0. Jazz are 3-0!

Lecture 19 Announcements

1. **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

   1.00×10^5, 3.00×10^5 Pa

   and you get 2.57×10^5 Pa as your answer…

   2.5723E5

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

   or 2.57E-5

   No spaces, no "x"s!

   If you put any spaces or x's in your answer, the computer will mark it wrong. (and I won't have sympathy since you've now been warned…)

2. Exam 3 going on…

   100 students taken

   median 80%

   Ave time 2hrs 8 mins

3. Afternoon Orbiter people: I'm still missing 2 names!

Solids

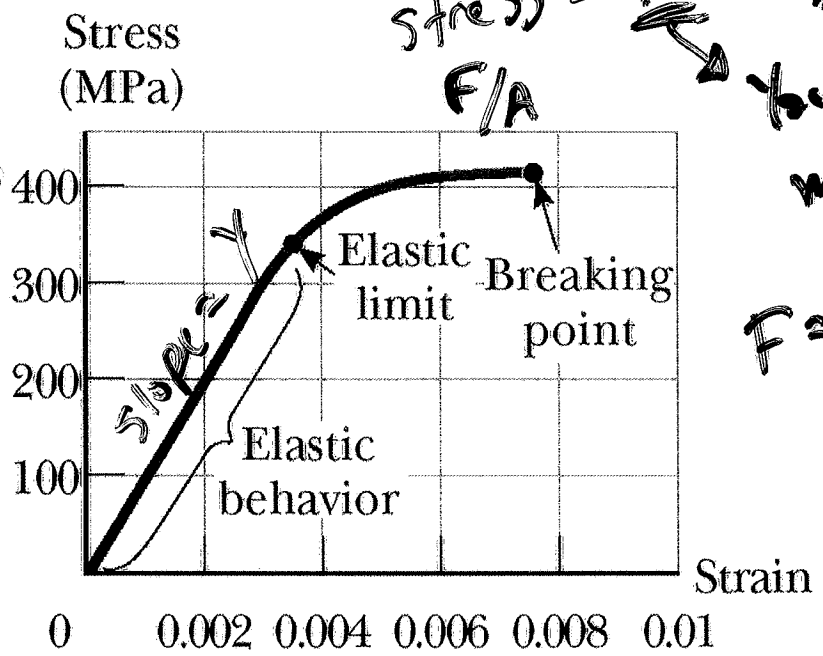
Like springs?

a. Amount of stretch proportional to force

Video: stretched wire

- "Stress" = …
- "Strain" = …

b. Elastic limit



"Young's modulus"

