College Physics I: 1511 Mechanics & Thermodynamics

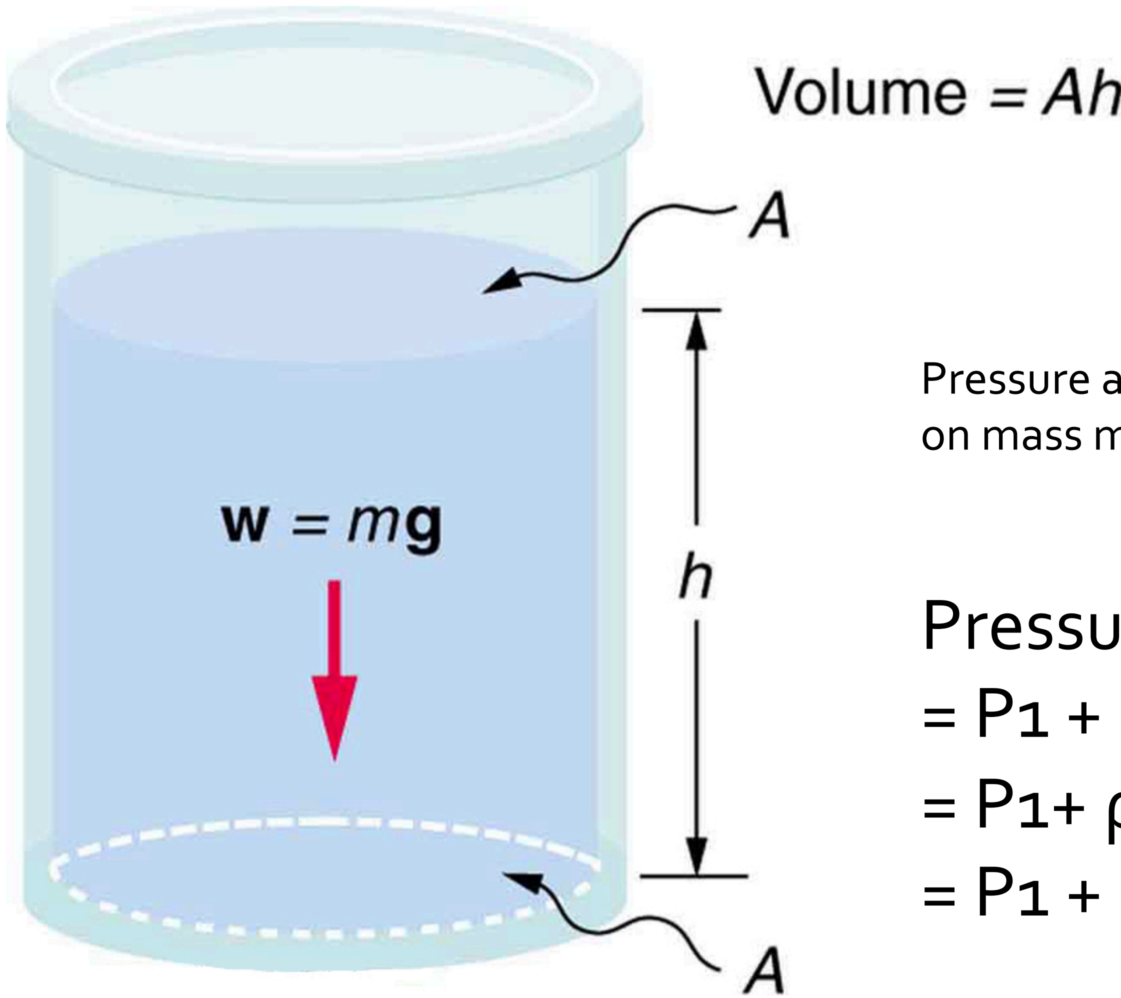
Professor Jasper Halekas
Van Allen Lecture Room 1
MWF 8:30-9:20 Lecture

Announcements

- Midterm #2 Equation Sheet and Sample Questions available on "Notes" page
- Midterm #2 next Friday:
  - Chapter 7 (~4q): All
  - Chapter 8 (~2q): 8.1-6 Not 8.7
  - Chapter 9 (~3q): All
  - Chapter 10 (~3q): 10.1-4* Not 10.5-8
  - Chapter 11 (~3q): 11.1-8 Not 11.9-11

