Announcements – Oct 31, 2013

1. Exam 3 ends Monday 2 pm; late fee after 2 pm Saturday

2. No homework due tonight

Pressure

$$P = \frac{Force}{Area}$$

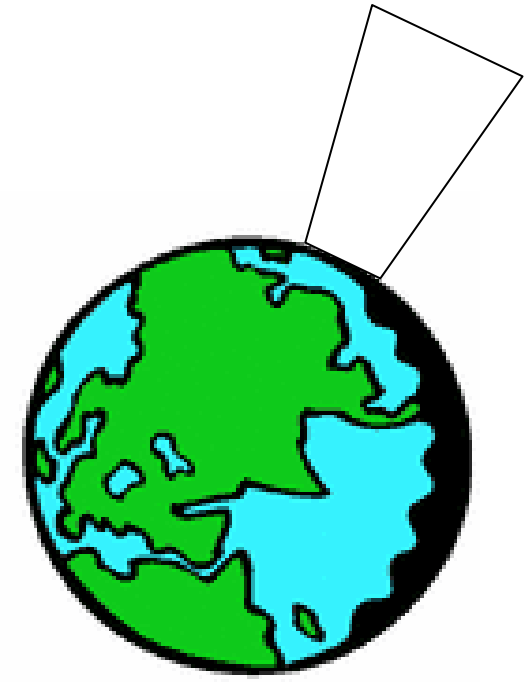
Demos: pressure vs. force; bed of nails (with sledgehammer!)

Why do they never show anyone *standing* on a bed of nails?

Atmospheric pressure: 1 atm = 14.70 lbs/in^2 (psi)

= 1.013×10^5 N/m^2

Comes from…..



Demo: Collapsing can

Demo: “Magdeburg hemispheres”

Otto Von Geuricke,
1602-1686

Deutsches Museum, Munich

Wikipedia: “Guericke's demonstration was performed on 8 May 1654 in front of the Imperial Diet, and the Emperor Ferdinand III in Regensburg. Thirty horses, in two teams of fifteen, could not separate the hemispheres until the valve was opened to equalize the air pressure. In 1656 he repeated the demonstration with sixteen horses (two teams of eight) in his hometown of Magdeburg, where he was mayor. He also took the two spheres, hung the two hemispheres with a support, and removed the air from within. He then strapped weights to the spheres, but the spheres would not budge. Gaspar Schott was the first to describe the experiment in print in his Mechanica Hydraulico-Pneumatica (1657). In 1663 (or, according to some sources, in 1661) the same demonstration was given in Berlin before Frederick William, Elector of Brandenburg with twenty-four horses.”

Density

$$\rho = \frac{mass}{volume}$$

ρ_{water} = 1000 kg/m^3

= 1.000 g/cm^3 original definition of a gram

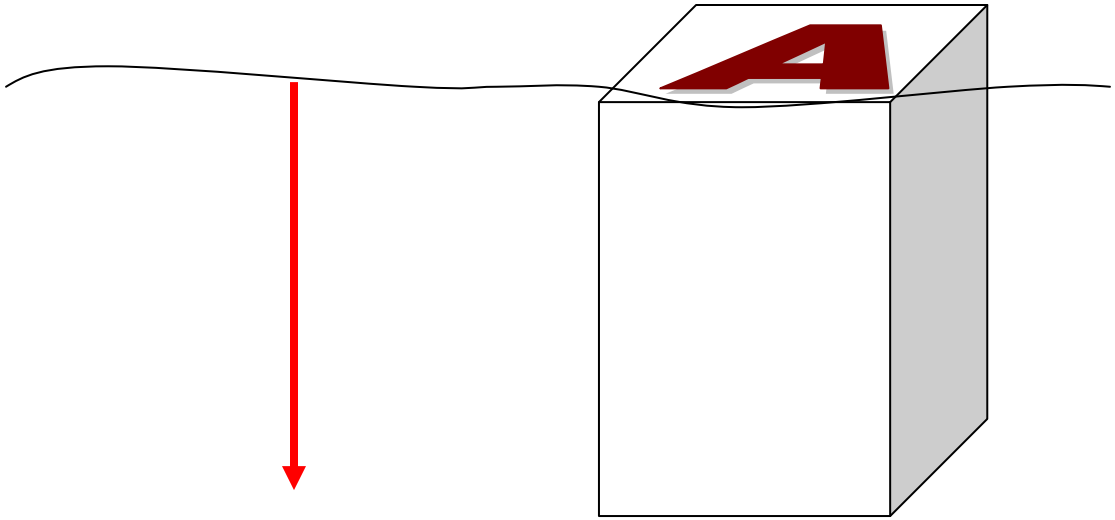
"Specific Gravity" = $\rho_{material}/\rho_{water}$