→ a type of spring constant

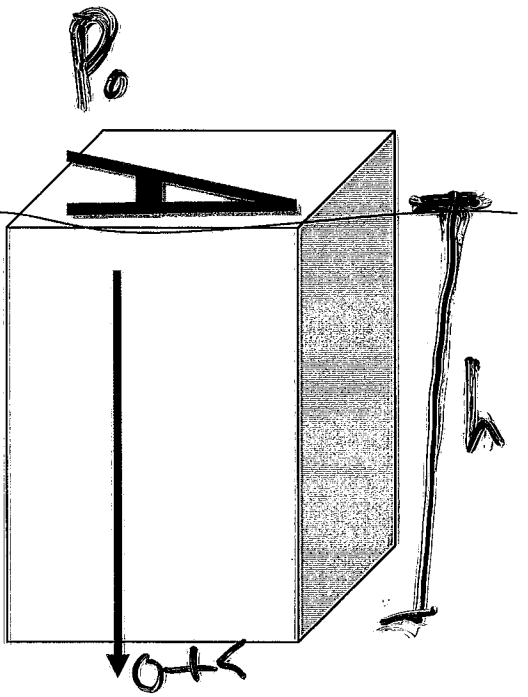
Compressibility

Solids vs. Liquids vs. Gases

incompressible

compressible

Pressure vs depth in a fluid



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

$$w = mg$$
$$= (\rho V)g$$
$$= \rho(Ah)g$$
$$w/A = \rho g h$$

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

$$\boldsymbol{P} = P_0 + \rho g h$$

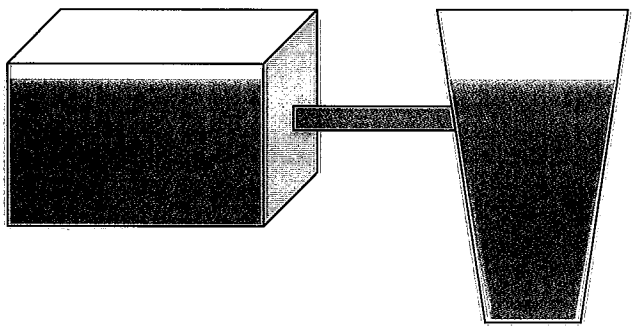
Videos: pressure vs depth, pressure pushes on all sides!

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.

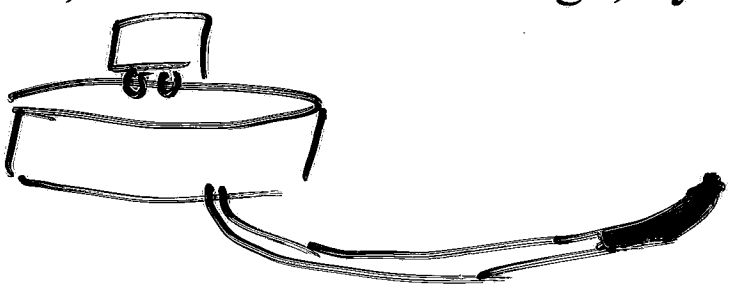
All parts of fluid at same depth have same pressure