*Only the portions of 10.2 covered in class

Pressure Vs. Depth



Pressure at depth d depends only on mass m_{fd} above depth d

Pressure P2 at depth d

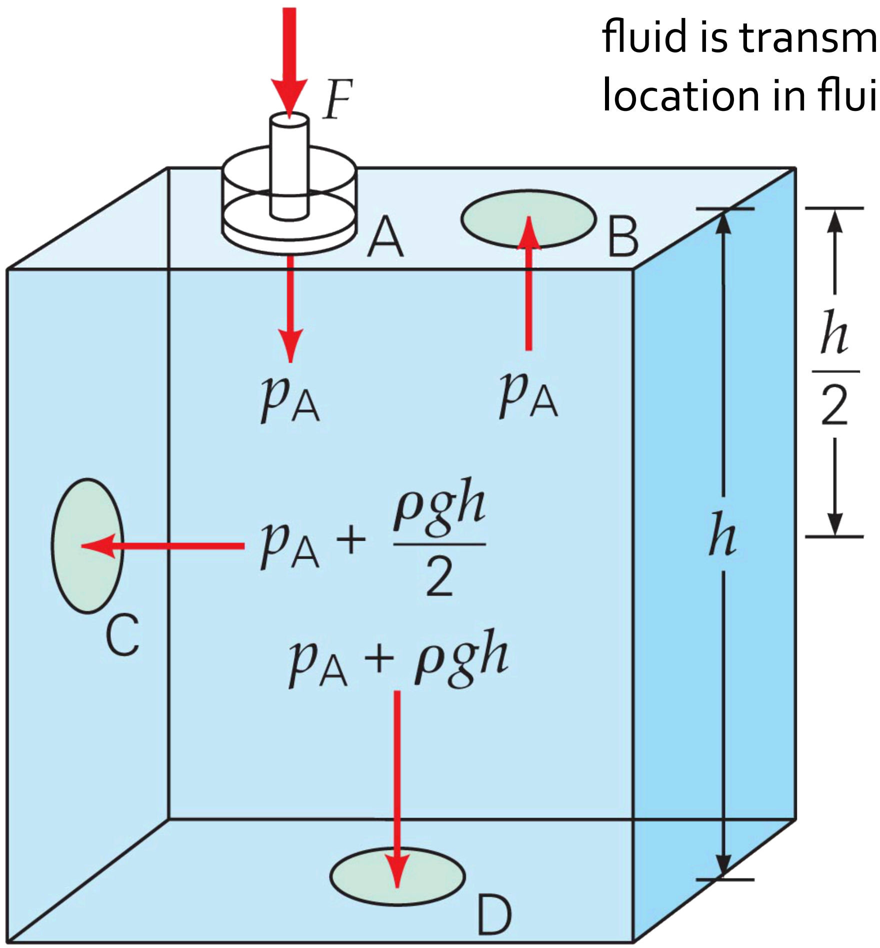
$= P1 + m_{fd}g/A$

$= P1 + \rho * A * d * g/A$

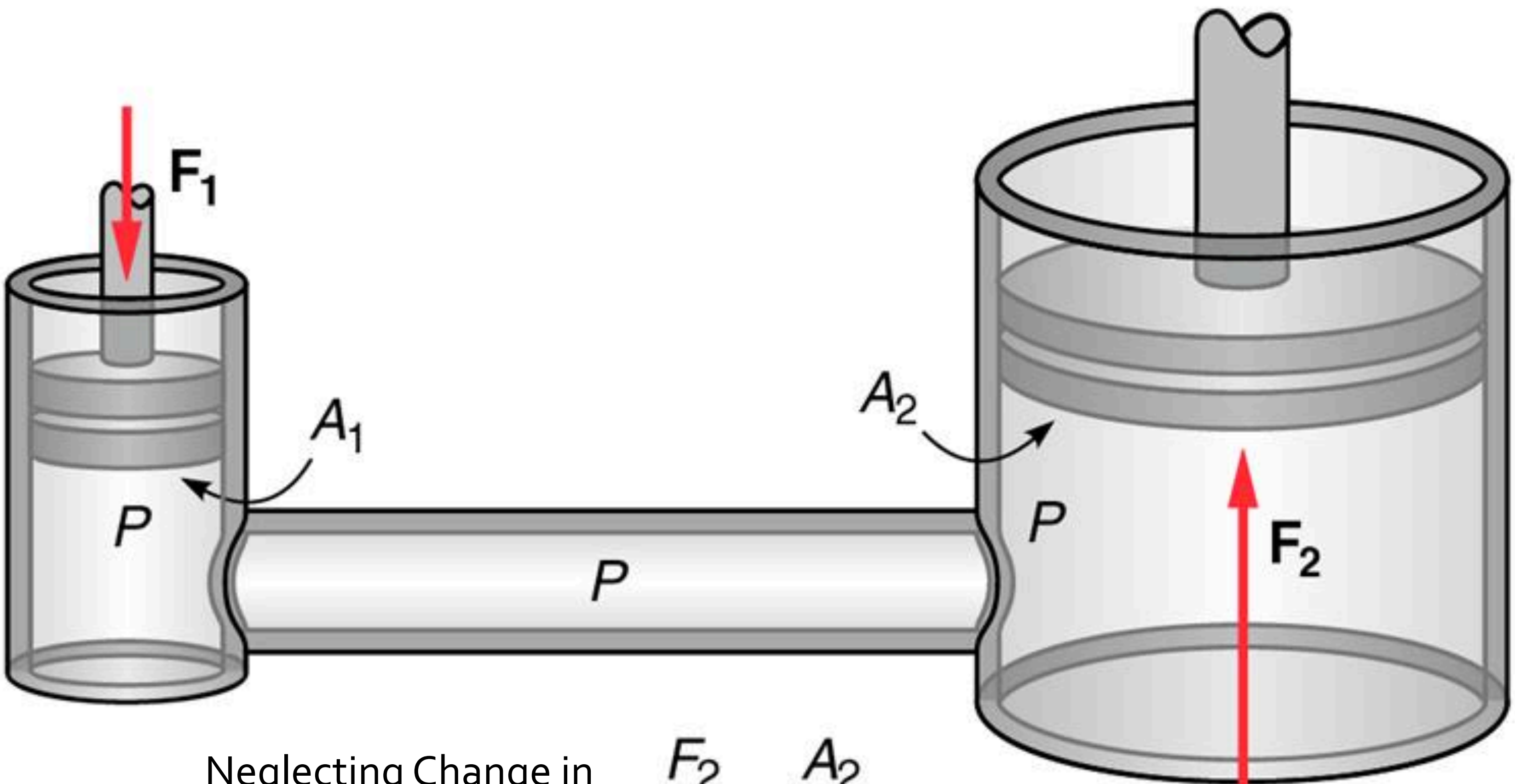
$= P1 + \rho g d$

Pascal’s Principle

Pascal's Principle: pressure applied to enclosed fluid is transmitted undiminished to every location in fluid as well as container walls.