(i.e., the density in g/cm^3 units)

SG of some common substances:

Air, standard conditions	0.0013
Wood(Oak)	0.6 - 0.9
Liquid nitrogen	0.81
Ice	0.92
Water	1.00
Bricks	1.84
Aluminum	2.70
Steel	7.80
Silver	10.50
Lead	11.30
Gold	19.30
Platinum	21.40

Pressure vs depth in a fluid



Weight of water above
some area A at a depth of *h.*

w =

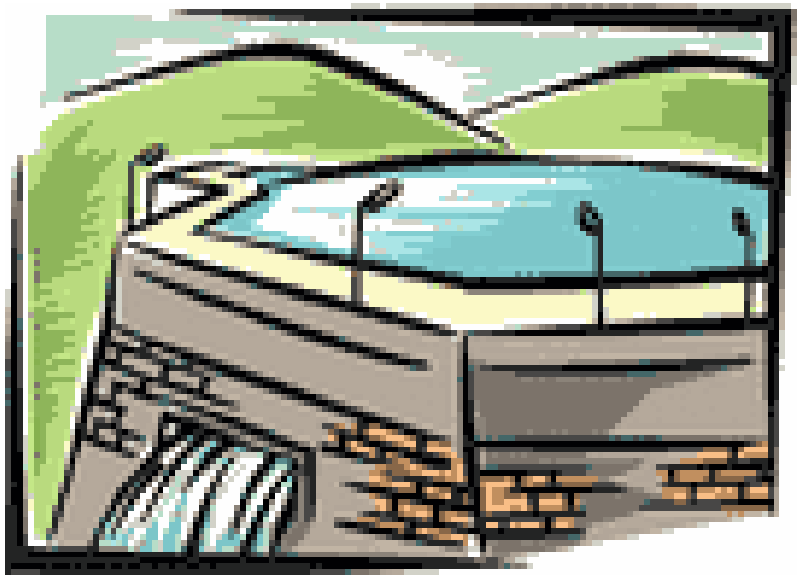
***Pressure at h*:** (Include the pressure on the top of the fluid).

***P* =**

Videos

pressure vs depth, pressure pushes on _____

Clicker quiz



For a longer canyon behind the dam (red arrow length), the dam…

a. can be weaker
b. must be stronger
c. can be the same.

From warmup

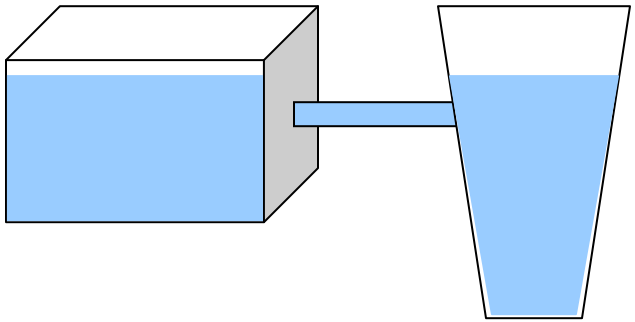
Where is the pressure greater, one meter beneath the surface of Lake Michigan or one meter beneath the surface of a swimming pool?

a. Lake Michigan
b. swimming pool
c. the same

Pascal's principle

For a fluid at rest, the pressure in the fluid depends only on the depth, not the shape of the (open) container.