$P = F/A$

$F = P \cdot A$



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



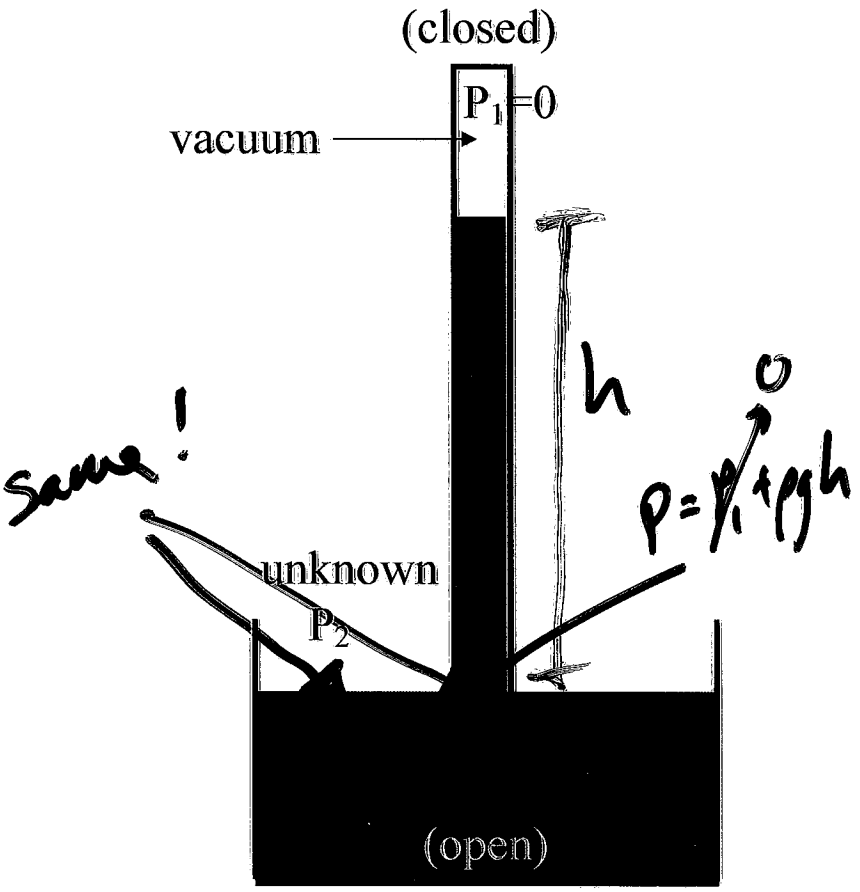
Absolute vs gauge pressure

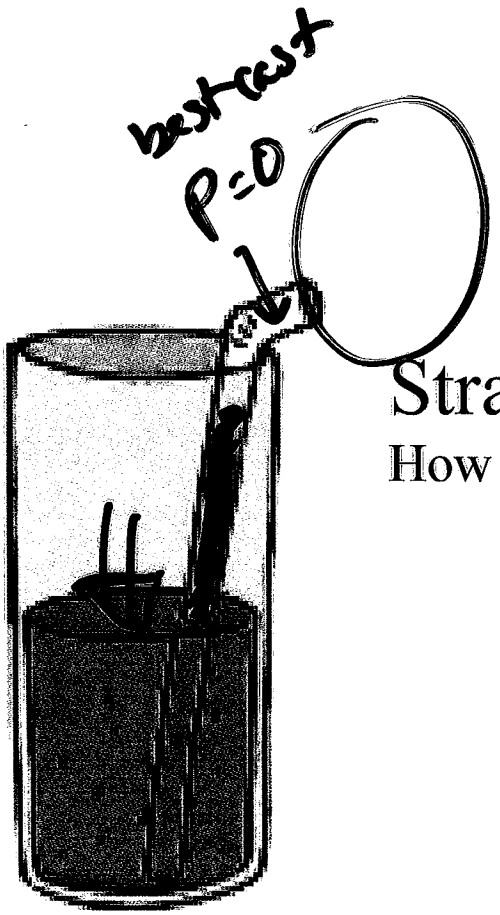
Gauge pressure is: the pressure a gauge reads

Barometers

How to read?

$P_2 = \rho g h$





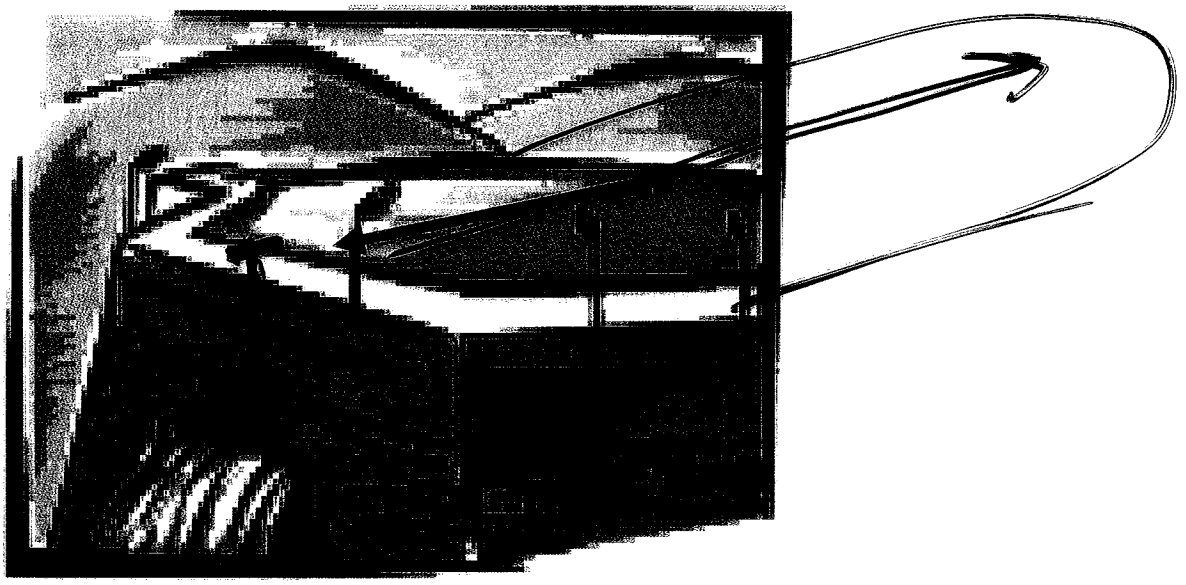
Straws:

How high can we lift water with a vacuum?

$1\ atm = (1000)(9.8)h$

$1.01 \cdot 10^5 Pa$

$h = 10\ m$



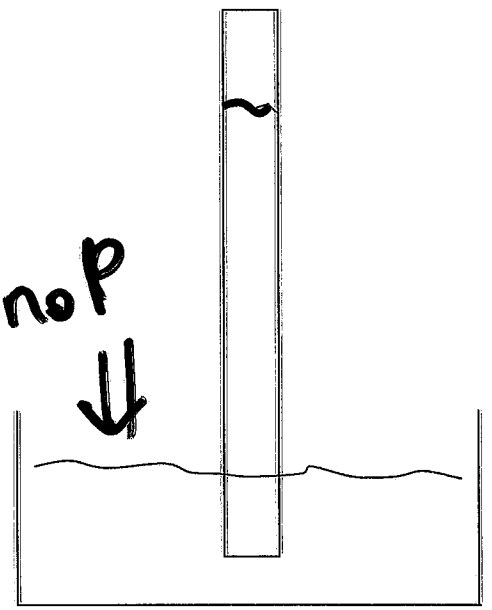
Clicker quiz: For a longer canyon behind the dam (red arrow length), the dam…

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

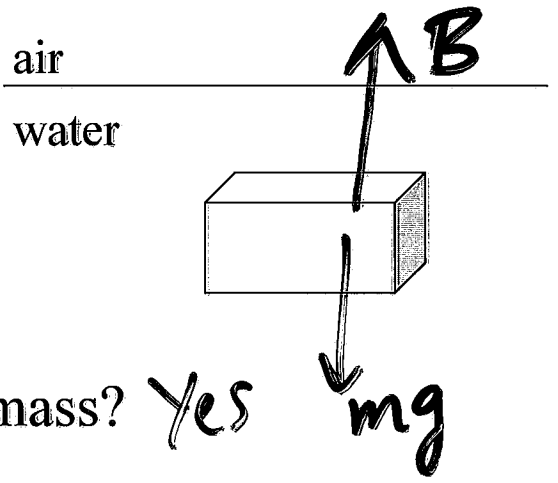
Pressure only depends on depth!

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.