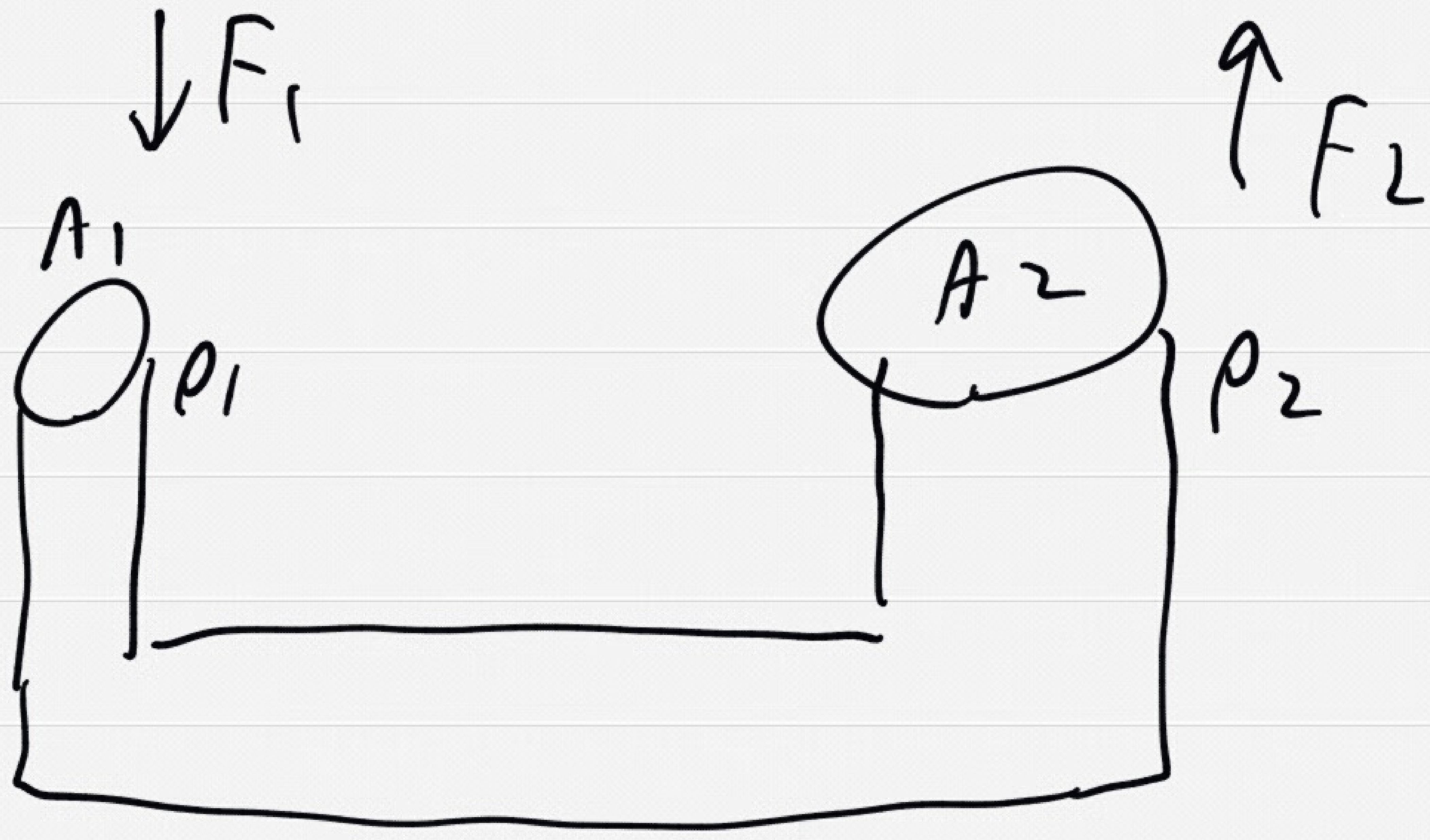


Pascal's Principle: Application



Neglecting Change in Pressure with Depth

$$\frac{F_2}{F_1} = \frac{A_2}{A_1}$$



$P_1 = P_2$ (same depth)

