular to the surface** of the side.*

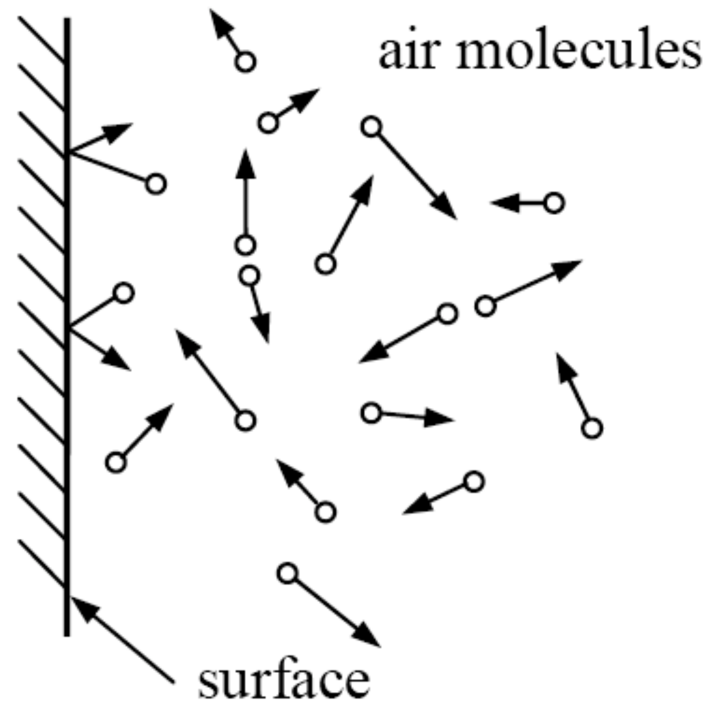
In the figure you see arrows for the force on each side of an imaginary cube of volume *V.*



Critical point: Pressure does not have any direction; the direction of the force from pressure depends on the orientation of the surface the pressure acts on.

Atomic View of Fluid Pressure from Air

- Air consists mostly of oxygen (O_2) and nitrogen (N_2) molecules.
- At room temperature, the molecules have thermal energy and are moving around rapidly (speed ≈ 400 m/s), colliding with each other and with every exposed surface.
- The pounding of the air molecules on a surface, like the pitter-pat of rain on the roof, adds up to a large force per area: P_{atm} = 14.7 psi.



Units of Pressure

$$P_{\text{at side of V}} = \frac{\left|\vec{F}_{\text{on side of V}}\right|}{A_{\text{of side V}}}$$

SI Units of Pressure: N/m^2 = 1 Pascal (Pa)

English Units of Pressure:
lb/in^2 = 1 pound per square inch (psi)

How do these unit compare in size?

Clicker Question

Room Frequency BA

Approximately what is 1 psi in the SI unit Pa? (1 lb = 4.45 N)

A) 5

B) 200

C) 7000

D) 4×10^4

E) 1×10^5

Both force and area units have to be converted!

$$\text{Guess estimate } 1\frac{\text{lb}}{\text{in}^2} \approx \frac{5\text{ N}}{\text{lb}} \bullet \left(\frac{40\text{ in}}{1\text{ m}}\right)^2 = 8000\frac{\text{N}}{\text{m}^2}$$

$$\text{Accurate Calculation } 1\frac{\text{lb}}{\text{in}^2} = \frac{4.45\text{ N}}{\text{lb}} \bullet \left(\frac{39.4\text{ in}}{1\text{ m}}\right)^2 = 6910\frac{\text{N}}{\text{m}^2}$$

Too Many Units of Pressure!