All parts of fluid at same _____ have same _____



Any change in pressure is felt by _____

Demos

fluid levels
mechanical advantage
hydraulic “force amplification”

From warmup

Ralph measures the pressure in his flat tire with a standard automotive pressure gauge. The gauge reads zero. This confuses Ralph, because he thinks there is probably still air in the tire. Help Ralph understand what is going on.

“Pair share”–I am now ready to share my neighbor’s answer if called on.

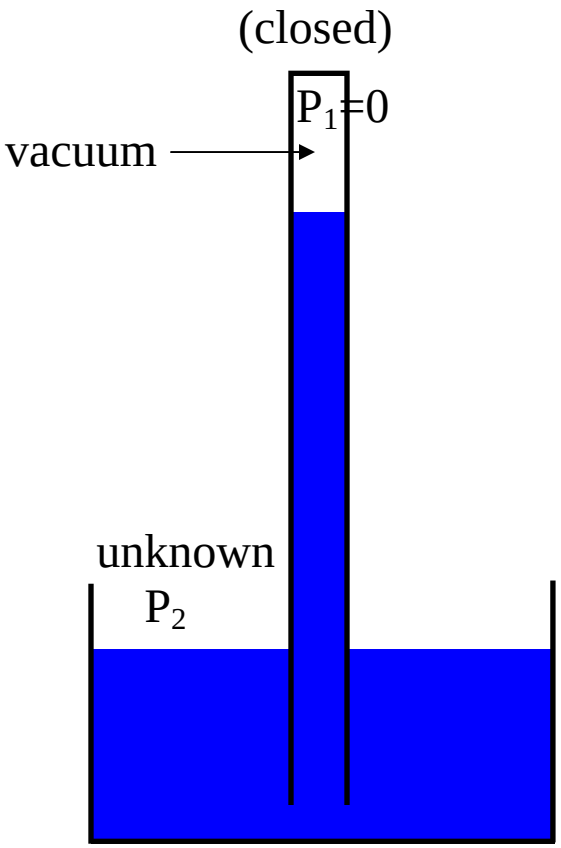
a. Yes

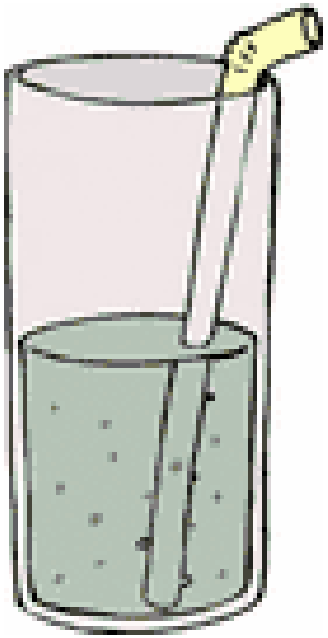
“Absolute” vs “gauge” pressure

Gauge pressure is: _____

Barometers

How to read?