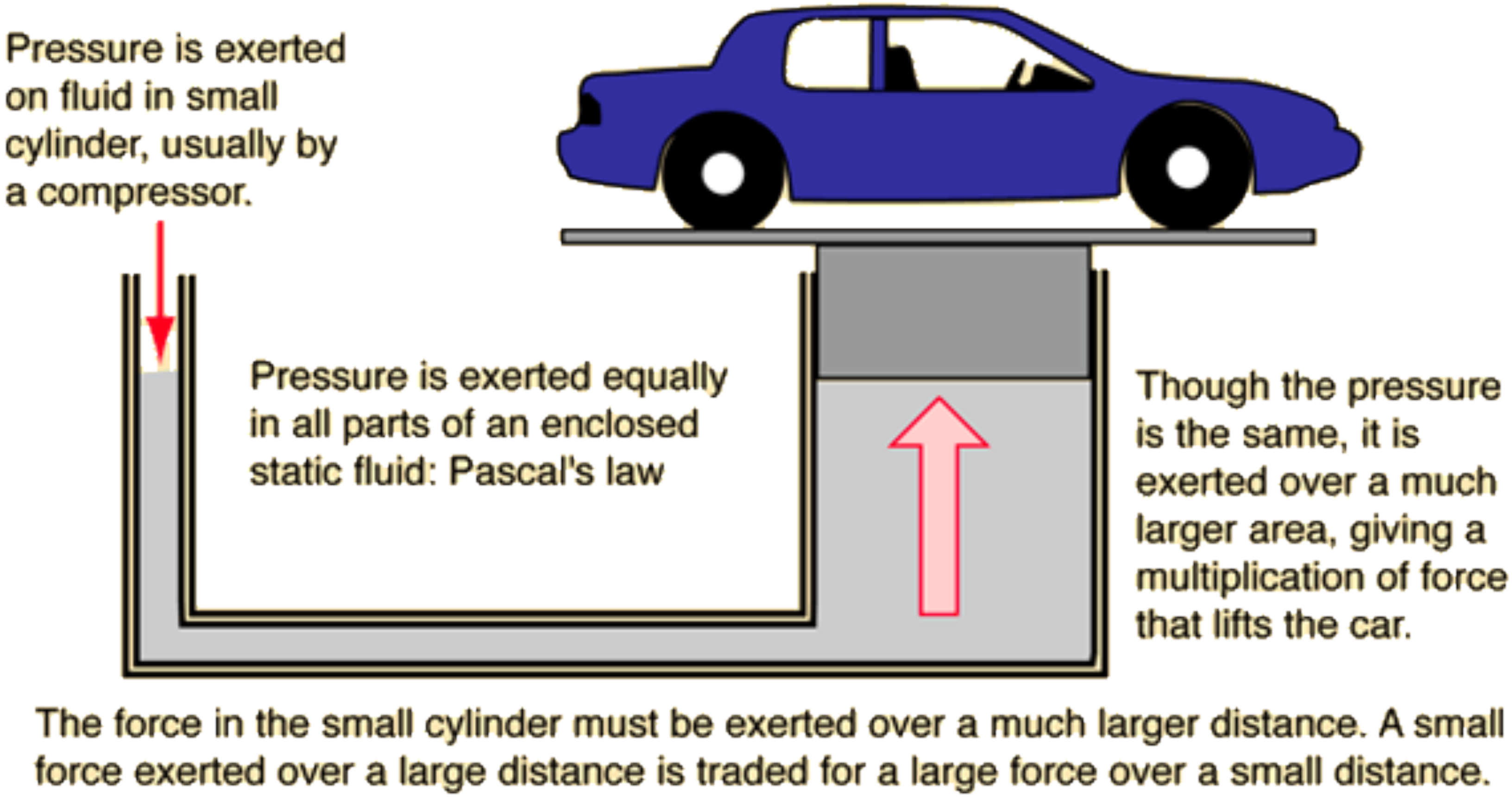
$P_1 = F_1 / A_1$

$P_2 = F_2 / A_2$

$$F_1 / A_1 = F_2 / A_2$$

$$\boxed{F_2 = F_1 \cdot A_2 / A_1}$$

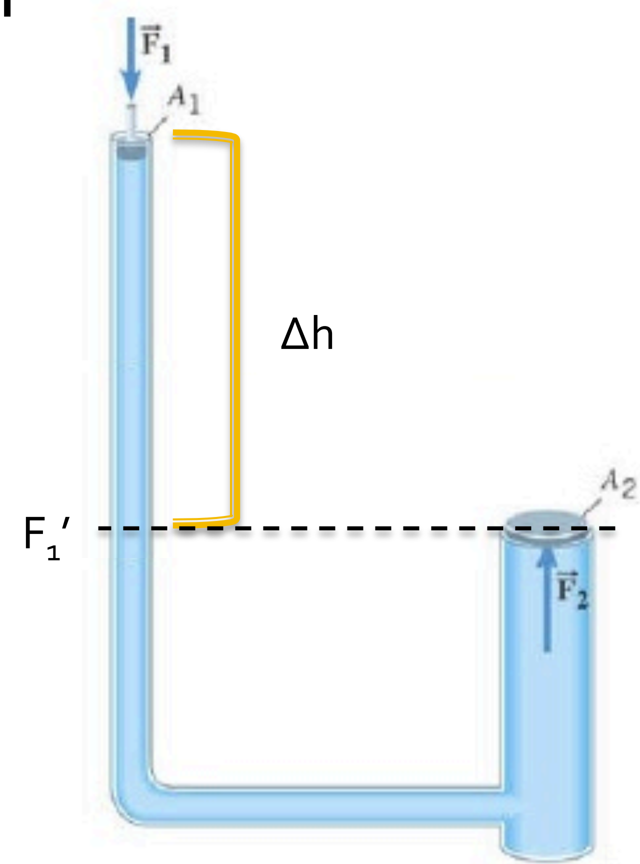
Pascal's Principle



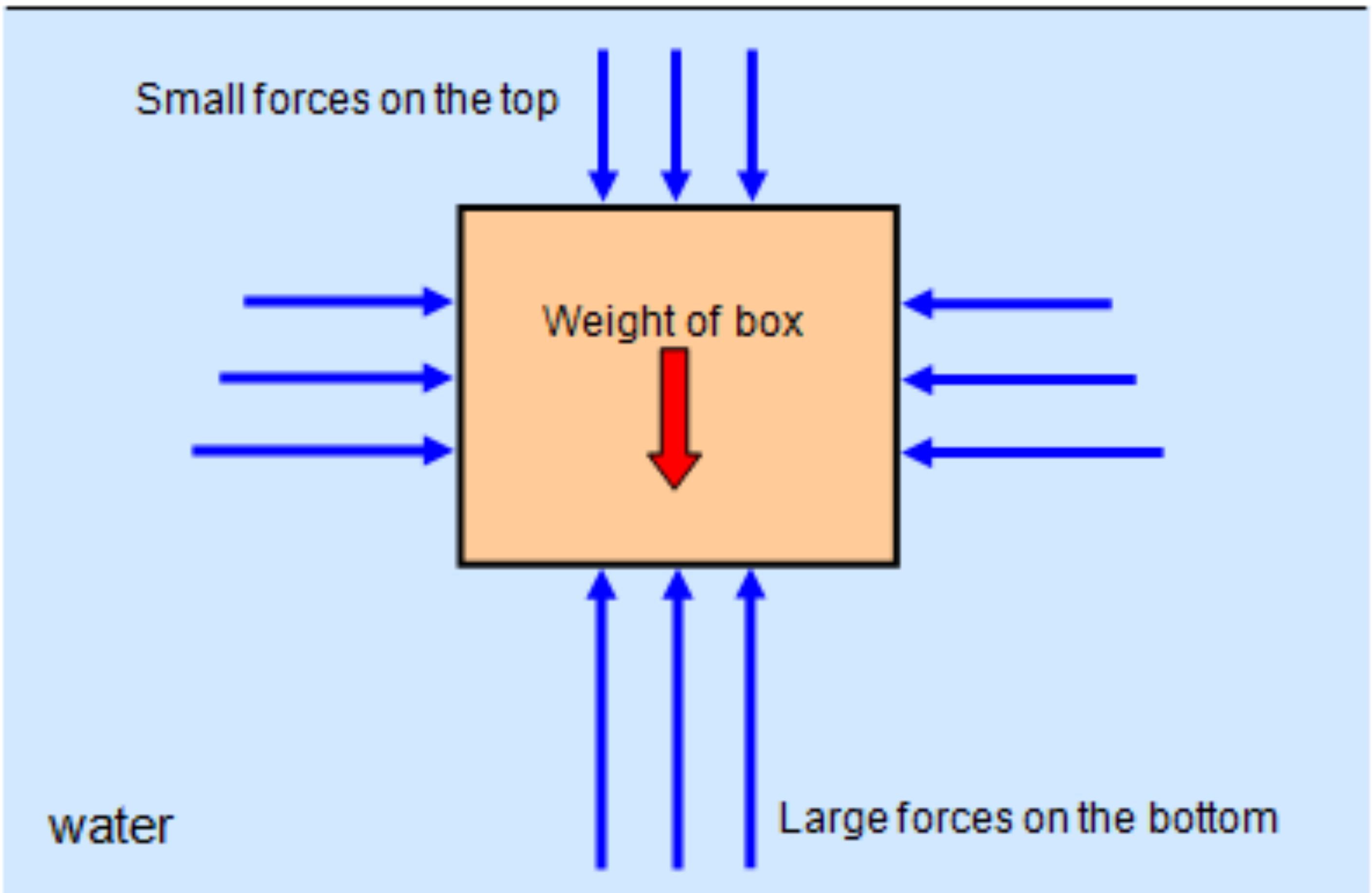
Pascal's Principle: Unequal Height

- In some cases, may need to take into account change of pressure w/ depth

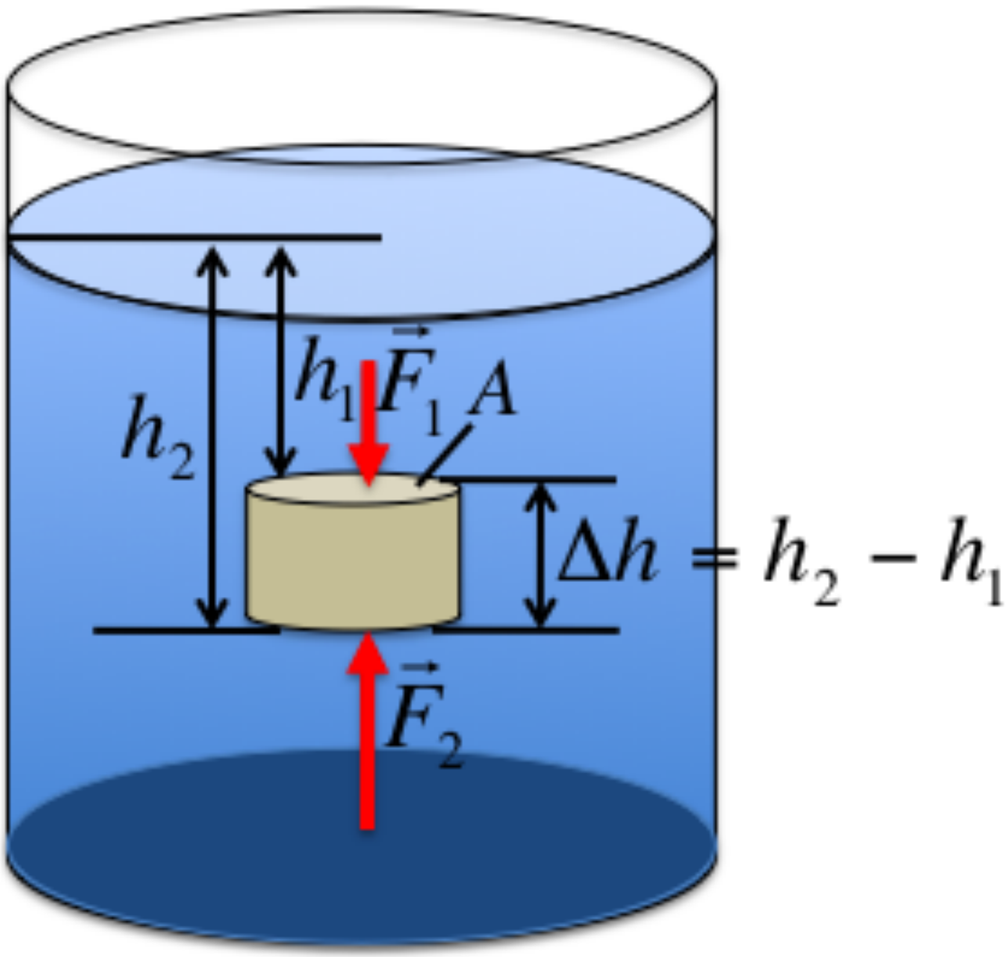
- In this case:
  - $P_2 = P_1' = P_1 + \rho g \Delta h$
  - $F_2 = F_1' * A_2 / A_1$