The most common pressure in everyday life is that coming from the atmosphere *(at sea level) !*

1 atmosphere = 1 atm = 14.7 psi

= 1.013×10^5 Pa

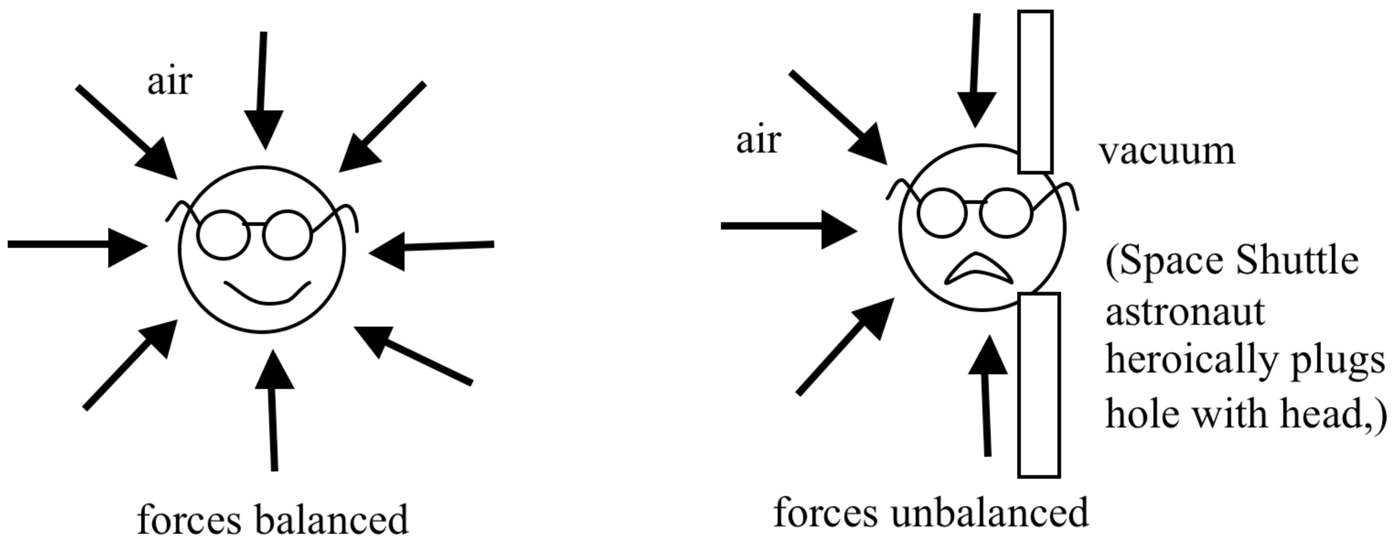
= 1.013 bar

= 760 torr

Is 15 psi a big pressure?

Yes!!!

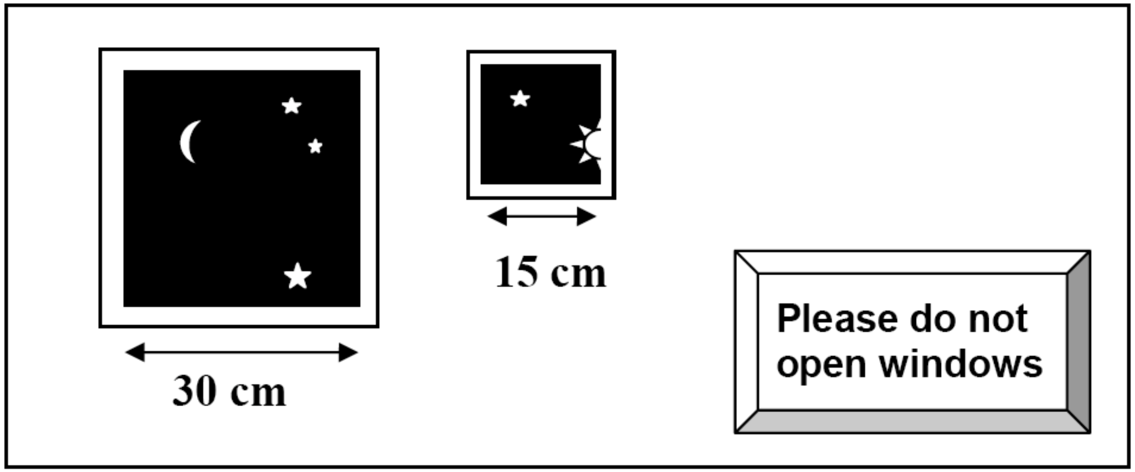
We are normally unaware of this because the external atmospheric pressure is balanced by our internal pressure.