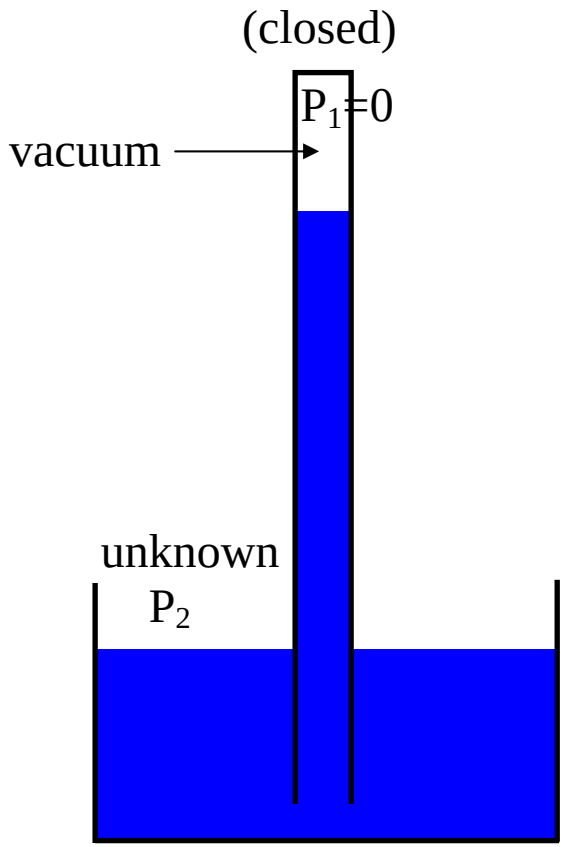




Straws:

How high can we lift water with a vacuum?

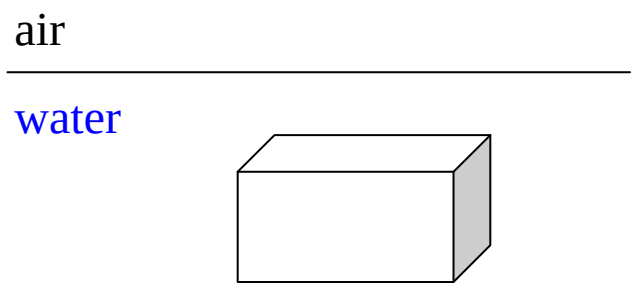
Clicker quiz



On the moon, where gravity is less but there is no atmosphere, if you pump out the air at the top of a barometer, the mercury would rise _____ compared to on earth.

a. higher
b. lower
c. the same
d. not at all

Buoyancy



Water in a rectangular plastic bag…

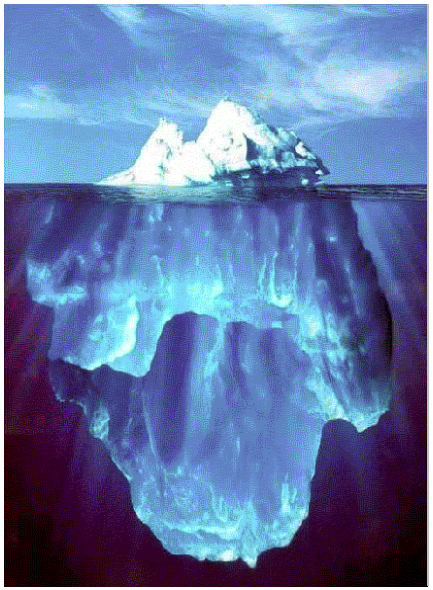
Does the water inside the bag have mass?

Does the water inside the bag have weight?

Why doesn't it accelerate down?

Archimedes' Principle

The buoyant force equals the weight of the fluid that the object is displacing at the moment.



$$F_{Buoyant} = B = m_{displaced\ fluid} \times g$$
$$= \rho_{fluid} V_{object} g$$

Demos

- Does a bottle of Coke sink or float?
- Does aluminum foil sink or float?

From warmup

The buoyant force of a submerged object always equals:

a. the weight of the object
b. the net force on the object
c. the weight of the water that would otherwise occupy the object's space

Sink vs. Float

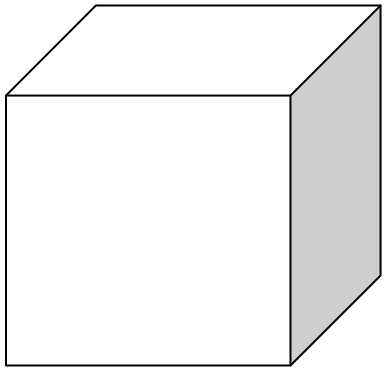
Objects will **sink** if

Objects will **float** if

Floating objects will rise out of the water until…

Clicker quiz

Three cubes of the same size and shape are put in water. They sink. One is lead, one is steel and one is a dense wood (ironwood). $\rho_{lead} > \rho_{steel} > \rho_{ironwood}$. The bouyant force is greatest on the _____ cube