Forces on Object in Fluid



Bouyant Forces Quantified



$F_1 = P_1 * A$
$= \rho_{fluid} g h_1 * A$

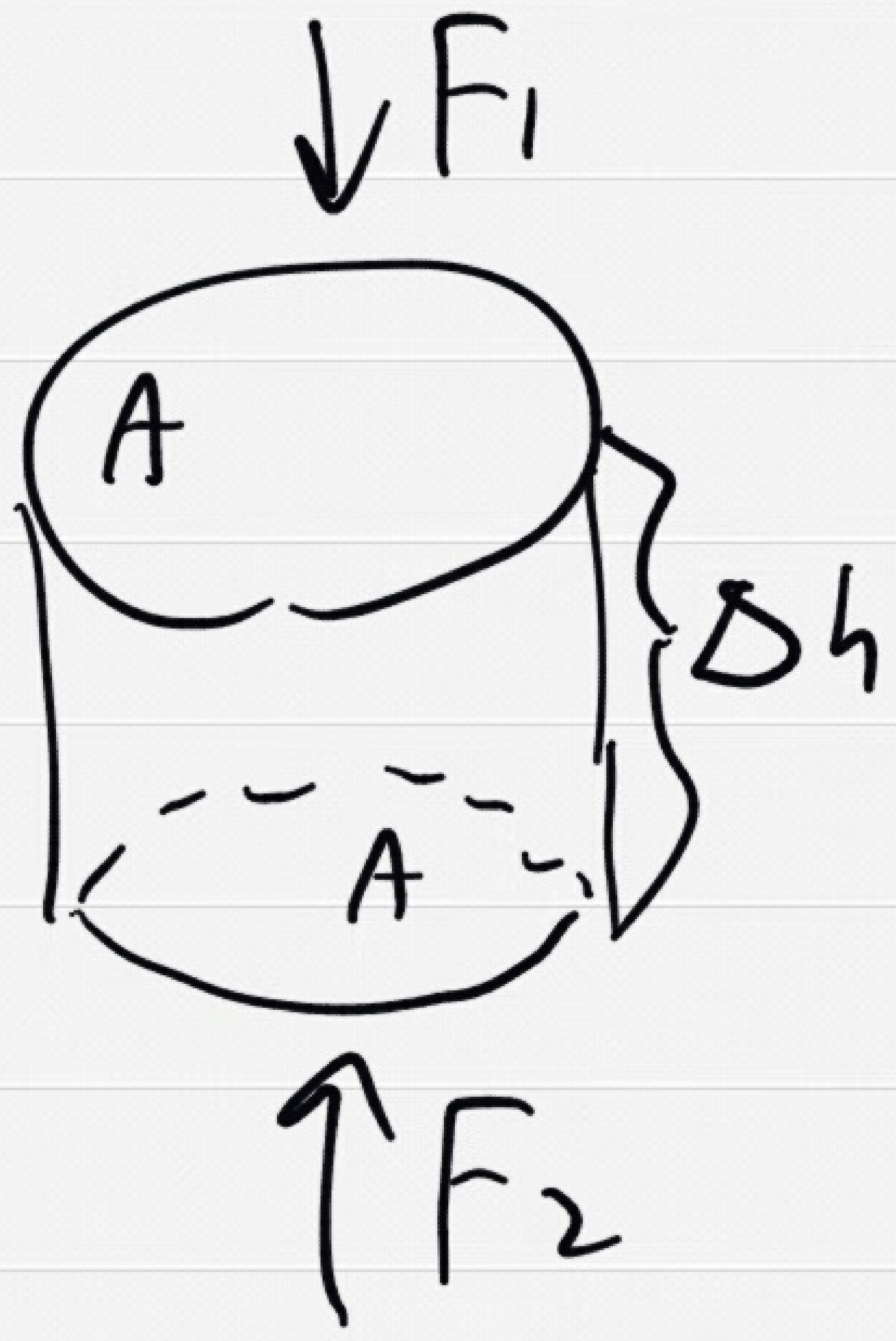
$F_2 = P_2 * A$
$= \rho_{fluid} g h_2 * A$

$F_{Bouyant} = F_2 - F_1$
$= (P_2 - P_1) * A$
$= (\rho_{fluid} g h_2 - \rho_{fluid} g h_1) * A$
$= \rho_{fluid}\, g\, \Delta h * A$

Archimedes' Principle

- $\Delta h * A$ =
  - The volume of the submerged object!
- $\rho_{fluid} g \, \Delta h * A$ =
  - $m_{fluid\_displaced} * g$ = the weight of the fluid that was displaced by the submerged object
- Archimedes' principle
  - The buoyant force is equal to the weight of fluid displaced by an object
  - True for any shape object in any kind of fluid
  - True whether fully or partially submerged

Bouyant Forces



$$P_1 = \rho_f g h_1$$

$$P_2 = \rho_f g h_2$$

$$F_1 = P_1 \cdot A$$

$$F_2 = P_2 \cdot A$$

$$F_{net} = F_2 - F_1 \quad \text{up}$$

$$= (P_2 - P_1) \cdot A$$

$$= (\rho_f g h_2 - \rho_f g h_1) \cdot A$$

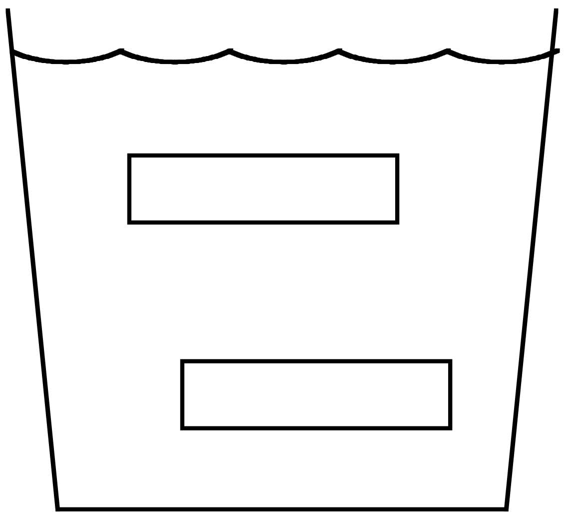
$$= \rho_f g \, \Delta h \cdot A$$

$$= \rho_f g \cdot \text{Volume\_object}$$

= Weight of fluid displaced by object

Concept Check

Two bricks are held under water in a bucket. One of the bricks is lower in the bucket than the other. The upward buoyant force on the lower brick is..



A) greater
B) smaller
C) the same as

the buoyant force on the higher brick.