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? Yes

Does the water inside the bag have weight? Yes

Why doesn't it accelerate down? $B = mg$

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

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

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

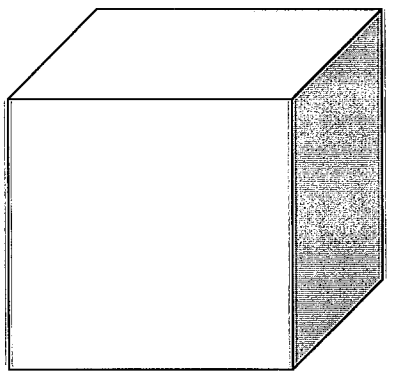
Objects will **sink** if $W > B$

Objects will **float** if $B_{max} > W$

Floating objects will rise out of the water until…

$$B = W$$

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



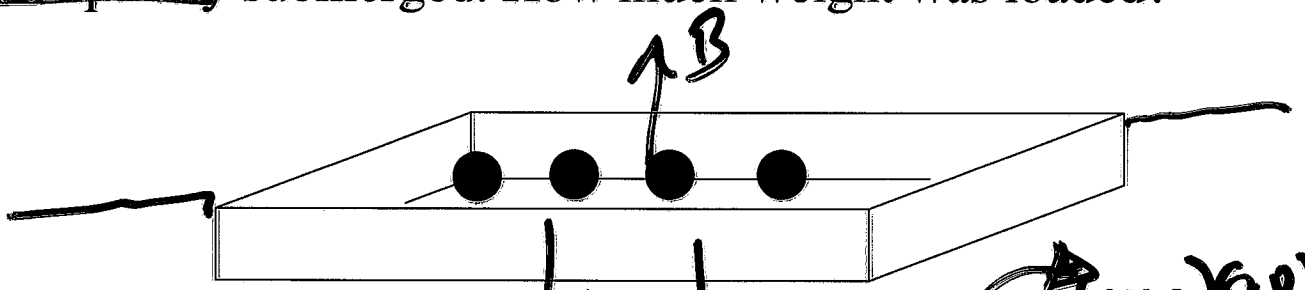
Clicker quiz: The bouyant force is greatest on the _____ cube

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

$B = \rho_{fl} g V_{object}$

$V = 15\ m^3$

Worked Problem: A raft of wood of size 0.5m × 6m × 5m weighs 30,000 N. It is loaded with cannon balls until it is (barely not) ~~completely~~ submerged. How much weight was loaded?



$\Sigma F_y = 0$

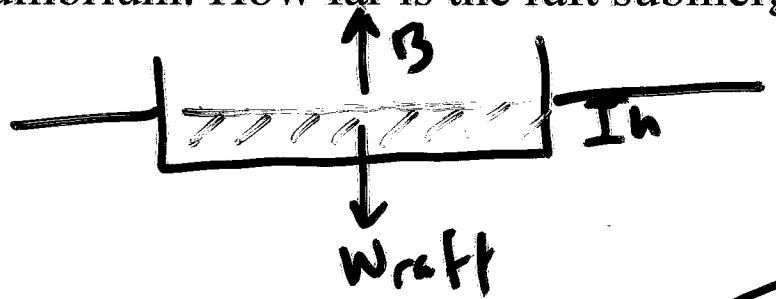
$B - W_{raft} - W_{balls} = 0$

$W_{balls} = B - W_{raft}$

$= (1000)(9.8)(15) - 30000$

$= 117000N$

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



$B - W_{raft} = 0$

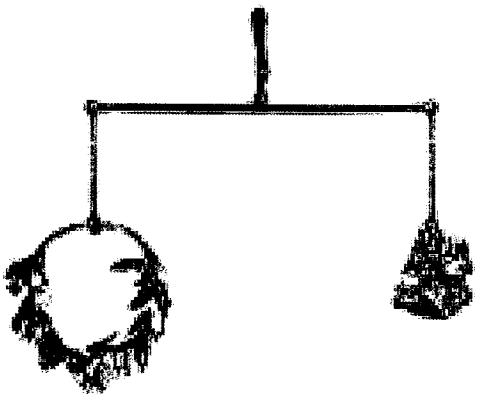
$B = W_{raft}$

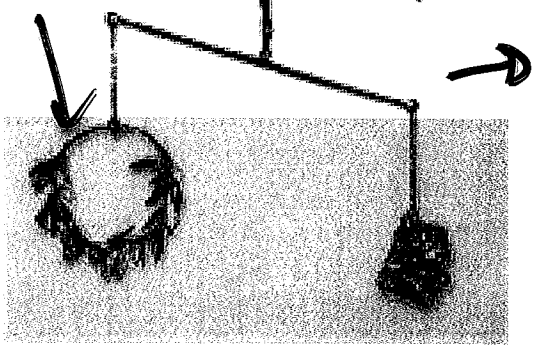
$(1000)(9.8)6 \times 5 \times h = 30000$

$h = .102m$

Answers: 117,000 N; 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