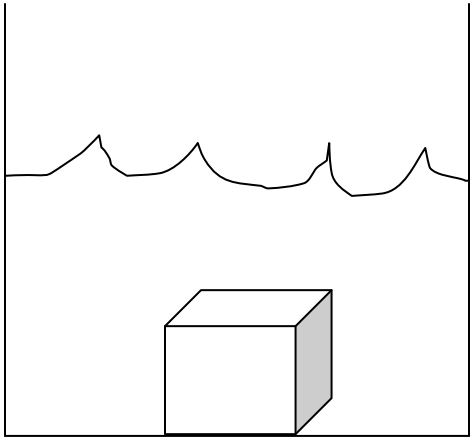


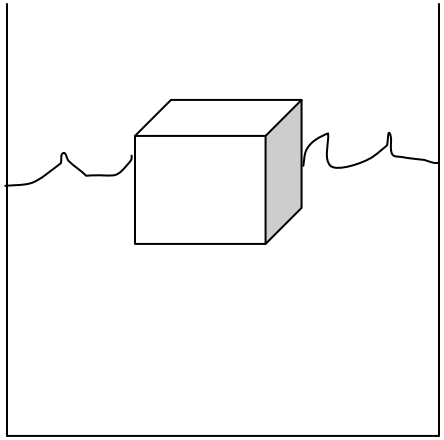
a. lead
b. steel
c. wood
d. same buoyant force

Clicker quiz

Two cubes of the same size and shape are made out of wood. The ironwood cube **sinks**, but the walnut cube **floats**. The bouyant force is greatest on the _____ cube

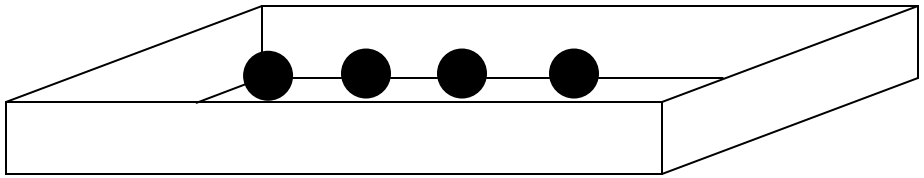
a. ironwood
b. walnut
c. same buoyant force





Worked Problem

A raft of wood of size 0.5m $\times$ 6m $\times$ 5m weighs 30,000 N. It is loaded with cannon balls until it is (barely) completely submerged. How much weight was loaded?



Answer: 117,000 N

Additional part: the balls are unloaded, and the raft now sits at equilibrium. How far is the raft submerged?

Answer: 10.2 cm

Archimedes: “Eureka”

Archimedes was charged with determining if a crown was pure gold. One method he may have used: he balanced the crown with pure gold outside water. After immersing, the balance tipped as shown.

Clicker quiz: The crown has density

a. more than gold
b. less than gold
c. same as than gold

Clicker quiz 1: A cannonball is put in a boat. The boat sinks down to displace more water. The amount of new water displaced is

a. a volume of water that weighs **more than** the cannonball
b. a volume of water that weighs **as much as** the cannonball
c. a volume of water that weighs **less than** the cannonball

Clicker quiz 2: If the cannonball now falls from the boat into the water and sits on the bottom of the lake, the amount of water displaced by the cannon is

a. a volume of water that weighs **more than** the cannonball
b. a volume of water that weighs **as much as** the cannonball
c. a volume of water that weighs **less than** the cannonball

From warmup (do as clicker quiz): Therefore…if the cannonball falls from the boat into the water and sits on the bottom of the lake, will the overall water level of the lake rise, fall or stay the same? (compared to when the cannonball was in the boat)

a. rise
b. fall
c. stay the same

Problem-Solving Tip: Limiting Cases

What happens if the cannonball has a very large density?

What happens if the cannonball has a very small density?