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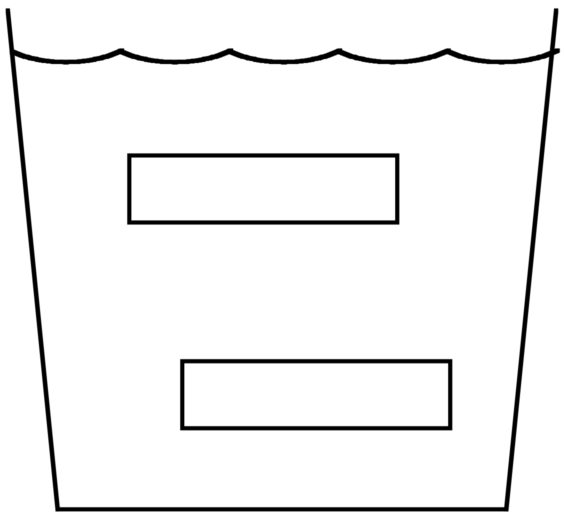
Two bricks are held under water in a bucket. One of the bricks is lower in the bucket than the other. The upward buoyant force on the lower brick is..

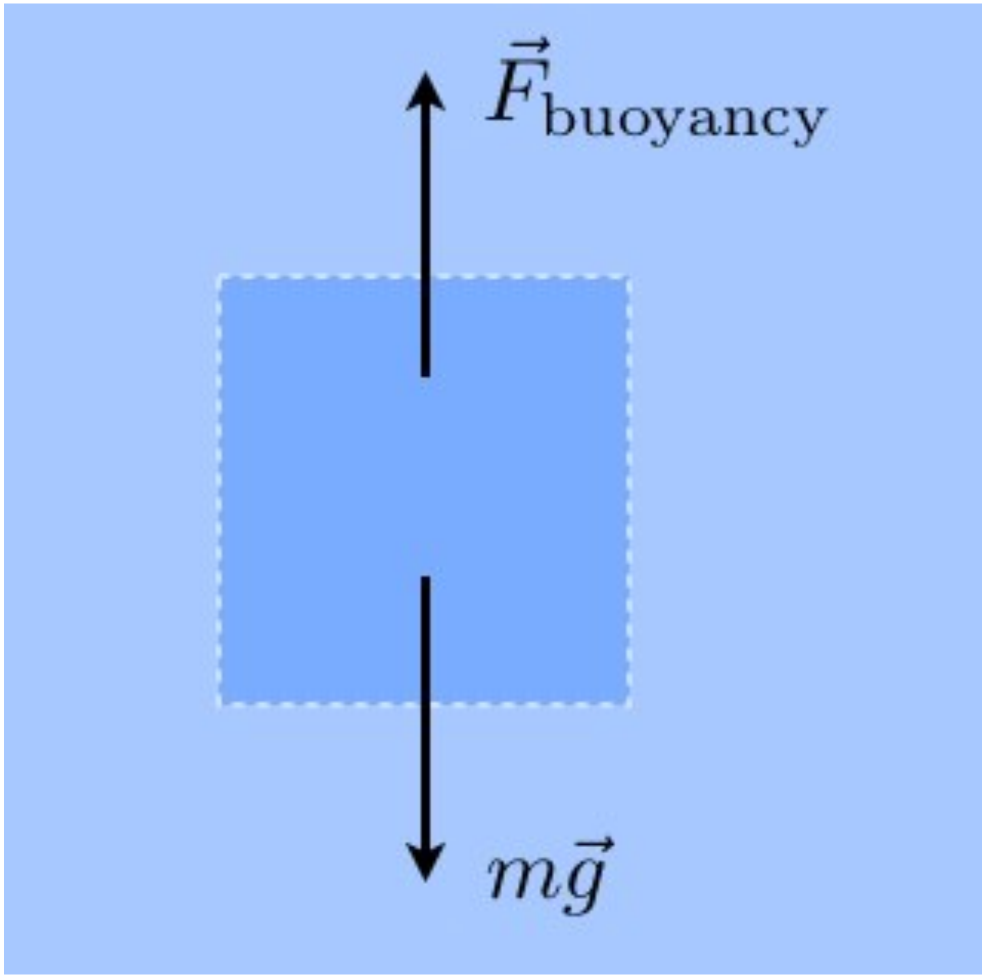


A) greater
B) smaller
C) the same as

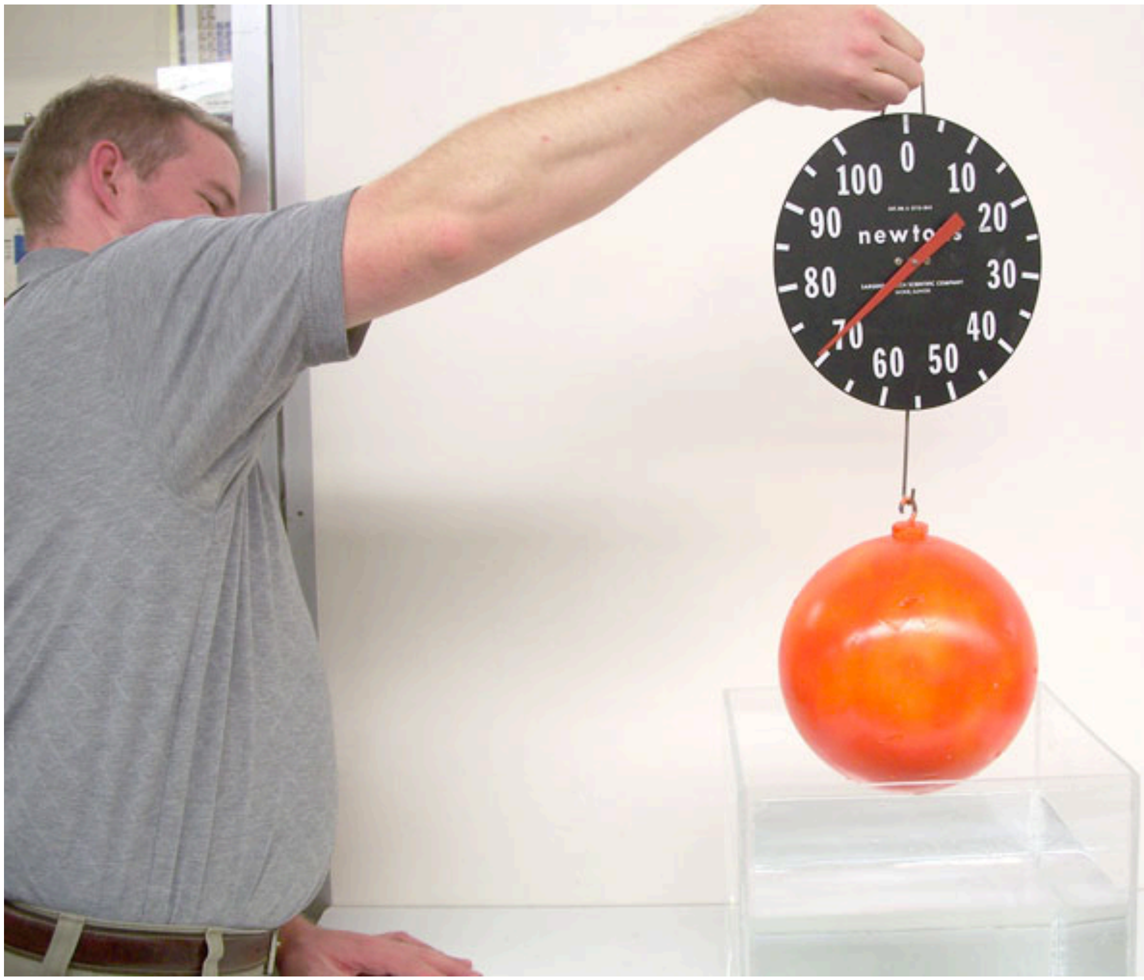
the buoyant force on the higher brick.

