

## Lecture 19 Announcements

- CAUTION:** Starting with HW 15 (due tomorrow), some of your HW answers will need to be written in **scientific notation**. For example, if the answer range says  $1.00 \times 10^5$ ,  $3.00 \times 10^5$  Pa

and you get  $2.57 \times 10^5$  Pa as your answer...

then you should type in the answer as **2.57E5**.

**No spaces, no "x"s!**

If you put any spaces or x's in your answer, the computer will mark it wrong.

- Exam 3 going on...

## Pressure

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

**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<sup>2</sup> =  $1.013 \times 10^5$  N/m<sup>2</sup>  
Comes from.....



**Demos:** collapsing can; "Magdeburg hemispheres"

## Solids

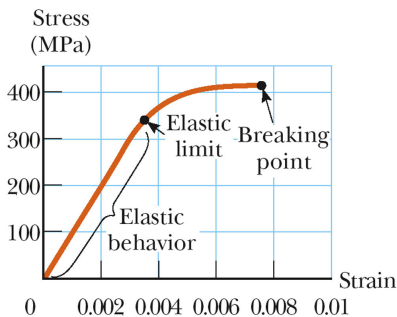
Like springs?

- Amount of stretch proportional to force

Video: stretched wire

- "Stress" = ...
- "Strain" = ...

- Elastic limit



**"Young's modulus"**

→ a type of spring constant

## Compressibility

Solids vs. Liquids vs. Gases

## Density

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

$$\rho_{\text{water}} = 1000 \text{ kg/m}^3 = 1.000 \text{ g/cm}^3 \quad \text{original definition of a gram}$$

"Specific Gravity" = density of material/density of water  
(also: the density in g/cm<sup>3</sup> units)

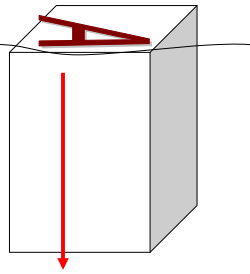
**SG of some common substances:**

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  $h$ .

$w =$



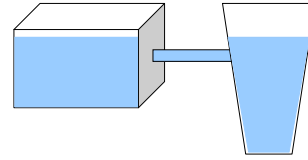
**Pressure at  $h$ :** (Include the pressure on the top of the fluid).

$P =$

**Videos:** pressure vs depth, pressure pushes on \_\_\_\_\_

**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 \_\_\_\_\_



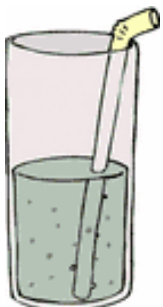
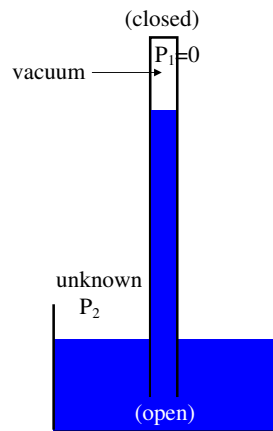
**Demos:** fluid levels; mechanical advantage; hydraulic "force amplification"

## Absolute vs gauge pressure

Gauge pressure is: \_\_\_\_\_

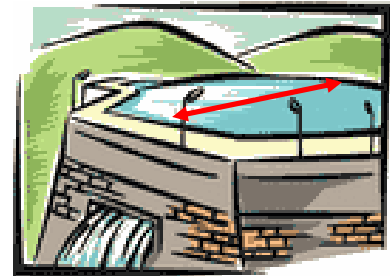
## Barometers

How to read?



### Straws:

How high can we lift water with a vacuum?

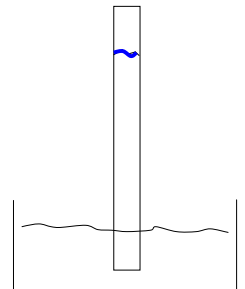


**Clicker quiz:** For a longer canyon behind the dam (red arrow length), the dam...

- can be weaker
- must be stronger
- can be the same.

**Clicker quiz:** On the moon, where gravity is less but there is no atmosphere, if you pumped out the air at the top of a barometer, the mercury would rise \_\_\_\_\_ compared to on earth.

- higher
- lower
- the same
- not at all



## Buoyancy

air  
water



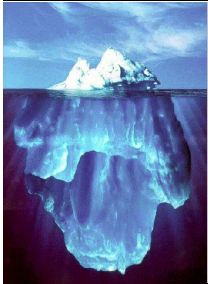
Water in a rectangular plastic bag...

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.



$$F_B = m_{\text{displaced fluid}} \times g \\ = \rho_{\text{fluid}} V_{\text{object}} g$$

**Demos:** Coke and other objects in tank  
Does aluminum sink or float?

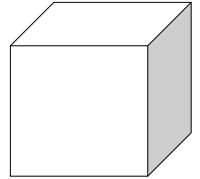
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Objects will **sink** if

Objects will **float** if

Floating objects will rise out of the water until...

Three cubes of the same size are **completely submerged** under water: lead, steel and dense wood (ironwood).

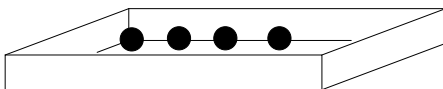


**Clicker quiz:** The buoyant force is greatest on the \_\_\_\_\_ cube

- lead
- steel
- wood
- same buoyant force

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



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

Answers: 117,000 N; 10.2 cm

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## 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

- more than gold
- less than gold
- same as than gold

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**Clicker quiz:** A cannon 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 cannon
- b. a volume of water that weighs **as much as** the cannon
- c. a volume of water that weighs **less than** the cannon

**Clicker quiz:** If the cannon 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 cannon
- b. a volume of water that weighs **as much as** the cannon
- c. a volume of water that weighs **less than** the cannon

**Clicker quiz:** Therefore...if the cannon 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 cannon was in the boat)

- a. rise
- b. fall
- c. stay the same