Clicker Question

Room Frequency BA

The air pressure inside the Space Station is P = 12 psi. There are two square windows in the Space Station: a little one and a big one. The big window is 30 cm on a side. The little window is 15 cm on a side. How does the **pressure** of the air on the big window compare to the **pressure** on the little window?



A) same pressure on both windows

B) 2 times more pressure on the big window

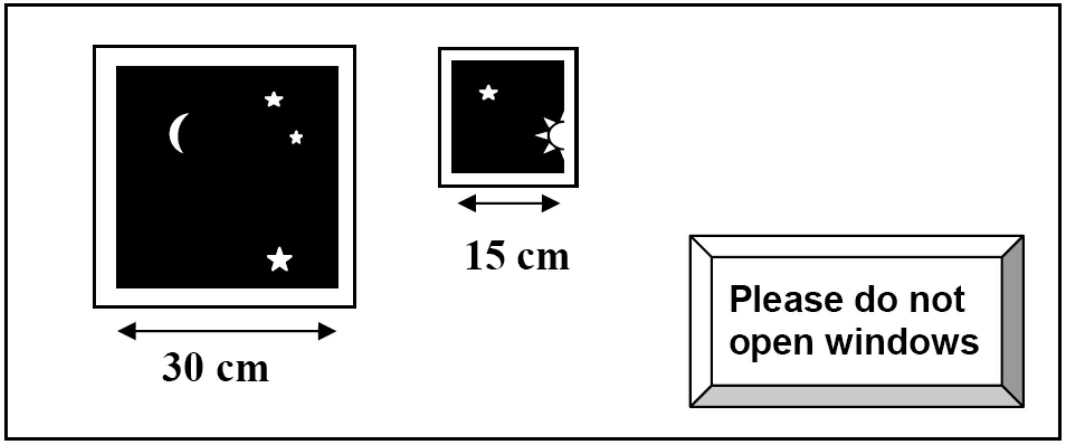
C) 4 times more pressure on the big window

D) 9 times more pressure on the big window

Clicker Question

Room Frequency BA

The air pressure inside the Space Station is P = 12 psi. There are two square windows in the Space Station: a little one and a big one. The big window is 30 cm on a side. The little window is 15 cm on a side. How does the **total force** of air on the big window compare to the **total force** on the little window?



A) same force on both windows

B) 2 times more force on the big window

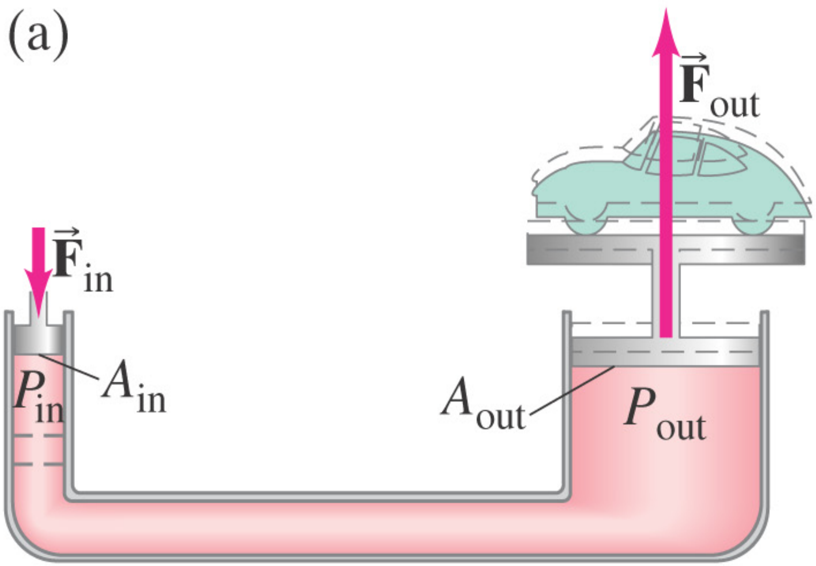
C) 4 times more force on the big window

D) 9 times more force on the big window

F = P A

Applying Outside Pressure to a Fluid

<u>PASCAL'S PRINCIPLE:</u> 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