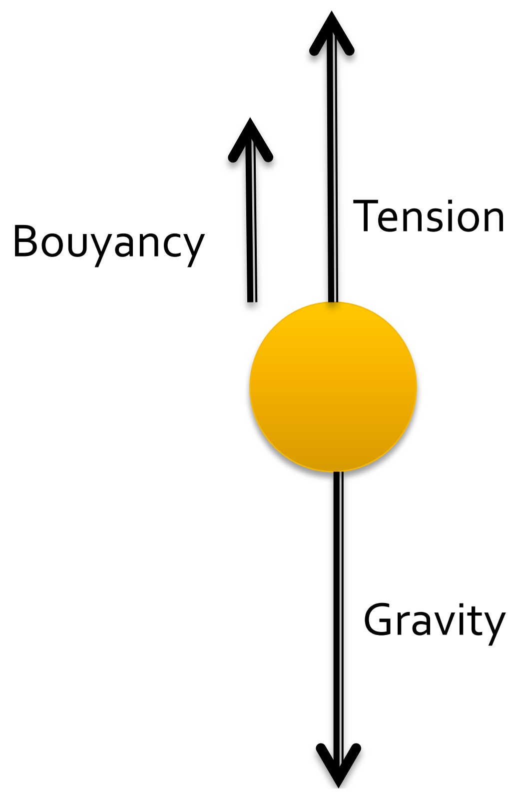
Answer would be different if fluid was compressible!

Forces on Floating Object



Bouyancy In Action

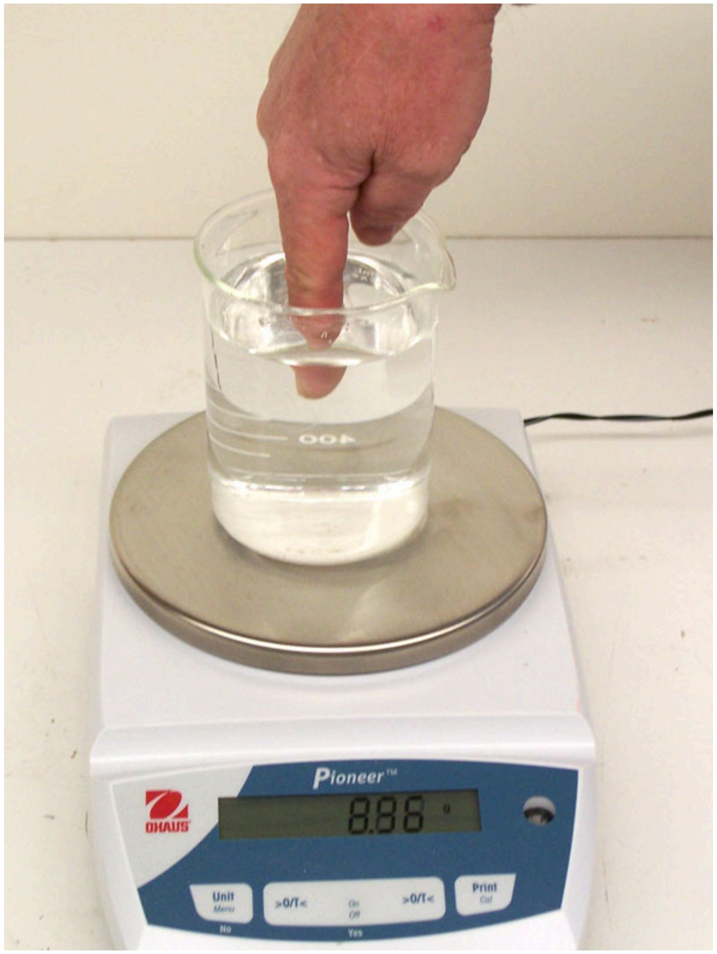




Concept Check

- How will the reading on the scale change when I dip my finger into the beaker?

A. No change since I'm not touching the beaker
B. Increase by the weight of my finger
C. Increase by the weight of water displaced by my finger
D. Decrease since I'm removing the atmospheric pressure on some of the water



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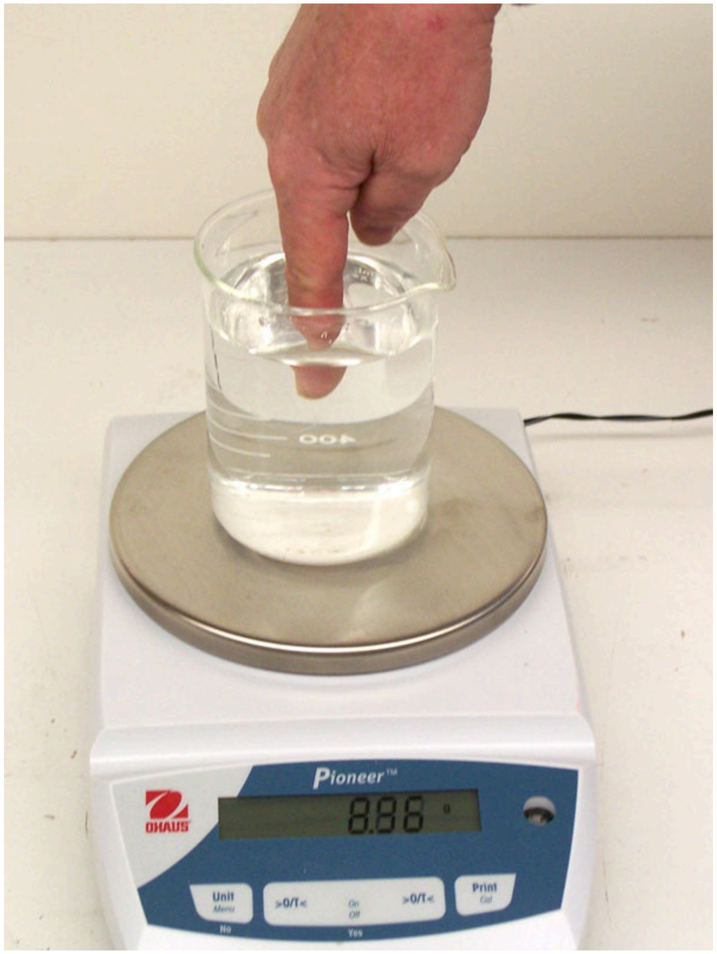
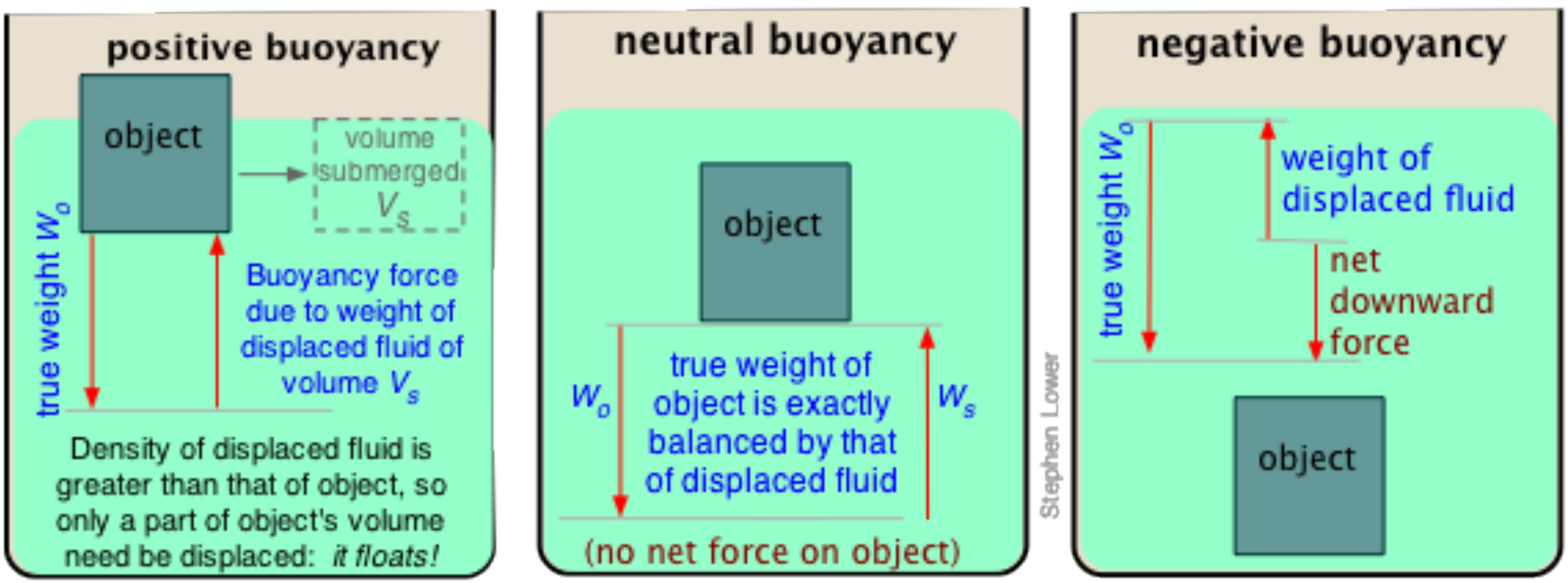


Bouyancy and Newton's Third Law

- If fluid exerts a buoyant force upward on an object, that implies that the object exerts an equal and opposite force downward on the fluid!

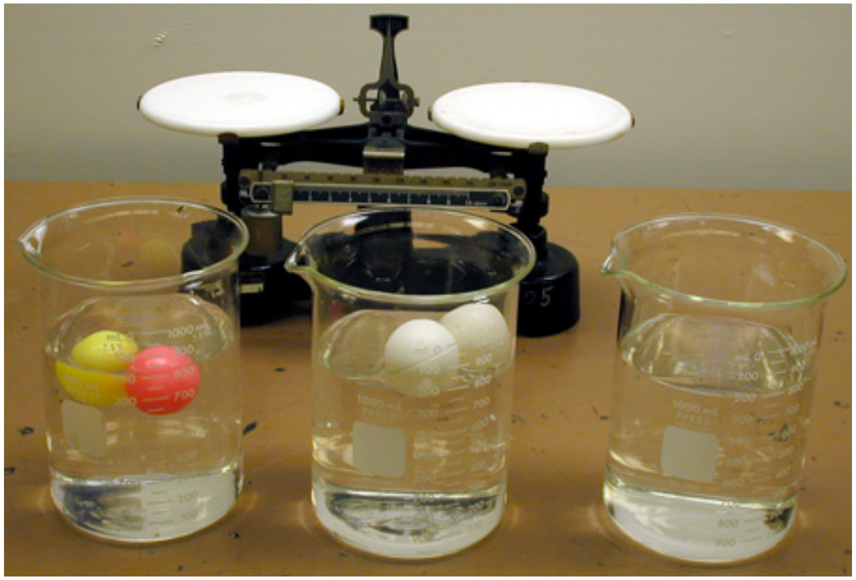
Result of Buoyant Forces Depends on Object Density



Concept Check

- Imagine three beakers as shown. All have exactly the same water level, but two have balls floating in them
- Which will weigh most on my scale?

A. Beaker with water
B. All the same
C. Beaker with light balls
D. Beaker with heavy balls



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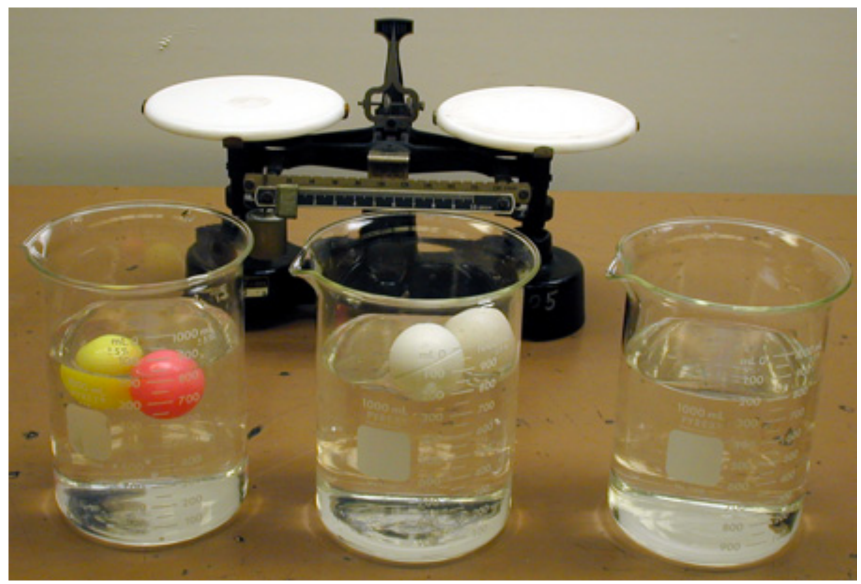

Buoyant Force Vs. Water Displaced

- In each case, the buoyant force is equal to the amount of water displaced
- Since the final water level is constant, we have removed the displaced water
- Since the weight of the objects balances the weight of the displaced (removed) water, the total weight of beaker + water + balls is the same for all three!

The Story of Archimedes

Is it gold???